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1st National Conference

ON

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Adaptive Responses to Climate Change - Impact on Water at low-income households in Coastal Tamilnadu

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Abstract: Water is a fundamental human need, without which the sustenance of life and livelihood would be impossible on earth. Yet we find ourselves in a situation of global Water Stress. India, as a fast-developing country with a rapidly growing population density, has one of the largest water demand world-over with 54% of its population is facing 'high' to 'extremely high' Water Stress (World Resources Institute). Climate Change has been observed and predicted to have the most detrimental impact on water resources, can thus further compromise the availability of water for human needs. By virtue of their location, coastal areas are even more vulnerable to Climate Change impacts such as floods, droughts, sea-level rise and seawater intrusion. Groundwater over-exploitation in coastal cities (such as Chennai) with a dense, rapidly growing population and urbanization causes seawater intrusion in coastal aquifers. This makes groundwater saline and unfit for consumption. The aim of this study is to study the adaptive responses of low-income households to salinization of groundwater - an impact of climate change on water, in coastal Tamilnadu, using a combination of on-field observation and interviews.

Keywords: Climate Change, Water, Adaptation strategies, Low-income households

INTRODUCTION

Water is a fundamental human need, without which human life and livelihood would be impossible. Yet we find ourselves in a situation of global Water Stress in which, almost half the population of the world is already living in 'potential severe water scarcity areas' for 'at least one month of the year' and 73% of the affected people lived in Asia (in 2010) (Peter Burek, 2016). This may be attributed to the growing demands of an increasing global population, exacerbated by rapid urbanization, and the accompanying pressure on land, which has been posing an enormous threat on the world's water resources.

Climate Change has been observed and predicted to have the most detrimental impact on water resources, in the form of changing temperature and precipitation patterns, increasing glacier melts, intense floods, droughts, storm surges etc. (K.Y. Raneesh, 2014). This can further compromise the availability of water for human needs.

India, as a fast-developing country, with a dense, rapidly growing population, has one of the largest water demand world-over (Peter Burek, 2016). 54% of its population is facing 'high' to 'extremely high' Water Stress, as per the maps released by the World Resources Institute in 2015. Figure 1 shows most of Tamilnadu facing a

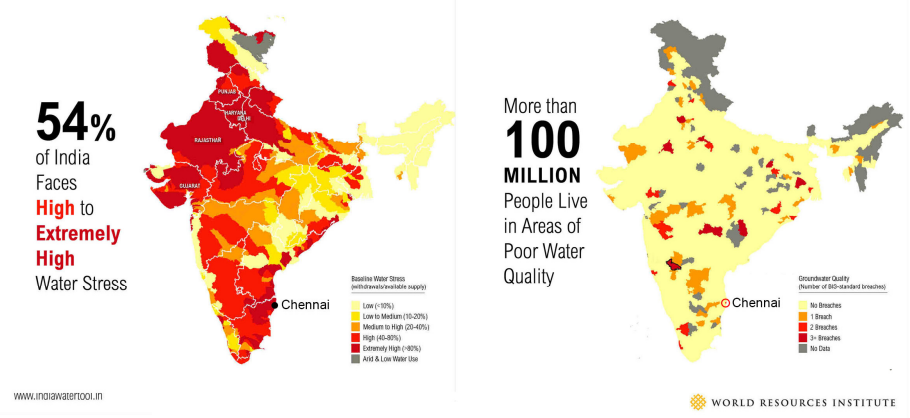

Figure 1. Water Stress by Country: 2040- Map from World Resources Institute, Published on 26 Aug 2015 (Source: India Water Tool 2.0 map)

water stress greater than 40%, wherein the City of Chennai falls in the area indicated to be under 'Extreme Water Stress'. The map also indicates that the groundwater quality of Chennai is heavily compromised as per BIS Standards.

CONTEXT

Chennai and its Setting

Located on a low-lying coastal plain on the Eastern coast of India, along the Bay of Bengal, Chennai, by virtue of its location and topography stands at a greater risk to climate change impacts on water such as floods, droughts, cyclones, tsunami, sea-level rise, coastal erosion and seawater intrusion. Chennai is also the fourth most-populated Metropolitan City in India, with an estimated population of over 10 million. Unchecked and unplanned growth, density, rapid urbanization and the rising pollution levels, make the water resources in the Metropolitan Area even more vulnerable to Climate Change impact (Ravinder Dhiman, 2018).

Precipitation Pattern

Three rivers (Kortalaiyar, Cooum and Adyar) flow through Chennai and its Metropolitan Area, however, none of them are perennial or healthy enough to sustain its water needs, making rainwater an extremely valuable source of freshwater. However, the region receives 60% of its rainfall between October to December (North-East monsoon months) and 33% between June to September (South-West monsoon months), and the rest is spread across the remaining months. The normal annual rainfall in Chennai (as per 1971-2005 data) is 1458mm, which is higher than the national average of 800mm. However, if the rainfall is not conserved during the short spells that it occurs, it ends up flooding low-lying areas and runs off into the sea (S.Suresh, 2012), leaving the city starving for water over the dry summer months.

The Public Water Supply System

The enormous responsibility of meeting the growing water demands of the heaving city, lies on Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) also known as Chennai Metro Water (http://www.chennaimetrowater.tn.nic.in/). CMWSSB mainly sources its water from both surface water sources as well as groundwater sources as shown in Figure 2.

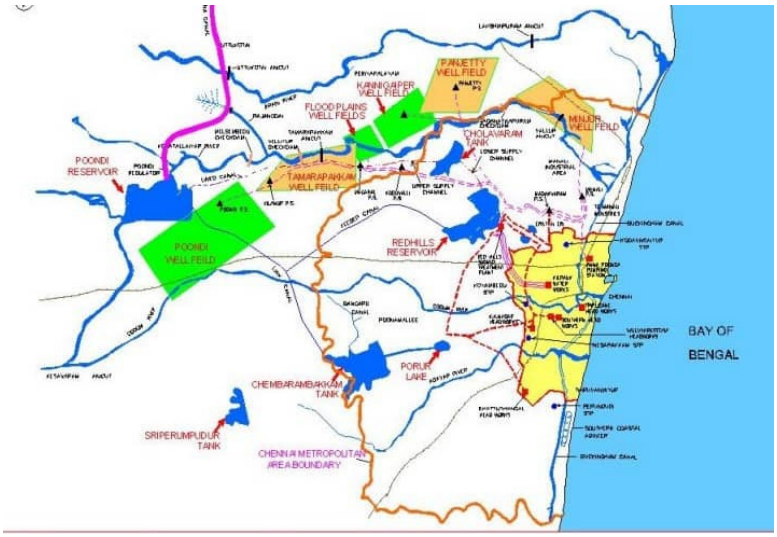

Figure 2. Water Source Surface and Sub Surface for Chennai Metropolitan Region
(Source: CMWSSB 2013)

Groundwater Depletion and Salinization

Groundwater is a critical resource that is catering to 85% of the drinking water demand in India, and is being exploited at an unsustainable rate, which can have a negative impact on our water security (Pahuja, 2010).

Climate Change is likely to impact groundwater levels due to decrease in number of rainfall days and increase in average temperature. The depletion of the coastal aquifers, in areas such as Chennai, can further cause salinization, which renders groundwater unpotable, as a resultant of saltwater intrusion - a hydrological response to lowering of the groundwater table (A.Valliammai P.Jothimani J.Gokila K.Balathandayutham B.J.Pandian & Kar, 2013). Seawater intrusion up to 9km inland was observed to have caused salinization of the Minjur aquifer in Chennai towards 1900. The State government began to take steps to preserve its groundwater potential.

Rainwater Harvesting Initiatives

In 2002, Tamilnadu was the first State in India to bring about a law to make the installation of Rainwater harvesting structures compulsory in buildings by linking it to building permits. CMWSSB has since then taken numerous initiatives to motivate residents to install rainwater harvesting structures, such as constituting a "Rain Water Harvesting Cell" to create awareness, offer free technical assistance, and to create and disseminate 'cost effective solutions' through electronic and print media.

Subsequent monitoring of groundwater levels demonstrated the success of the initiative, in both quality and quantity (CMWSSB).

Gap between Supply and Demand and the Private Water Market

Despite various Government initiatives, a 35% (of the total demand) gap exists between the supply and demand for water in the Chennai Metropolitan Area (CMA), of which 25% is met by the private sector. The private water market comprises of both, the bulk suppliers who supply water through water tankers, and the small suppliers who distribute water in plastic cans (bubble- tops), bottles, water sachets etc.

Despite the higher cost of water involved versus that for public water supply, the private market plays a significant role in making the water ends meet in Chennai (Venkatachalam, 2014). The source of water for these private vendors however, is a cause of concern to the food and water security of the City, as most of them "buy" groundwater from agricultural fields in the peri-urban area of Chennai, compromising water availability for irrigation needs and adding further distress to the fragile aquifer system, leading to potential salinization of groundwater (Samuel Roumeau, 2015).

Water Distress in Low-Income Households in Chennai

The low-income households, are the most marginalized when it comes to the public water supply distribution system in Chennai. They not only receive less per capita water from the system, but also end up spending time (with indirect cost implication) waiting in queues or traveling distances to fetch water in times of water scarcity,

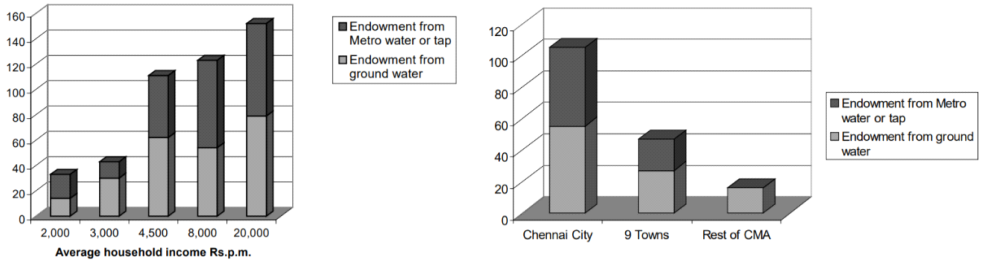

Figure 3. (a) Household Water Endowment in lpcd; (b) Household Water Endowment in lpcd as per location

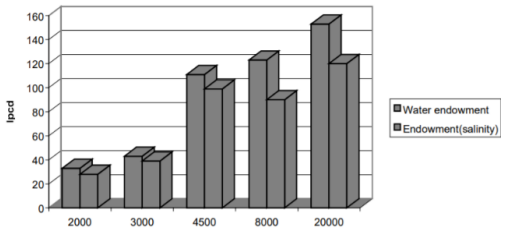

Figure 4. Change in Household water endowment due to salinity
(Source: Anand, 2001)

in addition to the money spent on private water markets to meet gaps in the public water supply. Their plight worsens in times of water scarcity and salinity of groundwater.

The Figures 3a and 3b highlight the inequality in access to water (i) across income groups in Chennai and (ii) based on location of the households, respectively. Figure 4 highlights the impact of salinity of water across income groups. (Anand, 2001)

INTENT OF THE STUDY

To explore the current trends in low-income household responses to climate change impacts on water as a resource, particularly the salinization of groundwater due to seawater intrusion in coastal aquifers in Tamilnadu.

Study area

Mylai Balaji Nagar is a resettlement colony constituted of approximately 2700 low-income families, evicted from the banks of the Buckingham Canal in Mylapore, during 1995, to make way for the MRTS project. The colony is located on the edge of the Pallikaranai Marshland, the largest natural wetland in the region, which is linked to the Bay of Bengal through a network of channel (refer Figure 5). Since the land on which it lies was once a part of the Marsh, the families were given a 'license' to live in plots measuring 15 X 18 feet, instead of outright ownership. Some of these 'licenses' are said to have transferred hands in the years that followed and only a section of the original families continues to live in the colony. This has been partially attributed to the poor access to water and other basic infrastructure, contrary to what was originally promised.



Figure 5. Mylai Balaji Nagar location and context
(Source: Google Maps, 2018)

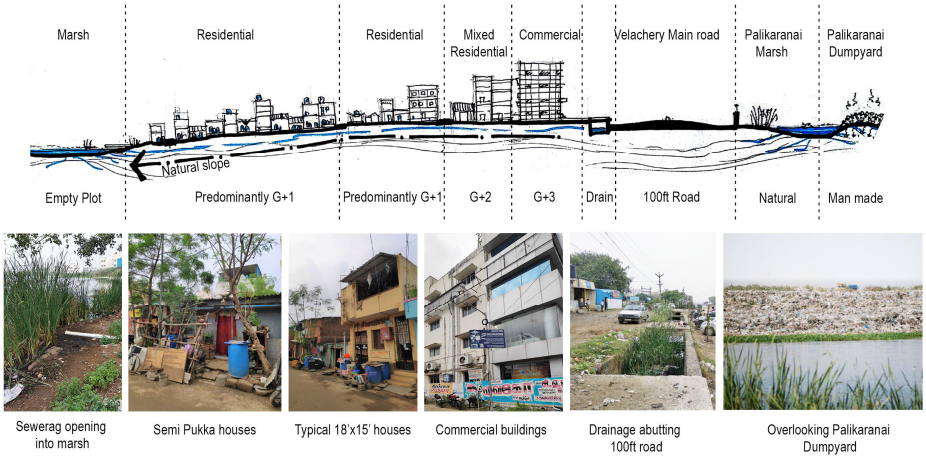

Figure 6. Cross-section across the study area showing the various building types and natural condition
(Source: Author, 2018)

The Pallikaranai Marshland, is partly encroached by the Perungudi (Corporation) dump yard, and is polluted by its leachate and from the effluents discharged from the Perungudi Sewage Treatment Plant. The groundwater table, which is fairly high at around 8 to 10 feet, is found to be 'partially toxic' and 'unsuitable for any domestic purpose' (C. Manoj reddy, 2018). Figure 6 below, shows the typical cross-section across the study area showing the type of buildings and the condition of the ground.

The Public Water Supply is distributed to the neighbourhood through a piped water system and by water tankers in times of need. However, the timings, frequency, duration, reliability and quality of the water supplied is erratic and fluctuates in response to the supply-demand dynamics of the city.

SURVEY METHOD AND OBSERVATIONS

The following observations are consolidated from data observed through background study, on-field observation of the neighborhood and its water- related behavioral patterns, photo-documentation and one-on-one interviews with a random selection of residents in the study area:

1. An array of large blue industrial plastic barrels (for water storage) outside every house in the neighborhood, underscores the fact that the availability and management of water as a resource, largely dominates the life of the residents.
2. On an average, a family of 4 members possesses 2 such barrels of 220-liter capacity (along with an assortment of other vessels) for its storage needs.
3. The groundwater in the area has been observed to be brackish and contaminated by the residents, who avoid using it due to health issues, such as rashes on the skin and hair loss that were noted.
4. The public water supply was delivered to the residents through pipelines to public stand-pipes (installed in the last two years) on a daily basis supplemented by water tanker supply twice a week. It was observed to be the lifeline of the community in the absence of potable groundwater.
5. At the time of the study, the public water supply to the area was reportedly regular. However, respondents mentioned that the supply has been unreliable in the past – both in terms of quality as well as quantity, duration and regularity of supply. They mentioned having waited hours together for the public water supply, or times when the supply was shut down for days owing to maintenance issues.
6. The water pressure in the stand-pipes was observed to lack pressure, and hence the quantity of water that may be tapped was limited. Occasionally, the residents used hose pipes to take the water directly to their homes when the pressure permitted.
7. The quality of water from the stand-pipes is mentioned to be fit enough for domestic use such cooking and bathing purposes. However, only a section of the respondents reported using it for drinking, with or without filtration. The rest seemed to prefer the 'bubble-top' (canned) water sold by private vendors, as it was considered 'safer' – especially preferred when they had toddlers or ailing members.
8. Government Water Tankers supplied water twice per week (based on need and availability). The water was generally reported to be used for washing and cleaning purposes.
9. The residents mentioned it to be a convenient mode of supply, as the water could be supplied directly to the storage barrels, which could then be diverted to overhead tanks using a small motor (refer fig. 9)
10. Rainwater harvesting (RWH) was observed to be adopted in a few households, as a strategy to augment their water supply.
11. The RWH systems observed were mostly made of do-it-yourself, low-cost material such as gutters and pipes that directed run-off water from the roof into strategically placed plastic barrels. This reduces their investment towards the system and allowed them to use the same storage units (barrels) for water from other sources during the dry months.
12. In the absence of a filtration system, the water thus harvested from roof-top run-off was used only for basic domestic use, such as cleaning, washing and watering plants.
13. The amount of water stored using RWH methods was observed to be 'unsatisfactory' by respondents because it was: (i) Seasonal (limited to the monsoons) and (ii) The quantity depended on climate variability, roof area/ storage capacity etc.

14. Underground sumps are rare in the area due to: (i) the high groundwater table and contamination (by virtue of the area being a floodplain of the marsh) and (ii) the tight plot sizes (15 feet X 18 feet).
15. Some houses have installed small motors to pump the water from the storage drums placed on-ground onto overhead tanks (in some cases the same industrial plastic drums double up as overhead tanks) on the roof, to enable an internal piped water system in the house.
16. The residents were observed to display a fairly thrifty manner in the way they managed the available water from various sources. They were sorting the water based on source and utility, with the help of water-holding containers in various sizes and shapes.
17. Some evidence of grey-water recycling was observed in the form of water from rinsing clothes being re-used to mop floors and vehicles or water from kitchen-use being re-used for watering plants etc.
18. The respondents expressed anxiety towards the impending water situation in the coming summer, given the poor rainfall observed this monsoon.
19. Water supply fluctuations were reported to be higher in the summer in the past throwing them at the mercy of private vendors with cost implications.



Figure 7. Left: Typical street view with barrels for storage, Right Abandoned well contaminated by groundwater; *(Source: Author, 2018)*



Figure 8. Piped water connection at every street corner (*Source: Author, 2018)*

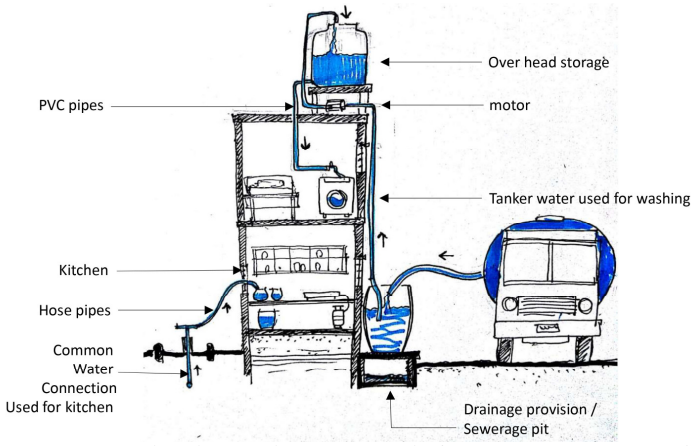

Figure 9. Water usage sketch - Tanker water and Pipe water *(Source: Author, 2018)*

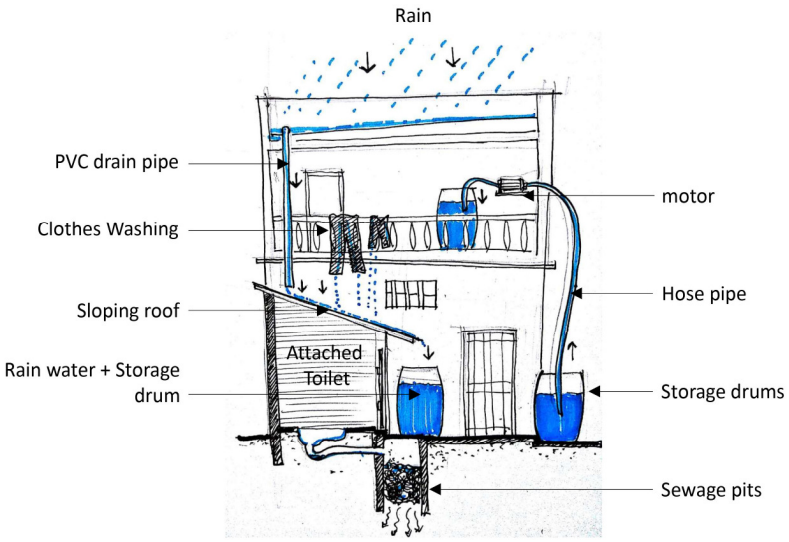

Figure 10. Water storage sketch - Rain water and tanker water
(Source: Author, 2018)

DISCUSSION

The groundwater in the study area has been rendered unfit for domestic use by the combined impact of climate change (groundwater depletion and saltwater intrusion) and anthropogenic pressure (over-exploitation of groundwater and contamination). This makes the community of low-income households in the neighbourhood, highly dependent on the public water supply system throughout the year.

A section of the community partly shows year-long dependency on the private water market, as it perceives the 'bubble-top' water to be 'safer' than the water supplied by the government. This dependency and the cost associated with it, may be eliminated by improving the quality of public water supply or the use of filters at the point of use.

The dependency of the community on the private water market is directly proportionate to the water stress they are subject to. This is found to be the highest during the summer months (April-May) when the public water supply is inadequate in quantity as well as reliability. This increases the per capita cost of water and further strains the low-income household.

The study validates the fact that the low-income households are highly impacted by fluctuations in the public water supply system. This may be offset by decentralizing the public water supply, by adopting both top-down as well as bottom-up approaches.

The RWH systems used by a section of the community to augment their water supply, seems limited in both quality and quantity, which may be enhanced by better design. The quality issues may be easily resolved with the help of suitable filters. Optimizing quantity might be more of a challenge, given the climate variability (fluctuating rainfall patterns etc.) on the one hand, and the limited resources (space and the cost required to build and maintain large-enough reservoirs) of the low-income household on the other.

The viability of enhancing the community-level "collective, long-term, rainwater storage capacity" of the low-income neighbourhood may be higher, compared to enhancing RWH storage capacities at the household-level, as a means to offset the water stress in the community.

On-field observation demonstrates the impact of large-scale over-exploitation of groundwater (groundwater salinization) on a marginalized community that hardly contributes to groundwater abstraction. It also draws our attention to the link between surface water contamination and the groundwater quality. Together, this establishes the link between water resource management and water security.

More detailed investigations on current water management (including rainwater harvesting and grey-water recycling strategies) and waste management at household and community level, might help up develop simple,

low-tech, scalable, environmentally sustainable, grass-root level solutions that might help reduce the city-wide demand for water.

This highlights the need for further research and action on larger issues that are beyond the scope of this paper, such as water resource management and waste-management across scales (house hold-, community- and city-level), since the lack thereof, directly or indirectly compounds the climate change impact on water resources. Detailed investigations on the current practices in water and waste management might help develop simple, low-tech, scalable, environmentally sustainable, grass-root level solutions that reduce the city-wide demand for water. This will in turn alleviate groundwater over-exploitation by the public and private water supply agencies trying to bridge the gap between supply and demand. Lessons and inspiration might be taken from the State-wide rainwater harvesting initiative taken by the Tamilnadu Government.

CONCLUSION

Low-income households are the most affected by the combined impact of climate change and anthropogenic stresses on water resources. This makes them highly dependent on the public water supply system and susceptible to fluctuations in the same. Such dependency and its impact may be offset by decentralizing the public water supply, by adopting both top-down as well as bottom-up approaches.

Given the limited capacities of the low-income households, community level strategies to enhance the "collective, long-term, water storage capacity", may be more viable.

The study highlights the need for further research and action in the areas of water- and waste management across scales (house hold-, community- and city-level), to mitigate climate change impact on water resources. Development of scalable, eco-friendly, grass-root level solutions for the same might be developed to help bridge the gap between supply and demand.

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Exploring energy efficiency in a guest house complex by implementing ECBC building envelope measures in warm-humid climate of Tiruchirappalli

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Abstract: People depend upon mechanical means for thermal comfort thereby increasing energy consumption of a building. Among commercial buildings, hotel buildings consumes substantial amount of energy for providing services and comfort to the guests, than other buildings, typically with low level of energy efficiency. The design features of envelope strongly affect thermal comfort as well as the energy consumption in the building. As a tool to improve thermal comfort, it is essential to come up with strategies that would enhance energy efficiency by using building envelope. Therefore, the study aims to understand the building envelope measures which are mentioned in Energy conservation building code (ECBC) 2017 to reduce energy consumption. This study also investigates the three levels of ECBC implementation and critically analyzes them and proposes guidelines for hotel buildings in warm-humid climate region. Understanding how the building envelope measures can help in reducing cooling hours will help us to reduce energy consumption and conserve electricity.

Keywords: Energy conservation building code, Energy consumption, Building envelope, Warm-humid climate, Hotel buildings

INTRODUCTION

In May 2007, Ministry of Power, Govt of India launched Energy Conservation Building Code (ECBC). It was considered as a first step towards energy efficiency in the building sector of India. ECBC focuses on building envelope, lighting system, HVAC system, electrical system and water heating and pumping systems and provides certain norms for the same. The design features of envelope strongly affect thermal comfort as well as the consumption of energy in the building. As a developing country, India is growing fast with increasing energy demand. So, in order to lower HVAC loads, reduced energy consumption and cost to save energy, ECBC regulations is a must in the current scenario of India.

Building envelope plays an important role in heat gains in warm-humid climate. Building envelope consists of walls, fenestration, and roof and it is one of the most important components of a building. Buildings are subjected to maximum solar gain in places like Tiruchirappalli which experiences maximum diurnal temperature between 26°C and 38°C. A good building envelope acts as a thermal shield, thereby reduces heating and cooling energy demands, reduces the HVAC size and load, and improves indoor comfort. ECBC provides some mandatory provisions for building envelopes to make a building energy efficient. By incorporating such measures in buildings we can reduce the energy consumption of buildings.

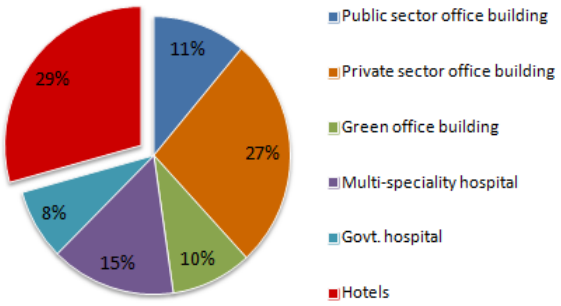

Figure 1. Annual energy consumption
Source: Building energy benchmarking study - USAID ECO III project, 2010

Existing buildings do not give much importance to energy efficiency. People depend upon mechanical means for thermal comfort thereby increasing energy consumption of a building. So it is essential to come up with strategies that would enhance energy efficiency by using building envelope as a tool to improve indoor comfort. Energy conservation and building code (ECBC) promotes energy efficiency in buildings and saves a significant amount of energy. Hotel facilities consumes substantial amount of energy for providing services and comfort to the guests, than office buildings, typically with low level of energy efficiency. So it is very important to promote ECBC measures in hotel category buildings.

Implementing ECBC measures in buildings will credit points in green rating systems of India like GRIHA and LEED rating systems. ECBC related criteria mentioned in GRIHA rating systems are as follows

- Criterion 13 - Optimize building design to reduce conventional energy demand :
- By adopting limited WWR and all the fenestrations meet the SHGC requirement of ECBC (3 points)
- Criterion 14 - Optimize energy performance of building within specified comfort limits: Follow mandatory compliance measures as recommended in ECBC (6 points)

Overview of ECBC 2017

The Energy Conservation Building Code (ECBC) is a applicable for all commercial buildings in India. The code specifies the energy performance requirements of these buildings by providing minimum requirements for buildings and their systems to deliver an energy-efficient building. The building sector in India consumes 33% of electricity, among which commercial sector and residential sector consumes for 8% and 25% respectively. The ECBC was developed to save energy to ensure a sustainable growth for the country

The code prescribes three levels of energy efficiency in buildings. They are:

- ECBC Compliant Building
- ECBC+ Plus Building
- Super ECBC Building

Potential for reducing energy use with technology and materials varies from building type to type. So in ECBC buildings are classified in to different categories. The different typologies are healthcare buildings, assembly buildings, hospitality buildings, educational buildings etc.

Previous studies

Chi-Ming Lai and Yao-Hong Wang (2011), investigates different types of roof, window glass and sunshield, and their effect on energy consumption in residential buildings in Taiwan. It was found that the use of an appropriate window glass reduced the annual energy consumption the most, followed by the shading device and roof construction. Kiran Kumar and AshokBabu (2017), NIT Karnataka, reviewed different combination of walls and window glasses to reduce HVAC loads in buildings. Among the combinations it was found out that the energy efficient combination was mud brick wall with bronze reflective window glasses. That combination reduces cooling loads to a great extent. Ingy El-Darwish, Mohamed Goma (2017), examined how different retrofits in building can bring energy efficiency in Egypt's hot arid climate. Higher educational building was the case study building. The study results show that simple retrofits like solar shading, window glazing, and insulation can reduce energy consumption to 33%. StergianiCharisi (2017), focused on the effect of parameters such as insulation, openings and shading devices on residential buildings in different climatic zones of Greece. The results suggested the right combination of parameters for each climate zone is different and the right combination can save 30% of energy. Among the parameters the thickness of the insulation layer is the effective solution to save energy. It can also reduce the total annual energy demand of the building to less than 50 kWh/m2.

Shivraj Dhaka and JyotirmayMathur (2012), Department of Mechanical Engineering, NIT Jaipur investigated different types of commercial building's energy consumption and their potential to save energy through the implementation of ECBC in Jaipur city. It was found out that the change in envelope measures in Hotel buildings showed maximum energy saving potential and retail mall showed the lowest. Through simulations, about 17%-42% energy was found to be saved from analysed buildings with ECBC compliance and it was concluded that if ECBC is implemented in city of Jaipur 12,475 MWh/y energy can be saved in the next five years. GovindaSomani and Mayank Bhatnagar (2015), undertaken a study to understand the effectiveness of

ECMs in five climatic zones of India. Study was focused to find out which building envelope contributed in energy savings more and which has less. Finally, the study proposes new U-values for roof, wall and glazing properties for better performance of ECMs in buildings of 5 climatic zones. Mayank Bhatnagar and Piyush Varma (2017) assessed the impact of ECBC at national level. It was found that S-ECBC scenario delivers maximum energy efficiency potential, but it does not offer cost-benefit whereas, ECBC scenario succeeds in providing cost-benefit along with energy efficiency potential

METHODOLOGY

Climatic conditions

The study was conducted in Tiruchirappalli, a state in Tamilnadu. The topology is almost flat, with an average elevation of 88 meters. The city is defined under warm-humid climatic zone of India. Tiruchirappalli climate is characterized by high temperature and low humidity with no major change between summer and winter season temperature. The city is the hottest in the state, with an annual mean temperature of 28.9°C. The hottest months are April, may and June. This results in comparatively high cooling loads on the HVAC systems. Monthly average temperatures range between 25 °C and 32 °C

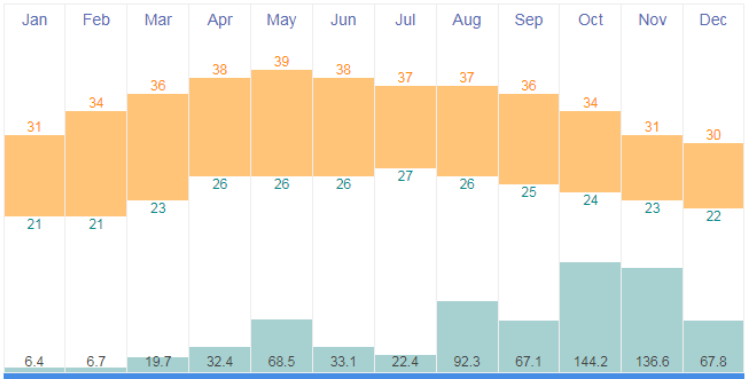

Figure 2. Temperature and rainfall data of Tiruchirappalli (2005-2015)
Source: Customweather, 2018

Study hotel description

The Guest house at NIT Trichy is selected as the study building. The guest house falls under the residential accommodation provided by colleges and that portion of occupancy shall be classified as a No-star Hotel as per ECBC classification. The existing new guest house complex is a modern and constructed in a conventional way. The orientation of the building is along north – south direction. It is a 4 storey RCC building with wooden doors and steel framed sliding windows. The building has a central open courtyard of 12.8m x 18.6m and typical room size is 5m x 3.5 m. Entrance is through the east side, all the other sides are surrounded by vacant plots with less vegetation. Roof, major portion of the walls and open terrace is fully exposed to sun.



Figure 3. Guest house at NITT campus and test model in IES VE

Modeling and simulation

Four test models of 5m x 5m were created for simulation to find out the effect of ECBC implementation in buildings. IES-VE (Integrated environmental solutions) software was used for modeling and simulation for this research. Each model were assigned with different envelope measures like existing condition, ECBC, ECBC + and super ECBC envelope measure respectively. Data were collected from architectural drawings and site visits.

Building envelope properties such as materials used for construction, roof and wall thickness, fenestration material were considered in the test model for the existing case model. For ECBC, ECBC + and super ECBC scenarios the U values provided in the ECBC 2017 are only considered. Material specifications are not taken into account on those 3 scenarios. The input variables are weather data and U values of envelope and the output variables are hourly average indoor temperature to compare it with comfort temperature and thereby calculating the overheated hours

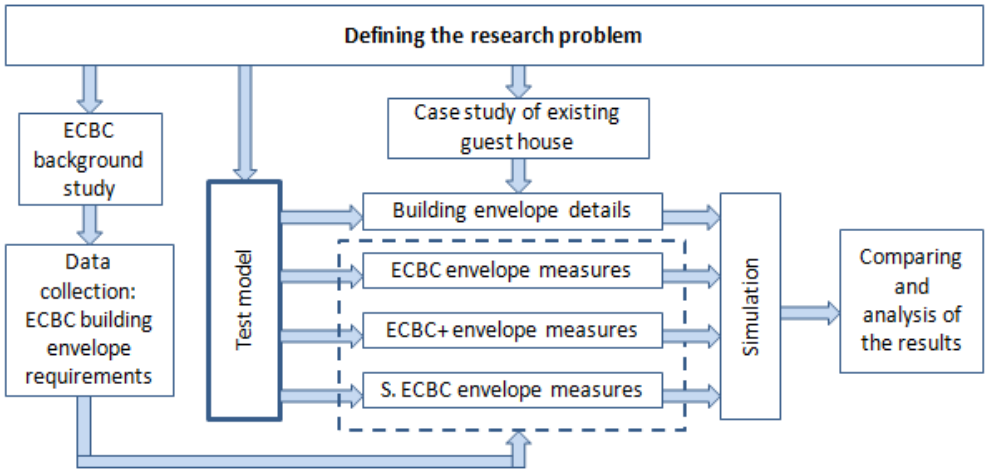

Figure 4. Methodology

Assigned existing, ECBC, ECBC+ and super ECBC envelope properties is as follows:

Existing - Uwall = 2.12 W/m² °C ;Uroof = 2.42 W/m² °C ;Ufenestration = 4.86 W/m² °C.

ECBC - Uwall =0.63 W/m² °C ;Uroof =0.33 W/m² °C ;Ufenestration =3.00 W/m² °C

ECBC+ - Uwall =0.44 W/m² °C ;Uroof =0.20 W/m² °C ;Ufenestration =2.20 W/m² °C

Super ECBC - Uwall =0.22 W/m² °C ;Uroof =0.20 W/m² °C ;Ufenestration =2.20 W/m² °C

RESULTS

Simulation results of existing case model and ECBC case model showed great difference in their indoor temperatures. There was not much difference between outdoor and indoor temperature in existing case model.

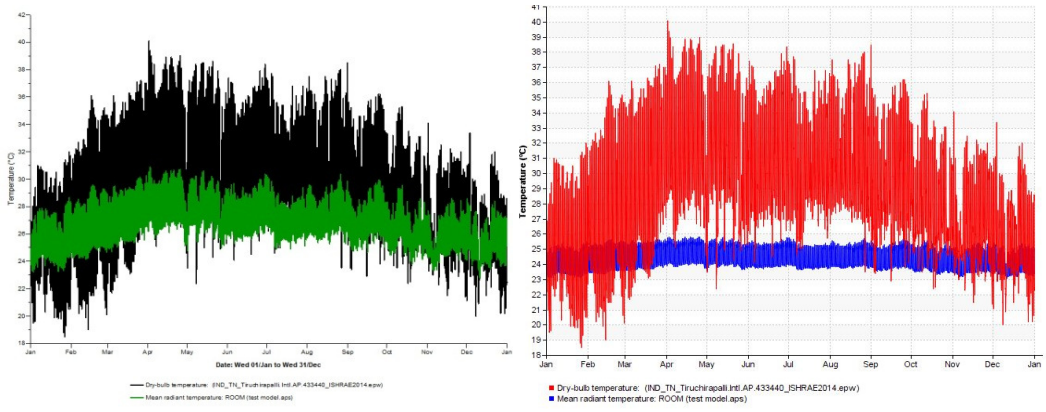

Figure 5. Outdoor temperature vs indoor temperature (Existing case and ECBC case) Source: IES-VE

There is a proposal by ministry of power BEE to fix the starting temperature or default temperature of air conditioners at 24°C. Also, as per standard comfort conditions, ideal room temperature is 24°C - 25°C (GRIHA, LEED rating systems) and as per medical definition, 'the range suitable for human occupancy is generally considered between 15°C and 25 °C'.

Since, comfort is a vague concept and subjective in nature which differs from people to people, in this study, the hours with indoor temperatures above 25°C are considered as overheated hours. This overheated hour are considered as the hours where the air conditioners are kept ON. Therefore, overheated hours are cooling hours of the HVAC systems to reduce the indoor temperature to a comfortable temperature, which contributes to the energy consumption.

From simulation results, hourly average indoor temperature of each month in a year is obtained for 4 cases. The hours with more than 25°C are marked and considered as overheat hours and found out the overheated hours in each month for 4 different envelope cases.

Table 1. Overheated hours in 12 months for four cases

Month	Total hrs	Overheated hrs				% of overheated hrs			
		Existing	ECBC	ECBC +	S. ECBC	Existing	ECBC	ECBC +	S. ECBC
Jan	744	466	222	91	56	62.6	29.8	12.2	7.5
Feb	672	579	264	199	141	86.1	39.2	29.6	20.9
Mar	744	738	328	254	171	99.1	44	34.1	22.9
Apr	720	720	351	281	229	100	48.7	39	31.8
May	744	739	342	267	178	99.3	45.9	35.8	23.9
Jun	720	720	326	248	170	100	45.2	34.4	23.6
Jul	744	739	302	214	124	99.3	40.5	28.7	16.6
Aug	744	744	323	232	131	100	43.4	31.1	17.6
Sep	720	703	281	180	104	97.6	39	25	14.4
Oct	744	616	236	122	69	82.8	31.7	16.4	9.2
Nov	720	488	189	103	56	67.7	26.2	14.3	7.7
Dec	744	454	193	86	52	61	25.9	11.5	6.9

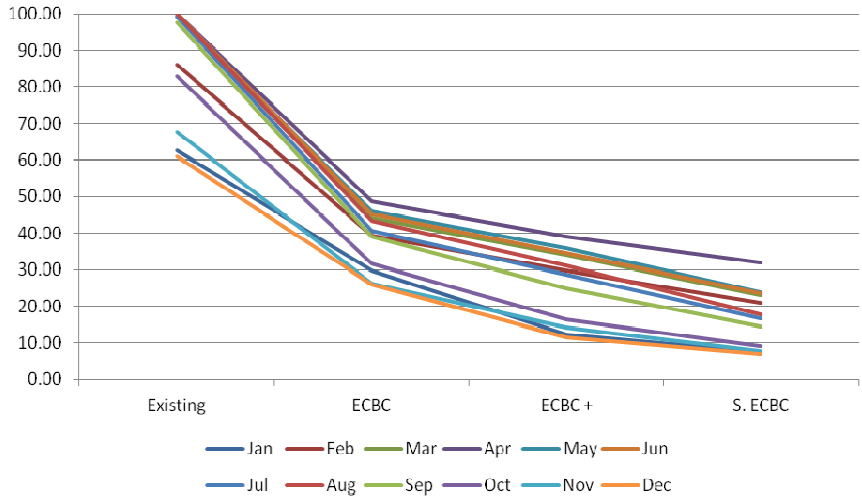

Figure 6. The percentage of reduction in overheated hours by implementing code building envelope measures

Out of 8760 hours in a year, 7706 hours are overheated as per the existing envelope condition. When ECBC measures are implemented a rapid decrease to 3357 hours, 2277 hours and 1407 hours are seen for ECBC condition, ECBC + condition and super ECBC condition respectively. With the implementation of ECBC in the model,, there is a reduction of 48.5% of overheated hours in a year.

It was also found out that, most of summer months in Tiruchirappalli are having all the hours as overheated indoor hours which results in increased cooling load to HVAC systems from March to September. In months like April, June and august, total number of hours is equal to overheated hours including night hours in that month.

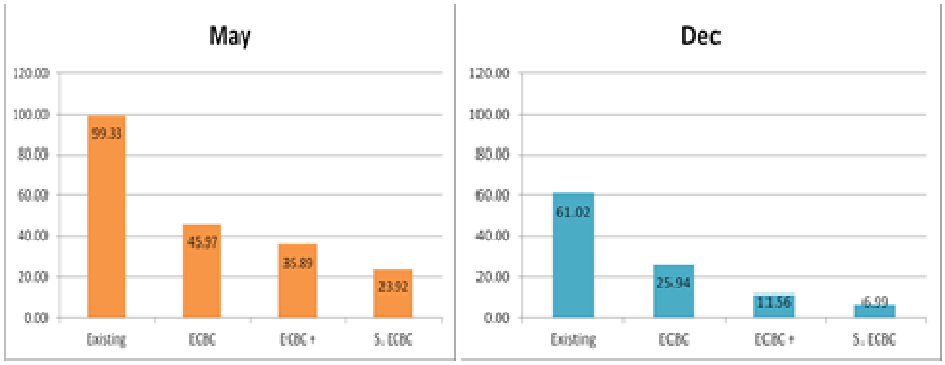

Figure 7. Percentage of overheated hours in the month of may (summer) and december (winter)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	29	31.1	34.6	36.5	33.2	39	36.4	36.4	36.2	32.5	32.4	28.3
2	28.9	32.6	35.6	37.8	38	38.4	37.2	34.7	36.8	35.8	32.6	29.5
3	31	33.6	34.6	38.6	37.6	37.3	34	35.3	36.6	34.2	31.7	26.7
4	28.2	30.4	35.4	40	38.4	38.3	38.3	35.6	37.4	33.8	31.6	28.2
5	29	32.3	35.4	39.3	37.8	33.3	31.4	35.6	35.4	35.1	32.2	28.6
6	30	32.1	36.2	38.5	38.3	36.4	35	34.6	35.8	35.2	28.1	29.4
7	28.9	31.6	38.1	38.5	39.2	37.9	33.5	34	36.2	35.6	32.4	29
8	30.3	31.9	36.5	37.8	39.8	36.5	32.6	34.4	35	36	26.2	28.8
9	28.7	32.1	34.9	37.9	40	37.3	35.6	35.5	36.5	35.6	30.3	29.2
10	29.2	32.2	34.5	39.9	40	37.9	36.1	33.6	36.4	34.4	31	27.8
11	30.7	33.4	35.1	40	40.5	35.7	35.6	29.7	36.4	34	28.4	28.6
12	30.6	33.5	36.1	40.6	41.3	36.7	36	34.5	36.5	33.7	28.1	29
13	31	33	36	39.1	37.4	34.8	35.4	35.4	35	34	25.4	28.3
14	30.5	32.8	36.1	37.6	39.6	35	37	35	35.3	34.2	25	29
15	29.6	33.9	36.1	39.2	37.2	35	35.4	35.4	35.1	32.9	29.5	30.1
16	30.3	34.7	36.1	40.9	36.8	35	35.4	36.8	35.4	33.4	27.6	30
17	30	35.6	36.5	37.6	37.1	35.2	34.6	36.8	33.5	33	30.9	29
18	30	34.6	37	36.8	38.2	35.8	34.8	37	32.5	32.4	30	30.1
19	30.6	33.9	37.5	29.6	35	35.7	36.4	37	34.1	29	30.9	25.6
20	30.4	33.7	39.8	34.3	38.2	37.4	36.3	35.4	34.1	28.7	30.4	29.6
21	30.6	34	40.2	35.8	38.7	37.1	34	36.8	34.6	31.6	30.8	30
22	29.6	32.6	38.6	40.1	39.1	36.3	37	37.4	35	26	29.5	29.6
23	30.9	33.6	37	37	40.6	37	37.6	36.8	34.7	29.6	29.8	29.7
24	32.2	32.1	37.3	38.9	38.4	38	35.2	37.4	33.7	28.7	30	29.2
25	31.5	33.6	36	37.7	40.3	38.1	36	36	33.4	29.6	30	29.8
26	31.4	34.1	36.7	39	39.5	37	33.9	38.2	34.4	28.4	29.6	30.6
27	31	34.5	35.7	40.3	39.4	37.4	35.4	38.2	31.4	27.1	29.4	30.4
28	31.4	34.4	35	40.5	36.6	36.8	33.2	36.9	30.4	26.2	29	30.4
29	32.4		35.8	40.6	37.1	38.2	36.6	35.6	31	27.4	27.6	30.7
30	32.7		36.9	41.8	36.1	36.8	34.1	36.8	31	26	28.1	30.8
31	31.2		38.2		34.7		37	35.8		27		30.5

Figure 8. Recorded high temperature in each day
Source: Climate consultant, 2018

From climate consultant, the recorded high temperature in each day of a year is obtained. From the data, it is found that the day with maximum temperatures are 21st of March, 12th and 30th of April, and 12th and 25th of May. Indoor temperatures of 4 different cases of those hottest days are evaluated to find out the effect of envelope measures in indoor comfort in a place like Trichy which is predominantly hot.

At some point of time, it was found that indoor temperature of the existing case is greater than the outdoor temperature. But indoor temperature of model which follows the code is found always below outdoor temperature maintaining a comfort range throughout the day.

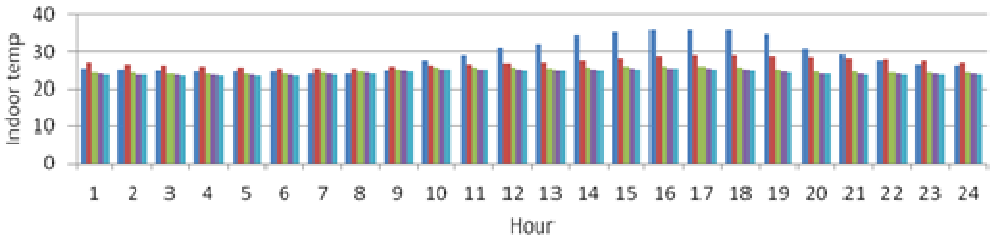

Figure 9. Indoor temperature variation of four cases on March 21st

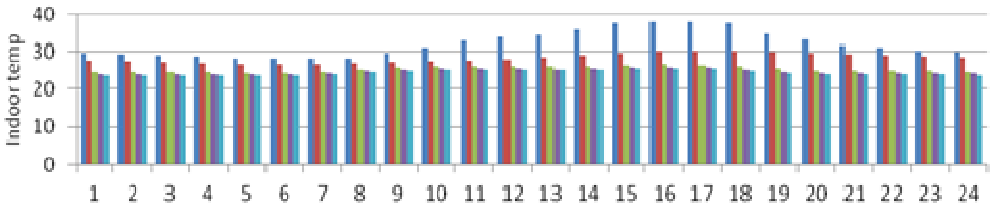

Figure 10. Indoor temperature variation of four cases on April 12th

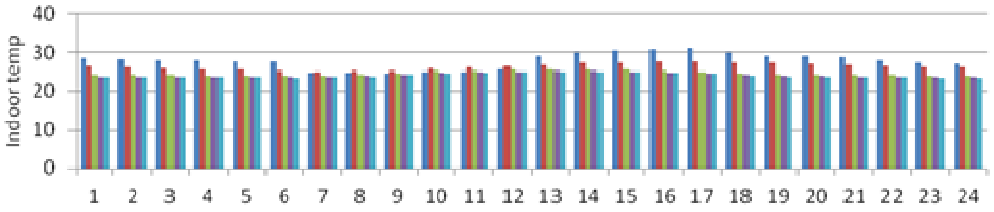

Figure 11. Indoor temperature variation of four cases on April 30th

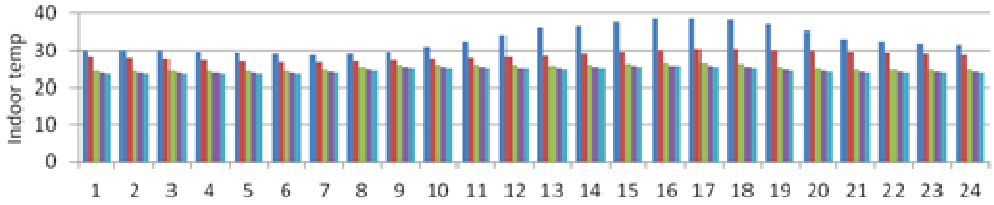

Figure 12. Indoor temperature variation of four cases on May 12th

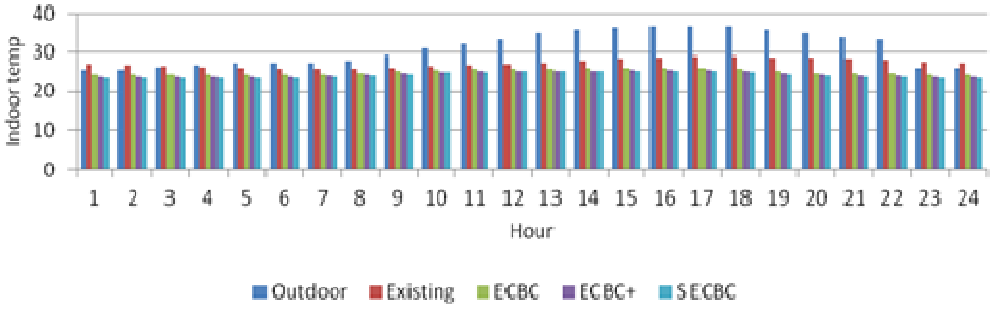

Figure 13. Indoor temperature variation of four cases on May 25th

ASSUMPTIONS

Reducing heat gains by implementing ECBC measures in building envelope there by reducing the energy consumption is the main focus of the study. Among the ECBC compliance measures, only building envelope is taken into consideration. Indoor temperature is the only considered parameter in the building thereby accessing the energy consumption. Other parameters like indoor air quality, visual and acoustical comfort are not taken into account. The research focuses only on warm humid climatic zone of India.

CONCLUSION

The study investigated the reduction of energy consumption by implementing building envelope measures recommended by ECBC 2017 in hotel buildings to improve energy efficiency. The study concludes that there is a large potential for energy reduction by reducing indoor temperature to a comfort range by use of building envelope measures. Energy savings significantly increases further through further levels of ECBC implementation measures. The key conclusions are:

- Adoption of ECBC compliant measures in hotel buildings can reduce cooling hours of HVAC systems from 32% to 58%.
- Adoption of ECBC plus compliant measures in hotel buildings can reduce cooling hours of HVAC systems from 50% to 72%
- Adoption of super ECBC compliant measures in hotel buildings can reduce cooling hours of HVAC systems from 55% to 80%
- It can also be concluded from the above data that :

- Out of the three levels, super ECBC yields more reduction in cooling hours followed by ECBC+ and ECBC compliant measures. But the ECBC+ can reduce cooling hours as much as super ECBC can.
- Since, for super ECBC, needs more thickness and insulation, it is not as effective and economical as compared to ECBC+ envelope measures.

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'Express'ing the cultural experience in historic urban centres: People and qualities

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Abstract: Human settlements across history are constantly evolving as historic urban centres of today. A number of studies assess cultural value towards conservation planning. Authorities attempt to conserve monuments and heritage sites in many historic urban areas. An understanding of how people experience cultural value may help towards participatory conservation planning in the context of historic urban centres. Forms and their embedded and/or surfacial qualities can facilitate people to experience cultural value of a place. The study has proposed four qualities namely as 'awareness', 'attractiveness', 'familiarity' and 'recognisability' with which people 'express' their 'cultural experience' in the context of historic urban centres. A survey was conducted among 270 participants in the historic urban centre of Tiruchirappalli, to examine whether people express their cultural experience through any of these qualities. Using 'Mean Analysis', the results were further analysed considering gender, occupation, years of association and locality information of the survey participants. It was found that people as both experts and insiders express their cultural experience largely through surfacial qualities such as 'familiarity' and 'attractiveness'. 'Awareness' and 'recognisability' of various forms and their embedded qualities is therefore necessary for people to express their cultural experience. Further study is required to understand forms and their 'experiential potentials' in the study area. Qualities are to be identified, with which people, are able to 'locate' their cultural experience in the context of historic urban centres.

Keywords: Cultural experience, Historic urban centres, built forms, Qualities

INTRODUCTION

Since several thousands of years, human settlements evolve across space and time. Natural landscapes have become an accessible and productive choice towards the sitting of any settlement. Transformation of such settlements as cities on a larger spatial-temporal scale indicates the very evolution of cultural and the related practices. One can find that, such cultural practices are commonly expressed in the built forms of many historic urban centers today. This paper is an attempt to address the question of how people 'express' their 'cultural experience' in a historic urban center. It examines a few significant 'qualities' that 'express' people's cultural experiences, in historic urban centers.

LITERATURE REVIEW

A number of studies define the terms, 'culture' and 'value'. Culture is often understood as a diverse and concentrated entity whereas values seem to evolve from the significant practices or events of the past. Such values are socially accepted among people groups, and are 'assessed towards conservation. The term, 'assess' here refers to an act of evaluating and/or analyzing from the data available in order to understand the cultural significance of a place.

Cultural value assessments often use approaches such as ethnographic, phenomenological, experiential, etc. Randall Mason (2002) examines a number of methodological approaches of value assessment in conservation planning. Setha M. Low (2002) suggests a number of anthropological-ethnographic methodological approaches for the assessment of cultural values in heritage conservation. Rapid Ethnographic Assessment Procedures (REAP) methodology is relevant in this regard towards identifying the elements of a local system and how they interrelate, through a qualitative data collection process of uncovering local knowledge.

Assessing the cultural value of a place may vary across disciplines. Besides disciplines, the people's experiences are often considered as a significant aspect in the assessment studies. Cultural values assessed by the 'insiders' (local people) contribute significantly on par with the cultural values assessed by varied disciplines. Hence, besides discipline based approaches, the cultural experience of 'insiders' (local people) can therefore be recognised as they possess a greater sense of belonging to the place that they are attached with.

'Value experience' of any place is often determined primarily by the people who experience and the value of place itself. Eva H. Cadwallader (1980), suggest "The Main features of Value experience" considered at the phenomenological level: "Brown et al. (2002) suggest that people hold certain 'values' but also express 'value' for certain objects. Kevin Thwaites, (2009) in his "Experiential Landscape Model", suggests ways about how to read "experiential potential" of people on any open spaces. However, in conservation planning, there are a very few methodologies which can learn from these models aforesaid, in order to examine 'qualities' with which people, as both experts and insiders, 'express' their 'cultural experience' along the public spaces of historic urban centres.

IDENTIFYING FORMS

The term, 'forms' here refer to a number of physical and tangible components, in and around the historic urban centres. Forms include natural features such as hillocks, river, water systems, etc., and man-made features such as buildings, remnants, routes, etc. These forms possess a number of qualities with which one can experience the cultural value of a place. Ethnographic methods are useful in identifying characteristic forms and their significant qualities in historic urban areas. These methods consider the expertise of both the disciplines as well as insiders (Local people).

'Transect walk' is a survey method from which the researcher him/herself can become the primary participant to experience the cultural value of a place. 'Familiarity mapping' is more of a collaborative tool in which people prepare mental maps of their own places. 'Historians' from the locality can be interviewed in order to get more insights about the etymological understanding of the place. 'Archival records' such as old maps are very helpful in identifying the early existence of buildings, settlement patterns in its surroundings etc. 'Architectural freehand drawings' can help experts such as architects, to represent spatial and visual qualities as the cultural experience of a place. Further, 'literature sources' such as monographs and published studies are often helpful in understanding the context of any town. Ethnographic methods, as suggested above, can help one to list a number of forms and their significant qualities of both the past and the present. These forms include natural areas, religious precincts, historic remnants, colonial institutions, parks, markets, bazaars, retail shops, theatres, restaurants, large stores, public institutions, transportation hubs, etc.

ASSESSING QUALITIES

Forms possess a number of significant qualities across time. One can primarily see many buildings which express layers of 'history' that are associated with the place it belongs to. Few of these forms are considered to be of 'sacred' quality even today. A number of forms do have greater 'visual' qualities attracting people. One can analyse the quality of 'spatial' relationships within built forms, between built forms along the public realm of a historic urban centre. People are often familiar with a few other forms that are part of their daily 'usage'.

There are also significant physical features such as natural areas etc., may inform about how people are familiar with their own place. Few forms, evoke the 'memorable qualities' of people, irrespective of whether it exists or not. Some of these forms may be of concern and sensitive to people, as they may be affected by the control of a few newer developments in and around. In all these qualities aforesaid, one can understand that the cultural experience of a place is therefore characterised, not only by the quality of forms but considerably on how people value such forms and their qualities.

THE CULTURAL EXPERIENCE

A number of forms and their related qualities have been discussed sofar. Qualities such as historical, sacred, visual, spatial, usage, physical, memorable and sensitive are expressed in the forms of significance in historic urban centres. However, these forms have multiple qualities with themselves. People, as both experts and insiders, considerably possess cultural experience on these forms and qualities. The intention of this study is to examine people's qualities that help to 'express' their cultural experience in the context of historic urban centres.

The historical and sacred forms and qualities in the historic urban centers are often understood by people when they are informed by the perception and/or knowledge of a particular fact or a condition. People are aware of historical and religious facts may be due to their geneaological connections and also the traditional practices being adopted by them in their place. Hence, the term, 'Awareness' is proposed. The term, "awareness" here

includes a well-informed interest on the historical and sacred qualities within and beyond the spatial and temporal boundaries of the historic urban centre.

Forms with visual and spatial qualities in the historic urban centres, are often observed by people as they are appealing and attractive in the manner in which the elments are positioned. For example, there are large stores cladded with attractive materials such as glass. On the other hand, one can observe many historical buildings with elegant architectural details. In either of the two examples aforesaid, people are attracted often due to its appealing colour, contrast in shape or form, balance in terms of the visual composition etc. Hence the term, "Attractiveness" is proposed. The term, "attractiveness" here includes a quality that expresses people's ability to appreciate visual and spatial qualities within and beyond the historic urban centres.

Forms of use and physical qualities in the historic urban centres, are often familiarised to people. For example, forms such as schools, commercial stores, public institutions, etc are of significant to people as they are always useful to them, as part of their daily routines. Further, forms such as natural features, can also be familiar to people due to their physical qualities of size, scale, etc. Hence the term, "Familiarity" is proposed. The term, "familiarity" here include a quality that expresses people's ability on being aware of forms of use and of physical qualities within and beyond the spatial and temporal boundaries of the historic urban centre.

Forms of memorable and sensitive qualities in the historic urban centres, are often recognised by people irrespective of whether they exist or not. For example, a travel along a few streets in the historic urban centres may expose the remnants of buildings and their past existence. By mere observation, people may recollect their nostalgic memories of association with that place as to what was originally there in the past. Such memories can inform the embedded character of the historic urban centre. Few other forms are not only memorable but also of a greater concern to people due to exploitations occurred by the modern development. The various concerns that are recognised by people include exploitation of large stores on small retail shops and street vendors, traffic, parking issues etc. Hence the term, "Recognisability" is proposed. The term, "Recognisability" here include a quality that expresses people's ability to identify memories and concerns on forms of memorable and sensitive qualities within and beyond the spatial and temporal boundaries of the historic urban centre. Figure 1 shows the proposed model for cultural experience that suggests the four significant qualities that express people's cultural experience in the context of historic urban centres.

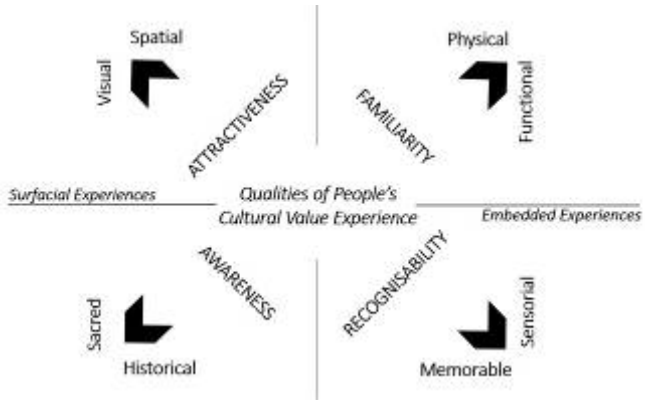

Figure 1. Proposed model for 'Express'ing the Cultural Experience
Source: Author, 2016

The four significant qualities that express cultural experience model are the following: 1) Awareness 2) Attractiveness 3) Familiarity 4) Recognisability. Besides, one can observe that these four qualities express different experiences based on values across time. Qualities such as 'awareness' and 'recognisability' can provided an embedded experience on cultural value in the historic urban centres. Qualities such as 'attractiveness' and 'familiarity' may provide more of a surfacial experience of the cultural value in the historic urban centres.

STUDY AREA

The city of Tiruchirappalli is developed from one among the oldest settlements that has been in existence since 2000 years. The historic river Kaveri, runs at the north of the city from west to east. On the west of the city, the river divides in to two namely as kaveri and kollidam. Further, on the east, where these two rivers join again

near one of the oldest stone dams in the world, called 'Kallanai'(The Grand Anicut). According to historians, this dam was built by a Chola king, 2000 years before. This dam was cleverly positioned in order to irrigate agricultural fields of the kaveri delta region in the entire landscape. Figure 2 shows the view of the study area.

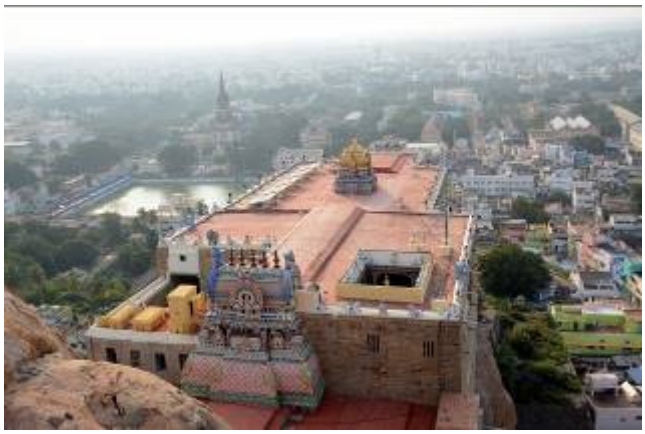

Figure 2. View of the study area from the age-old rock
Source: Author, 2016

The area of study is originally a fortified settlement, of about two square kilometres in its spatial extent. The study area has a very old hillock of about 92 meters high and it is a significant landmark thatsymbolise the city of Tiruchirappalli. There are a number of temples, churches, mosques, and historical buildings, remnants along with many residential streets in and around this hillock. One can also see a number of colonial establishments. The historic and other significances of this study area has facilitated in the economic growth of the place in the present scenario.

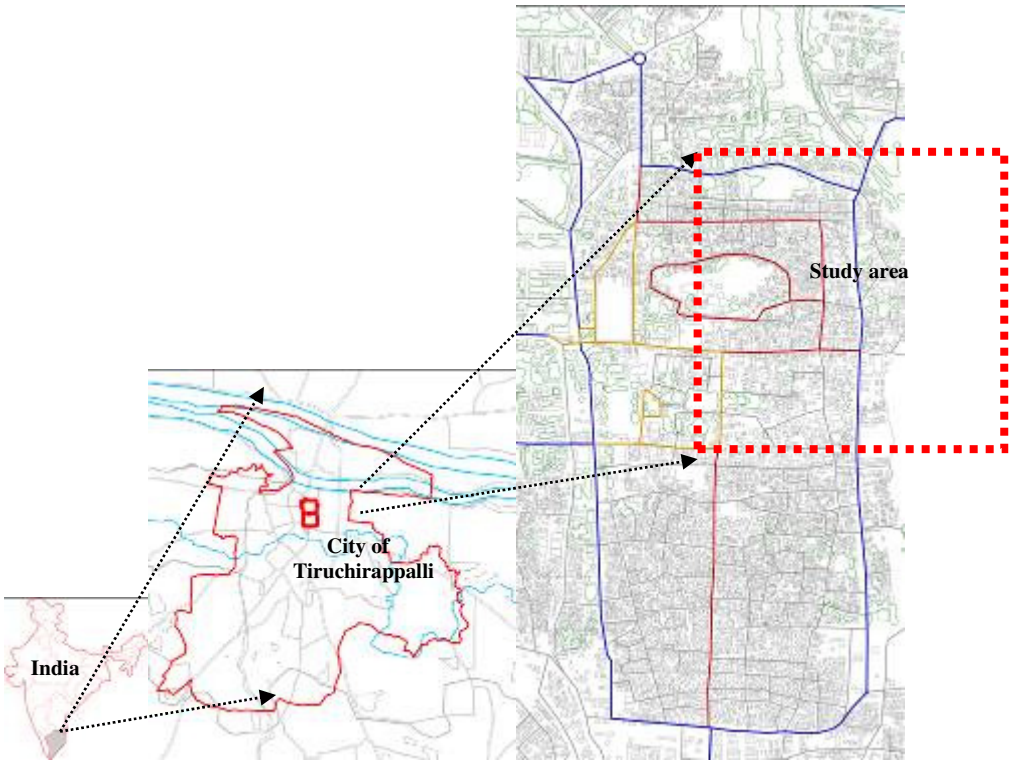

Figure 3. Location of the study area, Tiruchirappalli, India.
Source: google maps re-edited by Author, 2016

One can see a wide range of commercial activities in and around the old hillock. Further, the study area undergoes a rapid change due to the upcoming cultural trends of consumption in the form of globalisation. A number of large shops such as big box stores are expanding day by day. Inspite of all these, the historical and sacred values of the study area is fortunately alive.

STUDY METHODOLOGY

The study intended to test the proposed model for expressing the cultural experience of people. A survey was conducted in the historic urban area of Tiruchirappalli city in the state of Tamilnadu, India in the year 2016. A collective opinion of 270 respondents of varied age group, gender, occupation and years of association were obtained. Respondents were asked to respond sixteen objective statements given to them in a questionnaire based format. Participants chose their responses on a likert scale of five from 'agree' to 'disagree'.

Out of the sixteen statements, the first pair of statements was given for people's response in order to understand whether people are 'aware of' significant 'historical' qualities available in the study area. The second pair of statements was given for people's response in order to understand whether people are 'aware of' significant 'sacred' qualities available in the study area. The third pair of statements was given for people's response in order to understand whether people are 'attracted to' significant 'visual' qualities available in the study area. The fourth pair of statements was given for people's response in order to understand whether people are 'attracted to' significant 'spatial' qualities available in the study area.

The fifth pair of statements was given for people's response in order to understand whether people are 'familiar' with significant 'usage' qualities available in the study area. The sixth pair of statements was given for people's response in order to understand whether people are 'familiar' with significant 'physical' qualities available in the study area. The seventh pair of statements was given for people's response in order to understand whether people can 'recognise' significant 'memorable' qualities available in the study area. The eighth pair of statements was given for people's response in order to understand whether people can 'recognise' significant 'sensitive' qualities available in the study area. Participants were chosen based on the number of years of association, gender, locality and occupation in and around the study area. Table.1 shows the demographic information about the participants of the survey. Out of the 270 participants, nearly 70% had significant association with the study area. The participation of males was relatively more when compared to the female participants. Nearly one third of the participants live within the study area and the remaining majority is from the various parts of the city. Participants had varied occupations, and relatively a much balanced side from various backgrounds.

ANALYSIS AND RESULTS

The sixteen survey statements provided in the survey were tested using 'reliability calculator' created by Del Seigle. The reliability test shows the Cronbach's Alpha value of 0.9 which validates the significance of the statements given in the survey. The responses obtained were further analysed using 'Factor analysis' model. Further, a 'T' test was conducted in order to understand the significance of co-relationships exist between the eight qualities namely as historical, sacred, visual, spatial, usage, physical, memorable and sensitive. Table.1 shows one sample 'T' test on the various qualities of cultural experience.

Table 1.one sample 't' test on eight qualities of cultural experience

S.No.	**Qualities**	**Mean**	**Standard Deviation**	**t**	**df**	**Sig.(2-tailed)**	**Statistical inference**
1	Historical	5.6630	2.31717	40.158	269	.000	P<0.05 Significant
2	Sacred	7.1222	2.45780	47.616	269	.000	P<0.05 Significant
3	Visual	6.2185	2.39897	42.594	269	.000	P<0.05 Significant
4	Spatial	6.1111	2.34772	42.772	269	.000	P<0.05 Significant
5	Usage	7.6148	2.22519	56.231	269	.000	P<0.05 Significant
6	Physical	6.9667	2.70529	42.315	269	.000	P<0.05 Significant
7	Memorable	6.2741	2.63499	39.125	269	.000	P<0.05 Significant
8	Sensitive	6.2296	2.60380	39.313	269	.000	P<0.05 Significant

(Source: Primary data by Author, 2016).

This output delivers useful descriptive statistics, including the mean (Mean) and 95% confidence interval (CI), as well as the actual results from the one-sample t-test. It can be concluded that all the eight qualities correlated significantly and the quality of 'usage' has highest mean score of 7.61 and the standard deviation of 2.23. Historical quality has lowest mean score of 5.66 and the standard deviation of 2.31.

The responses of the sixteen statements for eight qualities of cultural experience were assigned values ranging from one to five. The first pair of qualities was expressed as 'awareness'. The second pair of qualities was expressed as 'attractiveness'. The third pair of qualities was expressed as 'familiarity'. The fourth pair of qualities was expressed as 'recognisability'. Values were assigned for each of these four expression qualities. With, 4 being the lowest value and 20 being the highest value, these four expression qualities were tested further using "Mean Analysis" based on the responses obtained from various participants across demography. Values on a range between 4 to 12 were considered to be of the lower end with the value 1. Values on a range between 13 to 20 were considered to be of the higher end with the value 2. Table.2 shows gender wise distribution of the mean score on the four expression qualities of the cultural experience.

Table 2. Gender wise distribution of the mean score on the four expression qualities of the cultural experience

Gender	**N**	**Awareness**		**Attractiveness**		**Familiarity**		**Recognisability**	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Male	160.00	2.00	0.00	1.99	0.08	2.00	0.00	1.98	0.16
Female	110.00	1.19	0.39	1.00	0.00	1.27	0.45	1.00	0.00
Total	270.00	1.67	0.47	1.59	0.49	1.70	0.46	1.58	0.49

Table 2. Gender wise distribution of the mean score on the four expression qualities of the cultural experience (Source: Primary data by Author, 2016).

The above table explains the gender wise mean distribution of various qualities of cultural experience. It shows that, male respondents have given highest score on the qualities of 'attractiveness' and 'familiarity' respectively. It has mean value of 2 and the standard deviation ±0.00. Whereas the female respondents have given highest score for familiarity and attractiveness respectively it has mean score of ±0.39 and ±0.45.

Table 3. Occupation wise distribution of the mean score on the four expression qualities of the cultural experience

Occupation	**N**	**Awareness**		**Attractiveness**		**Familiarity**		**Recognisability**	
		Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Teachers	30	2	0	2	0	2	0	2	0
Students	40	2	0	2	0	2	0	2	0
Architects	50	2	0	2	0	2	0	2	0
Other Professionals	25	2	0	2	0	2	0	2	0
Religious Priests	14	2	0	2	0	2	0	1.78	0.425
Shop workers	30	1	0	1.73	0.44	2	0	1	0
Shop owners	30	1	0	1	0	1.03	0.18	1	0
Street vendors	25	1	0	1	0	1	0	1	0
Auto/Taxi drivers	26	1	0	1	0	1	0	1	0
	270	1.58	0.49	1.67	0.47	1.70	0.45	1.57	0.49

Table 3. Occupation wise distribution of the mean score on the four expression qualities of the cultural experience (Source: Primary data by Author, 2016).

The above table explains that, experts such as teachers, students, architects and others professionals having similar opinion on cultural experience. It has mean value of 2 and standard deviation of ±0.00. whereas local people such as the shop workers, shop owners, street vendors and auto/taxi drivers has given low score among the other variables. It can be concluded that all the four expression qualities namely as attractiveness, awareness, familiarity and recognisability play an important role in determining the cultural experience in the study area.

Table 4. Years of association wise distribution of the mean score on the four expression qualities of the cultural experience									
Years of Association	**N**	**Awareness**		**Attractiveness**		**Familiarity**		**Recognisability**	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
<10	80	2	0	2	0	2	0	2	0
>10<25	110	1.72	0.45	1.92	0.28	2	0	1.69	0.46
>25<50	60	1	0	1	0	1	0	1	0
>50	20	1	0	1	0	1	0	1	0
Total	270	1.59	0.49	1.67	0.47	1.70	0.46	1.58	0.49

Table 4. Years of association wise distribution of the mean score on the four expression qualities of the cultural experience (Source: Primary data by Author, 2016).

The above table discloses that, attractiveness, awareness, familiarity and recognisability plays an important role for the respondents having less than ten years of association. It has mean value of 2 and standard deviation of ±0.00. Respondents having higher association has given less score on all the studied four expression qualities.

Table 5. Locality wise distribution of the mean score on the four expression qualities of the cultural experience									
Locality	**N**	**Awareness**		**Attractiveness**		**Familiarity**		**Recognisability**	
		Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Within study area	80	2	0	2	0	2	0	2	0
Visitor within city	150	1.53	0.50	1.67	0.47	1.73	0.44	1.51	0.50
Visitor outside city	40	1	0	1	0	1	0	1	0
Total	270	1.59	0.49	1.67	0.47	1.70	0.46	1.58	0.49

(Source: Primary data by Godwin Emmanuel Jeyaraj, 2016).

The above table describes the locality wise respondent's opinion on various qualities of the cultural experience. It shows that respondents within the study area have given high importance for all the variables. It has mean value of 2 and standard deviation of ±0.00. Respondents from within the study area believes that 'familiarity' will help them to express their cultural experience, followed by 'attractiveness' it has mean value of M =1.76, M=1.67: ±0.44, ±0.47 respectively. Respondents from outside city have given low mean score for the all four variables.

CONCLUSION

The study has so far analysed whether people express their cultural experience through qualities namely as awareness, attractiveness, familiarity and recognisability in the study area. In the 'gender' wise mean distribution, respondents express cultural experience predominantly through qualities of "familiarity" and "attractiveness". The two qualities expressed here are of surfacial experience. This shows that people are influenced more by 'surfacial qualities' to express their cultural experience in the context of the study area. In the 'occupation' wise mean distribution, respondents whether they are experts or local people, express cultural experience predominantly through all the four expression qualities namely as attractiveness, awareness, familiarity and recognisability. Only difference observed was the quantum of knowledge between experts and local people in which the cultural experience was expressed. This shows that people's cultural experience irrespective of their occupation, is largely influenced by both 'embedded qualities' and 'surfacial qualities' in the context of the study area.

In the 'years of association' wise mean distribution, revealed that respondents express cultural experience predominantly through all the four expression qualities namely as attractiveness, awareness, familiarity and recognisability. This shows that people's cultural experience irrespective of their years of association, is largely influenced by both 'embedded qualities' and 'surfacial qualities' in the context of the study area. In the 'locality' wise mean distribution, respondents within the study area, express their cultural experience

predominantly through 'familiarity'. This shows that people's cultural experience, is largely influenced by 'surfacial qualities' in the context of the study area.

Overall, it is found that the cultural experience was largely expressed by people's familiarity and attractiveness as surfacial qualities of the study area. The embedded qualities such as 'awareness' and 'recognisability' seems to have lesser influence on expressing cultural experience of people. This indicates a considerable lack of awareness and recognisability among people about various significant forms and qualities available within the study area.

The study has therefore attempted in identifying four qualities with which people express their cultural experience. Qualities that 'express' cultural experience was obtained from people as both experts and insiders. Besides people, 'forms' themselves can also express cultural experience. Cultural experience can be influenced by the locations in which the significant forms are positioned. Hence, it becomes important to identify qualities with which people are able to 'locate' cultural experience. Further studies can therefore focus upon locating the cultural experience in the context of historic urban centres.

ACKNOWLEDGEMENT

The author wish to express his gratitude to various historians, priests, architects, students, businessmen, vendors, school teachers, shop workers, shop owners, drivers and every participant who cooperated well towards the successful completion of the survey of this study. Special thanks to Dr.Sugumar for his guidance on quantification of data. Friends and Family for their kind support in completing this paper.

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An investigation on the thermal behavior of building envelopes using Infrared thermography

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Abstract: *Building envelopes in a consolidated urban area tend to absorb more solar radiation than rural surroundings. The rise in surface temperature of the building envelope leads to an increase in the outdoor ambient temperature of that particular area .Thus the building materials used in the façades play a very important role in enhancing both the outdoor and indoor thermal comfort in urban areas. In this paper an investigation of thermal changes in the surfaces of walls facing the streets of a busy urban area in Madurai city centre has been evaluated and also the variance due to surface materials has been studied using infrared thermography. The main objective of this paper is to identify the potentials of thermal infrared camera to evaluate thermal behaviour of the building envelope.*

Keywords: Surface temperature; thermal comfort; thermography; building envelope.

INTRODUCTION

Thermal imaging used for building examination is a very accurate and fast method of qualitative evaluation which has been used for a number of years, primarily to locate defects in the thermal envelope of buildings. Thermal imaging can identify thermal bridges, contamination of walls by moisture, and local cold air blow downs (Nowak and Kucypera, 2010). Infrared thermography is capable of extensive qualitative evaluation of heat losses in buildings of various types and may be successfully used to find comprehensive solutions for energy efficiency issues.

Recently, infrared thermography has found an interesting use in the non-destructive testing of historic buildings. Most often in these structures, it is not permissible to test via opening up the structure. Hence, a non-destructive testing method is required such as infrared thermography.Dall'O' et al., 2013, has done an extensive study to understand the application of the thermography on 87 public buildings especially schools. The results were helpful to qualitatively assess the thermal behaviour of various building elements and materials. The authors have also addressed the issues in infrared scanning in their research paper.

Building envelopes are defined as physical separators of the habitable spaces from the outdoor environment. The components of the building envelope include: walls, floors, roofs, fenestrations and doors. Building envelopes are the critical component of any building since it not only plays a major role by protecting the inhabitants of the building but also by modulating the indoor and outdoor environment quality as well. The objective of this work is to investigate the variations in the exterior surface temperatures of different building envelope materials with the help of thermal imaging camera. The field investigations were carried out for two hours across a busy urban street in Madurai city. The results revealed that materials which were exposed to direct solar radiation like concrete pavements, plastered walls, glass facades and roofs with metal sheets or asbestos, had higher surface temperatures when compared to wood or stone cladding and shaded walls.

TOOLS USED

The Infrared (IR) images were captured using a hand-held Thermal Imaging Camera (FLIR E60). The FLIR E60 is easy to use and offers a temperature range of -20°C to +650°C (-4 to +1202°F) with an accuracy of ±2% and 0.05°C thermal sensitivity. The IR camera serves dual purpose: to capture an impressive infrared image quality with a 320 x 240 (76,800) pixel resolution and a 3.1 megapixel digital camera provides fixed picture-in-picture allowing the overlay of thermal and visible images for easy location identification and clearer documentation. Hobo data loggers were used to record the ambient temperature at the study area.

METHODOLOGY OF THE STUDY

A field campaign was undertaken across a crowded street (town hall road) situated in the urban core of Madurai city to investigate the thermal behaviour of the exterior building envelope. The field investigations were performed for different wall materials at different orientations, roofs, concrete pavements, roads and landscape elements over a period of 2 hours from 10.00am to 12.00am on 26th of December 2015. The locations of the buildings investigated are shown in the map given below (Figure 1). The markings 2, 3, 4 and 5 represented in Figure 1 are the locations of the Figures 2, 3, 4, 5 and 6 respectively. The infrared images were then analysed to identify the materials with higher surface temperatures on the exterior surface. The ambient temperature was recorded using hobo data logger simultaneously while capturing the thermal images. The statistical weather data of Madurai for 26th December 2015 was also referred to validate the ambient temperature recorded by the data logger (Figure 7).



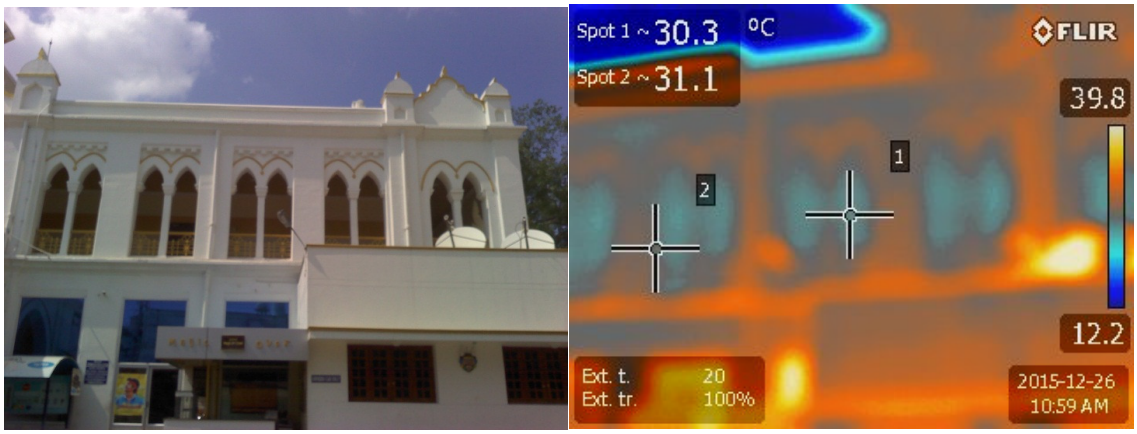
Figure 1. The location map of selected buildings in the study area.

RESULTS AND DISCUSSION

Results from the thermal images revealed that the surfaces that were exposed to direct solar radiation had higher surface temperatures and were represented by dark red and orange colour (Figure 2). The shaded surfaces and surfaces with cooler temperature were shown in shades of blue. The walls were mostly brick walls with cement plaster, glass or Aluminium panels on the facades. The roofs were mainly flat with weather proof tiles on the top. The building heights varied from single storey (3m) to a maximum of four stories (12m).

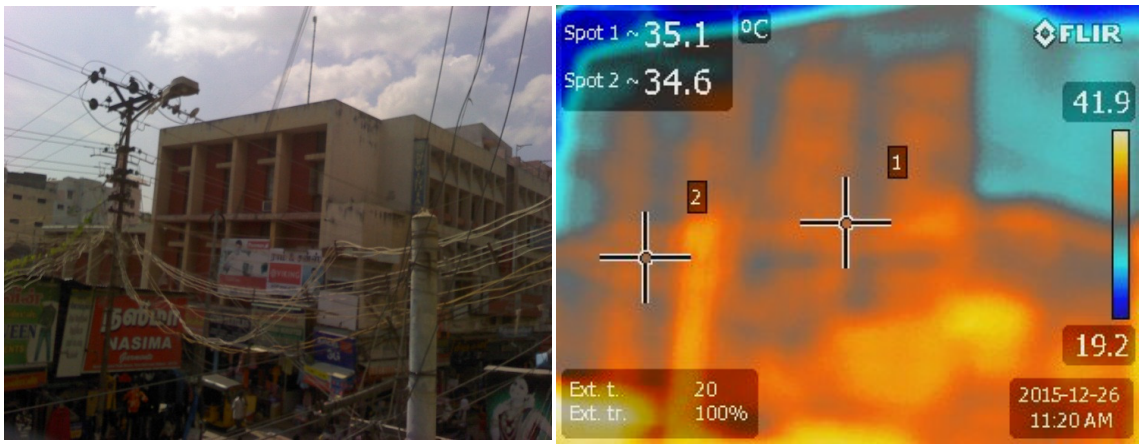
Figures 2, 3 and 4 show the images of east facing walls of different buildings taken at different timings on the same date. Figure 2a shows the original image of east facing wall of building and Figure 2b shows its thermograph. It is noticed that thesurface temperature of the concrete surfaces reached 39.8°C (11:00am) as shown in Figure 2 when the outside ambient temperature was 28°C, with maximum difference of 12°C, higher than the ambient temperature. The shaded areas showed lower surface temperatures (represented by cyan colour in Figure 2). In Figure 3 shows the front view of commercial building made of brick and concrete structure. The image was captured 20 minutes later to Figure 2. It can be noticed that there is a rise in temperature on the

concrete wall surfaces facing east to a maximum 41.9°C (11:20am).Figure 4 shows the image of a commercial building with aluminium cladding and glass façade. In this case, it is noticed that the alcopanel cladding is cooler than the glass surfaces. The temperature of the glass surface reaches up to 39°C (at 11:58am). This clearly proves that the materials like concrete and glass store heat and dissipate it to the surroundings at night.



(a) (b)

Figure 2. Original and thermal Image of east facing building facades.



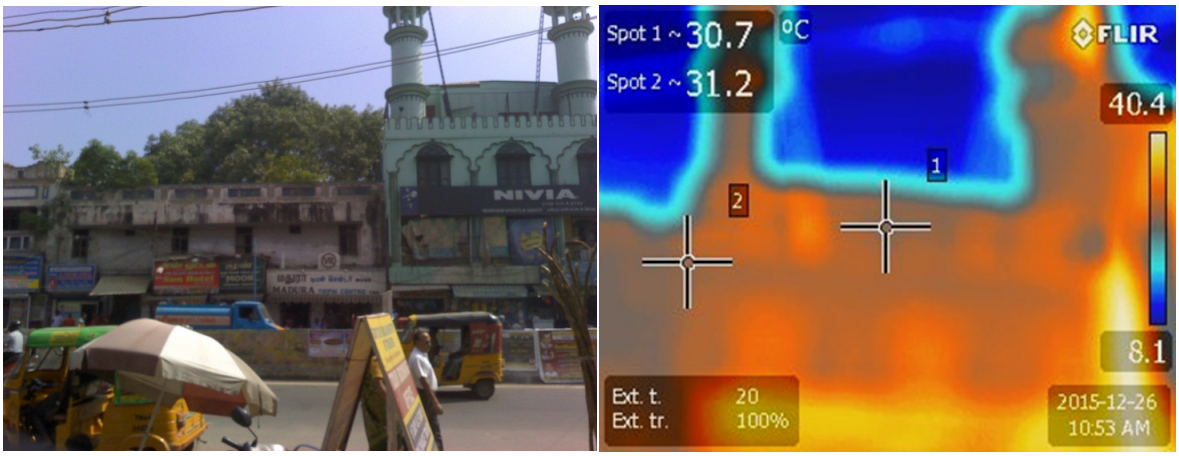
(a) (b)

Figure 3. Original and thermal Image of east facing building facades.



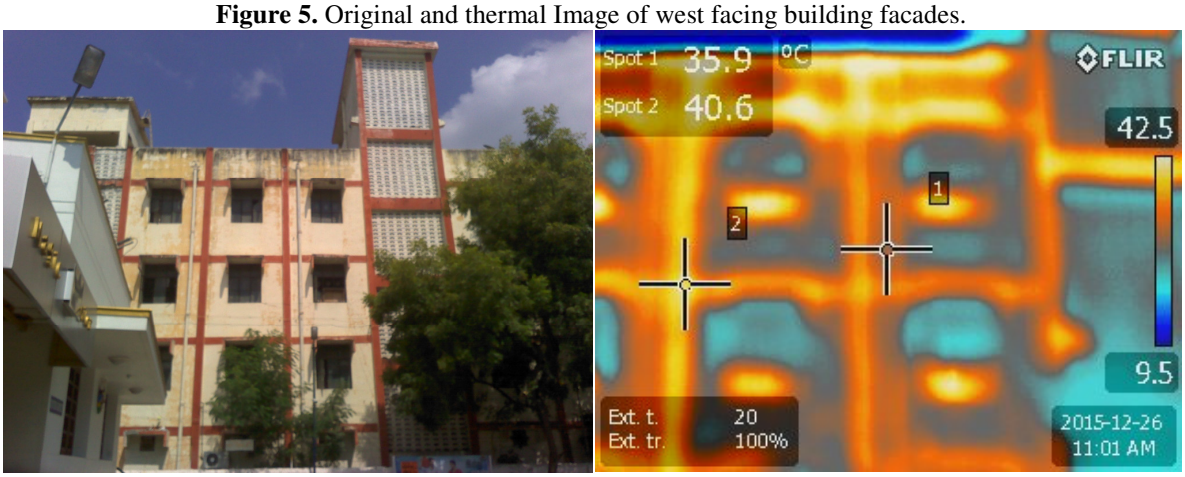
(a) (b)

Figure 4. Original and thermal Image of east facing building facades.



(a) (b)

Figure 5. Original and thermal Image of west facing building facades.



(a) (b)

Figure 6. Original and thermal Image of south facing wall

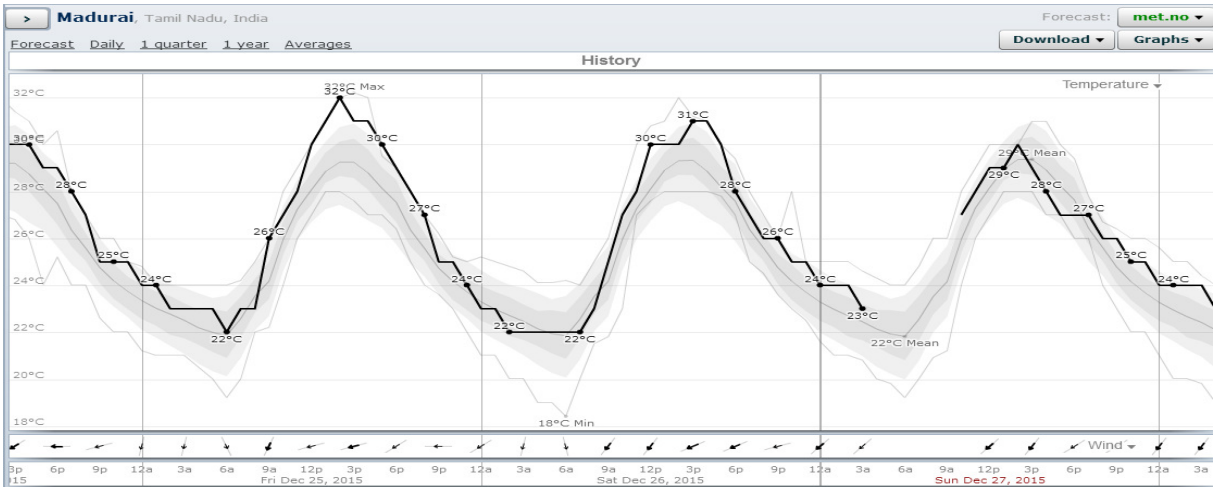


Figure 7. Weather data of Madurai from 24th -27th December, 2015.
(Source: www.weatherspark.com)

Similarly Figure 5 and 6 represents the image of a west facing wall and south facing wall respectively. In all the cases it is seen that the concrete and brick wall temperatures are higher than the ambient temperature. The physical characteristics of the building materials are the major governing factors for the heat gained by the exterior surface of the building. When the surface temperature is closer to the ambient temperature then it means

that the transmission of heat to the outdoor environment is lesser. The convection and radiation of heat transfer capacity of the building materials is determined by the intensity of the solar radiation falling on the exterior surface of building envelope. Hence, to identify a suitable material for exterior wall in hot climatic regions, the normalised heat for each material should be calculated (Din et.al, 2012).

CONCLUSION

The present study has been done using hand-held Infrared thermo camera to detect the surface temperatures of the building walls in terms of its material and orientations. The capacity of the materials to store heat and dissipate to the surrounding has been recorded. It is evident that these materials store heat and dissipate it to the surrounding environment at night thereby contributing to the rise in outside temperature than the ambient temperature. The thermography has benefitted to acquire data for multiple areas on-site at ease and more accurate. It was very easy to handle and the data acquired was very useful to understand the thermal behaviour of various building envelope materials. Further studies on this can be helpful to provide guidelines for designing external facades elements so as to store less heat on its surface. The limitation of this study is that, it was possible to do a qualitative assessment only, since the images were captured only one a time.

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Urban Morphological Role of Housing Typologies on Energy Demand: A Case of Navi Mumbai

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Abstract: The need for looking at sustainability of cities at the larger scale begins with the efficient design of our neighbourhood's. Historically Mumbai has seen a traditional variety of housing types that stood as testimonials to their working culture and daily life style. Growing trends of urbanization put the urban planners and designers at the pedestal giving them large parcels of land to create, design, idealise, and transform. The process of developing newly planned cities is crucial in terms of the urban form and its geometry they hold. The intent of this research is to find whether the geometry of the built forms have significant impact on their use of energy. The neighbourhood layouts in Navi Mumbai present a vivid example of diversity of built forms in the housing typology, and gives us an understanding of various possible urban forms, but the question still remains which Urban Housing forms emerge as a significant less user of energy and show higher levels of efficiency. To fully understand this question, a cross comparative analysis of the four most dominant housing typologies is done and these are compared for the basic morphological parameters such as building density (linking with the housing typology), total exposed surface area and plan surface coverage and geometry. The obtained results from the comparison of the neighbourhoods are then correlated for the annual consumption of electricity. The comparisons are made with a set of urban morphology parameters on one side and the corresponding cooling loads on the other side. The results obtained are then correlated and checked if there is any design related issues and patterns that could significantly help change the current housing developments. The reports and conclusion are then formulated as possible guidelines for planning level neighbourhood energy intervention. The paper concludes by trying to present a detailed methodology for approaching the urban level energy studies linked with housing typologies.

Keywords: Urban Morphology, Housing Typology, Building Geometry, Thermal Loads.

INTRODUCTION



Figure 1. Typical Skyline of Navi Mumbai showing various typology of housing neighborhoods from low to mid to high rise. The question still remains which typology of buildings is more energy efficient? Source: CIDCO 203

The recent trends of urbanization made the cities to further expand their horizons, and as a process large satellite town are being developed which are critically connected to crucial parts of the city. Navi Mumbai has been created with the same idea of decongesting the already overly populated Mumbai. As seen in the adjacent Figure1, high rise developments have taken over the typical skyline and catered the need for the housing demand in which large planned neighborhoods are developed which vary typically in terms of their typology, geometry, urban factors and design levels. How far does the planning phase in neighborhood development influence the energy consumption? Are there any design level interventions that can be taken to reach a better energy profile for the neighborhood? is what the core idea of this paper. To achieve this comparative study of 4 typical residential building typologies in a planned city of Navi Mumbai are taken and are assessed for its annual cooling loads. The results are correlated with the physical parameters for the each of the selected samples. The research stands out as a guideline indicator for new neighborhood designs and also for understanding design level interventions in the various housing typologies for better thermal performance.

BACKGROUND TO THE STUDY

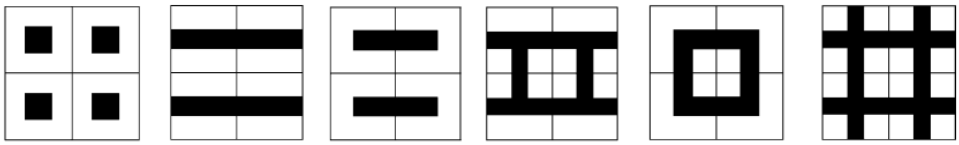

Figure 2: Figure shows broad Urban forms of Martin and March which are analyzed effectively in terms of energy by Steemers et al. (K.Steemers, et al., City texture and Microclimate, 1997). The following models represent pavilion blocks, Continuous slabs, Terrace Blocks, Terrace Courts, Pavilion Courtyard and Courtyard Blocks Source: Ratti, Carlo & Raydan, Dana & Steemers, Koen. 2003.

Martiand March's Studies over the thermal performance of hypothetical models as seen in the adjacent Figure2 stood as a foundation for the further research to critically evaluate the comparative performance of urban blocks. Apart from the archetypes developed by Martin, there is an over-all absence of learning showing the thermal performance of real-life existing urban morphology types in the Indian cities. Parisian Urban blocks were simulated for their block level thermal performance which consisted of a working methodology by classifying the buildings by their age but not on its urban form. This study was conducted by the Paris Urbanism Agency known as Apur, also another research done by Salat for city level assessment using cross scale indicators was a considerable addition to this subject. But the Indian context research showing the most often used urban forms and hosing typologies and their considerable energy impact is still on the development at large. Arboit's research about the density of urban environments and their respective solar opportunities stood as a classic study showcasing the energy performance of urban forms and highlighted the solar potential of a given neighborhood which is low-dense. (Okiel, 2010) has researched and presented how the urban block can be developed with good performance in both the seasonal extremities. He developed the Residential Solar Block and analyzed its solar passive potential for the overall energy efficiency. The larger work into this field focused on developing the required methods , tools and techniques but less on the direct implication of which housing typology stands as a best efficient model for energy consumption .Various researchers contributed substantial amounts into this field with Arboit dealing with one sector of a city and looking at its energy aspects and Okiel (2010) developing the Residential Solar Block which reduces the exposed surface area of the envelope by letting solar rays maximize over the façade and minimum over the roof , also the contributions of Cheng (2006) who worked extensively on the particular morphological variables like density .All these research couldn't signify the exact form and design of typology shapes for a specific location in a Indian Context .The main intention of this paper is to show a approach for a morphological energy consumption perspective for a neighborhood.

Bakers and Steemers has addressed two compelling reasons why urban form should be considered when considering opportunities to reduce building energy consumption .First , the urban form factors are less likely to change and tend to remain same as the technology and occupant changes ,he suggests that urban form factors have a long term impact on its users be it positive or negative , and they also suggest that a good urban form can have much positive effects on the systems involved in the neighborhood . Also, the work of Wener and Carmalt (2006) (Wener & Hannah, 2006) suggest that form-based design choices which takes places early in the design process for example use of compact building shapes are less dependent on, or vulnerable to, behavioral variations than technologies demanding occupant interaction. Various literatures highlighted that energy consumption and Green House emissions are largely based on the urban forms they belong to; The challenge lies in describing and quantifying the specific energy and GHG impacts of urban form, particularly in the neighborhood scale.



Figure 3. The widely understood misconception that courtyards can only be used in high temperature context is negated in this example of Cambridge UK where it is cold region. Source: Building Form and Environmental Performance: Archetypes, Analysis and an Arid Climate. Carlo Ratti.

HOUSING TYPOLOGY - EFFECT ON ENERGY DEMAND

The design of neighborhoods for a newly developing city starts with the question of first understanding the role of density vs. geometry vs. planning. Recent trends in urban design research have reiterated the important role of cluster of buildings i.e., neighborhoods in the energy performance of cities. The role of density in creating neighborhoods is crucial as a low dense neighborhood shows a particular energy consumption pattern compared to a high dense neighborhood for the same site area. Density has been always an important parameter for understanding energy consumption and a crucial tool for design, planning and development of cities. Density is one key reason for growth of new city of Navi Mumbai. The initial research involving the relation of density and energy recommended that the urban designs with a greater dwelling unit density are related by greater temperatures and UHI, thereby significantly increasing the cooling loads in buildings. During the course of contributions of research on urban level energy consumptions, the importance of urban form has been notified.

However, the wide scope of urban form and energy relationship has created wide differences among researchers concerning the approach and the actual scale and magnitude of the impact of urban form on energy. The trademark research developed by Ewing and Rong gave few probable orientations by which urban design has a role in influencing the energy use of the residences, they are

Transmission and Distribution of electricity and its associated energy loss

Energy consumption and Demand associated with the Urban Heat Island

Energy use alteration by the geometric properties such as size, shape and housing typology of the neighborhoods.

The morphological role in the energy consumption is seen in the third pathway where the role of design and planning of neighborhoods plays a larger role in energy consumption. The contributions of Lee and Lee [10] showed us the urban block form and its influence on Co2 releases in household level for the biggest 125 urban areas of United States. The results found that increasing compactness or population density can significantly decrease the energy consumption of residences by 35%, the research by Lee found out results that support the idea which states the compactness and smart city layouts are important macro level inputs to mitigate the harmful greenhouse gas emissions.

Residential Electricity Consumption Survey owned by US-EIA Energy Information Administration, was used by used by another researcher named Nikhil Kaza to find the relation of density and energy use at the household level. His results negated the much-accepted theory that closely spaced building designs are better in energy efficiency [8]. Further researchers also tried to show that density cannot always suggest energy consumption. for example, the work of Radke in the year 2014 couldn't notice any results which can link the physical density on the energy consumption for cooling during the summer seasons which openly contradicts Wilson's results. Other critical observations of the research include the positive impacts of parameters such as orientation, green space, and vegetation on the predominant sun exposure directions of the dwelling can show considerable impacts in mitigating the energy consumption for cooling during the summer period. All the aforementioned research though primarily had an empirical base was lacked as there was no consensus in studies that have shown successfully using simulation methods to understand the same.

Density and energy consumption were one of the intriguing research areas for the architects who were interested in urban energy efficiency, the early research by Steemers (2003). (K.Steemers, 2003) showed the rise in urban block level density leads to great increase in energy consumption in buildings of offices in the city of London, this research couldn't extend to the residential zone. Another researcher Rode [16] found out results something in contrast to that of Steemers in which he said building density need not necessarily influence the energy consumption rather he observed that greater urban densities or high-rise buildings tend to create higher heat energy efficiencies at the neighborhood scale

Understanding the role of building parameters such as, building density green cover, and sky view factor, Wong et al. [18] in Singapore analyzed the effect of the above parameters on Lt (Lt = Local Temp) and total energy use of the building at street block level. Research done by Wong showed that the Lt varied about 2degree by change of FAR and thus analyzed that efficiency of about 4% can be created by increasing the design potential

of the urban form. The concept of Heating and Cooling degree days was further researched by Hou et al (2014) [19] in the city of Shanghai from the years 2003 to 2007. Electricity consumed per day and avg. temperature was the main parameters for the research, the results have shown a direct link of rise in urbanization and change in heat and cooling degree days , he further researched the outdoor air temperatures in residential areas by simulation and observed the increase in cooling loads in summer in the urban residences up to 10 – 35% , while the winter heating loads didn't show much effect in relation to urbanization(2011). The idea of understanding urban morphology and energy demand was started with a comparative analysis which was successfully performed by Zhang and Yang. The comparative analysis of six typical neighborhoods was performed by Yang and Zhang in the year 2016 specifies that greater densities creates more energy efficiency in the neighborhood level.

INDIAN CONTEXT – URBAN DESIGN ROLE -PROBLEM IDENTIFICATION

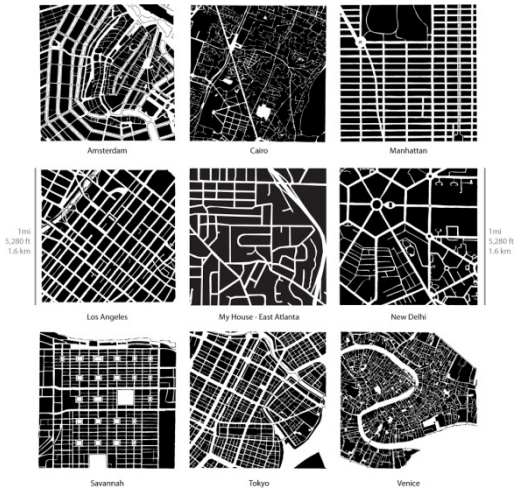

Figure 4. Figure grounds of various cities in the world starting from Amsterdam, Cairo, Manhattan, Los Angeles, East Atlanta, New Delhi, Savannah, Tokyo, Venice. The question still remains which urban form is the most suitable for a given context with good energy performance
Source: http://www.urbanmorphologyinstitute.org/urban-form-matters/

The methods for modelling energy and urban form is mostly hypothetical with most of the studies relying on Martin and March's archetypes, and issue is that they often don't inform the real-life urban morphologies and their associated energy consumptions. Broad research on this subject largely dealt on abstract tests of hypothetical morphology types by Cheng et al., 2006 or detailed morphological analysis of very small subsets of urban form typologies by Salat (2009) and Ratti et al., 2005.The real life urban forms largely differ from the existing literature .The figure adjacent shows the figure grounds of various cities across the world, the important question still remains for the planners is what urban form makes the best use of land and consumes less energy suited to the context?. Numerous authors have contributed on urban form and building energy relationships like multivariate analysis (Mitchell, 2005), improved analytical approaches (Steemers, 2003) and simplified tools to evaluate at the early stages of design process by Bakers and Steemers, 2000. These works though inform certain guidelines and methods, tend to neglect the exact role of urban morphology and building characteristics that can influence the energy consumption. Despite the increased awareness that a sustainable city design should begin with an energy efficient neighborhood, local governments have not yet taken this idea too seriously. The design of housing for large neighborhoods often tends to follow to a rigid and commercial method of planning often ignoring the energy aspects and possible efficiencies that can be created by them, one of the reasons being a clear lack of quantifiable and spatial information availability on specific relationships of urban form choices pertaining to certain energy consumption. This information and guidelines are critical for solid rationale support for effective energy and emission policies and their implementation. The present planning principles followed by the city designers lacks the energy parameter. Growth of smart cities lays a huge responsibility of architects and planners to develop a smart and energy efficient neighborhoods.

RESEARCH APPROACH

The intent of this research is to provide more comprehensive understandings of relationships between urban form and building energy to better inform urban planning and development decisions. Towards that end, the project examines several identified urban form characteristics (Building Shape, Orientation, and urban structure (Building spacing and arrangement) to achieve this, the thesis addresses urban form and building thermal performance in three-part approach. To fully understand the relationships between energy performances, we must consider the means by which to describe and measure urban form, the means by which to describe and measure energy and the means by which to discern relationships between two. The research tries to morphologically asses the energy demand for four selected neighborhoods of a grid size of 300M X 300M. The selected neighborhoods in Navi Mumbai are as follows



Figure 5. The figure ground of Mumbai showing the selected neighborhood sites in Navi Mumbai, namely Vashi, Karave, Seawoods estate and Kharghar present inside the marked circle.

METHODOLOGY

The study comprises of selection of four typical neighbourhoods identified in the planned city of Navi Mumbai. The intent of the paper is to ascertain which hosing typology forms emerge as less consumer of energy among the most dominant housing typologies of Navi Mumbai. To ascertain this a cross comparative energy analysis is done to find out the least consumer of energy and know the most affecting building parameter that is contributing to that can leveraged for a direct linkage to energy demand. The earth images for the four selected samples were created and then spatial data is obtained from it like basic plan depth, surface coverage etc. The stage wise approach of the research is to find out the relevance of the building design including shape, form and massing on the energy demand aspects. The question as to which design form has the best effective energy consumption profile starts from identifying that particular building parameter that has the direct link/association with the energy demand. The basic morphological parameters that can have a direct role in energy demand could be from several types like

• Building Size, volume and particular massing of the block which could harness the solar exposure

• The proportions and shape of the plot in which the building is put and the respective building alignments with the street.

• Urban Blocks can have a varied energy consumption patterns with the change of street layouts, including its width, furniture, vegetation etc.,

• The most influential urban morphological parameter is the density of the urban block, which directly affects the consumption profile of the neighbourhoods.

• To achieve a feasible cross comparative analysis another parameter can be used like the surface coverage of the building, after simulation of the energy consumption, the results could be correlated with the values for the surface coverage of the buildings and specific regulations and recommendations could be done to the enhance the planning of the further neighbourhood's in the country. The compact buildings such as courtyard apartment buildings consume less energy are taken as the theoretical base of the research findings. But the idea is what great design options are available for a given parcel of land other than the conventional forms and typologies and what is rank of energy performance for the most common used typologies in the city is intent of this paper. The above listed urban morphology and building parameters are compared for all the four samples and results are being compared for their respective energy performance and the correlation is derived.

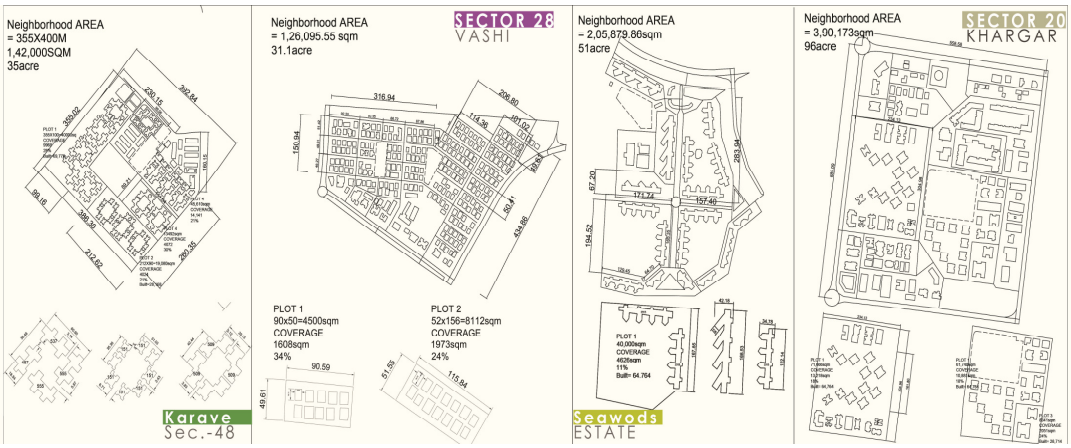

Figure 6. The site plans for the four typical selected neighborhoods for the study in Navi Mumbai
Source: Author

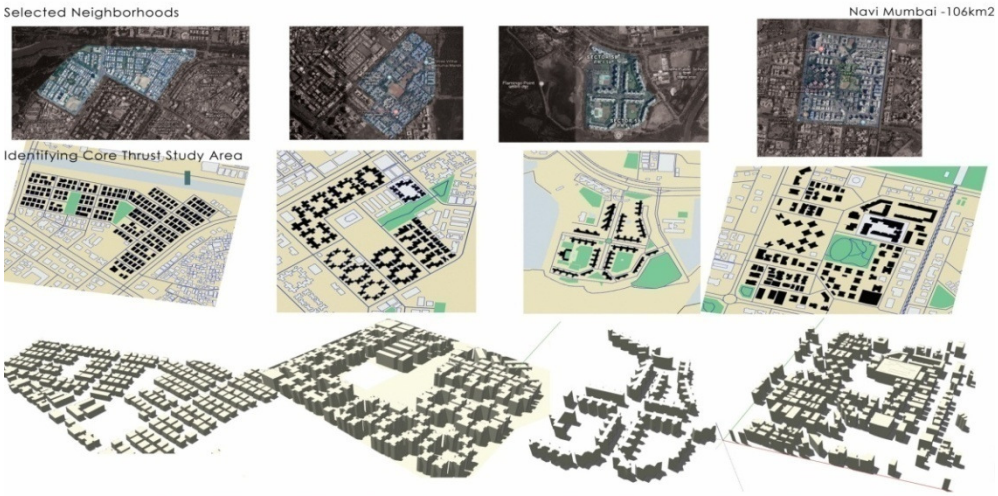

Figure 7. Levels of Analysis, from identifying the most dominant housing typologies and then deriving the spatial building parameters that could have a direct relation with the energy demand:Source: Author



Figure 8. Working Methodology Flow Chart,

CONCLUSION

The intent of this paper is to present a workable methodology for understanding the morphological role of buildings on the energy consumption aspect. To make it as a formidable reality following stages of approach is required , the preliminary stage is to identify the suitable urban city which has a diversified range of housing typologies and select four such typical neighbourhoods which are unique among themselves and dominant across the city .The selected neighbourhoods are then extracted for their typical design and shape of the building block , as in the case , there are bungalow , courtyard type , continuous blocks and individual tower blocks identified in the study with each of them having its own dwelling units density ,surface coverage, building size , plan depth, and height . These extracted shapes are then modelled and ideal forms are created. Then the four neighbourhoods are compared for the building parameters listed in the methodology above. The results after energy simulation are then compared to the building parameters and seen for any correlation, the most significant parameter identified is then taken and entire building is redesigned till the optimum energy performance is achieved. The summer months of Navi Mumbai become extremely uncomfortable with higher humidity levels forcing the well-off neighborhoods of Navi Mumbai to afford and use the air-conditioning in the discomfort period. The relationship between the operational energy use and urban form is always rigid and needs to be looked in greater dimensions for a better understanding. The constant need to reduce humidity forces the user to adopt the air-conditioning and thus creates greater cooling loads.

Hence to improve the building efficiency and make the typologies less consumer of energy by enabling the design to influence much into the energy aspects. The wind flow and solar exposure greatly affects the indoor energy consumption and hence needs to adequately include in the planning phase. Urban density plays a greater role in energy performance and site layout can be very crucial aspects in the planning phase.The most common approaches in this field tend to ignore the basic design aspects which this research tries to address to the core. The paper also tries to explain how to analyze the housing typologies for energy performance using the morphology parameters. Also, the effect of neighborhood housing typology on energy demand is not always the same in all seasons. Growing trends of urbanization is tending the cities to more adopt a Highrise apartment that are standing as only possible option for a low surface coverage high dense, so the question every designer needs to ponder is how to improve the energy performance of such widely accepted typologies and make them better in their own domains.

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Understanding the sustainable construction techniques practised in Auroville and how well they perform by taking the case of a building

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Abstract: Sustainable construction development is the need of the hour in developing countries like India. As the population keeps increasing, the need for the resources keeps increasing. As a result, the renewable resources like water, soil, etc gets reduced. Sustainable development can be achieved by integration of renewable energy sources, appropriate building technology, and appropriate architectural design and energy efficient materials. Auroville, Pondicherry is one such community which has introduced various sustainable construction techniques and has incorporated in their own buildings. The ever experimentation of Architecture and design has made auroville unique. So the aim of the research paper is to bring out such new sustainable construction techniques in auroville and studying a building in auroville which has incorporated all these techniques. The conclusion would state how effective these techniques are and how well they reduce the energy consumption.

Keywords: architecture; sustainability; auroville; renewable energy;

INTRODUCTION

Sustainability is "the need of the hour" and it is one of the things that is in the topic of discussion in both national and international level. This has brought green technologies and innovations to limelight which will lessen the impact of reducing natural resources and changing climatic conditions. Several NGO's, organisations and institutions are working to make the earth green by using various technologies. By this, the conditions of the current society will improve and the world will become a healthier place to live in. Auroville is one such self-sufficient community which is working rigorously for the betterment of the world. By researching on their modern technologies and innovations, we will get an insight of how all these sustainable techniques work, how they can be maintained and implemented in our buildings by seeing an example of a building in Auroville "Vikas community".

SUSTAINABLE TECHNOLOGY

Sustainability can be achieved mainly by modern and innovative technologies. Several technologies are developed by Auroville after an extensive research. Old and new technologies are juxtaposed and many innovative modern technologies which reduce energy and water consumption are introduced.

SOLAR TECHNOLOGY

Auroville is situated in tropical wet and dry climate, where summer lasts for almost six months a year. So using sun as an energy resource would be highly beneficial and solar energy would form a major part of the alternative renewable energy. Heating of water, generation of electricity, street lights, etc. are some of the applications of this technology.

SOLAR KITCHEN IN AUROVILLE

1. Solar Kitchen predominantly uses most of the solar technology that is produced in Auroville. Approximately 1000 meals/day can be prepared by this solar kitchen using solar technology.
2. The power system in the solar kitchen is basically a big bowl with a heat receiver located in the centre. Lots of mirrors are provided which will direct the solar rays towards the receiver.
3. This receiver has coils around it which contains water. The water gets heated inside the coils and vaporises which is then sent to the kitchen for preparing food.

4. The kitchen is also equipped with an alternate energy supply to fulfil the energy requirement during the times of bad (rainy/cloudy) weather. It can run with the help of fuels such as diesel during emergency cases when the energy produced by solar technology is not sufficient.
5. All the culinary equipments had to be modified to go in hand with the kitchen's requirements.



Figure 1. The Solar bowl



Figure 2.PV Panels



Figure 3. Solar pumping

SOLAR ELECTRICITY

Solar panels are the best investment in a step towards sustainable construction. The solar electricity generated through this system not only powers the buildings but can also be stored for future purposes. Today more than 450 buildings are running entirely on energy generated by the sun in Auroville.

SOLAR WATER PUMPING AND HEATERS

The solar energy that is produced using the PV panels is majorly used to either heat or pump the water. Activities including waste water management and bore wells are supported by this energy to transport water.

Table 1. Comparison of energy consumption outside Auroville and in Auroville

General consumption	Consumption in auroville
350 kWh/house	280 kWh/house
350kWh x 1700 houses	280kWh x 1700 houses
5,95,000 kWh Unit used	4,76,000 kWh Unit used
Rs. 42,50,000 by a colony in city	Rs. 33,32,000 by a society in Auroville

WASTEWATER TECHNOLOGY

1. Auroville community implemented innovative techniques in the treatment of waste water with the help of the Centre for Scientific Research (CSR) to cater to the needs and desires of the people.
2. Integrated Decentralized Waste Water Systems has many techniques and they have been used in Auroville as they are cost-efficient when compared to other techniques. Here, water is stored underground, followed by pre-filtration and sent to overhead tanks for polishing and oxygenation.
3. For modernised areas like urban communities which has no area to accommodate water bodies, a system of cylindrical vortex is designed which oxygenates the water using forces like centripetal and centrifugal.
4. This produces the grey water which can be used for plants or sent to underground to restore the water table.

SUSTAINABLE DESIGN TECHNIQUES

Sustainability will be achieved only when the buildings are built close to nature. Use of locally available materials in construction like use of earth as a building material would prove beneficial. Auroville would serve as a perfect example as it has constructed many buildings using earth as a material. Such materials would have an advantage over fired bricks:

1. Fired bricks walls are costlier to construct than walls made of CSEB blocks.
2. Energy that is embodied by local fired bricks is 15 times more than CSEB blocks.
3. Strength of these blocks is higher when compared to conventional materials.

Earth which are rammed, stabilised and used for construction of walls is slowly coming into construction industry. Auroville uses various other techniques like:

1. Raw rammed earth.
2. Blocks made of adobe, mud brick which are sun dried.
3. Wattle & daub which usually involves plastering of mud on a wall called as wattle usually made of Palmyra or bamboo.

MANAGEMENT OF RESOURCES

When building with earth, management of resources plays major role. Auroville displays numerous options to use the excavations: as ponds to harvest water, to treat the waste water, as underground floors or can be used to design landscape, tot lot, green spaces, etc.

EARTH WALLS WHICH ARE STABILISED AND RAMMED

It was implemented only in the project of a school and not in any other buildings as a new type of special formwork has to be developed after several researches, planning and design. Elevation of the panels takes place and pier walls are built.

This method works just like the rammed earth system which is practiced in modern times in various other countries, but altered according to the local context of our country.

COMPRESSED STABILISED EARTH BLOCKS

Auroville Earth Institute designed a variety of equipment for the earthen construction. One of this equipment is Auram equipment. It includes wide range of products such as press for CSEB blocks, devices which control quality for block making, equipment for handling, scaffolding, rammed earth tools and equipments. The Auram press of series 3000 is used majorly.

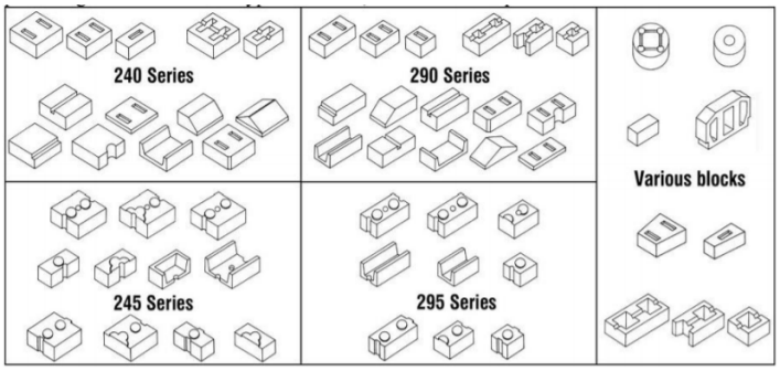

Figure 4. Various kinds of CSEB blocks; Source:Auroville Gazette

1. CSEB produce with a cement content of 5% in Auroville
2. It has a dry compressive crushing strength (average) of 50 kg/cm² which is equal to 5 MPa
3. It has a wet compressive crushing strength of 25 kg/cm² which includes 10% water absorption.
4. Bricks which are done using fired system have approximately dry compressive strength of 35 kg/cm²
5. It has 12% water absorption

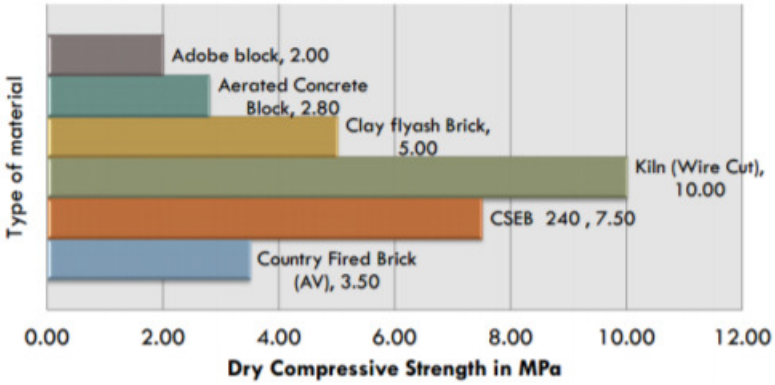

Figure 5. Dry compressive strength for different materials (MPa)

ENERGY EFFECTIVENESS

The energy required to produce CSEB is much less than that of country fired blocks. Huge amount of wood is burnt to create very less amount of fired bricks, approximately in the ratio of 0.36. It is proved that for same area, building made of wire cut bricks and fired bricks use 5 and 15 times more energy than that of CSEB blocks. The original embodied energy of CSEB is in general less than other building materials. CSEB are environmental friendly as:

-No firing of blocks is required but requires only curing

-Less transportation is required and the production is manual.

-CSEB consumes 10.7 times less energy than bricks which are fired and used. (Pondicherry)

-CSEB consumes 7.9 times less energy than bricks which are fired and used. (India Average)

-CSEB consumes 3.9 times less energy than kiln fired bricks. (India Average)

-Emits 12.5 times less carbon dioxide than fired bricks.

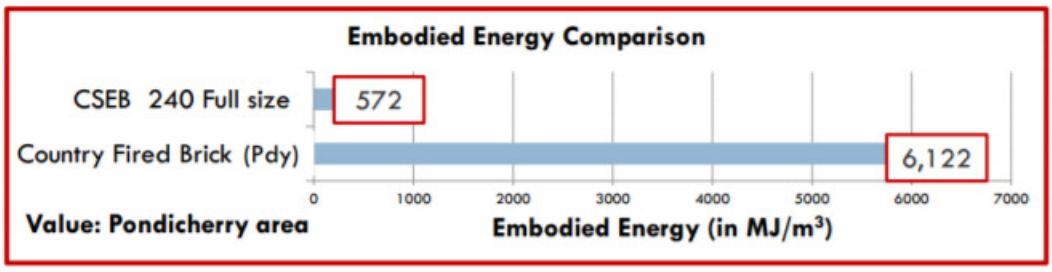

Figure 6. Embodied Energy comparison

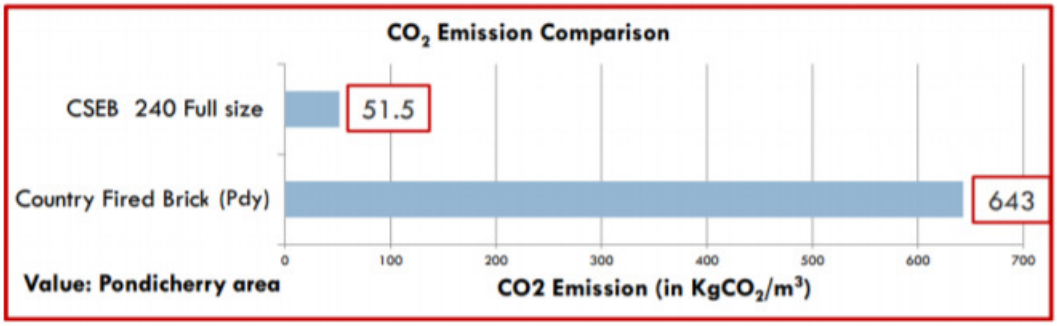

Figure 7.graph of CO2emission in CSEB

Table 2. Comparative Analysis Of Various Materials Used In Auroville

Product information	Wire cut bricks	Country fried bricks	CSEB 240	Rammed Earth
brick size (L,W,H) in cm	22x10.5x7.2	22x10.5x6.5	24x24x9	(wall cast insitu)
Volume of brick	1.66 Ltrs	1.50 Ltrs	5.18 Ltrs	(wall cast insitu)
Weight per unit	3.12Kg	2.18Kg	10.00Kg	10.10Kg
Wastage of raw material	3%	12%	5%	0%
Pollution emission	39kg/cu.m	126kg/cu.m	16Kg/cu.m	16Kg/cu.m
Energy consumption	539Mj/cu.m	1657Mj/cu.m	110Mj/cu.m	110Mj/cu.m

CASE STUDY OF A BUILDING IN AUROVILLE- VIKAS COMMUNITY

It is a residential building which was completed in the year 1998 with a plot size of 10,000 m2 and built-up area of 1448 m2

INTRODUCTION

The whole project consists of individual apartments and houses with common facilities. The project uses environmentally sustainable materials, renewable sources of energies such as energy from wind and sun, water management using ecological method (Waste water treatment using biological method and watershed harvesting) and sustainable technologies in buildings (earth, ferrocement, etc.)Earth was stabilised and it was used in the foundations and its usage was extended right up to the roof. Vikas community sets an example for other buildings as it used earth for the entire construction and it was the first project in Auroville to do so.

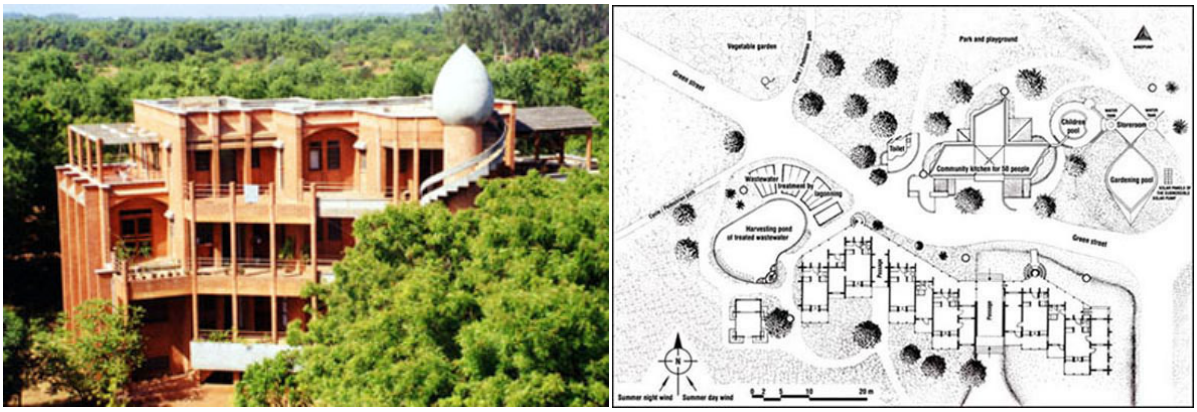

Figure 8. Left:Vikas apartments view; Right: Vikas community layout

DEVELOPMENT OF THE PROJECT

Stages of development: The first two blocks were built between 1992 and 1998 while 13 apartments was a later addition which constituted the 3rd block. The third floor consists of a basement and 3 floors were built above it.

Concept behind the project:The main idea behind this project was to make it self sufficient for the soil needs. The carpet floor area of the building was 819 m2 and the soil for making the compressed stabilised earth blocks was dug from the basement floor (approximately 1.20 m below the ground level).

MATERIALS

High walls (13.40m) were made of CSEB blocks (24mm thick) and stabilised rammed earth was used for the foundations. “Free-spanning” technique done using CSEB blocks were used to build the vaults and domes.



Figure 9. Initial stage of development

THIRD BUILDING AND ITS SPECIFICATIONS



Figure 10. Third block of 13 apartments

SCARCITY OF SOIL

The requirement of the soil was much more than the amount got from the basement and hence there was a need of soil from other places. As a result of this, a basement floor was planned in the third block which had half its structure below ground and half above ground.



Figure 11. Shows the basement excavation

SUFFICIENT AMOUNT OF CSEB BLOCKS

The volume of soil that was saved was equal to the volume of the basement floor and hence there was sufficient soil to produce the CSEB blocks to construct the entire third block.Landscape design: The basement is protected from the effects of rainwater by shallow crater which is designed in such a way that it drains rainwater into the percolation pit. Soil got from the surroundings was more than the amount needed for the building because of this landscape design.

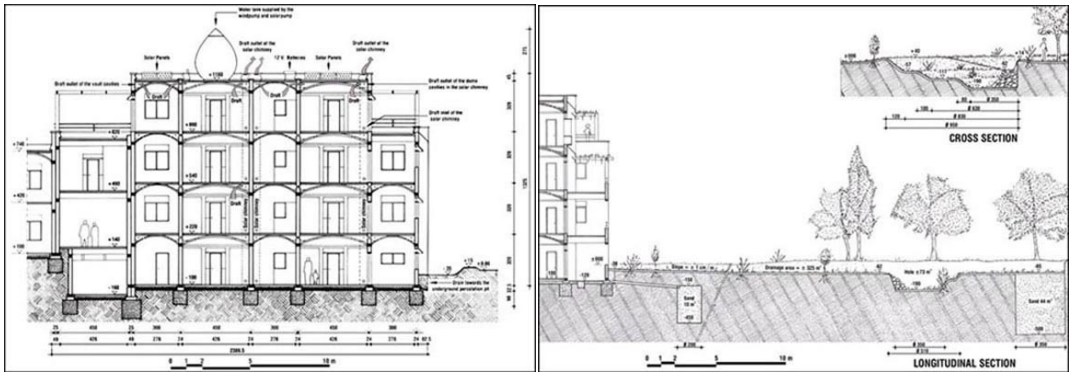

Figure 12. Left: Section of the third building; Right: System of percolation of the building which was added later

MAIN LISTING OF THE 3RD BUILDING

1. Earth which was stabilised was used for the foundations.
2. AURAM blocks of grade 240 were used for the basement.
3. AURAM blocks of grade 240- 1.5 sizes were used to make RCC plinth beam casted in a block shuttering and were used for the plinth beam.
4. Walls were finished with bitumen and floors were laid with pebbles for waterproofing of the basement.
5. Ø 3" slotted PVC pipe were used for drainage that ran underground and it was passed to underground pit and this acted as the basement drain.
6. Flooring for the galleries was done using AURAM tiles of grade 240.
7. Flooring for the apartments was decided according to the choice of the people.
8. AURAM blocks of grade 240 were used for the walls.
9. Floors and roof (Vaults and domes) - Done with AURAM blocks of grade 240 and it had no support.
10. Some walls used earth plasters which were stabilised.

ARCHITECTURAL DESIGN

- Buildings which is energy efficient
- Ventilation through natural means
- Protection from solar radiation
- Integrity- Building with the surrounding land, the nature around, plants, etc.
- Adaptability- should adapt to the changing weather, direction of wind and solar radiation, etc.

TECHNOLOGIES USED IN BUILDINGS AND MATERIALS

- Foundations- Earth which is stabilised and rammed with cement content of 5%
- Walls, plinth, etc.-CSEB blocks
- Walls- Earth which is stabilised and rammed with cement content of 5%
- Floors and roof (Vaults and domes)- CSEB blocks
- Wall finishes like plasters, paints, etc.- Earth which is stabilised
- For Floorings- Usage of CSEB (compressed stabilised earth blocks) tiles
- Ferrocement doors, shelves- 12mm thickness
- Water tanks and ponds- Ferrocement plasters

SUSTAINABLE MATERIALS

- CSEB blocks
- Stabilised rammed earth
- Ferrocement

RENEWABLE ENERGY SOURCES

- Solar energy- Solar water heaters, solar pumps

MANAGEMENT OF RESOURCES

- Water management- Rainwater harvesting, waste water treatment
- Earth management- Self-sufficient soil, percolation pit, waste water treatment pond

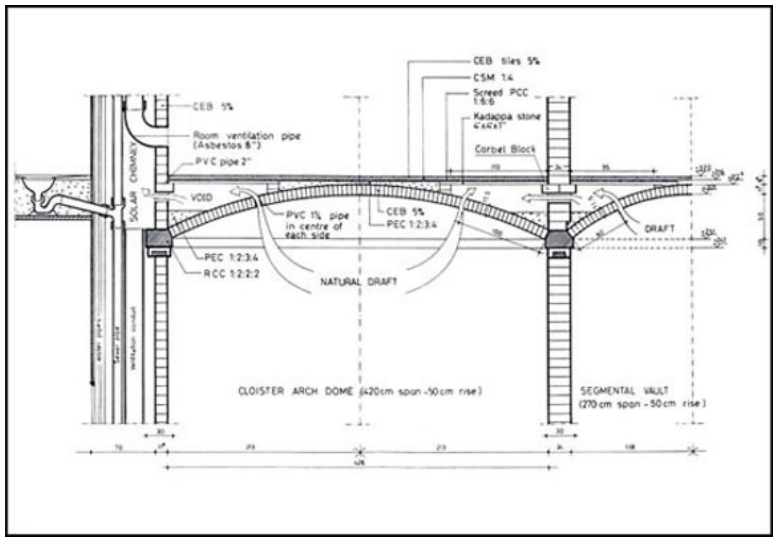

Figure 13. Solar chimney- structure which is vaulted allows natural ventilation through it

LAND CONSERVATION AND RAINWATER HARVESTING

Development Plan for Landscaping

Concept

Integration of buildings with vegetation was the main idea.The existing trees were preserved and more trees, plants and bushes were added to create a shelter from sun.The later added vegetation should be a continuation of the buildings and existing vegetation and not as separate.

Protection against Water Erosion

Erosion

Auroville faces very serious land erosion from monsoon as it is situated in a tropical climate. They adopted the idea that every sqcm of land should percolate water.

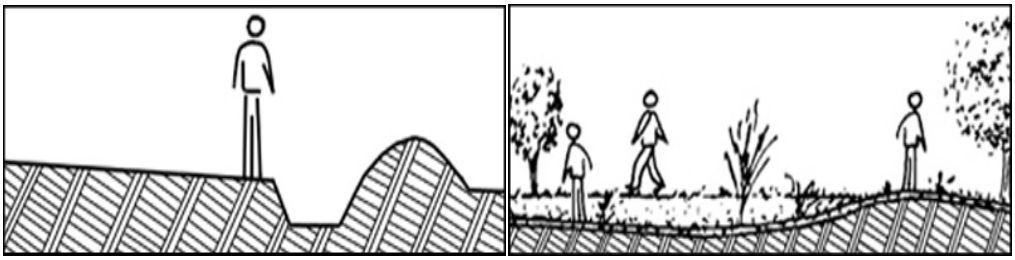

Figure 14. Left: General bund; Right:In Vikas community

Shallow Depression

The bunds were replaced by smooth landscape. Rainwater gets collected by the slopes with shallow depression. Water was retained by top edges which has pedestrian path over it. Integrity was achieved as this development was totally in line with the landscape

Percolation Pits integrated with Landscape

A pit for percolation is a recession where water from the rain gather and percolate to the earth through the ground. Here, the pit for percolation is guarded with grass, shrubs and various other vegetation are used to landscape for the following reason.

Increasing the Effect of Percolation:

1. Vegetation increases its performance. Draining of rainwater is much faster by the roots of the vegetation.
2. Humus also increases the percolation rate as it contains the biological system with microorganisms. This is adopted by the percolation pit created in the park.

Present Condition

A heavy storm in Auroville had affected the percolation pit. This has scraped off the grass and vegetation over the percolation pit and it has not been repaired till now. If vegetation covers the system, even heavy rainfall would take a day or two to percolate into the ground.

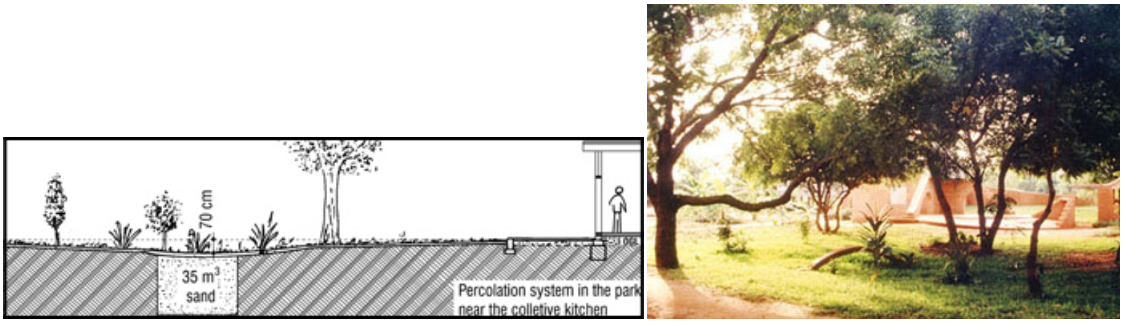

Figure 15. Percolation pit

WASTE WATER TREATMENT BY LAGOONING

Two Phases of "Lagooning"

1. Anaerobic Decantation-Digestion:

It takes place in watertight pit- decanter-digester. The floating matter covers the top of the pit. This is what they call as macrophyte water treatment.

2. Treatment of Water Using Macrophyte:

The covering is with various kinds of plants in aquatic system. Only 66% of the watertight pit is covered fully while the remaining is covered only for 20% of it area to enhance re-oxygenation and photosynthesis.

Present Condition

This treatment proves beneficial but the amount of maintenance required for this system is very high.

Maintenance

The biological system couldn't survive because toxic products such as bleach, caustic soda were used. As a result the aquatic animals died, foul smell occurred and breeding of mosquitoes increased. But if the toxic water was replaced by normal water, the system works fine again.

Replacement of Lagooning System

As the lagooning system required more maintenance, it was replaced by system called "baffle reactor "which was more resistant and requires less maintenance. The main aim was integrity with the buildings and surrounding landscape as they did not want this system to be out of lace.

Impact : As a result of this, the surrounding buildings also started adopting this system.



Figure 16. Wastewater treatment integrated with the buildings and nature

CONCLUSION

Auroville has experimented on various scales of sustainability by integrating nature in to design, planning, and execution and achieved a great success in saving a lot of energy. Auroville presents a simple and advanced model for sustainability.

India along with various other countries are facing the threat of drastic climatic changes due to the high level of global warming and fall of resources which are available naturally. Sustainable construction is the only hope of balancing nature and hence must be given top most priority as its failure will lead to lot of problems which will show an impact on the human race.

Through this research we conclude the following:

1. Auroville is a community which develops sustainable techniques keeping the local climate in mind. Using the same technique in place elsewhere (For eg. Jammu and Kashmir) won't lead us with any positive effect. So the techniques should be developed considering the local climate.
2. The techniques developed should go with the surrounding environ. This majorly includes the locally available materials. Auroville majorly uses earth, bamboo, bricks, etc. that are locally available. Exporting the materials from elsewhere and constructing a building won't be cost efficient.
3. The case study revealed how sustainable techniques developed might be successful or not so successful.
4. Percolation pits integrated with landscape could not shine much because of the poor maintenance.
5. Lagooning system was fully replaced as the maintenance required was very high
6. Still many techniques proved very successful like system for protection against erosion, landscaping, etc.
7. In a nutshell, Auroville as a whole acts as a self-sufficient community and it teaches the rest of the world to change to energy efficient techniques so that human race will experience a "Sustainable Future".

ACKNOWLEDGEMENT

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Mitigation of Adverse Impacts of Flooding in Environmentally Sensitive Areas with Specific reference to Coorg District in Karnataka

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Abstract: The Coorg District is located in a highly environmentally sensitive area of the Western Ghats parts of which are listed amongst the global biodiversity hotspots. It is the smallest district of the Karnataka State in India. The district known for its hardy people – the Coorgis- involved in the cultivation of coffee, oranges, pepper and other cash crops. After the impact of the IT industry in the state it has emerged as popular tourist destination because of its proximity to Bangalore the state capital. Several tourist facilities have emerged including home-stays and time-share resorts to cater to the tourists who flock here typically in the summer months to enjoy the beauty of the environs. This region does not appear to have a history of flooding although landslides are common because of the hilly terrain. In mid- 2018 several parts of the district were ravaged simultaneously by floods and landslides with major loss of lives and livelihoods. Indiscriminate urbanization or settlement patterns may have been one of the causes of the natural disaster.This paper will examine the various factors responsible for the Flooding in Environmentally Sensitive Coorg District in Karnataka and will explore the application of Green Infrastructure strategies for the mitigation of the adverse impacts on people and places for a sustainable development.

Keywords: Coorg District, indiscriminate urbanization, urban Flooding, Green Infrastructure

INTRODUCTION

Kodagu, formerly Coorg, is located in south-western Karnataka. It is a part of Western Ghats in India. It is Karnataka's smallest district. It is hilly, picturesque and characterized by an ethereal scenic beauty. The Western Ghats are listed amongst the biodiversity hotspots of the world and parts are UNESCO World Heritage Sites



Figure 1. Picturesque Coorg

As an impact of the IT industry in the state this region has emerged as popular tourist destination because of its proximity to Bangalore the state capital and IT hub. Several tourist facilities have emerged including home-stays and time-share resorts to cater to the tourists who flock here typically in the summer months to enjoy the pristine beauty of the environs.



Figure 2. A Time-Share Resort in Coorg

In July-August 2018 Coorg district was ravaged by a major natural disaster in the form of intense flooding and landslides. This paper seeks to examine the causative factors for the flooding and landslides leading to loss of lives, livelihoods, disruption in the economy of the region due to environmental degradation and loss of built-infrastructure.



Figure 3. Before and After Flooding

COORG: A BRIEF BACKGROUND

THE PEOPLE



Figure 4. Coorg Map

The Kodavas are the dominant community of the district and they own a large percentage of the picturesque coffee plantations. The Kodavas are renowned for their pride, valor and coat of arms providing many brave men to the Indian Army. They have also been instrumental in developing options for livelihood through tourism. Kodagu has carved itself a niche in the tourism map of India, for displaying to the world its natural beauty and the unique hospitality of the Kodavas.

Kodagu attracts the traditional religious tourists as well as urban nature lovers. It offers a unique combination of religious and eco-tourism and facilitates the tourists with a variety of hospitality options including the home-stays.

Kodagu also has a sizeable Scheduled Tribes population made up of several tribes like Yerava, Kudiya, JenuKuruba, KaduKuruba, and oligas.

THE PLACE

Coorg or Kodagu District, located, in the Western Ghats. It has an area of 4,102 square kilometers (1,584 sq. miles). The three directorial talukas are Virajpet, Madikeri, and Somwarpet. Virajpet being the largest Taluka, the important town are Gonikoppal, Ponnampet, and Ammathi. Madikeri, or Mercara is the district capital and principal town. The other important towns are Virajpet (Virarajendrapet), Kushalanagara, Somwarpet and Gonikoppal.

The administrative borders of Kodagu District are: towards the northwest Dakshina Kannada district , towards the north Hassan district , towards the east Mysore district , towards the southwest Kannur district of Kerala, and Wayanad district of Kerala towards the south.

Kodagu located in a global biodiversity hotspot boasts of a rich flora and fauna. It comprises of three wildlife sanctuaries and one national park. They are Talakaveri, Brahmagiri and Pushpagiri Wildlife Sanctuaries. The Nagarhole National Park, is also called as the Rajiv Gandhi National Park



Figure 5. Talakaveri

Kodagu is an undulating and hilly district. Its lowest elevation is above sea level by 900 meters (3,000 ft.). Tadiandamol is the highest peak, which rises up to 1,750 meters (5,740 ft.),At 1,715 meters (5,627 ft.) Pushpagiri being the second highest.

Kaveri is the main river of Kodagu. Talakaveri, located on the eastern side of the Western Ghats is the origin of the river. This river along with its tributaries drains the Kodagu district.

The soils of the district are of a varied character and heterogeneous profile. Lateritic debris are found in different stages of laterization and weathering. Red loamy soils are found in the valleys and slopes – being fertile they are invaluable for cultivation of plantation crops. Dark clay soils are found in the eastern zone. They are susceptible to water-logging during monsoon and cracking during summer. Loamy soils are present in the central zone. In the western zone, soils are highly leached, lateritic in content and shallow.

Kodagu district experiences a tropical climate which is pleasant and healthy. The climate is slightly humid (due to proximity to the coast), has heavy rainfall and a cool summer. There is a distant monsoon period which starts in June and lasts up to September end. It rains in the post monsoon months of October and November in some certain parts of the district. Thus the district receives a significant amount of rainfall.

The days are quite sultry during October because of the cloudy weather. During the second half of November the days become brighter. The cold season starts from December and goes up to February. During this period the days are bright, mornings are foggy and nights are cool. The summer season is from March to May with day temperature rising to be harsh through March. The early part of June is marked by the onset of the southwest monsoon. June, July and August, are generally, the months that experience heavy rainfall. The precipitation in July is very heavy and incessant.

There was a considerable variation in the quantity of rainfall and the number of rainy days within the district. The last 10 years data analysis revealed that the highest rainfall (Average 3302.46 mm) had prevailed in Madikeri taluka, located in the western part of the district and is densely forested. The least rainfall (average 2105.22 mm) occurred in Somwarpet taluk which lies in northern part of the district and has smaller forest cover and is adjacent to Maidan (Plain) region. The spatial distribution of rainfall is clearly an influence of topography and rainfall is found to go on decreasing as from the western part of the district to the eastern part. Considering the 10 years average yearly rainfall, all the three talukas experienced less than average rainfall in the three consecutive years 2001, 2002 and 2003; this effect was more distinct in Somwarpet and Virajpet taluks.

THE ECONOMY

A comparative study of the districts of Karnataka with respect to gross per-capita shows Kodagu to be one of the affluent districts. It is also significant to note that the highest Cumulative Annual Compound Growth Rate (CAGR) was registered by the primary sector. The District Domestic Product (DDP) grew at CAGR of 6.81% (GDDP).

Kodagu district is driven by a thriving rural agriculture based economy. The climate, soil-type and terrain of the region are suitable for the cultivation of coffee, black pepper and cardamom. These are high-valued cash plantation crops. However, the agricultural sector does face critical problems. These include labour shortage as the region is a low population one, volatile prices due to competition in the global markets and high transportation costs because of the terrain.

Kodagu attracts many tourists with its exceptional scenic beauty and natural landscapes. The income from tourism supplements the economy.

COORG: FLOODING AND LANDSLIDES

In July-August 2018 as incessant monsoon rains wreaked havoc over the Western Ghats, Coorg District faced a major crisis caused by flooding and landslides. Eight people had died — as per official figures — since 14 August in the floods in Kodagu district. News agency IANS reported that 4,320 people had been rescued till 20 August. Hundreds had remained marooned in various parts of the hilly, coffee-growing district located in the Western Ghats. Low-lying areas had been completely inundated by the monsoon rains — which began in the first week of June — and all major roads leading to Kodagu had remained blocked.





Figure 6. Landslides in Coorg; **Figure 7**.Landslides in Coorg
Source: Sindhu 2018

As on 18 August, 123 km of road had been damaged in Kodagu besides 58 culverts, 278 government buildings, and 3,899 electricity poles and transformers. Airlifting by helicopters had not been possible due to diminished visibility in the rain and fog among the hilltops. However the Chief Minister HD Kumaraswamy had conducted an aerial survey of many of the affected areas in the district on 18 and 19 August 2018. Rescue operations had been in full-swing with at least 948 rescuers — as of 18 August — from multiple agencies involved. At least 75 boats and rafts were deployed from the Army Engineering Task Force. The rescuers in Kodagu include 60 soldiers from the Dogra Regiment; 12 expert divers (surface rescuers) with rafts from the Indian Navy; 31 members of the National Disaster Response Force (NDRF); 525 members of the fire force, home guards and civil defence; 45 rescuers with from the civil defence (Quick Response Teams) with rafts and rescue equipment; and about 200 members of the NCC. The Hindu reported that, as on 18 August, five medical teams had been sent to Kodagu. The newspaper said "the Bruhat Bengaluru MahanagaraPalike has deployed 300 pourakarmikas, seven health inspectors, and engineers." The Hindu also reported that National Highway 275 had also been severely damaged. Over the 24 hours between 19 and 20 August, reported the IANS, Kodagu district received an average of 6.1 cm of rainfall according to the Karnataka State Natural Disaster Monitoring Centre. The India Meteorological Department (IMD) had continually predicted the occurrence of moderate to heavy rains till the end of August.



Figure 8. Chief Minister HD Kumaraswamy had conducted an aerial survey
Source: an image from a website

CAUSATIVE FACTORS AND THEIR IMPACTS

ENVIRONMENTAL FACTORS

The 2018 monsoon period was characterized by a low pressure which remained constant over India's western coastline- Kerala-Karnataka coastline- for more than 15 continuous days. Together with unprecedented heavy rains this caused severe floods in Kerala and Kodagu district in Karnataka. As a result, about 46% of the total rainfall was experienced by the coastline of Kerala and Karnataka in India constituting to rainfall of approximately 7,158mm.

Table 1. Comparative Rainfall in 2018 (Source: Author, 2018)

Area	Rainfall Received In 2018
Konkan Goa Coast	2,418.7 mm
Karnataka Coast	2,565.7 mm
Kerala Rest of India	2,191.1 mm 15,530 mm

Bhagamandala, the origin of the River Cauvery also called Talakaveri and an important tourist destination, in Kodagu recorded 106 mm of rainfall on 12th August 2018.

FACTORS FOR THE HEAVY RAINFALL IN 2018

Table 2. Comparative Rainfall Received in 24 Hours (Source: Author, 2018)

Area	Rainfall Received In 24 Hours In 2018	Rainfall Received In 24 Hours In 2017
Somwarpet	52 mm	NA
Madikeri	106.4 mm	1.5 mm
Bhagamandala	113.2 mm	17.6 mm
Virajpet	185.8 mm	12.2 mm

Deforestation is one of the main reasons for this increased monsoon intensity. Evapotranspiration from the green cover of the Western Ghats is responsible for around 50% of the total rainfall received by southern peninsular India. Deforestation in these areas has contributed to Global Warming which has caused the monsoon intensity to increase steadily since the 1990s.

INDISCRIMINATE URBANIZATION

Human incursion and unscientific development in these environmentally and ecologically sensitive areas have also been cited as reasons for this natural disaster. According to environmental scientists, this disaster could have been averted if the recommendations of the Gadgil committee had been implemented. Kerala and Karnataka were among the six states in the Western Ghats that unanimously opposed the recommendations.

URBAN FLOODING AND ITS IMPACT

The heavy rainfall and consequent urban flooding had an adverse impact on tourism as tourists travelling to Kodagu were advised to either change or postpone their plans. Academic hours were lost as a holiday had been declared for all educational institutions in the area. Transport connectivity was disrupted as many major roads including those in Kushalanagar, Virajpet, Napoklu, and Ponampet had been submerged. Talacauvery had been cut off from the rest of the district by 6 feet of water over the Bhagamandala-Aiyyangeri road. Minor landslides had also been recorded at many points along the Madikeri-Mangaluru Highway (NH 275) and the Mukkodu-Hanjala Road leading to loss of built- infrastructure.



Figure 9. Landslides in Madikeri-Mangaluru Highway (NH 275)

GREEN INFRASTRUCTURE MITIGATION MEASURES

Coorg district is both environmentally and ecologically sensitive. The pattern of urbanization that should be adopted should be an urban pattern that is both suitable and sustainable to the region. Greater emphasis has to be placed on the development of Green infrastructure rather than grey infrastructure! Green infrastructure mitigation measures would include discrete urbanization of valleys that would in no way hinder the natural movement of rainwater as well as stormwater. A restricted development of grey infrastructure on the slopes to

prevent landslides as well as choice of built-form patterns and materials that are more green than grey. Other green infrastructure strategies would include re-afforestation as trees and vegetation are the greatest assets of green infrastructure and limiting impervious surfaces especially ground surfaces and replacing them with more pervious surface choices.

CONCLUSION

The natural disaster that struck Coorg district in July-August has both environmental causes as well as anthropogenic causes. Environmental causes include mild tremors that had struck the district which adversely affected the existing hill-valley topography causing variations in the stability of the ground surface. Unprecedented heavy rainfall resulted in flooding and landslides. Anthropogenic causes include indiscriminate urbanization and development of grey infrastructure beyond the natural carrying capacity of the region! Mitigation measures would include a greater emphasis on the development of green infrastructure including afforestation, controlling urbanization of the valley floors, developing a system of surface-runoff and storm-water management and strictly controlling impervious ground surfaces and replacing them with more pervious surface choices

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Energy Efficiency & Sustainable Design Strategies in Nahargarh Fort, Jaipur

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Abstract: Now that the current grey ages are forecasting the miserable future, as an outcome of prolonged & dubious exploitation of environment, man is crawling back to history to borrow the past age practices of sustaining in optimum resources. Mechanical manipulation of ill-designed built envelopes is bleeding the resources. Peeping into the past, crops up many sustainable architecture solutions, which are standing dynamic through the centuries. One such example stands on the ridges of Aravalis in Jaipur, Rajasthan- Nahargarh Fort, roaring its smart and sensitive design volumes. Madhavendra Palace, a royal summer palace to the primacy of Jaipur, overlooks the pink city from Nahargarh Fort. This palace exhibits its proficient design strategies of flushing the zoetic volumes, with daylight and sufficient air changes. Tracing the general concepts of its space designing and keen habits of daylighting and ventilating the spaces, shows that the complex was not only drafted in track with the nature, but also the nature flowing in the royal volumes was at times synthetically pivoted. This editorial intent to showcase few of the ancestral sustainable building design solutions from Nahargarh palace, which could be implemented in today's world, thus fabricating more efficient awake spaces and retains the natural resources.

Keywords: Energy Efficiency, Nahargarh Fort, Sustainable Design, Daylight, Ventilation

INTRODUCTION

Amidst the royal architectural fabric of Rajasthan, stands one more efficient past age Indo-European sustainable superstructure, which roars over the city of Jaipur, designated as Nahargarh Fort. At approximate height of 700 feet, built in 1734, by Maharaja Sawai Jai Singh II, Nahargarh is one of the three forts (Amber fort, Jaigarh fort, Nahargarh fort) along with the connecting fortification wall running over the crest of Aravalis hill ranges, protecting the pink city, since past ages.

The fort was formerly known as Sudarshangarh Fort. Later, it was given a new name, Nahargarh which means 'abode of tigers'. It is am maze of terraces, gardens and courtyards, and it is blessed with breathtaking view of scenic surroundings. It was never intended to be a permanently occupied residence, but was a retreat place for the regal families of that era. Nahargarh's water reservoir is a deep one cut out of the rock, which is supplemented by additional water storage tanks and canals.

Another attraction in the fort is the 'Madhavendra Bhawan'- a royal residential complex. Other structures inside the palace include Diwan-I-Aam, an open air enclosure where the king met the common men and listened to their problems and complaints. This article focuses on Madhavendra Bhawan, in addition to brief study of the entire Nahargarh fort.

SITE & ORIENTATION- MADHAVENDRA BHAWAN

Sustainability started from the point the past age planners located the Royal complex on its site, because



(a) (b) (c)

Figure 1. (a) Madhavendra Bhavan, Nahargarh Fort; (b) Nahargarh Fort site plan; (c) Madhavendra Bhawan

locating a site for a building is as important as its design brief. In climatic extremities of Rajasthan, the outdoor climatic conditions are constantly changing. Its effect on any built form depends upon the location and orientation of that complex.

For proper and economic functioning of any building, the factors like daylighting, rate of heat absorption, in-ward and out-ward heat transfer, heat islands, cross ventilation, play major role. The royal complex is aptly designed in pace with its surrounding nature, as built forms has major share in manipulating its interior and exterior environment. Being located on the ridges of mountain range, the fort gets an added advantage of



Figure 2. Left: Winds flowing over Nahargarh fort; Right: Openings in Madhavendra Palace

The yellow arrows demarcate the prominent WNW winds on site, which rush upon the Aravalis and over the step wells before flooding into the built complexes. The blue arrows demarcate the secondary winds.

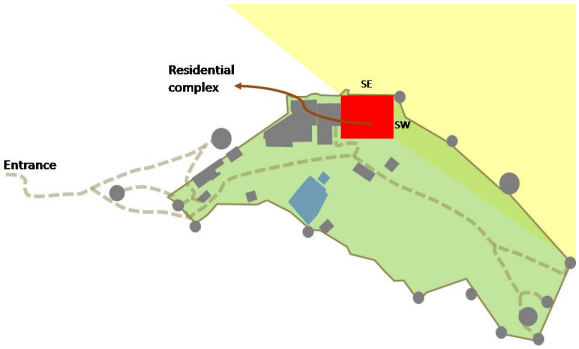


Figure 3. Schematic plan shows the south east and south west faces of the royal complex exposed to angled sun, which is consciously or unconsciously the direct outcome of its orientation on site.

abundant natural air flow.

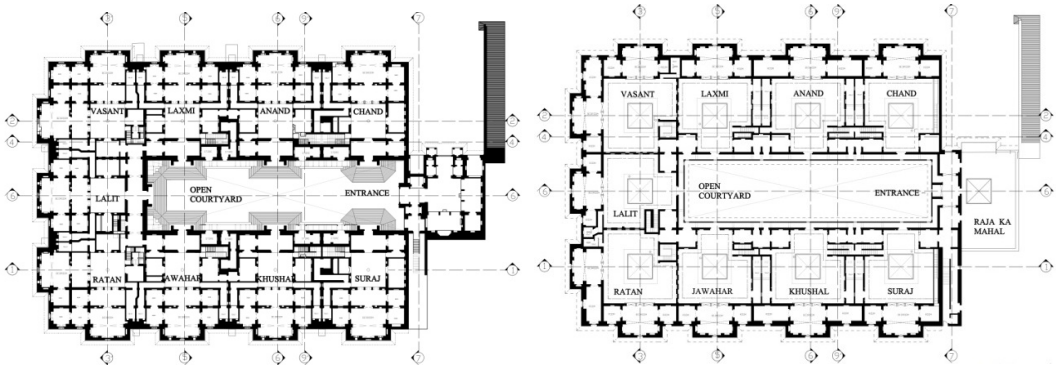
The Palace is blessed with views and vistas, ventilation and daylight from all sides. The residential complex is designed in tune with nature, to increase its efficiency and comfort level. Also, the design is such that even nature is manipulated at times in Bhawan and its surrounding envelope. Also, its location being at height, the fort is secured from direct and sudden attacks of enemies.

Madhavendra Bhavan being residential volume, demands continuous high comfort levels in terms of temperature and ventilation, unlike limited comfort demanding hours in formal spaces. The residential complex is orientation at an angle over the north-east and south-west axis, which naturally prevents the striking of true south and west sun on the residential facades. The respective placement of various structures on fort site and their orientation, play major role in daylighting, physiography and ventilation of built and unbuilt dimensions. Same and this very basic concept of rational orientation of building on site, in modern architecture, can develop conscious and sound spaces and save the non-renewable energy, which is nowadays heavily drained in thermally and visually manipulating the poorly designed volumes.

PLANNING OF MADHAVENDRA BHAWAN

The main residential palace inside Nahargarh Fort is Madhavendra Bhawan built by Maharaja Sawai Madho Singh II (1880-1922 A.D.).

The entrance of the fort leads into spacious courtyard, with large 'dwars' on both sides embellished with decorative motifs of elephants, warriors on horseback, flowers and birds. There are also weather-worn cannon carriages. The complete Royal residential complex- Madhavendra Bhavan, highlights the design elements like symmetry, ratio and hierarchy, rhythm, which makes its functionally and visually pleasant. This palace was designed by Ar. Vidyadhar Bhattacharya. There are two floors, first on the ground floor meant for summer and the first floor for winter residence. The floor has nine suites, one for each of the nine queens of the maharajah. There are bathrooms, toilets, and kitchens, all well-lit and ventilated. An interesting feature is the long but narrow, corridors, some with windows overlooking the main courtyard. It is believed that these corridors were used by the maharajah to access each queen independently without the others having knowledge of his whereabouts, but hopeful of a visit nevertheless. Its nine identical apartments are Suraj Prakash, Chand Prakash, Khushal Prakash, Anand Prakash, Jawahar Prakash, Laxmi Prakash, Ratna Prakash, Lalit Prakash and Basant Prakash.



(a) (b)

Figure 4. (a) Madhavendra Palace- Ground floor plan; (b) Madhavendra Palace- First floor plan;

Plinth

There is a gradual and prominent lift of the plinth as we move towards the more private sections of the palace, which demarcates the area function superiority, natural drainage created in plan, visual hindrances for outsiders and extended vision for the end user royal families. As outsiders cannot peep into the interiors of palace, due to its plinth height, the designers placed the windows at lower height, which also helped in efficient ventilation of inner residential chambers and courts. The rain water is drained off into the step wells, due to the site topography as well as the raised built form.

The space under raised plinth acts as hidden service areas for the palace.



(a) (b) (c)

Figure 5. (a) Madhavendra Palace; (b) Madhavendra Palace- Central Chief Courtyard; (c) Madhavendra Palace- Individual residential suite Courtyard;

Madhavendra Bhavan central courtyard depicting symmetry and hierarchy along both the axis. Madhavendra Bhavan- Courtyard inside courtyard concept of individual residential suites, which helps in creating thermal and daylighting comforts.

Design elements

Madhavendra Palace holds multiple design elements throughout its extent. Datum, symmetry, ratio, hierarchy, rhythm, flow, harmony and so on. The intensity of few of these elements increase and decrease with the succession of the spaces and its activities, like the plinth level increases as we move towards the more private areas, the intricacy of decorative art increases on the path to the royal private chambers.Entire royal palace highlights symmetry chiefly in its plan, holding nine identical residential apartment suites. This element of symmetry runs from plan to elevations and sections. Hierarchy is seen in plan, expressing the flow pattern of privacy, air and light.

Courtyard inside courtyard is a beautiful example of hierarchy, ratio and rhythm, which is highly efficient climate responsive building element. Ratio running across voids and solids on walls i.e. window: wall ratio play a major part in creating thermal and visual comfort.

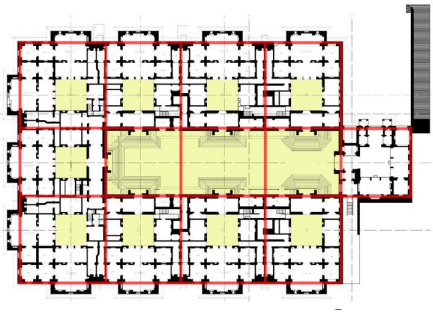


Figure 6. Madhavendra Palace plan showing symmetrical and rhythmic layout of spaces

The hierarchy in designs and scales of doors, arches, windows, domes and chatris, create exquisite pictures in the palace. The amalgamation of such elements willfully helps in creating elegant play of daylight and wind flow. Besides aesthetics, these features help in filtering and manipulating the micro-climate on site.

Micro-climate of the site is a direct outcome of the combination and synchronization of all these design elements and passive techniques. The courtyards act as light wells and helps in out-ward movement of air. The architectural setting of palace shows hierarchy in transition of spaces i.e. courtyards, series of verandas and fenestrations. The central open court enveloped by verandas (semi-covered front passage) helps in filtering of



(a) (b) (c)

Figure 7.(a)Madhavendra Palace exterior view; (b)Madhavendra Palace Interior view; (c) Ground floor plan of Madhavendra Bhavan depicting hierarchy of privacy, and art intricacy;

The Figure 6a shows window: wall ratio, and also the apparent windows painted on facades for retention of rhythm in view. The Figure 6b shows the play of daylight, as a result of beautiful overhangs, arches, passages and courtyards.

human circulation, air flow and daylight, thus initiating the physical and thermal comfort.

Also, the ratio of courtyard plan to its height is higher, which directly helps in shading the inner open court area, and also initiates upwards vortices effect of exiting air, thus flushing the volumes with active air changes. These air changes take place because of temperature differences inside and outside the enclosed volumes.

Site drainage

The climatic zone being hot and dry, site drainage and rain water harvesting are given prime importance.

The fort complex has two Baolis, catching the surface run-off water of the site, located on natural slope lower levels. These step wells (baolis) have organic curvy steps, which donot make these step wells look out of context on site. The curvy steps makes step well appear as a part of the site contour itself.

Proper provision was made in the palace, to harvest the maximum possible rain water, from its built and open surfaces. Each single residential apartment in Madhavendra palace is provided with rain water chamber in the center of its courtyard. Roof terraces where given gentle slope and where provided with ducts to catch rain water at regular intervals over each dwelling unit.



(a) (b) (c)

Figure 8. (a) Nahargarh Fort Site drainage view (Aerial view of Nahargarh fort, depicting the slope of site and the location of Step wells on lower levels); (b) Step well at Nahargarh fort; (c) Rain water harvesting on site;

All the rain water, from roof terraces and courtyards, was harvested into the step wells, through hidden underground ducts. The ducts joining water from terrace and courtyard of each unit where further opened into single bigger duct, which lead to first smaller well and further to the larger step well. Also the entire fort complex holds natural and also planned landscaping, which survives best in minimum available water. Softscaping also helps infiltration of air flow, and also sometimes slower the sand-storm winds. The trees help in lowering the outer temperature around the residential complex, thus comforting the open envelope around. At times the hot air rising from the pink city, located at foot hills, is cooled due to the green fabric of the fort site. Facades of Madhavendra Bhavan have windows on all faces, providing views of elegant vistas on all sides.

DESIGN ELEMENTS AND THEIR ROLE IN DAYLIGHTING AND VENTILATION

Courtyards

Madhavendra Bhavan is aligned along NE-SW oriented central major rectangular courtyard. This major courtyard transits into nine smaller courtyards of individual residential unit. In hot and dry climate of Rajasthan, rather than designing a single solid volume that would entrap heat inside, planning around open courts (angans) is recommended. These courtyards helps in lowering the temperature, by creating buffer, and also helps in continuous air movement, thus creating thermal comfort.



(a) (b)

Figure 9. (a) Madhavendra Bhavan plan depicting light wells and daylighting; (b) Madhavendra Bhavan residential courtyard;

The forced air entering through smaller and smarter openings, rushes through the series of spaces, and flows out through the courtyards, thus ventilating the closed, semi-open and open spaces in the palace. The courtyards act

as light wells for illumination of spaces on inner face of palace. Thus courtyard is one such climate responsive architectural design element, which takes the built-form towards sustainability.

Openings

The royal residential complex shows smart and optimum fenestration locations of just appropriate sizes and shapes. Thick stone walls of palace holds smaller windows, to limit the inwards transfer of heat, while daylighting and ventilating the interiors. Jallis on openings let air and light flow into the interiors, and control

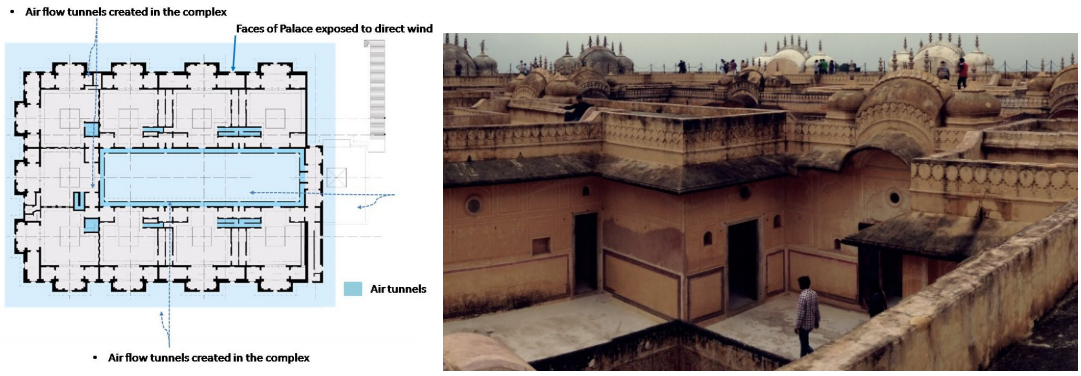


Figure 10. (a) Madhavendra Bhavan- Ground floor plan (Plan of Madhavendra Bhavan depicting the air movement, on facades and air tunnels effect created in narrow passages and staircases

the inside view, sand cyclones, and glare into the enclosed volumes.

The windows are placed at lower height, as it helps in ventilating the interiors with fresh cool breezes, raising the warmer air up, which leave the interiors through very small openings (Jharokas) at upper levels. The higher plinth of the palace do not allows the view outside to inside. Smaller window to wall ratio, thicker walls, jallis, courtyards, verandas etc. helps in keeping the age old interiors cooler in summers and warmer in winters, through the centuries. Toilets have angled openings, along the wall thickness, to create visual hindrance and ventilate the space simultaneously. The decorative rajputana style overhangs (chajjas) over the windows, provide protection from harsh sun and rain. Windows also play a very vital role in creating a play of daylight in the enclosed volumes, besides illuminating the habitable spaces. In few areas, portholes in walls break monotony of darkness, creating spotlight effect. Smaller openings also forces air inside the built forms creating air tunnels, thus ventilating the interiors. The larger cross openings make way for air to leave the volumes, rushing through verandas and out form the courtyard. Domes and Chatris added on the terraces, not only demarcate the reign superiority, but practically also shades the open courts inside, to some extent.

Air Tunnels



Figure 11. Kitchen vent opening on terrace

The palace has many hidden air tunnels, sometimes ventilating the interiors most efficiently and sustainably. Few air tunnels open out at the top of domes. Kitchen air vents are smartly manipulated in the interiors and diverted out. Presence of hidden air tunnels helped in proper air flow, thus increasing comfort conditions in the spaces.

These air tunnels run through the section of walls, few of them diverted outside sideways and few upwards.

Interiors

The royal palace being residential by activity, special attention was given to interior decoration. It shows intricate floral paintings (Arish work) in the interiors, on walls, nisches, ceilings, floorings etc. The colour theme of the interiors was kept a bit lighter, as the inner spaces could be illuminated by reflecting the daylight, thus making the spaces look more spacious.

Use of mirrors on walls, columns and ceilings of the interiors reflect light, thus awakening the interior dimensions the doors and windows show traditional wood art, with Belgium glass.

The play of light, through the various sizes and shapes of windows, arches, cut-outs, doors, jallis and colored glasses, enhance the royal interior volumes and moods, at different times of the day.The interiors remained cooler, as a result of smart design strategies. In past ages, they also used draperies, which also played role as buffer for temperature, besides for aesthetics and privacy reasons. Also the intricate carvings in sandstone on outer facades help in keeping the building cooler, than the plain facades.



Figure 14. Passage for kings and passage for queens respectively



Figure 12. Left: Madhavendra palace private chamber interior view; Right: Intricate carvings on outer surfaces of the palace



Figure 13. Daylighting in Palace



Figure 15. Frescos in the interiors & Painted walls and ceiling- Arish work



Figure 16. Sand stone is widely used in the exteriors

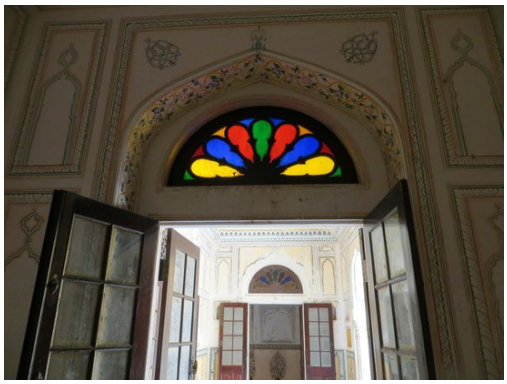


Figure 17. Wooden doors & windows with Belgium glass

Staircases and passages

Narrow passages and staircases don't serve only the purpose of transition, but also act as air tunnels enforcing the air changes in the interiors. The narrow low height continuous passages encircling the larger central courtyard, on first floor, were hidden transiting spaces for the royal kings and queens. The setting of staircases and passage ways and cut off areas are such as to segregate and overlap the activities and movements of kings and queens, supporting staff, and visitors, at times. The passages have small multiple low height windows for view and ventilation. These small windows and Jharokas lit the passage way in minimal comfortable fashion. Winds when passed through narrow spaces form forced wind streams, thus flooding the interior rooms.

CONSTRUCTION MATERIALS

Construction of the fort offered a safe sanctuary from marauding bandits and invading armies and also offered employment to the people. The heavy walls and narrow staircases where designed for security purpose of the residence. Constructed from red sandstone to limestone, the materials used help to give this majestic abode an impression of being incredibly defensive and a solid stronghold.

The walls are clad with colorful murals and frescoes. Red sand stone is widely used in the exteriors and the interior is done with Arish work finishing, consisting of lime which helps in absorbing the moisture content present in the air due to its exothermic properties. Arish work finishing is done on the interior walls, ceiling and floors as it provides a smooth finishing surface which is then beautifully painted in light, natural color, thus it enhance the interiors and add moods to it. Not only the strong structural material like stone stood through the test of time but the intricate and delicate paintings too, are embellishing the regal envelope till date. The intricate carvings on the external facades, besides the aesthetic reason played a major role in reduced the heat gain by

creating multiple miniature shadings. Red sand stone in the exterior reduces the solar gain thus creating the thermal comfort inwards due to its thermal resistant properties.

Belgium glass is beautifully used as transom which creates an elegant light effect as well as protect from scorching sun. The tinted unglazed glass also helps in reducing the U-value, thus enhancing the thermal comfort.

Application of ancient sustainable design strategies in modern designs

In today's world, where humans are draining the natural resources rapidly and environment is degrading blunderingly, there is rising an urgent need to take our lifestyle and settlement fabric towards green future. Inspiration from elderly traditional and vernacular architecture lend us many passive design strategies, which work best in optimum resources and with greater comfort, unlike some modern ill-designed buildings requiring pumping of cooled air to create temporary comfort conditions.

CONCLUSIONS

- Inspired from past age structures, live planning helps the building to work in minimal artificial resources (e.g.: electricity), thus cutting down the pollution around the built envelope.
- The traditional buildings set an example of sustainable architecture, by lowered energy consumption, through application of the passive design strategies, and developing its own micro-climate.
- Any and every type of building affects its surrounding environment and vice versa. Micro-climate of any site is the outcome of the site planning, landscaping, design of built forms, construction materials and techniques etc.
- Conscious design strategies like designing in tune with site topography, orientation, courtyards, optimum windows with smart locations and shading devices, thermal insulation, water harvesting etc. can be used in modern buildings, which can lower the energy consumption and increase the functional lifespan of habitable spaces.

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An investigation of passive strategies adapted in a Government hospital, Chennai

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Abstract: A sustainable, energy-efficient and healthy environment is achieved through passive strategies. In older days, the use of traditional, context specific techniques were developed to improve the indoor thermal comfort. With an intention to explore these approaches, through spatial planning, architectural features, building components, building materials that contribute to improve the thermal comfort conditions, a Government hospital constructed in the early 20th century is identified as a live case study. This paper further investigates how the impact of these techniques has evolved in today's context.

Keywords: passive strategies, traditional approaches, thermal comfort, hospital.

INTRODUCTION

A key to sustainable building is passive design. Passive strategies respond to local climate and site conditions, maximizing user's health and comfort while minimizing the energy consumption. Climate responsive building is designed to adopt itself to the precise area and weather conditions where it is constructed. The movement and location of sun, seasonal changes, and natural features in the surrounding topography, environmental aspects, and climatic records are considered to achieve thermal comfort and wellbeing of the inhabitants.

Chennai located on the thermal equator, experiences hot and humid climate most of the year. May to June has a higher temperature of around 35 to 40 °C, December to January being the coolest months with temperatures around 19–25 °C. Being hot and humid, amount of moisture in the air is high almost throughout the year which causes thermal discount eventually affecting the efficiency of the inhabitants. The average rainfall is about 1400mm; Chennai gets most of its rains from northeast monsoons and cyclones from mid-September to mid-December. The wind direction varies according to the site location and topography.

The ancient traditional construction was an influence of social, cultural, economic and climatic factors and geographical constrains of the region. The vernacular architecture principles of Chennai were derived from various observations and experimental knowledge gathered over the past several centuries.

The highly efficient strategies for providing thermal comfort in all seasons were based on natural and passive techniques in Traditional Colonial architecture. Influence of British rule in Chennai was evident in the architectural development during that period to facilitate the need for administration and health care. This paper is an attempt to study the old traditional approaches and passive strategies in architectural heritage building of early 20th century. The old Regional Institute of Ophthalmology and government ophthalmic hospital Egmore.

METHODOLOGY

This paper illustrates the vernacular architecture of hospital building. The study comprises of 2 phases, quantitative and qualitative analysis emphasizing on thermal comfort.

Quantitative analysis

On site measurements and readings were taken to study the thermal comfort of the Lady Lawley block. Air temperature and relative humidity (Thermo hydrometer), wind movement (Anemometer), natural illuminance (Lux meter) were measured for 12 hours, in 8 fixed locations at an interval of one hour, for a period of 2 days. The instruments were kept at 1.5m height from ground level and 1m away from the walls and surfaces. Weather data was collected from Nungambakkam meteorological station as a reference for the study.

Qualitative analysis

To investigate and understand the thermal comfort a survey was conducted to the inhabitants with set of questions on the day of study and the results were formulated.

Site:

Location

The old government ophthalmic hospital is located in the Rukmanilakshmipathi road, Egmore. The oldest block of Egmore eye hospital started, is Lady Lawley block. It was inaugurated in 13 February 1911. The new hospital is constructed right opposite to the old hospital across the road, in 1962 to facilitate new technology and surgical procedures.

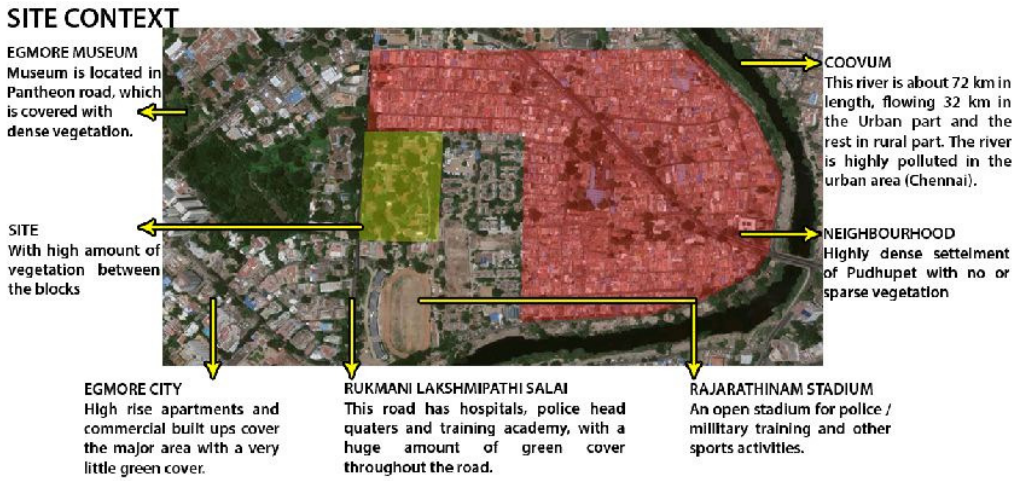


Figure 1. Site context
(Source: DigitalGlobe 2018. http://www.earth.google.com [October 26, 2018])

The site (8.2 acre) is covered with a huge number of trees that contributes to the micro climate of the area. The urban heat island survey conducted by the Anna university students in 2017(figure below) shows the adverse effect of rise in temperature throughout Chennai. The impact of green cover and vegetation in and around the site helps in improving the thermal comfort. The UHI is measured in a 5 point scale and shows that the north madras a severe urban heat island effect when compared to the central and the south zone. The impact of urbanization and reduction in green cover is reflected through this study.

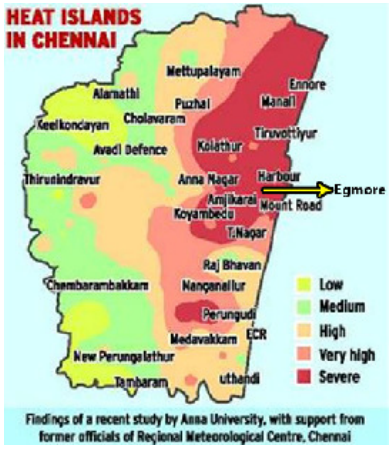


Figure 2. UHI effect Chennai
(Source: Urban heat islands study by the Centre for Climate Change and Adaptation Research Centre, Anna University)

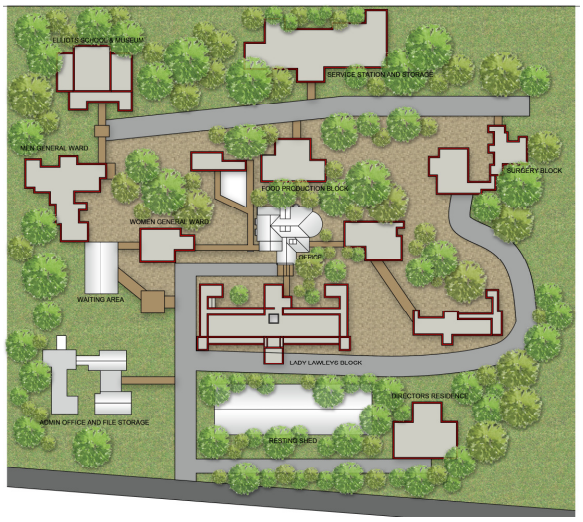


Figure 3. Site Plan
(Source: Author, 2018)

Building – Lawley Block

Floor plans

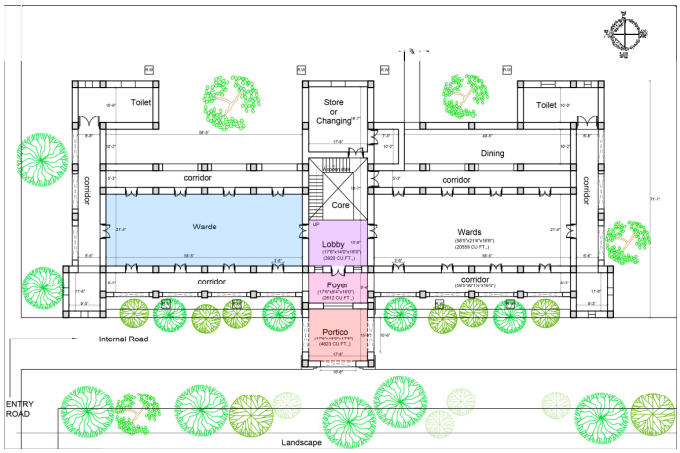


Figure 4. Ground floor layout
(Source: Author, 2018)

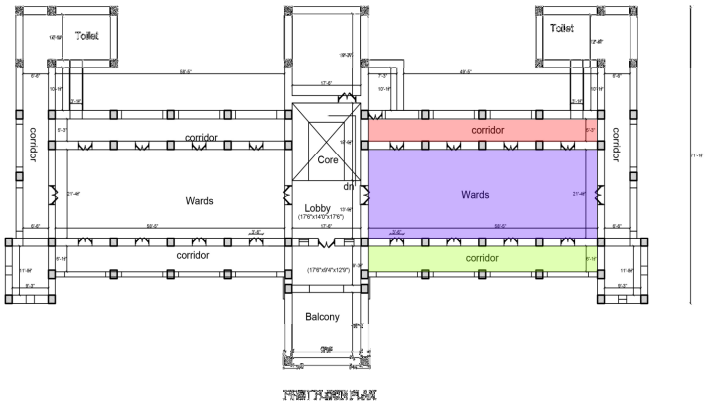


Figure 5. First floor layout
(Source: Author, 2018)

The longer axis of the Lawley block is oriented along East West direction, with façade facing west. Ground floor has 2 wards containing 20 beds each. The wards are surrounded on all sides with corridors. It also has a changing room, toilet and dining room on its rear sides.First floor has 2 wards containing 20 beds each. The wards are surrounded on all sides with corridors. There are two small wind towers on the front corners and a terrace/ balcony above the portico. Terrace floor has a flat roofed terrace, of two varying heights with skylight above the core and a water tank is placed above the central tower.The highlighted spaces are the zones where the readings for the quantitative analysis are taken.

PASSIVE STRATEGIES AND FEATURES

Form and orientation

Rectangular in plan the staircase is located at the center dividing the space into two simple halls with toilet designed as separate units to the rear. The ward spaces are surrounded on all three sides with a corridor which acts as a buffer space, excluding the direct solar radiation.

Building envelope

Wall – The thickness of the walls are 1'9", which has a high thermal mass insulating the indoor ward spaces from solar heat gain.

Floor height - The floor height at ground floor level is 17'0". In the first floor level wards are at a height of 18'8" with clerestory windows which facilitates air movement through stack effect, the corridors have a floor height of 13'4". The higher ceilings help in stack effect as the hot air rises up and also diffuses light throughout the wards.

Fenestrations – The wards surrounded by corridors has high arched door openings. The corridors that act as a buffer zone has huge arches covered with steel mesh. These openings are aligned along the west and east sides of the wards to promote cross ventilation. The doors are made of teak wood with movable louvers. There were no significant shading devices present, eaves overhang in the exterior facades were architectural projections which was designed to protect from rain.

Wind tower – The two corners along the front façade has double height wind towers with linear louvered openings for air movement. This stack effect promotes air movement in improving thermal comfort.

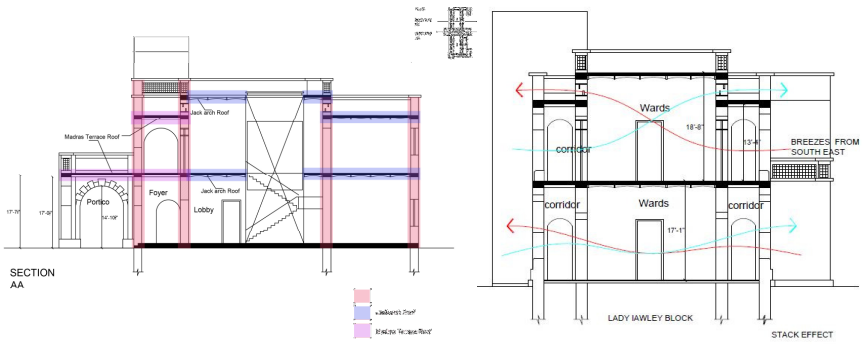


Figure 6. Left: Section through the shorter axis; Right: Section through the wards *(Source: Author, 2018)*

Roof – The wards are flat roofed with Jack arch roof (No structural steel reinforcement is required within the arches, for they naturally transfer loads along their curvature.) The corridors has traditional Madras terrace roof which has a high thermal mass.

Materials – The exterior walls are made of exposed red bricks and the interior walls are finished with lime plaster. Lime mortar is carbon neutral and keeps the enclosure cool due to water evaporation. The louvered doors and the madras terrace roof are made of teak wood. The flooring of the wards are finished with white marble which has a very low thermal conductivity. The corridors and the outdoor spaces has Kota floor which is a natural and locally available.

Landscape – The site 70% covered with vegetation which predominantly had native species like Mango, Almond, Konna, Alari are to be found in and around the building.

ANALYSIS AND RESULTS: Quantitative analysis

Air Temperature

Through are observations we can identify the difference in temperature between outdoor spaces and indoor spaces follows a pattern,

- Open spaces has the maximum temperature.
- Semi open spaces has 2-3 degrees lesser than outside temperature.
- Closed/enclosed spaces has 4-5 degrees lesser than outside temperature

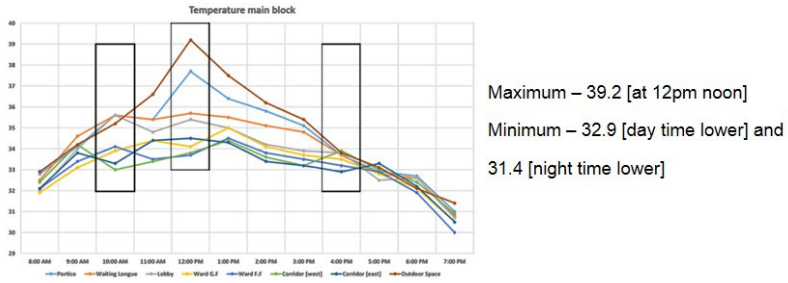


Figure 7. Air temperature graph
(Source: Author, 2018)

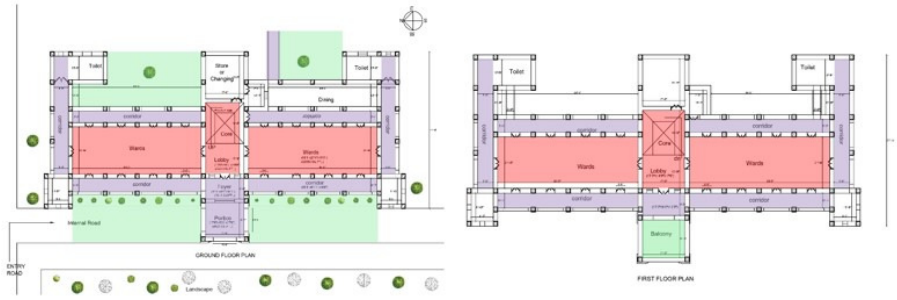


Figure 8. Floor plan for analysis *(Source: Author, 2018)*

For instance at 12.PM [hottest point of the day], the open space has a temperature of 39.2 degree Celsius, whereas semi open spaces such as corridors and waiting lounge has a temperature of 34.5 and 35.4 respectively. The completely enclosed spaces such as wards had a temperature of 33.7 degree Celsius.

Relative humidity

Humidity is found to increase with decrease in temperature and decrease with increase in temperature.

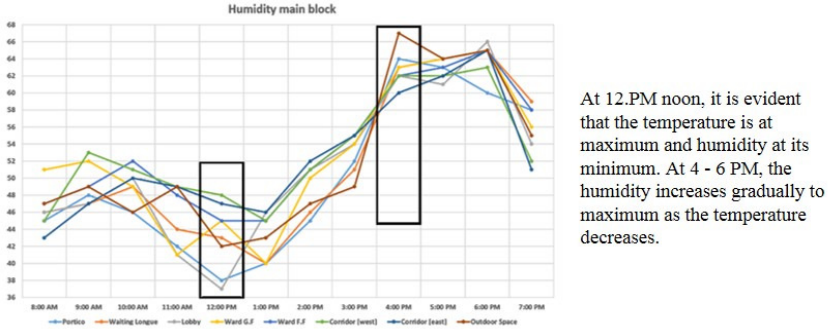
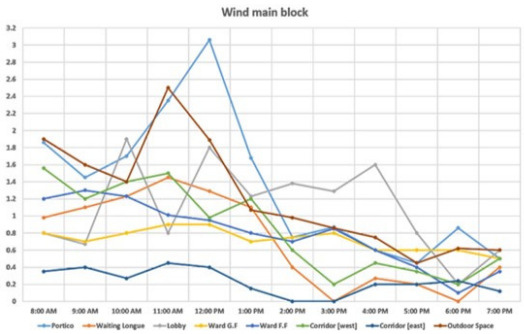


Figure 9. Relative Humidity Graph *(Source: Author, 2018)*

Wind analysis



Wind speed graph readings denote that,
Maximum wind flow

- 3.06m/s at portico. -
2.5m/s at outdoor spaces.
Minimum wind flow - 0

Figure 10. Wind Speed Graph
(Source: Author, 2018)

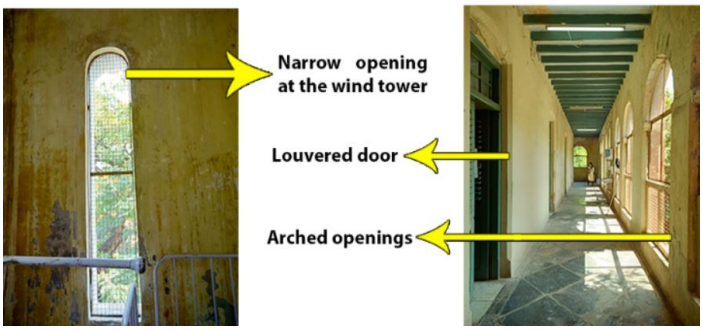


Figure 11. Fenestration
(Source: Author, 2018)

The wind direction that is experienced in the site is South West [land breeze] and South East [sea breeze]. Portico, lounge, west corridors, first floor wards gets more wind flow during day time, peaks at 11 am and 12 pm. Ground floor ward has less air movement compared to first floor as the trees blocks the movement of air at that level. East corridor has very minimum flow of air due to buildings form and height, as well as the presence of huge dense tree and its branches which blocks the air movement.

Lighting analysis

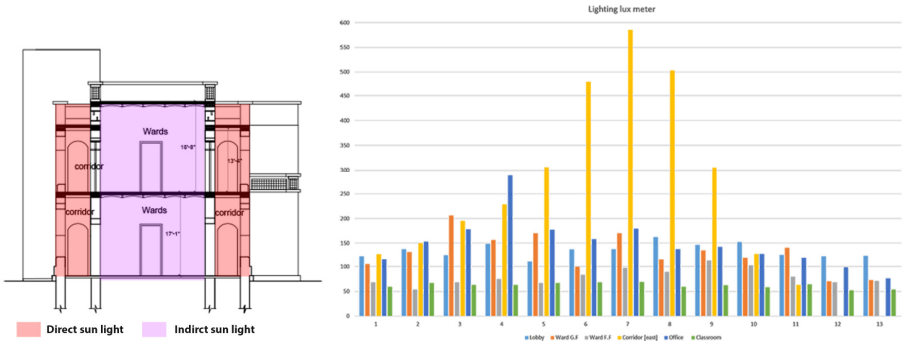


Figure 12. Left: Section for day light analysis; Right: Day lighting graph
(Source: Author, 2018)

The readings indicate that the outdoor spaces and the spaces which are open and partially covered gets more natural lighting. The Portico, corridors are illuminated by direct sun radiation. The wards have corridors on all sides which obstruct the direct solar radiation, hence have lesser illuminance values. The louvered doors are kept closed due to mosquitoes and that blocks the major amount of natural light coming in.

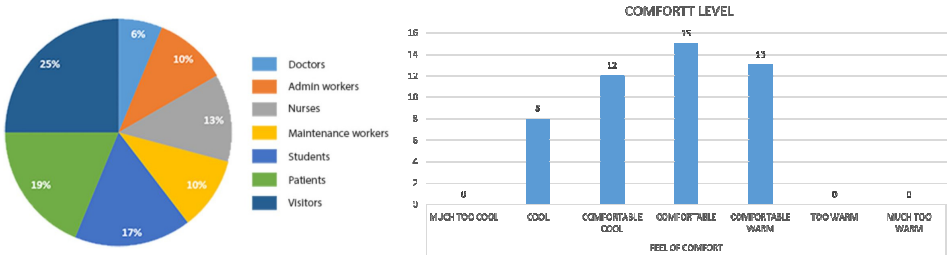


Figure 13. Population and Comfort Graph *(Source: Author, 2018)*

Qualitative analysis

The qualitative analysis was done based on a set of question on the temperature, air movement, comfort level, humidity and the overall conditions of the building. The results were found to be positive, with almost 82% of people feeling comfortable and comfortably cool. The remaining percentage of people felt comfortably warm. Lack of natural day light was experienced in few spaces like the lobby and wards. The overall conditions of the building were thermally comfortable and accepted by the inhabitants.

CONCLUSION

Wind movement: Cross ventilation in the wards is the major reason for wind movement. But the door are kept closed almost throughout the day due to mosquitoes because of the presence of huge number of trees. This affects the movement of air. Louvered doors are present for the movement of air even if the doors are kept closed. But the louvers are not in movable condition now, as they are struck due to the painting work that has been done to maintain it.

Wind towers: Wind towers have a louvered window and a small opening at the top. The louvers in the window are not in working condition, affecting the stack effect.

Wards: The buffer spaces around the wards that protects the interiors from direct solar radiation, decreases the amount of light entering the space.

Keeping the doors closed, with louvers not functioning, completely blocks the natural day light in the wards, and hence provides way for mosquitoes and other insects to grow, causing discomfort as a whole for the patients.The traditional passive strategies that were planned and designed for the climatic conditions to promote thermal comfort around 100 years ago, are not being maintained according. Hence the efficiency of these passive strategies is being lost and in turn there is an increasing load on the energy consumptions. Though the traditional techniques are old, they prove their immense importance even in today's scenario.

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*Passive environment control system of Kerala vernacular residential architecture for a comfortable indoor environment: A qualitative and quantitative analyses A.S. Dili a, *, M.A. Naseerb , T. Zacharia Varghese a [Department of Civil Engineering, National Institute of Technology Calicut, Kerala, India]*

Evaluation of thermal comfort in a rail terminal location in India Chirag Deb, A. Ramachandraiah 1 Civil Engineering Department (BTCM Division), Indian Institute of Technology Madras, Chennai 600036, India*

Analyzing the Deciphering Planning Strategies used in Ancient Dravidian Temple Architecture

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Abstract: Indian sacred architectural manifest moods, communicates messages by its built form. In Temple Architecture there is always a provision of clues and informed choices for all individuals and specific to their personal pursuits in the play of spaces. In sacred Architectural monuments there is always a unique character which enhances the Environment special in outdoor spaces here the shift axis planning system is not only a simple change in the original physical axis of Temples when it was erected even after so many transitions at present also the Spaces and its Environment remains fresh and its relevance after these many centuries. This research would empirically to find out the strength and value of Planning systems incorporated and its deciphering strategies which interpreted in Kailasanath Temple, Kanchipuram and Brihadeshwara temple, Tanjore - This research would empirically to find out the strength and value of Planning systems incorporated and its deciphering strategies of the individuality interpreted in Kailasanath Temple, Kanchipuram and Brihadeshwara temple, Tanjore. An Assessment of planning strategies in the temple Architecture of two dominant kingdoms Chola's and Pallava's and their Architectural Masterpiece's makes them eternal. Both temples positioned in South India at the state of Tamil Nadu and its validation is the suggestive solutions for modern public Holistic Spaces.

Keywords: Shift Axis Planning; Deciphering planning strategies; Indian sacred Architecture, Tanjore Brihadeshwara temple; Indian sacred Architecture, Kanchipuram Kailashnatha temple;

INTRODUCTION

The two highly significant monuments of South Indian temple Architecture erected in two different period of timeline is Unique by its Deciphering Planning Strategy and Shift Axis Planning Theory. This study carried out by documenting the case studies and assessing the planning principles using Person environment Research. Architectural criticism always has four major outlined elements 1. Politics, 2.Aesthetics, Sociology and 4. Culture (Andrea Hardy, 2014).

INTRODUCTION – KAILASHANATHA TEMPLE, KANCHIPURAM

KanchiKailashanatha Temple was constructed during 685 to 705 AD by the Pallava King Raja Simha (Shown below in figure 1). The talented King, beyond the spiritual – himself a devotee of the Cosmic Dancer the Lord Ranganatha. During his period he is an expert in many art of that period and was supposed to be one of the very few experts in the Elephant Sastra too. His period saw the emergence of many grand temples in and around Kanchipuram a dominant capital of pallava Dynasty.



Figure 1. Front Approach view of KanchiKailashanatha Temple – North East View.
Source: Author 2018.

This site was announced as one of the Heritage sites in India by UNESCO and INTACH which is also the oldest structure amongst other temples of this region.

ARCHITECTURE – KAILASHANATHA TEMPLE

The main shrine of this structure was built during the reign of Rajasimha approximately dating to 685 – 705 AD stated early, although the actual completion of the temple as a whole was taken by his son Mahendravarman III but with the exception of a few additions to the east. Two isolated buildings the sanctuary and mandaba joined together by a spacious inter mediate hall or Antarala.

The medieval addition has robbed the main structure of architectural appearance and it is better to visualize it without an intervening compartment. It will be seen from the drawing the main building is tall sanctuary at the eastern end of the enclosure and that in principle it conform to the monolithic proto type of the DharmarajaRatha. Certain elaboration in the supplementary shrines attached to and projecting from its free 3 sides, which aid its effective presentation. Every aspect of this temple is complete with informative features. The primitive shape of the Mandapa – pillars.

The constant repetition of the rampant lion pilaster the composition of the whole building makes grey pile of Kailasanathar the most fascinating study. The pyramidal tower or Sikhara has distinctive treatment of the feature in the development of Dravidian style, which is best observable. Apart from the main structure of this temple there are certain arrangements in connection with the entrance to the courtyard which are noteworthy.

In place of the main gateway a large subsidiary chapel has been introduced and complete with cella, vestibule and stairway approach the actual doorways in courtyard. Although a place of worship, the mahendravarman shrine is built in such a manner, closely with it's accompany to suggest the beginnings of the gopuram or entrance pylon. Realizing importance of the selection in the matter of their building materials is shown by the fact that in the kailasanath, the foundation of the temple is of granite. The Upper portions are of sandstone, thus providing a hard and firm substructure to carry its weight and more a plastic substance for the sculpture.

The dedicated kailashnatha temple holds main shrine with a 16 sided Shiva idol in Lingam form which is purely made up of black granite stone. There in the main shrine walls are carved with images of god and goddess with various is forms and is padabhandaadhisthana (main pedestal) with a sculpted Nandi. The inner sanctum holds dwarapalas the security statues adjacent to that a small niche which surrounds the inner sanctum shows the massive thickness of the walls around Garbagriha.

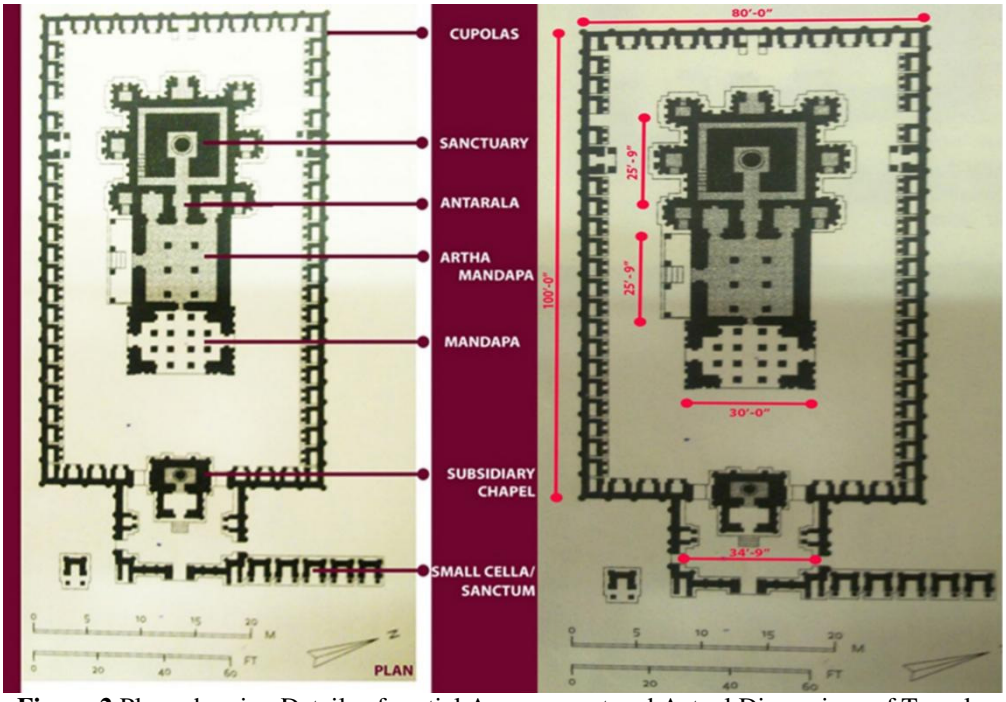

Figure 2. Plans showing Details of spatial Arrangement and Actual Dimensions of Temple.
Source: Author 2018.

The Temple Complex having a circumambulatory passage covered by the outer temple wall holds 58 small shrines around the temple Entrance to entrance shows the symbolic meaning of various stages of life and saga's of lord Shiva. Entrance is narrow and crawl space where seven steps must be climbed in order to reach the passage. Passing through the narrow passage is indicative of passage through life. After the circumambulation, the exit is through a pit or another narrow passage symbolic of death. It is believed that making the circumambulation round the various deities would usher the same blessings as visiting paradise.

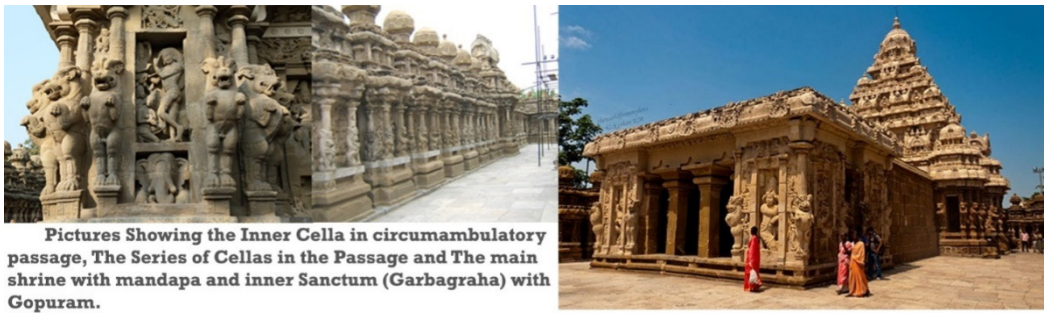

Figure 3. Exterior view and Interior Views of Kailashanatha Temple.
Source: Author 2018.

Approach of the temple start in the south direction from the road which lead to the Entrance gate in the east, south side have one cell and north side have five cells split up. It gives simple and logical entrance. Then the path lead to subsidiary chapel, from this point, approach way or path is shifted, then it enter temple complex. This is totally disparate from visual axis which is shown below in figure 2 & 3.

INTRODUCTION - BRIHADESHWARA TEMPLE, TANJORE

This Brihadeshwara temple is one above 1000 year oldest monument dedicated to lord Shiva located in Tanjore, built by Raja RajaChola I. it is constructed during 1003 -1010 AD This structure is surrounded with a huge moat.

In this temple, the devotee approach follow the spatial narration, from the Raja Gopuram, Nandi Mandapam, MahaMandapam, ArthaMandapam and finally it reaches the Garbagriha with the largest shivaLinga in this Eastern stretch of Tamil Nadu. After reaching Garbagriha devotee can move out by ArthaMandapam, the structure holds one of the tallest grand gopuram of south India shown below in figure 4.

The temple is an eminent architectural symbol of Chola dynasty. The entire temple premise is compounded, entire temple was constructed using stones. As we all know this temple structure lies over a stone podium and the structure doesn't use any mortar (Dry – Order, Temple Architecture).



Figure 4. Exterior view of Tanjore Brihadeshwara Temple.

Source: Author 2018

ARCHITECTURE – BRIHADESHWARA TEMPLE

The main shrine of this structure was built during the reign of Raja Raja Chola I. The entire structure was placed over a raised platform using man made mounds, the rectangular symmetrical plan covers the dimensions of 790 feet east-west and 400 feet North-south.

The temple complex consists of five major sections in which the main inner sanctum with Lord Shiva in lingam form holds the tallest tower, Vimana (Sri Vimana). As soon as you enter the front gateway treated with holistic motifs engraved the construction process and myths in Gopuram, barrel vaulted which sized is perfectly half the percent of main Sri Vimana.

After Cholas Gopuram (Gateway Gopuram) we have Nandi hall which is said to be Nandi Mandapam, between the inner sanctum and Nandi hall there is a huge community hall, during festival seasons the God and Goddess Idols were placed there and it is said to be Mukha Mandapam, before these two there is a great gathering hall as Maha Mandapam also connecting Maha Mandapa with sanctum they have a pavilion called Artha Mandapam.

Around the temple complex there is a vast space provided as Prakaram which is used to go around the main shine and Nandi idol together. Here in this Brihadeshwara temple it is covered with pillared stone roof structure and space in between the main sanctum and Mandapa's with Nandi and the Prakara path a vast courtyard space with a perimeter of 1480 feet shows the massiveness of main Vimana in beautiful views at all points.

DECIPHERING ARCHITECTURAL PRINCIPLES & SHIFT AXIS PLANNING OF TEMPLE ARCHITECTURE

Any study related with Criticism specifically in Sacred Architecture, There the importance of the objectectivity has to be stresses is quite Common and mandatory Aspect of the study.

A lot is demanded of the critic in the judicious administration of this goal. It has to be allied to good Sense and clear judgment, to sagacity and it must be in the hands of someone who can hold their own against the spread of mediocre mass cultural values (sharp, 1984). The mediocre mass cultural value which elaborates the audience criticism supposed to be insulated from and also consumed by the respective subjective testing element (sharp, 1984). The aspirational qualities of Indian temple Architecture are extended beyond context and various researches demonstrated that this Indian temple Architecture and planning strategies are beyond criticism also a given quality performance to the public reveals for timeless immortality of the place.

SHIFT AXIS IN TEMPLE ARCHITECTURE

"Shift axis means Shift or change of axis from its original axis". The first Temple form evolution start from second century, that time Sri Idai Kadar sithhar is the person who arranged the positions of the nine planets (Nava Graha) that are being followed in the temples of India.

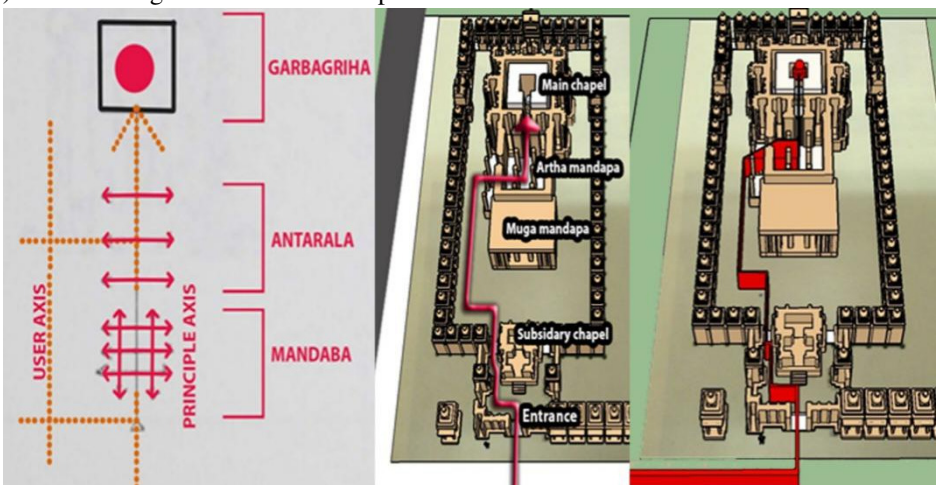

Figure 5. Above Composed three picture's, showing the parts and its axis of planning and users, 2ndshows the physical model of kailashnatha temple with people movement axis around Mandapas and 3rdshows the Model of temple with Shift Axis. Source: Author2018.

Earlier in temples the Nava Grahams were placed circularly i.e. all the nine planets were facing each other and could interact directly (Sathuragiri Kanchi madam organization, 2014). Idaikadar sidhar (saint – pronounced in Tamil literature) - modern day arrangement of the nine planets used in all the temples throughout India. In this arrangement the value of individuality of the nine planets by placing idol in a square format and approaching the circumbalatory path in a clockwise pattern. Every time a person moving around the nine planets have to shift from his usual axis and need to turn to start his prayers. Here is the first origin of shifting of axis.

Participation in the journey into the temple is believed to be in three ways. 1. Manasa or intellectual, 2. Vaacha or verbal, and 3.Karmana or physical. Circumambulation around different spaces and objects in a temple evoke physical participation of the people.

The Case Study of Kanchipuram Kailashnatha temple is planned symmetrically but the axis is drifted from entrance to main shrine because of two Mandapa's placed after entrance immediately which is shown in figure 5 and figure 6.

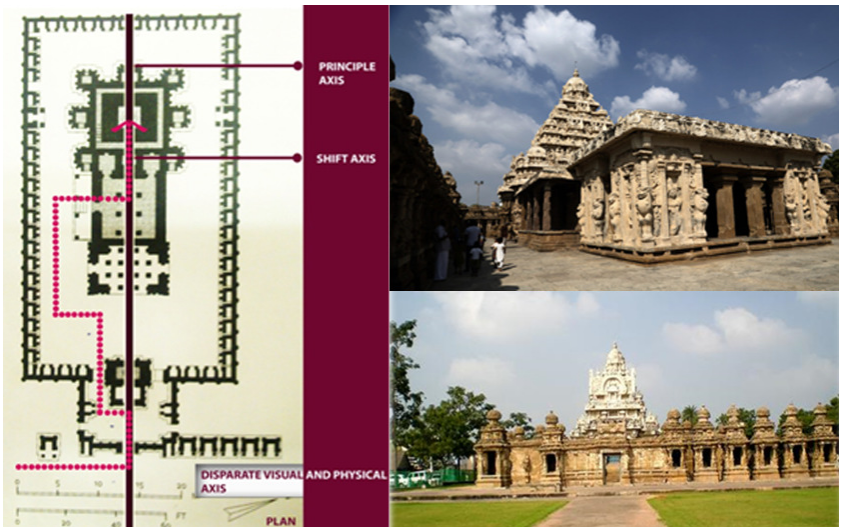

Figure 6. Plan with principle axis and shift axis, Views exterior shows direct axis and interior shows the shift. Source: Author 2018.

The Case Study of Tanjore Brihadeshwara temple is planned symmetrically with a linear axis plan but the axis is drifted from entrance to main shrine because of Nandi Mandapa placed after entrance which is one of the biggest Nandi statue in Indian temple's shown in figure 7 and figure 8 shows the people movement shift over the Shift axis path.

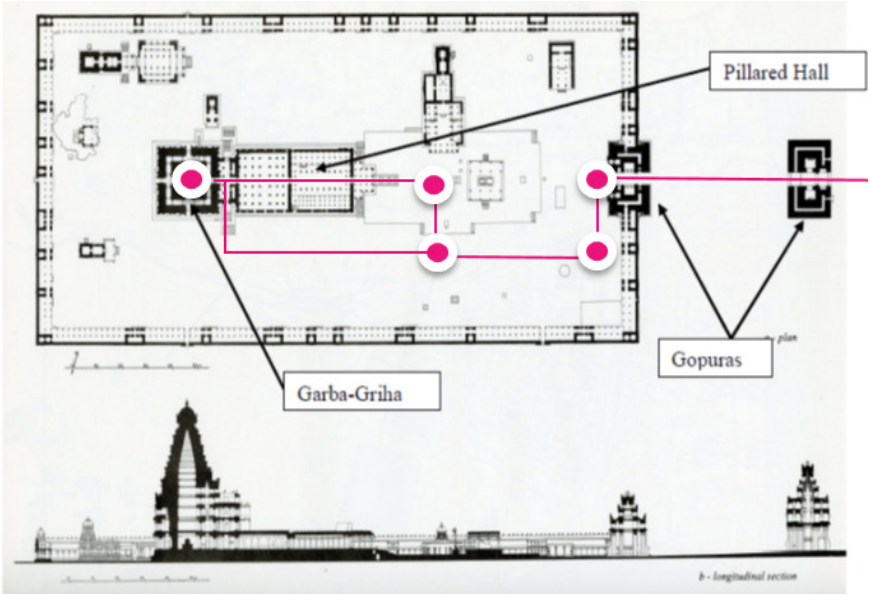

Figure 7. Plan & Cross Sectional elevation of Brihadeshwara Temple showing the nodes of Axis and its shift... Source: Author 2018.

Although the visual path in temple is always straight, the physical path is never straight. It is always are around various components of the temple like the bull hall, the cosmic pillar, the shrine and around the temple. The circumambulation is usually performed in the clockwise direction for an odd number of times.



Figure 8. Exterior view of Brihadeshwara Temple, Tanjore with People movement in Shift Axis -path.
Source: Author 2018.

DECIPHERING SACRED ARCHITECTURAL PRINCIPLES

There are various Planning principles are used in extreme efficient manner out of which 6 unique characters manifests moods and the craft of bilateral symmetrical planning system in the sacred premise, provision of clues and informed choices for all individuals with respect to their individual choices of personal pursuits.

- Incongruent visual and physical axis
- Choices of movement path for personal and intuitive experience
- Indoors disintegrated with outdoors and keep peaceful environment
- Kinesthetic as the organizational and proportioning tool
- Layering for the sequential unfolding of spaces
- Movement A key to conditioning of the mind

The Incongruent Visual and Physical Axis: In kailasanath temple plan - principle axis is straight linear which is different from physical axis. The straight axis (principle axis) which give a straight visual from the Entrance – subsidiary chapel and the physical axis or user axis is shifted/ changed from original axis.

Similarly in Brihadeshwara temple plan – principle axis is linear and straight to the inner Garbagriha but the initial Mandapa where Nandi statue changes the principal axis and the divergent shows the visual axis focusing inner main sanctum but the user axis is changed shown in Figure 6, Figure 8 and Figure 9.



Figure 9. Shows Front Gopuram & Interior of Brihadeshwara Temple, with People movement in Different Axis.
Source: Author 2018.

Choices of Movement Path for Personal and Intuitive Experience: Both the passages and pathways exist in and around the temples are changing the experience of each and every individual with respect to their choices.

Choices are changing by virtue of

- Age
- Gender
- Social profile exists Economy
- Political scenario etc.).



Figure 10. Interior Landscapes & Exterior view of Kailashnatha temple &Brihadeshwara Temple.
Source: Author 2018.

Indoors Disintegrated With Outdoors & Keep Peaceful Environment: In each and every spaces like main Shrine, inner Mandapa's like Artha Mandapa/Maha Mandapa/ Nandhi Mandapa (because the both temples are dedicated to lord Shiva)/Mukha Mandapa etc., Circumbalatory passage and small shrines in the outer Compound wall shows their own character and individuality of spaces and its choice of integration with the surroundings.



Figure 11. Interior Landscapes & Exterior view of Kailashnatha temple &Brihadeshwara Temple.
Source: Author2018.

Kinesthetic as the Organizational and Proportioning Tool: Experimental richness and ability to identify with pluralistic value systems is the hall mark of timeless Pallava and Chola architecture.

The Both Dominant kingdom and their Architecture have ably demonstrated the universality of its communication as well as its validity within multiple values systems.

This is achieved essentially by relying on spatial experiences derived through narratives - dynamic perception of space while in motion - its 'Kinesthetics'. The interactive process of encoding and decoding between the space and perceiver then becomes the key aspect of orchestrating spatial narratives.



Figure 12. Interior Richness of circulation& Exterior view of Kailashnatha temple &Brihadeshwara Temple.
Source: Author 2018.

Layering for the Sequential Unfolding of Spaces: From the main entrance Gopuram and outer compound walls to inner passages and various Mandapa's and to the inner sanctum all the Spaces are sandwiched one another. The Traditional Dravidian Architectural climax of identifying keys to open up next phase shows the Individuality of temple architecture.



Figure 13. Sequential Interior Spaces of Kailashanatha Temple.
Source: Author 2018.

Movement a Key to Conditioning of the Mind: Above mentioned dictums reveal the truth behind the temple architecture and it justifies the notion of shifting axis. And, it helpful to define space hierarchies and territories in terms of personal and public realms. The conditions of outdoors inherently not remaining same changes consistently making the same space appear different and fresh all the time….

but Absence of landscape element in the temple premises make a feel of missing something.



Figure 14. Interior Spaces, Landscapes & Exterior views of Kailashnatha temple &Brihadeshwara Temple. Source: Author 2018.

CONCLUSION

From the study it is evident that the temple planning strategies have clear-cut objectives of conveying a range of messages, preparing the people to reach the unreachable. In pursuit of this, the entire planning is orchestrated with specific norms like shift in axis, monumentality in physical forms, and intricacy in details.

Thereby, all the people visiting the temple complex could get the following experiences:

i) Flow of experience where in the self- in process prepares to experience the change in the sense of self.
ii) Experience of cohesion achieved through action and reflection within a grandiose and idealized physical setting.
iii) Regulating people's activity by initiating shift in axis, organizing the drives through various sculptures and art forms which mediate internal and personal / environmental conflicts.
iv) Change in perception by Moving towards the Garbagriha crossing various Mandapas through shift axis symbolizing the possibility of reaching the unreachable.

Finally, facilitating to understand and experience a constant, unchanging self, existing apart from its material environment and material body which transcends the life of the physical body to super conscious state by its physical order of the built environment manifesting the conceptual meaning through the articulation of spaces.

Also through its qualities enriched by the expression of scale and proportion ensure the people to experience the perceptual nuances embedded in its physical planning principles.

Hence, it is deciphered that the overall planning of the temple is programmed in this order so as to exist as an evolving entity in the synthesizing of experiences of the people to show the path to move from knowable to unknowable.

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Thermal Comfort Analysis of Rammed Earth in the Indian Context

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Abstract: As one of the age-old vernacular building practices, rammed earth is a very sustainable and low-cost material. Although rammed earth is a very apt building material in many regions of India, it is mostly neglected in favour of relatively higher energy materials, such as concrete and steel. This study aims to analyse the thermal comfort of rammed earth buildings in the Indian context to bring favour to this building material. For this, a single room of rammed earth is placed in five different climatic zones of India and analysed for its thermal comfort using TRNSYS simulation and IMAC comfort models. From this analysis, it can be observed that rammed earth as a building material can be thermally comfortable in most parts of India.

Keywords: rammed earth, earth construction, thermal comfort, comfort analysis, trnsys simulation, iMac

INTRODUCTION

Earth is one of the oldest building materials known to man. It is also one of the most commonly used materials in vernacular architecture of India (Sarkar, 2015). From the Shey Palace and Monastery in Ladakh to the Bhonga houses of Rajasthan, earth constructions can be found in all kinds of climates in India. Rammed earth is a building material resulting from the application of compaction of certain soils (Miller, 1980). It is one of the oldest and most durable construction techniques associated with earth construction.



Figure 1. Rammed Earth Wall
(Source: From Red Soil Nature play by the author, 2016)

Rammed earth is picking up favour in current times due to its low embodied energy and sustainability quotient (Reddy & Kumar, 2010) (Kariyawasam&Jayasinghe, 2016). Many new buildings, especially in the residential sector, are using this material for construction.

Rammed earth is generally considered to provide good thermal comfort within the building. In this paper, the amount of thermal comfort provided by rammed earth, especially in the Indian context, is studied to see the suitability of the material.

METHODOLOGY

Humans adapt according to the current climatic conditions of the location to maximise their thermal comfort. This is considered as the Adaptive Model of Comfort (ASHRAE, 2010). To provide an appropriate adaptive model specific to Indian climate, the India Model for Adaptive Comfort (IMAC) was developed which provides a monthly range of thermal comfort for different locations in India (Manu, Shukla, Rawal, Thomas, & Dear, 2016). This IMAC model is considered for analysis by comparing results obtained through the TRNSYS simulation with the monthly thermal comfort ranges given.

By placing a room with the same specifications in five cities of different climatic zones of India, the amount of thermal comfort provided by rammed earth construction can be quantified.

In this analysis, the ambient temperature and the relative humidity are considered, keeping all other possible climatic variables as constant (values considered for simulation: Appendix 1).

Room specifications

The room considered is of the size 10m x 8m with a simple construction of 300mm rammed earth walls with no insulation. In order to maintain the consistency of earth construction, a jack-arch roof and earth foundation are considered here.

Given below is the plan of the room considered along with the wall section. A table depicting the thermal properties of the individual materials is given in the appendix (Appendix 2).

Table 1. Construction specifications

Sl no.	Element of Building	Construction
1	External Wall	300mm Rammed Earth Wall
2	External Roof	10mm Brick tile + 10mm Mortar + 70mm Lime Concrete Slab + 200mm CSEB + 6mm Mud Plaster
Figure 2. Plan and wall section of the room considered for simulation		
3	Floor	10mm Brick Tile + 10mm Mortar + 6mm Screed + 175mm Waste Mud Filling + 200mm Stone Filling

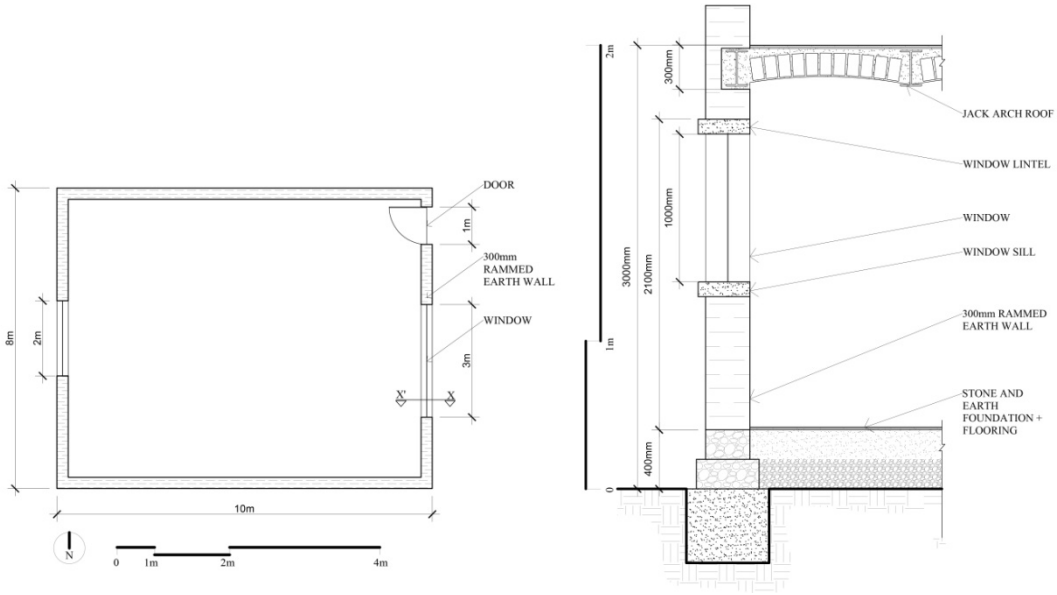

Figure 2. Plan and wall section of the room considered for simulation

Indian climatic classification

India is classified into five major zones according to climate (National Building Code: Volume 2, 2016). Considering this classification, five cities with these climatic profiles are selected for this analysis. They are:

- Hot and Dry (HD) – Jodhpur
- Warm and Humid (WH) – Bhubaneswar
- Composite (Com) – Indore
- Temperate (T) – Bangalore
- Cold (C) – Shillong

Table 2. Temperature and relative humidity ranges for selected cities					
City	**Climate Classification**	**Temperature Range (deg C)**		**Relative Humidity Range (%)**	
		Max	**Min**	**Max**	**Min**
Jodhpur	Hot & Dry	45.25	4.95	93.5	14
Bhubaneswar	Warm & Humid	42.1	11.45	100	33
Indore	Composite	42.8	6	100	12
Bangalore	Temperate	36.55	13.4	99	28
Shillong	Cold	26.75	0.1	100	7

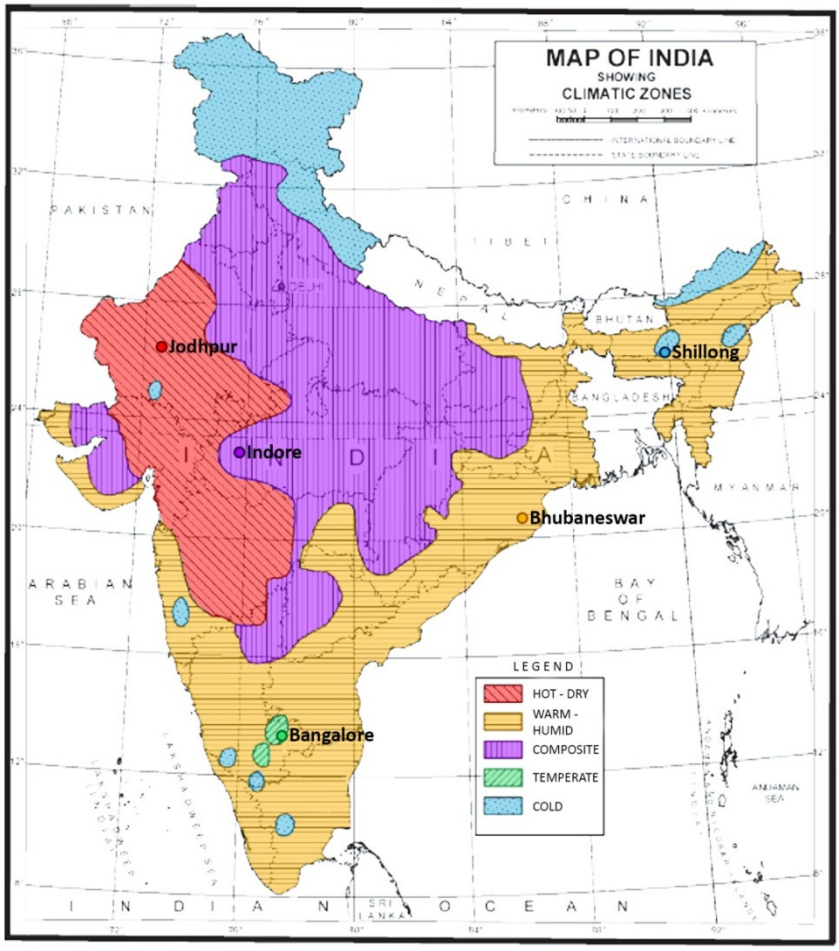

Figure3. Climatic classification of India
(Source: National Building Code: Volume 2, 2016)

RESULTS

The results of the simulation show that rammed earth construction can effectively balance out the effects of temperature on the indoors but significantly increases the humidity levels. Although this is desirable in most climates, it may not be preferred in high humidity climates. The city-wise results are shown below.

Jodhpur (HD)

Although a few temperatures are not within the comfort zone, when compared to the outdoor temperatures, the indoor temperatures seem to balance out the effects of the outdoors by making the indoors relatively warmer in the colder months and relatively cooler in the warmer months. As the relative humidity inside the rammed earth structure increases, it provides comfort during the dry months.

Table 3. Jodhpur simulation results						
	Average DBT		**Average RH**		**% Comfort**	
	Indoor	***Outdoor***	***Indoor***	***Outdoor***	***DBT***	***RH***
January	18.81	17.13	59.05	44.92	25%	55%
February	20.81	19.61	48.96	34.95	43%	92%
March	25.01	24.79	42.49	30.21	53%	99%
April	28.67	29.15	38.48	27.68	55%	94%
May	32.21	33.56	41.29	30.81	55%	100%
June	32.24	33.39	63.84	52.49	61%	35%
July	30.73	31.6	82.7	70.53	71%	2%
August	28.75	29.2	82.8	70.99	81%	0%
September	28.54	28.77	84.25	73.44	69%	0%
October	27.01	27.04	56.83	46.12	44%	65%
November	22.71	21.79	52.91	40.8	24%	79%
December	19.92	18.51	61.31	48.43	22%	45%

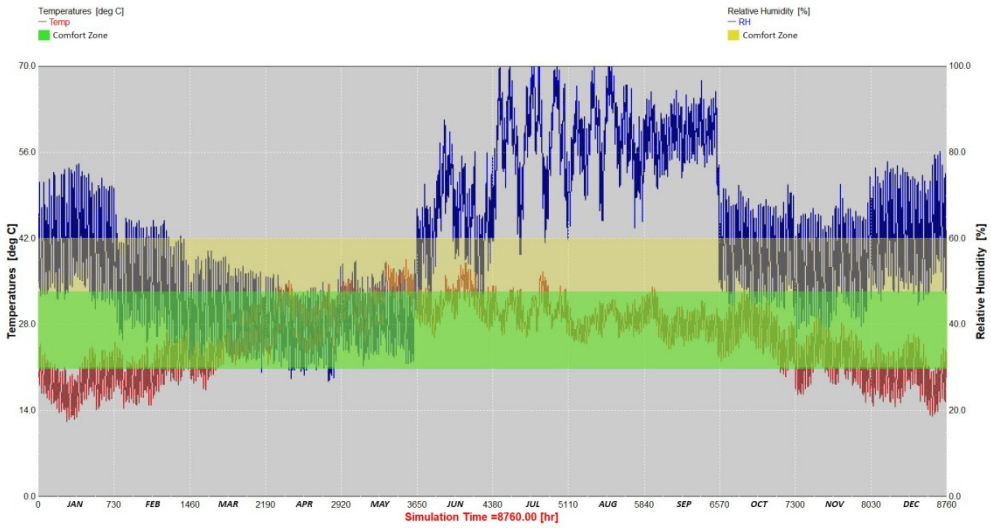

Figure4. Jodhpur Simulation Output
(Green highlight = comfort range for temperature; Yellow highlight = comfort range for relative humidity)

(Orange = underheated, low humidity; green= comfortable; red = overheated, high humidity)

Bhubaneswar (WH)

Rammed earth gives most comfort in this climate type with respect to temperature. But, when considering relative humidity, the indoor space has relatively more humidity than the outdoors, which makes it extremely uncomfortable. This can be dealt with by providing more ventilation.

Table 4. Bhubaneswar simulation results						
	Average DBT		**Average RH**		**% Comfort**	
	Indoor	***Outdoor***	***Indoor***	***Outdoor***	***DBT***	***RH***
January	23.07	22.23	73.98	63.35	54%	1%
February	25.52	25.12	75.95	65.81	61%	0%
March	28.43	28.63	76.96	66.48	67%	1%
April	30.11	30.54	78.03	67.59	65%	0%
May	31	31.71	81.24	70.07	58%	0%
June	29.83	30.27	88.05	76.88	76%	0%

July	28.55	28.79	92.97	82.8	85%	0%
August	28.23	28.42	94.95	84.28	94%	0%
September	27.96	28.1	94.01	84.21	90%	0%
October	27.67	27.63	89.41	79	87%	0%
November	25.14	24.53	84.06	74.4	63%	0%
December	22.95	22.03	73.57	63.09	55%	8%

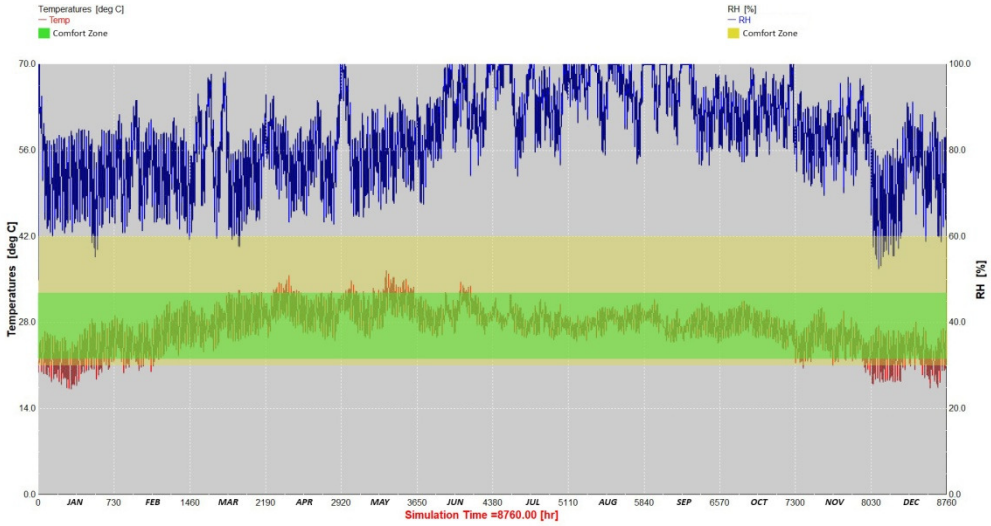

Figure5. Bhubaneswar Simulation Output
(Green highlight = comfort range for temperature; Yellow highlight = comfort range for relative humidity)

(Orange = underheated, low humidity; green= comfortable; red = overheated, high humidity)

Indore (Com)

Similar to Hot & Dry climates, rammed earth in composite climates does go below the comfort range in a few months. But, when compared to the outdoor conditions, the indoor temperatures seem to balance out by making the indoors relatively warmer in the colder months and relatively cooler in the warmer months. Relative humidity levels are also within the comfort range for most of the year.

Table 5. Indore simulation results

	Average DBT		**Average RH**		**% Comfort**	
	Indoor	***Outdoor***	***Indoor***	***Outdoor***	***DBT***	***RH***
January	19.83	18.24	62.25	49.76	40%	40%
February	21.36	20.14	53.44	40.93	45%	77%
March	25.46	25.3	40.99	29.26	51%	97%
April	29.06	29.62	35.36	24.92	49%	78%
May	31.28	32.48	43.06	32.5	51%	100%
June	29.23	29.65	68.63	57.49	61%	18%
July	26.81	26.79	87.61	76.53	67%	0%
August	25.41	25.11	93.3	82.98	78%	0%
September	25.9	25.67	85.65	75.11	77%	0%
October	25.65	25.36	64.08	53.36	59%	31%
November	22.61	21.58	58.82	47.37	41%	55%
December	20.33	18.84	58.8	46.31	36%	54%

(Orange = underheated, low humidity; green= comfortable; red = overheated, high humidity)

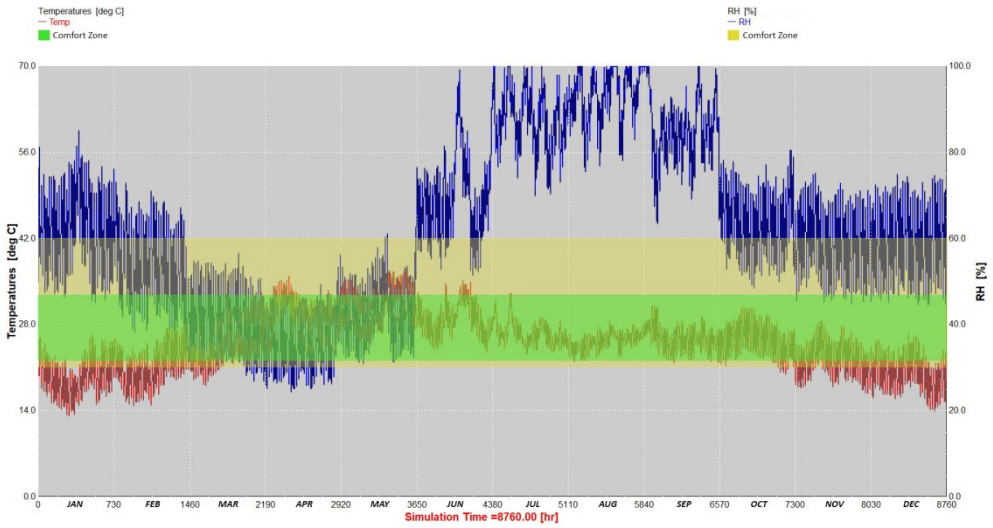

Figure6. Indore Simulation Output
(Green highlight = comfort range for temperature; Yellow highlight = comfort range for relative humidity)

Bangalore (T)

Temperate climates are generally comfortable throughout the year. Rammed earth construction seems to improve the comfort with respect to temperature by balancing out the outdoor temperatures. Since relative humidity is increased, it can become extremely uncomfortable during a few months. This can be dealt with by

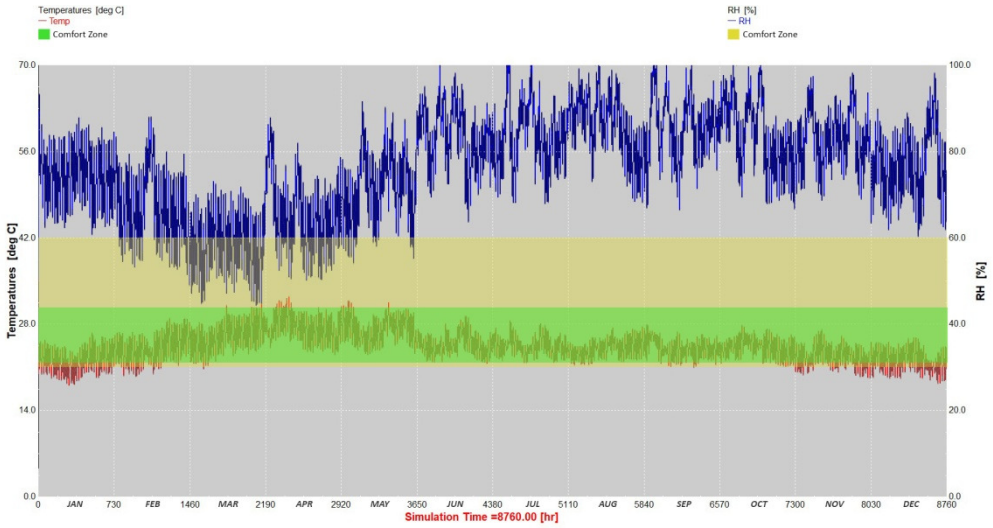

Figure7. Bangalore simulation output
(Green highlight = comfort range for temperature; Yellow highlight = comfort range for relative humidity)

providing more ventilation.

Table 6. Bangalore simulation results

	Average DBT		Average RH		% Comfort	
	Indoor	***Outdoor***	***Indoor***	***Outdoor***	***DBT***	***RH***
January	22.32	21.3	74.38	63.44	54%	0%
February	24.18	23.59	67.53	56.53	64%	20%
March	26.22	26.11	58.2	47.12	67%	59%
April	27.58	27.66	65.12	54.39	75%	29%
May	27.37	27.47	71.83	60.86	72%	8%

June	24.88	24.29	83.47	73.23	53%	0%
July	24.57	24.01	83.76	73.19	69%	0%
August	24.16	23.52	86.29	75.89	69%	0%
September	24.21	23.59	85.76	75.22	68%	0%
October	24.37	23.78	84.33	73.78	75%	0%
November	22.94	21.95	83.3	73.22	49%	0%
December	22.2	21.11	77.26	66.53	50%	0%

(Orange = underheated, low humidity; green= comfortable; red = overheated, high humidity)

Shillong (C)

Most of the year seems to be uncomfortably cold. Although rammed earth improves the condition in a few months, the rest of the months still appear to be below the comfort range. To combat this, more thermal mass or efficient insulation can be provided to improve the indoor thermal conditions.

Shillong, having a cold and cloudy climate, has higher relative humidity values. Hence, rammed earth may become extremely uncomfortable in certain times of the year. This increased humidity will be a benefit in cold and sunny climates, such as in Ladakh, which have lower relative humidity values (Joshi, 2013).

Table 7. Shillong simulation results

	Average DBT		**Average RH**		**% Comfort**	
	Indoor	***Outdoor***	***Indoor***	***Outdoor***	***DBT***	***RH***
January	10.94	6.81	90.4	79.02	8%	3%
February	12.54	8.83	84.93	72.75	24%	7%
March	15.39	12.23	85.41	75.98	43%	7%
April	18.54	15.88	77.96	70.04	57%	17%
May	19.29	17.01	92.41	85.40	43%	0%
June	20.85	18.97	96.43	90.28	61%	0%
July	20.84	19.01	97.9	92.19	48%	0%
August	21.1	19.32	95.17	88.39	54%	0%
September	20.11	18.15	96.95	90.32	36%	0%
October	18.31	15.95	94.64	87.68	28%	0%
November	14.44	11.22	93.09	84.36	9%	0%
December	12.17	8.53	88.47	77.00	11%	9%

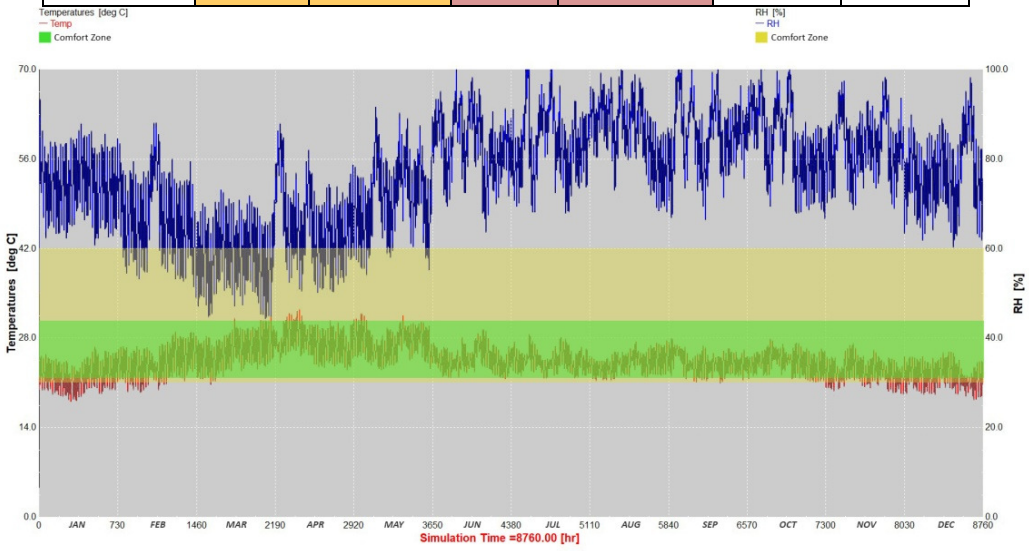

Figure8. Shillong simulation output

(Green highlight = comfort range for temperature; Yellow highlight = comfort range for relative humidity)

(Orange = underheated, low humidity; green= comfortable; red = overheated, high humidity)

CONCLUSIONS

Plain rammed earth construction can be extremely comfortable when considering temperature variations. This is apparent from the results as more than 50% comfort is achieved in most of the selected cities with respect to temperature. The relative humidity in the structure seems to be more than that of the outside, making it uncomfortable in locations which high humidity levels.

Table 8. Average yearly percent comfort in selected cities

Location	Temperature	RH
Jodhpur	50%	56%
Bhubaneswar	71%	1%
Indore	55%	46%
Bangalore	64%	10%
Shillong	35%	4%

The humidity can be dealt with by providing better ventilation into the structure. Another factor to be taken into account in locations with good rainfall is the amount of rainfall falling on the site. Proper protection should be provided to the walls to prevent erosion (Jagadish, 2014).

Rammed Earth is shown to be comfortable in Hot & Dry and Composite climates. This is also apparent with most of the vernacular houses being built using earth construction in locations with these climates (e.g.: Bhonga houses of Rajasthan) (Sarkar, 2015).

Simple rammed earth constructions may not be completely comfortable in cold climates. This can be improved by providing more thermal mass or efficient insulation such as providing an air gap in the wall. These were practices followed in vernacular earthen houses of colder climates (Joshi, 2013) (Jaquin, 2011).

Acknowledgements

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APPENDICES

1. Thermal properties of materials considered in the room

Table 10. Thermal properties of materials considered; Source: (Handbook on Functional Requirements of Buildings (other than industrial buildings), 1987)

Slno	*Material*	*Thermal Conductivity (W/m.K)*	*Density (kg/m³)*	*Specific Heat (kJ/kg.K)*
1	Rammed Earth	1.211	1958	0.85
2	Mud Brick	0.75	1731	0.88
3	Lime Concrete	0.73	1646	0.88
4	Brick Tiles	0.798	1892	0.88
5	Mud Mortar	1.211	1958	0.84
6	Mud Plaster	1.211	1958	0.84
7	Screed	0.41	1200	0.84
8	Waste Mud Filling	1.211	1958	0.84
9	Stone Filling	5	2000	1

2. Values considered for simulation

Table 9. Inputted simulation data

Slno	Data	Building Data	Source
1	Building Dimensions	h = 3m; w = 10m; d = 8m	
2	Simulation Type	Transient	
3	Simulation Engine	TRNSYS	
4	Lighting Power Density	17.2 W/m²	ECBC 2017
5	Equipment Power Density	8.875 W/m²	Calculations
6	Occupant Loading	6 people	
7	Occupant Schedule	24h x 365d	
8	Ventilation	6 ACH	ECBC 2017
9	Glazing	6mm Single Glazing	
10	VLT	0.9	
11	U-value	5.23	SP 41 1987
12	SHGF	0.86	

3. IMAC comfort ranges for selected cities –

Table 11.IMAC thermal comfort ranges for selected cities (range in deg C)

	Jodhpur	Bhubaneswar	Indore	Bangalore	Shillong
January	20.8 - 25.56	22.31 - 27.07	22.31 - 27.07	22.04 - 26.80	14.47 - 19.23
February	20.83 - 25.59	23.75 - 28.51	23.75 - 28.51	22.96 - 27.72	14.58 - 19.34
March	23.54 - 28.83	25.52 - 30.28	25.52 - 30.28	24.21 - 28.97	15.83 - 20.59
April	26.90 - 31.66	26.80 - 31.56	26.80 - 31.56	25.43 - 30.19	17.82 - 22.58
May	28.67 - 33.43	27.06 - 31.82	27.06 - 31.82	25.46 - 30.22	19.36 - 24.12
June	29.20 - 33.96	27.89 - 32.65	27.89 - 32.65	24.64 - 29.40	20.29 - 25.05
July	28.34 - 33.10	26.67 - 31.43	26.67 - 31.43	23.72 - 28.48	20.71 - 25.47
August	26.86 - 31.62	25.86 - 30.62	25.86 - 30.62	23.36 - 28.12	20.85 - 25.61
September	26.78 - 31.54	25.82 - 30.58	25.82 - 30.58	23.43 - 28.19	20.58 - 25.34
October	27.14 - 31.90	25.44 - 30.20	25.44 - 30.20	23.33 - 28.09	19.56 - 24.32
November	24.90 - 29.66	24.17 - 28.93	24.17 - 28.93	22.90 - 27.66	17.51 - 22.27
December	22.39 - 27.15	22.70 - 27.46	22.70 - 27.46	22.10 - 26.86	15.50 - 20.26

Traditional Sustainable Design Strategies - A Case of Pol Houses of Ahmedabad

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Abstract: Fast-forwarded urbanism of Indian cities amidst huge pressures of development is resulting in unrelated growth, unplanned urbanization and disconnected urban form. Extreme urban ecological conditions and environmental crisis are the consequential results of this unplanned urbanization in the majority of Indian cities. Various driving forces especially in the residential sector majorly contribute towards environmental quality of the urban areas. The spatial organizations and the quality of spaces of the traditionally built residences are the manifestation of regional context and testimonials to the assertive responses to the prevailing climatic, socio-cultural conditions as well as locally available resources. Most importantly these environmentally sensitive built forms are customarily built by the community. These dwelling units do not control the climatic conditions by themselves, but passively can modify the internal micro- climate even though they are affected by the external environments. The orientation, form, volumes enclosed, the building materials obtained from natural resources and services contribute to the climatically sustainable performances of the housing units. These diverse factors and patterns predominantly reflect in the housing texture in turn in the urban form. Through the case example of Pol houses in Ahmadabad, this paper highlights the influence of traditional sustainable construction technologies in building design patterns and physiographic pattern of a region.

Keywords: Urbanization, Urban environment, Micro-climate, Sustainability, Construction Technologies

INTRODUCTION

The new development in tier one and tier two cities in India is resultant of rapid urbanization. Fast-forwarded urbanism of Indian cities amidst huge pressures of development is resulting in unrelated growth, unplanned urbanization and disconnected urban form. Extreme urban ecological conditions and environmental crisis are the consequential results of this unplanned urbanization in the majority of Indian cities. Various driving forces especially in the residential sector majorly contribute towards environmental quality of the urban areas. The report by KPMG (2014) project construction of 40-45 million housing units by 2028. It becomes very vital for the contemporary growth to be sustainable. This sense of sustainable development very much prevails in traditional architecture.

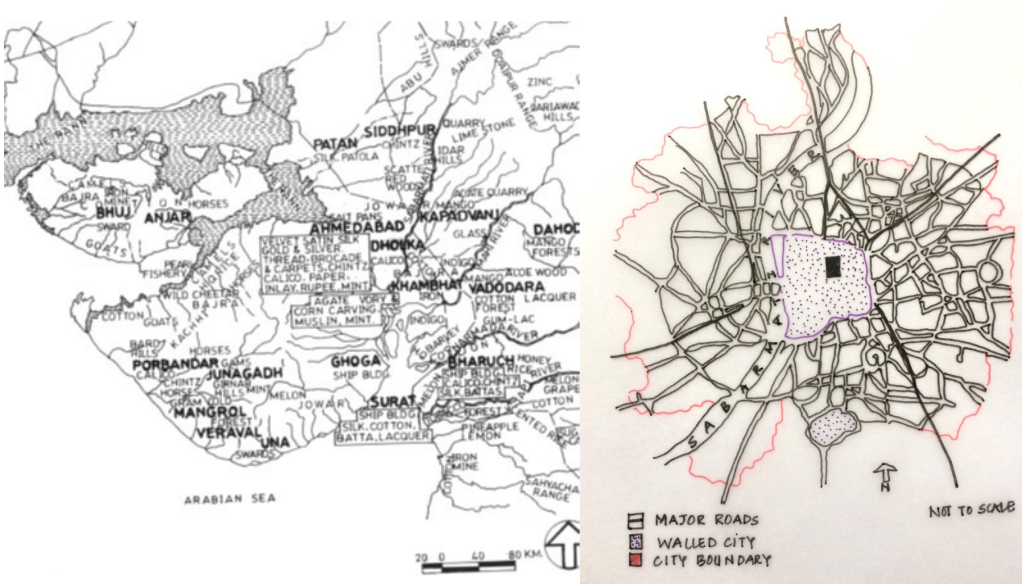
The spatial organizations and the quality of spaces of the traditionally built residences are the manifestation of regional context and testimonials to the assertive responses to the prevailing climatic, socio-cultural conditions as well as locally available resources. Most importantly these environmentally sensitive built forms are customarily built by the community. These dwelling units do not control the climatic conditions by themselves, but passively can modify the internal micro- climate even though they are affected by the external environments. The orientation, form, volumes enclosed, the building materials obtained from natural resources and services contribute to the climatically sustainable performances of the housing units. These diverse factors and patterns predominantly reflect in the housing texture in turn in the urban form.

The pol hoses are the traditional built forms of Gujarat respond appropriately to the prevailing climatic, cultural and contextual setting. The traditional sustainable design strategies practiced are relevant to the contemporary scenarios and hence they can be adopted with required modifications.

CITY AND ITS EVOLUTION

The UNESCO World Heritage City Ahmedabad is located in Gujarat on the western side of India. The city was founded in 1411A.D by Sultan Ahmed Shah and hence the name Ahmedabad. The location of the city favored growth of trade and commerce. The economic base of the region remained predominantly trading. The city shape and form derive its inspiration from Vedic city form Sarvatobhadra /Dandak plan. With Sabarmati on one

side, the plan must have developed as Karmuka later (Bhatt n.d.). Citadel, three gates and Friday mosque are the key elements which were present in the beginning and the public avenue connected these nodes.



(a) (b)

Figure 1.(a) Map of Gujarat*(Sejpal, 1987);* (b) Walled City of Ahmedabad*(Source: Author 2018)*

The seventeen major road networks adorned the city. The old part of the city (walled city) is layered historic precinct. The built fabric of walled city is a beautiful concoction of Islamic, Hindu, Jain, Colonial style of architecture. Ahmedabad also referred as "Manchester of East India" has seen critical changes in its urban fabric after 1818(after British East India Company took over). The banks of Sabarmati River have witnessed the two distinct type of development on east and west. Eastern side is dotted with cluster neighborhood, approximately three hundred pol houses, historic buildings, religious buildings and many tourist attractions, meanwhile on the western side grew the Cotton textile industries.

Impact of the colonial domination led to modern planned residential and institutional establishments. The river and the bridges (Nehru Bridge, Ellis Bridge etc.) helped in the expansion and urban development of the city. The western side of the city is growing enormously on the eastern side the space seems to have been frozen in time. The impact of the alteration in a way to adapt to the essential needs of present time has resulted in tweaking of architecture.

URBAN PLANNING

Urban Form and Morphology

The case example of pol – a dense residential neighborhood has been highlighted for the study of sustainable traditional architecture. The pol houses are the integral part of the morphology of walled city. Many Pol houses are as old as 300 years and have stood by the test of time. These Pols have a well-defined boundary. All the pols have a well-defined main gateway which is connected with neighborhood level streets along with cluster of adjoining houses.

The gates used to be shut at night. The gates had a slate (black board) engraved on the wall adjoining the entrance gate. The important announcement with respect to community would be written on it for everyone to know.

The narrow streets open into irregular quadrangle, with a temple/mosque, chabutra, well or any other community space. The Houses in the pol houses are mostly G+2 or G+ 3 structures which allow the mutual shading in the streets and the common community activity area.



(a) (b)

Figure 2. (a) Pol – A typical map showing dense urban fabric*(Source: Author 2018);* (b) Aminities at Pol level*(Source: Author 2018)*

TRADITIONAL POL HOUSES

A Pol is a dense housing cluster in the historic core of the old walled city built around five hundred years ago. Pols are comprised of several families belonging to diverse caste and occupation. The following sub-sections of the paper explore different traditional sustainable design strategies adopted in the planning, designing and construction at various levels (neighborhood, cluster and individual dwelling units) of Pol houses while focusing on the co-relation between social behavior and spatial organization that are climate, culture, time and place specific responses.

Co-relation between social behavior and spatial organization

Social behavior is the most important trait of human beings and this reflects in the evolution of patterns and order of the societal fabric they inhabit which are highly complex social phenomenon. The social behavior is primarily governed by the space organization and vice-versa. The spatial organizations and layouts of the dwelling units are not only the manifestations of regional contexts with differing resources but are also the prevailing social structure, behavior as well as hierarchy of social interactions. In this context, traditionally built dwelling units mirror the cultural attitude and their form and organization echoes the assertive relationship between human and the environment. Most importantly these environmentally sensitive built forms are customarily built by the community reinforcing the continuity of passing on the skill set to the successive generations promoting local over global.

POLS- NEIGHBORHOOD PLANNING AND DESIGN

Pols are highly dense clusters with meandering narrow lanes form a series of micro-neighborhoods. Singular access with cul-de-sac streets of Pols render them highly secured. The typical form of these bordering rows of houses and the hierarchy of spaces are the prominent character of these houses. City of Ahmedabad is characterized by hot semi-arid climate having strong solar radiation throughout the year with average outdoor temperatures ranging from 20 to 38 degree Celsius. Hence, controlling the solar heat gain is the most effective strategy in the planning of the neighborhood, clusters and individual units.

Traditional Pol houses being strong reflections of their geographical conditions represent a pattern of space governed by intricate conventions and configurations about spaces and their co-relation with specific activities. Spatial organizations of these traditional houses have evolved with the society and the social structure. Various activity areas and their relationship represent inhabitant's response to space. Effective tools such as compact planning, hierarchy of streets and spatial order support in organizing the structure of the neighborhood. Thus the

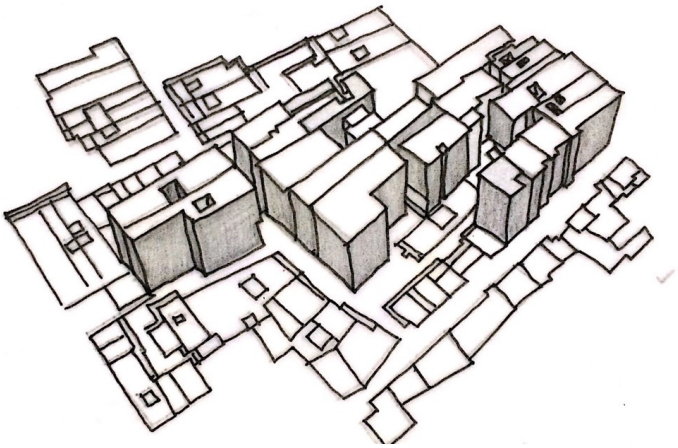


Figure 4. The linear and compact arrangement of dwelling units casting mutual shading*(Source: Author 2018)*



(a) (b)

Figure 3. (a) Pol – A typical map showing dense urban fabric*(Source: Author 2018);* (b) Aminities at Pol level*(Source: Author 2018)*

neighborhood has grown organically into a dense built fabric over the centuries reflecting specifically the culture and climate of the region (Refer Figure 3a).

The streetscape of the neighborhood is characterized by flat as well as sloping roofs. The street orders of the neighborhood create a hierarchy of comfortable micro-climates that help the inhabitants to gradually transition from the partly unshaded main roads to completely shaded inner streets to. The optimum comfort levels are generated largely by the street's hierarchy, orientation, geometry, canyon as well as the outdoor shade by the mass of the built forms (Refer Table 1).

Table 1. Street hierarchy and percentage of shading *(Source: Authors, 2018)*

Street orientation	**Height/Width Ratio -1.2**	**Height/Width Ratio -1.7**	**Height/Width Ratio -5.7**
North-South	70% shaded	85% shaded	95% shaded
East-West	50% shaded	70% shaded	80% shaded
NW-SE & NE-SW	65% shaded	85% shaded	90% shaded
	Primary road	Secondary road	Inner connecting street

POLS- CLUSTER PLANNING AND DESIGN

Traditional Pol houses are distinctive in its character and nature. The characteristic features of Pol cluster is defined by the transitional spaces referred as Otlas. Otlas or verandas with rows of carved columns are semi-covered transitional spaces between the street and the house. It demarcates the extent of the house with steps (acting as plinth) the house. Otlas, shaded by the projections of the balconies in the upper floors promote and reinforce the social encounters of inhabitants. Solar exposure of the built forms is effectively reduced by means of recessed façade and meanwhile it also drops the magnitude of radiation received along the edges of the street.

Various design strategies such as narrow cul-de-sac streets, open-built ratio, interconnectivity, multiple squares, compact and homogenous built forms, etc. have been contributing to the better life quality that has been sustained through centuries. Several considerations and notions can be directly related to design strategies adopted (Refer Table 2).

Table 2. Notions and design strategies *(Source: Authors, 2018)*	
Notions	**Design strategies**
• Cluster geometry & Street hierarchy • Otlas • Chowks • Recessed facade and internal layout	• Thermal comfort for inhabitants & enhanced social interaction • Vibrant street character • Improved air-light ventilation and community interaction. • Internal thermal comfort and privacy

POLS- INDIVIDUAL UNITS PLANNING AND DESIGN

Pol houses occupy the entire plot area and share common walls forming the rows of houses. The houses are 5 to 7-meter-wide and 10 to 18-meter-deep with their narrow frontage facing the road. Most of the houses are two or four stories high and have an open courtyard which renders porous character. This particular aspect is an apt response to the prevailing cultural and climatic conditions. Each house is self-sustained with the capacity to store its own grain and water.

The narrow plan of the houses forms linear arrangements of the spaces following a specific order of spaces from public, semi-public to private and are also functionally adaptable as per the needs of the users. Relation between the space and the related function is specific feature of a dwelling unit. In the case of Pol houses, other than kitchen and toilet (that require specific layout and setup) all the different spaces are not given function specific names which directly implies at the multi-natured usage of the spaces at different times as well as occasions of the day and year. Multi-spatial activities are the trait of the Pol houses. Interestingly, spaces are named on the basis of the nature of the enclosure such as Chowk (courtyard), Otla (verandah), Khadki/Baithak (living space), Parsal (family space), Osri (semi-open family space), etc. (Refer Fig.8, 9 & 10).

The front volume of the house is lower than the rear volume. The volume on the upper floors is separated by the courtyard and is connected by passage.

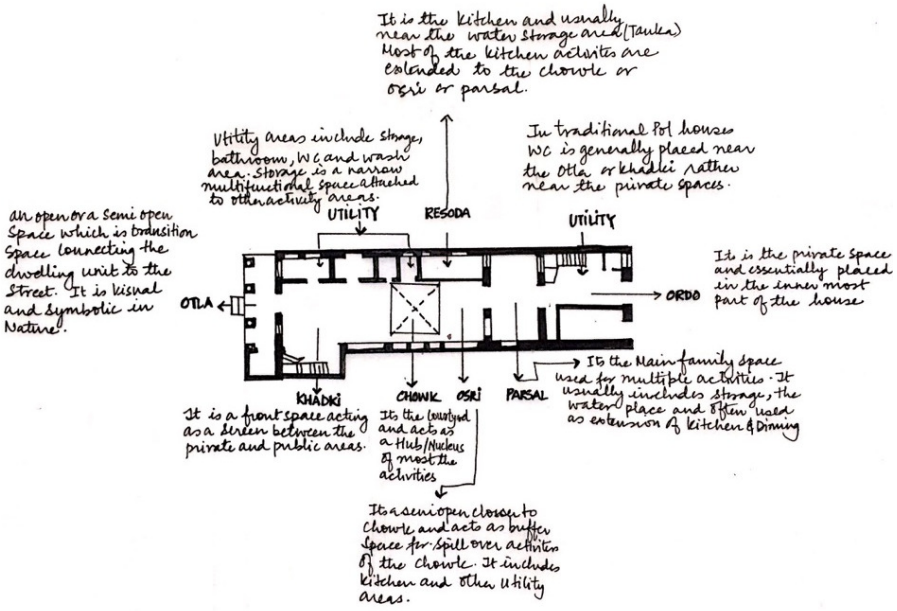


Figure 5. Spatial organization of Pol house*(Source: Author 2018)*

The frontages of the houses have balanced composition of projecting balconies and window openings. Pol houses do not control the climatic conditions by themselves, but passively modify the internal micro- climate even though they are affected by the external environments. These dwelling units respond effectively to the climate with shared long walls, light weight roofs, thick walls with high thermal mass, small but deep courtyards, etc. Siting and orientation of the Pol house provides appropriate shading as the long walls are shared, while only narrow end walls are exposed.

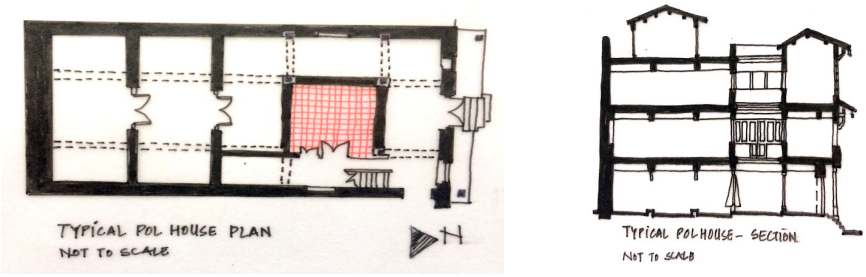


Figure 6. Pol house – Typical plan & section

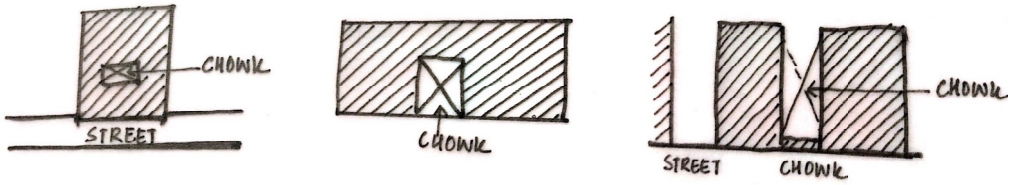


Figure 7. Different configurations of Chowk *(Source: Author 2018)*

Inhabitants respond to extreme weather conditions by having a diurnal and annual cycle of varying multi-spatial use patterns as they rely on passive systems to achieve thermal comfort. Summer daytime is spent on the ground or intermediate floors, whereas upper floors are used during night. Whereas in winter, upper floors or courtyards are used for daytime activities and intermediate floors are used at night. This pattern of migrating occupancy by the inhabitants from the shielding house interiors during the day times to the open roofs at night allows them to take advantages of the coolness of the night sky.

These multi-spatial use configurations are supplemented by the closing and opening of windows which in turn follows a pattern specific to winter and summer. Window openings have detached wooden paneled shutters rather than glass panes. These detached shutters are opened or closed as per the daily activities and the time of the day to take advantage of the prevalent weather conditions.

Chowk (the courtyard)

Although, narrow and densely shaded streets and compactness of the built forms are particularly advantageous for both outdoor and indoor thermal comfort levels, it leads to considerable reduction in the light levels in inner rooms. In this regard, the open spaces are of utmost importance in the dense urban fabric. The courtyard referred as the Chowk is the most important feature of Pol houses as it connects inside to outside functioning as ventilation shaft. The various types of internal courtyards help in maintaining the thermal performance while improving the light and air ventilation. The appropriate and narrower proportions of the courtyards (about 5 to 10 SqM) extending from ground floor to the roof level, act as an aperture in a compact layout serving as a passive climate regulator of the built form. The floor of the chowk is tiled and attached either to a water tank below or to the earth.

Effective evaporative cooling is optimized and supplemented by daily household practices such as washing activities in the Chowk alleviating the increasing solar radiation during summer. The stack effect created by the courtyard flushes in cooler air and exhausts hot air. The Chowk provides a steady micro-climate and acts as a connecter of interiors to exteriors.

Thermal behavior of the Pol houses in different seasons

Thermal behavior of the Pol houses is cumulatively affected by the orienting, positioning and massing of the Pol house along with solar radiation, shading, thermal mass and the occupancy patterns of the residents. The densely packed courtyard houses function as protective envelope by keeping the outside heat away. The strategies of occupants such as having a diurnal and annual cycle of varying multi-spatial use patterns, shading, earth coupling and evaporative cooling to provide cooler surfaces work in combination creating a comfortable micro-climate inside the houses during the summer months.

During the monsoon, the hot-dry desert like climate dramatically turns into hot-humid tropical type of climate. The daily patterns of occupancy on a diurnal basis become less important and make the house as a open connector with the outdoors throughout the daytime. The coolness of the rains becomes important external factor in achieving thermal comfort.

As the temperatures cool down during winter season, the Pol houses resume functioning on a diurnal basis. The upper floors and terraces become hub of activities as they provide much required thermal comfort. The activities co-relate to festivities such as kite-flying in January on the terraces of the houses throughout the day.

POLS- CONSTRUCTION TECHNIQUES AND MATERIALS

Pol houses have evolved through successive generations. Pol house construction is fundamentally based on the framework of wooden posts and beams with infill walls of brick. The street façade characterized by load bearing masonry walls, flat and sloping roofs, projecting balconies, wooden structural and intricately carved columns including carved columns, brackets, window shutters and balconies.

The load bearing walls are constructed using locally made bricks and are plastered externally and internally. Floors have wooden joist- stone slabs and the roofs are made of mud tiles. The sloping roofs of the Pol houses not only shed the monsoon rains, they also provide loft space which is used for various purposes.

However, flat roofs of the majority of the Pol houses provide multi-usage space. Thermal comfort primarily related to the thermal capacity of the materials used. Concealing the exposed mass of the wall with wooden details is the most successful and appropriate strategy to improve the thermal comfort. A shield between incident solar radiation and the thermal mass of the house is achieved through the carved wood facings owing to their low thermal capacity. The internal walls of the Chowk are also detailed with carved wood facings, wooden shutter, windows, etc. to keep the wall mass shaded. The horizontal and the vertical bracing (wooden) in the walls act as not only the aesthetic feature but also provide seismic stability.

WAY FORWARD

Exploring the tested methods especially spatial organization, cluster planning, construction techniques, climatic considerations, etc. and adapting them with necessary changes will support in developing planning and design guidelines for new residential clusters to adapt to the evolving and changing perceptions of the city dwellers. Similar methodology and approach can be deliberated not only in Ahmedabad but in most of the other Indian cities of comparable context and climatic factors. Owing to their unique planning and design characteristics responding to the extreme climatic conditions, the Pol houses perform in assertive manners. They particularly react to the hot-dry climate while minimizing the issues of thermal storage and exposure to overhead sun providing thermal as well as spatial comfort to the dwellers. As discussed in the sub-sections of the paper, Pol houses offer much required solutions for most part of the year. Analysis of the spatial organization and its relevance in contemporary times shall substantially support the fundamentals of the design process in the creating holistic living environment.

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"Sense of place" and identity elements alongside the old and the new highways in Tamil Nadu, India

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Abstract: Many of identity elements of our old travel routes have appeared to vanish, in a significant measure over the recent decades. Passers-by and vehicular travellers of the previous two decades will remember having seen the many teashops and shading trees that have very limited visibility at existent. The pause points for vehicular fuelling and automatic money transaction centres are the immediate requirements for travellers of today's expressways. Changes in our highway architecture and the ensuring loss of its identity elements remain an area of limited academic pursuit. This paper addresses the need to reconsider our lost components in view of their social imperativeness. The old urban areas have got transmuted by the growing pressure from the developmental agendas. We are in the part of the world that is witnessing rapid changes in the states of economy and habitation, bringing about distinctive, multitudinous changes in the ways of work and commute. An extension of old roads is among the most important happening in our nation. Without exception, the state of Tamil Nadu is susceptible to several transformations in functional requirements and physical changes happening to its landscape. This research paper surveys loss of identity elements of the previous decades alongside the highways and identifies the lacunae in the present landscape of stopover spots that has been a concern to most peregrinators and passers-by. In the end, the amalgamation of components is discussed to provide a character enriched experience with identity elements.

Keywords: identity elements, highways, sense of place, place character, travel routes

INTRODUCTION

Since ages, people have been transforming their ideas and value systems, especially in the experiences along their travel routes. The past three decades has been witnessing uninformed and unexpected levels of transformations in the transport sector. The connectivity between places in lesser time with more comfort of increased speed of travel is the need for the people of the present decade.

The new proposals of highways as well as the widening of old roads have been ingesting more land and growing at an expansive pace. The people in India see it as a scope to expand their business territories alongside the highways, most of which are motels, hotels, resting lodges and restaurants. Highway design is often associated with geometric design, safety and services guidelines; the unseen part of it often associates with the memory of people, associations with their surroundings and orientation of oneself with places along travel routes. An innovative and meaningful design can real to place making along highways. This paper examines the present conditions and the vanishing elements from travel routes with a case study from India.

As elsewhere, the travel corridors of India were well known for certain elements that stood for the place's cultural identity. Our highways lack the visual and functional character that the peregrinators have once rejoiced. Focusing on a highway stretch that the author has been frequently passing by across the years in the state of Tamil Nadu, India, this research informs about the missing elements that once allowed highway riders do develop a sense of place.

The research does not get into the details of highway construction and other services. For data collection, the research asked a group of respondents to complete a questionnaire invoking Likert-type responses on the perception of safety of the study stretch in view of its boring landscape and regarding the absence of elements of interest alongside the highways. With the extent of the country's national highways measuring 96,260 km, two-lane expressway is the majority model, covering 56,362 km (http://planningcommission.gov.in/). Two-lane expressway is also the object of interest to this research. However, the study has fair generalizability to both 2-lane and 4-lane highways. For 6-lane and 8-lane highways, the present research will have little to draw from.

PREVIOUS RESEARCH

Issues along highways

The past few decades in research has brought forth a number of publications in the area of place identity and place attachment. There is special coverage on 40 years of place making researches by a researcher, published in Elsevier as well [1]. The observation of elements which create the experiences of place identity and attachment is of significance to understand the pragmatic aspects of this concept. Every single element along the highway contributes to the identity of places connected along the travel route. The developing countries have witnessed many concerns and issues caused due to loss of such elements along highways [2]–[5]. Cities in India have been discussed with the impacts of highway on the cultural decline due to removal of elements alongside highways [5]–[7] with reference to big cities such as Bangalore and Chennai. The present study considers a case study involving a highway that passes through small towns. Literature has been heavily consulted and guidelines were drawn out in how to go about observing, analysing, and categorizing the elements of a highway landscape. The study drew motivation from the books View from the road [8].

Elements of Place Identity along travel routes

The elements along highways are the indicators of place identity for a traveller, who gets to observe it in a second, minute or spend an hour based on the available time of the traveller and the nature of the element in the place. The elements can be natural such as trees [6], [9], [10], landforms, water bodies [11], [12] etc., or manmade such as shrines, temples, resting stones etc. These elements can also be functional such as toilets, tea shops, restaurants, lodges,[13] thereby varying in scale. Some places have specific cultural elements such as a gateway, monoliths, memorial stones etc. These elements provide information to the present and future generations. They also help to identify a place along travel with its unique identity, which is curbed by the monotonous modernised non unique architecture of pause points along highways. Some elements in India are depicted in Figure 01.

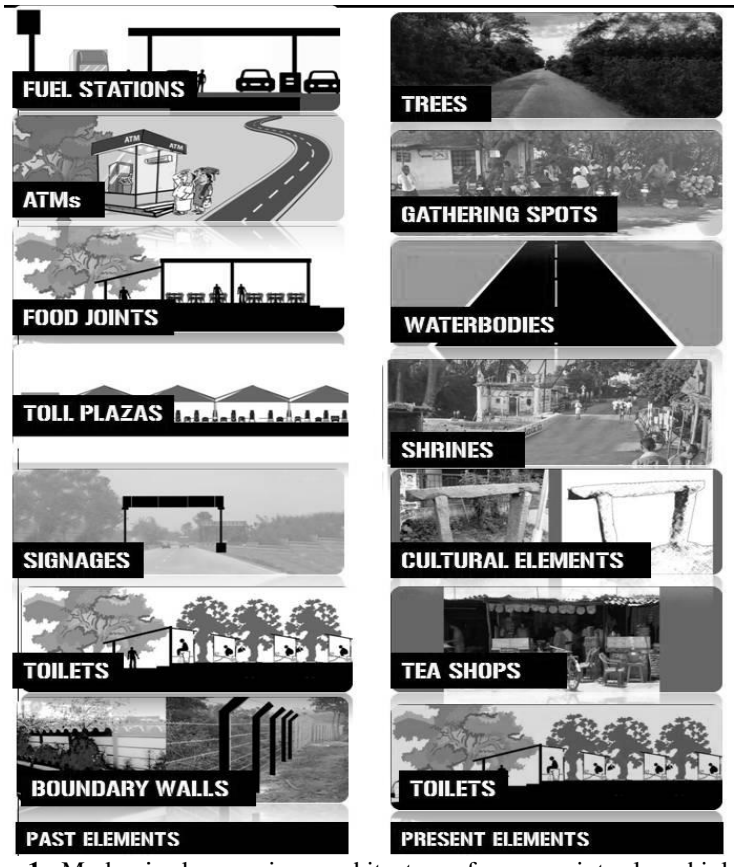

Figure 1. Modernised non unique architecture of pause points along highways

HYPOTHESIZED LANDSCAPE MODELS

Based on the literature and physical observations on the study stretch, a hypothesized model of place identity considering the setting, environment, and physical conditions of the place was constructed for this study. By Making personal visits along the study travel corridor, the patterns of settlements and neighbourhoods as well as the perceptions of place identity of the highway riders were documented by the study author with a view to examine the possibilities of creating a place identity by suggesting restoration of components that have notable qualities of cultural heritage. The speed limit of travel and the time of pause points along the corridor were also accounted for.

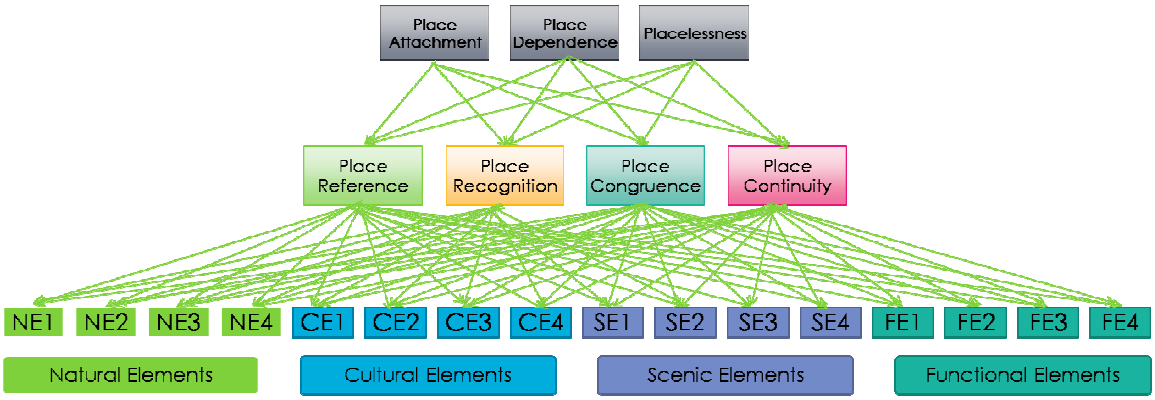

Figure 2. Hypothesized model of place identity

To explore the fullest potential of our hypothesized model, the natural, cultural, scenic, and functional elements of the study stretch needed to be figured out. One could think of including social, economic, and political elements too. Depending on one's choice of the study area, the elements are categorised; whereas other places attract people for their scenic elements, such as the river bank, coastal, or hilly areas. In some places, a single element may make a larger impact, than a group of elements in some other place.

Elements in Tamilnadu – A case study stretch

The study stretch is of 200 kilometres from Manaparai a developing town to Coimbatore, a two tier city connected by state highway and national highway. The roads connect many villages, towns and cities of strong historic, cultural, commercial and functional significance. The allowed speed limit is 60 – 100 km/hour. A number of natural, functional, cultural and scenic elements can be found alongside the road on either side for observations. The location is specified in figure 03 a, b and c.

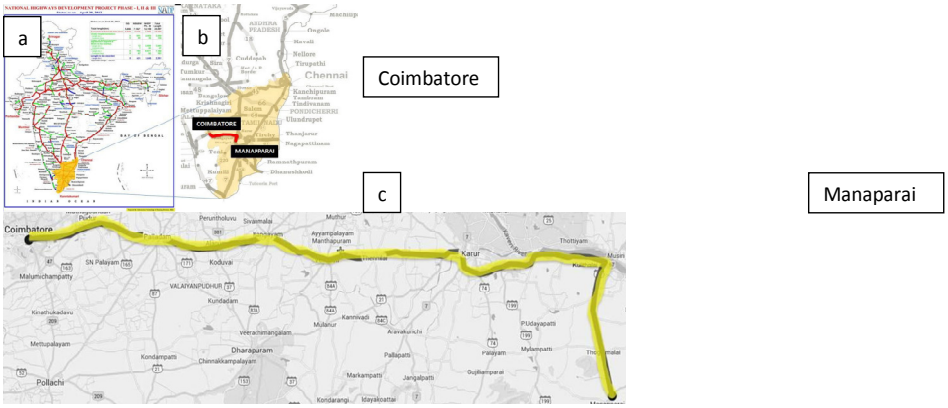

Figure 3.(a) Map showing the location of the State of Tamil Nadu. (b) The Stretch between Coimbatore and Manaparai that is the focus of this work. (c) Map of the study stretch

Research methods and data collection

Based on the physical observations using expert observation method, face to face interviews and survey questionnaire 20 identity elements were identified and 12 were shortlisted from the priorities of people. The past three decade elements mentioned by the people who participated in the interviews were taken for the survey. The existing elements are documented by the researcher, as available at the time of this writing. Informants who regularly commute through this area also provided the necessary information for tabulations. For the purpose of this work, the choice of study parameters was arrived at after due considerations of prior research from literature reviews. The vehicular travellers were considered as prime participants for the survey. Age, gender did not make

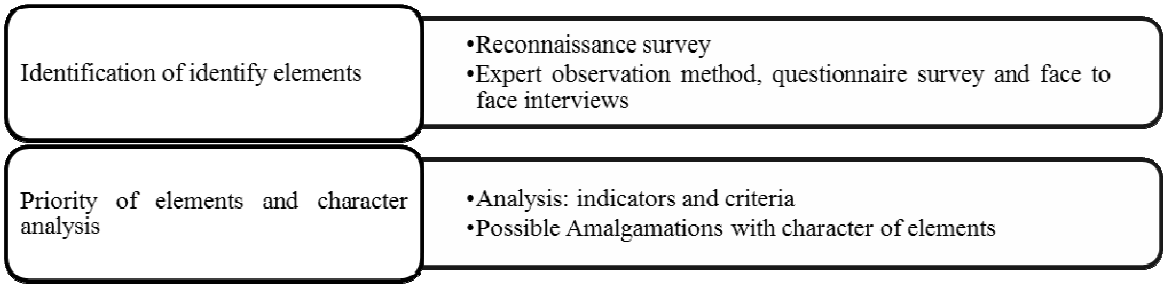

Figure 4. Framework of research

a stronger impact, as the study dealt with identification of elements alongside the roads. The participants were enthusiastic in sharing their experiences of identifying themselves with the elements and places.

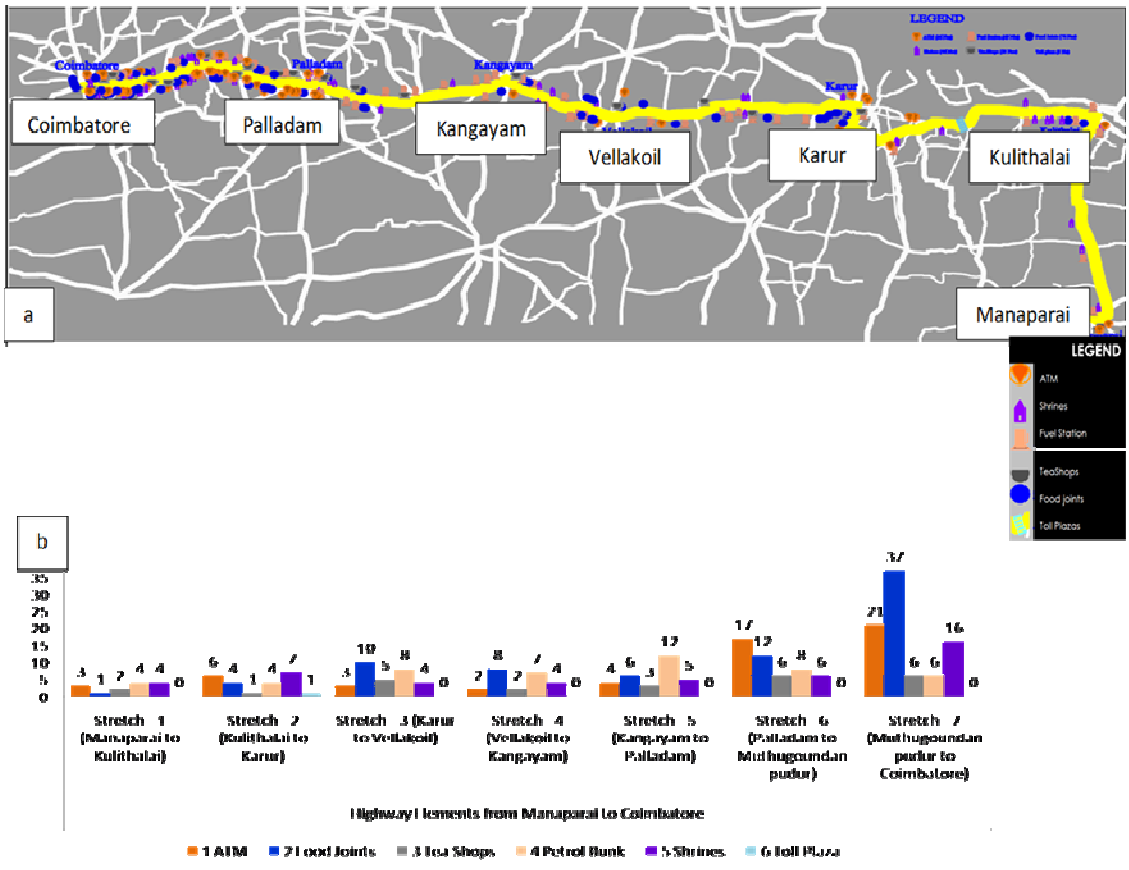

Figure 5. (a) Identification of elements along the study stretch (b) Graph showing the 7 predominant elements in the stretch for sample

Identify elements along the highways

Table 01: Author observations – Expert observation method using Harvey's Balls ○=1,◔=0.25, ◑=0.5, ●=1

Elements/ indicators	History	Heritage & culture	Biodiversity	Road safety	Present usage need	Monetary benefits	Benefit to pedestrians	Benefits to vehicular travellers
Trees	●	●	●	◑	●	◑	●	◑
Natural resources	●	●	●	◑	●	◔	●	●
Teashops	●	◑	○	◑	●	●	●	●
Gathering spots	●	◑	◔	◔	●	○	●	●
Shrines	●	●	○	◔	◔	○	●	●
Sumaithaangi kal (resting stone)	●	●	○	◑	○	○	●	○
Fuel station	○	○	○	●	●	●	○	●
ATM	○	○	○	○	●	●	●	●
Food joints	●	◑	○	◔	●	●	●	●
Toll plazas	○	○	○	●	●	●	○	●
Signage	●	◑	○	●	●	○	●	●
Boundary walls	○	◑	○	◑	●	●	●	●

Physical observation along the stretch was marked in maps as direct representation of elements with a legend. The map showed the concentration of elements towards the two tier city – Coimbatore and the elements were sparsest words the villages and small towns as represented in Figure 5. (a). However the resting points at half the distance of travel had more travellers who rested there and the secondary importance was the rest points at one- third the distance of travel.

Based on the values a graph is generated to show the ranking of elements as experienced by the researcher. Natural resources were ranking highest as they fitted into most of the study parameters. However this is further verified with the survey asked to people.

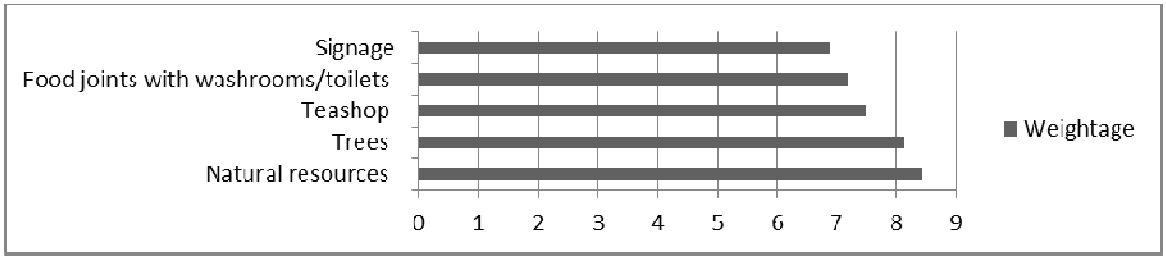

Figure 6. Graph generated with the top 5 results of expert – observation method

Questionnaire design

A subjective survey was carried out based on the questionnaire which evidently resulted in categorizing of the listed 12 elements into 3 categories with functional elements, natural elements and cultural elements. The priorities of people are grouped as shown in figure 12. 100 samples are selected, and based on their responses; factors affecting place identity are listed and grouped under similar parameters such as perception, angle of view, environment/context and reason of travel. The Intangible aspects such as ambience of travel and distractions are also mentioned by the respondents. A Likert-type scale was employed to design the questionnaire to collect responses from highway travellers, who frequented the study stretch with a minimum of 2- 3 visit times per month. The participants were asked 10 questions to understand their travel experiences in the stretch. The question significant for this paper is the ranking of the identified 12 elements along the stretch

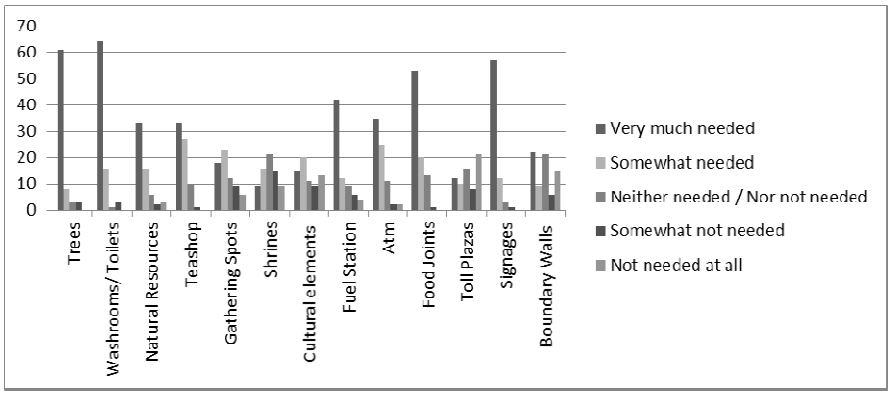

Figure 7. Showing the ratings for needed identity elements by respondents



Figure 8. Needed identity elements as prioritized by survey participants

based on their degree of importance to the particular element. The response score ranged from 5 (very much needed) to 1 (not needed at all) for each question. The poll was conducted and the responses were grouped for analysis. Here are some responses suggesting group dynamism. Individual reasons, excursion, and work-related travel were the reasons that respondents stated for peregrinating the study stretch. Since the travel destinations were separated by 200 Km, when asked how many times they would halt for a break, 50 respondents said they might halt just once and 26 said they might halt 2-3 times. Most of the respondents stopped for restrooms, food breaks and refreshments along travel.

Table 3: Intercorrelations among identity elements

Correlations	1	2	3	4	5	6	7	8	9	10	11	12	13
Trees	1												
Washroom	.880**	1											
Natural	.715**	.603**	1										
Teashop	.947**	.808**	.833**	1									
Gathering	.841**	.715**	.939**	.932**	1								
Shrines	.829**	.703**	.910**	.924**	.971**	1							
Culture	.782**	.663**	.952**	.897**	.977**	.970**	1						

Fuel	.922**	.788**	.906**	.969**	.973**	.939**	.934**	1					
ATM	.972**	.849**	.818**	.974**	.913**	.905**	.882**	.961**	1				
Food	.877**	.934**	.706**	.834**	.775**	.757**	.735**	.836**	.872**	1			
Toll	.709**	.603**	.900**	.838**	.941**	.959**	.969**	.870**	.822**	.668**	1		
Signage's	.988**	.858**	.744**	.958**	.858**	.842**	.805**	.936**	.974**	.874**	.729**	1	
Boundary	.817**	.699**	.939**	.915**	.969**	.968**	.970**	.936**	.908**	.769**	.948**	.841**	1
**Correlation is significant at the 0.01 level (2-tailed).													

It is obvious from the results that the present day needs of people are more functional and less emotional. The results showed that the signage, washrooms, food joints and tea shops ranked the top priorities. Trees were considered significant by people as they are useful for shade, rest and also green visual character.

According to our table, almost all the variables correlated significantly with each other at 99% of the confidential level. The presence of trees is placed as an important need among the 13 studied facets, followed by gathering spot.

Culture is no less important for the majority of our information. The washrooms, teashops and signage with trees are found significant in the correlation matrix as well. The food joints are an important priority of people. When testing our hypotheses using one sample t-test, except for the factor of gender, the rest of the 15 variables showed a positive relationship with each other and so their null hypothesis was rejected, as shown in figure 9. This means that most of the study variables significantly correlated with each other.

S. No.	Null Hypothesis	Test	Sig.	Decision
1	The categories defined by Gender= 1.000 and 2.000 occur with probabilities 0.5 and 0.5	One sample Binomial test	.194	Retain the null hypothesis
2	The categories of trees occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
3	The categories of washroom occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
4	The categories of natural elements occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
5	The categories of teashop occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
6	The categories of gathering points occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
7	The categories of shrines occur with equal probabilities	One Sample Chi Square Test	.002	Reject the null hypothesis
8	The categories of culture occur with equal probabilities	One Sample Chi Square Test	.001	Reject the null hypothesis
9	The categories of fuel stations occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
10	The categories of ATM occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
11	The categories of food joints occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
12	The categories of toll plazas occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
13	The categories of signage occur with equal probabilities	One Sample Chi Square Test	.000	Reject the null hypothesis
14	The categories of boundary walls occur with equal probabilities	One Sample Chi Square Test	.001	Reject the null hypothesis
15	The distribution of area is normal with mean 1.920 and standard deviation 0.95	One Sample Kolmogorov- Smirnov Test	.000	Reject the null hypothesis

Figure 9. Hypothesis test summary – Asymptotic significances are displayed the significance level is .05

Amalgamation of study elements

We attempted to amalgamate identity elements considering the character of the elements mentioned in the hypothesis model – Natural, cultural, scenic and functional character. The five elements resulted as first five prioritise of people were considered as obligatory elements along the highways. The characters of the site for the location of these resting points are also considered to enhance the experience of the traveller. These would

enhance the place identity memory of the traveller, thereby increasing the sense of orientation along the travel route.

Character study

For a further analysis of the characters, three sites with rest points along the highway identified were observed with Kulithalai – a settlement along the river landscape 3) Kongu mess- a functional element (highway motel) near Karur.The three pause points displayed functional character in the first rest point, the second rest point was predominantly cultural and natural, and third site represented scenic, cultural and natural character. By juxtaposing the subsisting elements at these pause-points against the needed elements, a solution for regaining the identity of these pause points can be arrived at. Along the entire route, a number of pause point locations by means of the presence of various elements; natural, cultural or functional were observed in order to understand the nature of existing elements present in the study stretch.



Figure 10. Functional Character – Case of Kongu, Mess, Karur, Tamilnadu

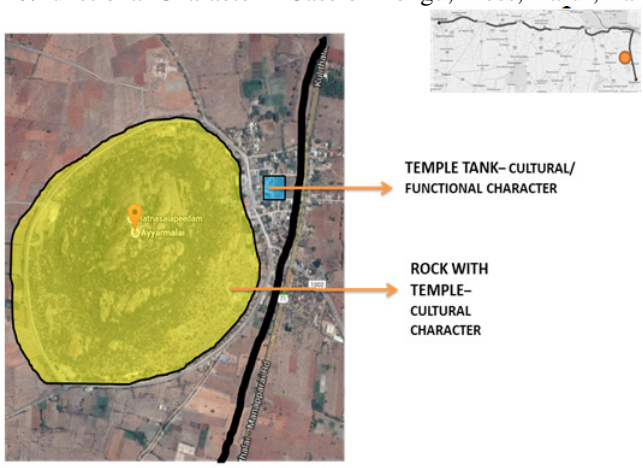

Figure 11. Natural, scenic and cultural character – Case of Iyermalai, Manaparai, Tamilnadu



Figure 12. Natural, scenic and cultural character – Case of Kulithalai, Tamilnadu

The first site in Fig. 10 is that of an existing purely functional pause point in busy highway connecting important cities in Tamilnadu. The Kongu mess – a functional pause point is located at 77 kilometres from the starting point. The motel has a tea shop, bakery, Hotel, restrooms, and kid's play area. The parking space is also available for 25 cars. The fuel station abutting it also makes it comfortable for travellers to stop by attracting people travelling in cars and private buses. A local context is shown in figures (11). This location is 34 kilometres from the starting point. The location has visual elements such as a huge rock with a temple on top and a temple tank nearby. The people of the place have established more connections with these structures. As a traveller, this might be an interesting spot to pause. The second pause point identified in the study is Kulithalai – a settlement along the river landscape. The identified pause point is 42 kilometres from the starting point. The temple demarcated in Fig. 12 is said to be the reason for the origin of the place and has a great connection with the river Cauvery with the natural feature on the other side. These areas have specific elements, which might be a better site selection criterion to locate pause points or stopover areas along travel corridors.

The correlation between the factors affecting perception of elements and the character of the pause points becomes ardently important to plan and locate elements along the travel corridors. The regular intervals and the speed of visual connection with the elements can be worked out by understanding this correlation. The movement patterns is not only a visual syntax, but as a coherent expression of functional, ecological and other contextual matters of identity. The routes would rather become interesting to the traveller if they are one among the following categories or similar in nature as shown in figure 13.

ELEMENTS / PAUSEPOINTS	Elements of Natural Character (C_N)				credits	Elements of Recreational Character (C_R)				credits	Elements of Functional Character (C_F)				credits	Elements of Cultural Character (C_C)				credits	Total
	a	b	c	d	x 3	a	b	c	d	x 1	a	b	c	d	x 2	a	b	c	d	x 4	
CASE 01 – KONGU PAUSE POINT, KARUR				0	0		3			3	5				15				0	0	18
CASE 02 – AIYAR MALAI, MANAPARAI	5				15			1		1			1		2	5				20	38
CASE 03 – KADAMABAR TEMPLE, KULITHALAI	5				15			1		1			1		2	5				20	38

Where	Credits
a = 5	Natural Character = 3
b = 3	Recreational Character = 1
c = 1	Functional Character = 2
d = 0	Cultural character = 4

Figure 13. Character analysis of the pause points

CONCLUSIONS

Consideration of people's perspective of the sense of space is indispensable to the planning and designing of stopover spots along the highways. An overture of cultural, natural, and functional elements should be made obligatory in order that highway riders are better able to process the nature of place identity alongside the travel routes. The construction of rest points with information and character reflecting place identity of the places connected at specific intervals should be mandatory.

In addition, the importance of natural water bodies should not be overlooked in the planning. Planting of trees, maintenance should be an integral part of design. Construction measures for restaurants, gathering spots are to be eco-friendly. Tea shops inculcate the culture of socializing with friends and colleagues, and our respondents desired to see more of these outlets in the study stretch. However, the restructuring must suit the desiderata of the present generation of highway riders to ensure more patronage to such efforts.

Through this research, the perpetuating public need for introducing the desired identity elements or reviving the existing elements along our highways is emphasized, enabling the people to build a character and a "sense of place" around the location they pass by in their journeys.

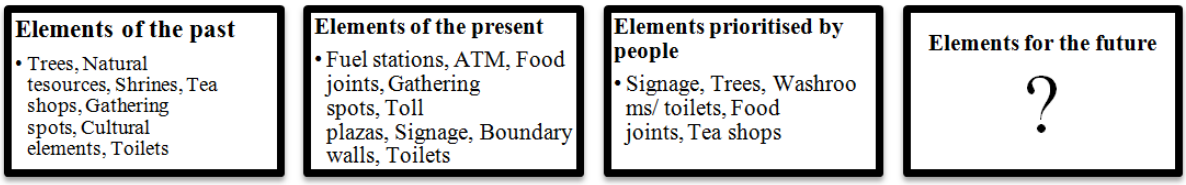

Figure 14. Sense of place: the evolution of identity elements

The study further stressed on the cultural importance of identity re-engenderment. To conclude, wayfaring should be given paramount importance in the planning of stopovers to revive the cultural historic and social identity of the places with information and recreational facilities for the present and more generations to come. These identity element location equations help in retaining few cultural and heritage values of the place. Usually this is not considered in the planning of highways, whereas if considered, it will help to retain the identity of places along highways.

This paper provides few suggestions for notable landscape characteristic elements. There are sites which are rich in cultural character, natural character such as a rock, river, pond, lake or temple pond, and/ or historic character. The analysis in a sample stretch clearly shows the loss of identity along Highways and also in the planning guidelines. Major importance is given to the functional elements, whereas the natural, cultural and scenic elements were in the second and third priority.

The indigenous character of the place, need to be reflected specifically along the highways as many elements are eradicated in the process of proposing new highways and widening of old roads.

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Assessment of daylight performance in classrooms: To achieve optimal daylighting design strategies for classroom through simulations.

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Abstract: Artificial light is used as the main contributor to the visual environment for the performance of reading, writing or other tasks in school classrooms. In school classrooms of Kerala, there is a large quantity of daylight availability and the entire study period is enclosed within daylight hours. The study will concentrate on the daylighting performance of classrooms in the city of Malappuram, Kerala state, India. There are several reasons which are responsible for creating the problems regarding daylight penetration inside the classroom spaces, which introduces the extreme dependency on electrical lighting, even on a sunny day. Some of those problems are created due to lack of understanding on daylight benefits, and its impact on student's performance. A detailed literature study provided the knowledge base for the thesis research. The literature study found the research gap and the scope of the research study which also provided research questions of the study. A detailed field study was done at MESHSS Mampad, Malappuram to understand the daylight levels of classroom and illuminance levels on each desk of selected classrooms are recorded. The field investigation also encompasses a questionnaire survey which was conducted among the students and their feedback contributed to understand the connectivity of daylight performance with students. The evaluation of daylighting in classrooms is done based on climate based daylight modelling (CBDM). A three dimensional model of the school building is made using Rhinoceros software and applied material properties and climatic features. Diva plugin is used to evaluate the daylighting performance of the classrooms. The findings of the study understands the different daylighting metrics including daylight autonomy, daylight availability, illuminance levels, useful daylight illuminance simulations and glare index of the selected classrooms.

Keywords: Daylight, Classrooms, Design strategy, CBDM, Field study, Questionnaire

INTRODUCTION

The lighting of any space is one of the fundamental parts of a design. However majority of the practicing architects give very little attention to it during the design of a building. From the field study, it is observed that artificial light is used as the main contributor for the visual environment. Even though daylight is available for the entire occupancy period of school hours. Studies show that daylight in classroom enhances students' performance and creating a better visual environment for the students.

The primary means of allowing daylight into a building is through windows. In early times, window design was controlled by physical limitations of material and construction techniques. Now with advances in building technology, it is possible to have a window as large, or as small as we desired. With the development of artificial lighting, in the mid twentieth century, daylight received less attention as a functional element and, dependence on artificial lighting became dominant, particularly in the design of classroom spaces. A school building is only in use during the school hours and the entire study period is enclosed within daylight hours but artificial lights are the main contributor to the visual environment in classrooms.

Need for study

There are several reasons which are responsible for creating the problems regarding daylight penetration inside the classroom spaces, which introduces the extreme dependency on electrical lighting, even on a sunny day. Some of those problems are created due to lack of understanding on daylight benefits, and its impact on student's performance. Improper direction of day light penetration often causes glare and is responsible for visual disturbance.

This unawareness on the potential of day lighting in a school classrooms need to be addressed. The introduction of daylight inside the classrooms can increase the quality of environment, and this research will evaluate how it impacts on the student's performance.

Aim and Objectives

- The research is also aimed to investigate the relationship of the physical parameters of the classrooms spaces with daylight condition.
- To propose several daylighting technologies/ strategies that can be implemented in school classrooms, allowing uniform distribution of natural daylight while creating a comfortable school environment.
- To do a comparative study on the effectiveness of various design strategies for class rooms.
- To identify the proper daylighting strategies for school classrooms in Kerala which avoids the direct sunlight on the work plane, reaches a uniform lighting distribution, and avoids the glare disturbance in the student's visual field.

Research Questions

- How to control the natural daylight in order to get the proper quantity and uniform distribution of light in a classroom according to the needs of its users?
- How to achieve protection against glare which causes disturbance on the classroom activities, such as glare on the working desks?
- How the properties of the glass are affects the daylight performance in a classroom?
- How WWR are affects the daylighting performance of a classroom space?
- What are the daylighting design considerations & strategies to be followed for classroom in the context of Kerala?

METHODOLOGY

The first step of methodology is the introduction of the topic which include the title, aim and objective of the research followed by literature study and data collection. The next step is the analysis of the collected data and information which is followed by results and conclusion of the research study.

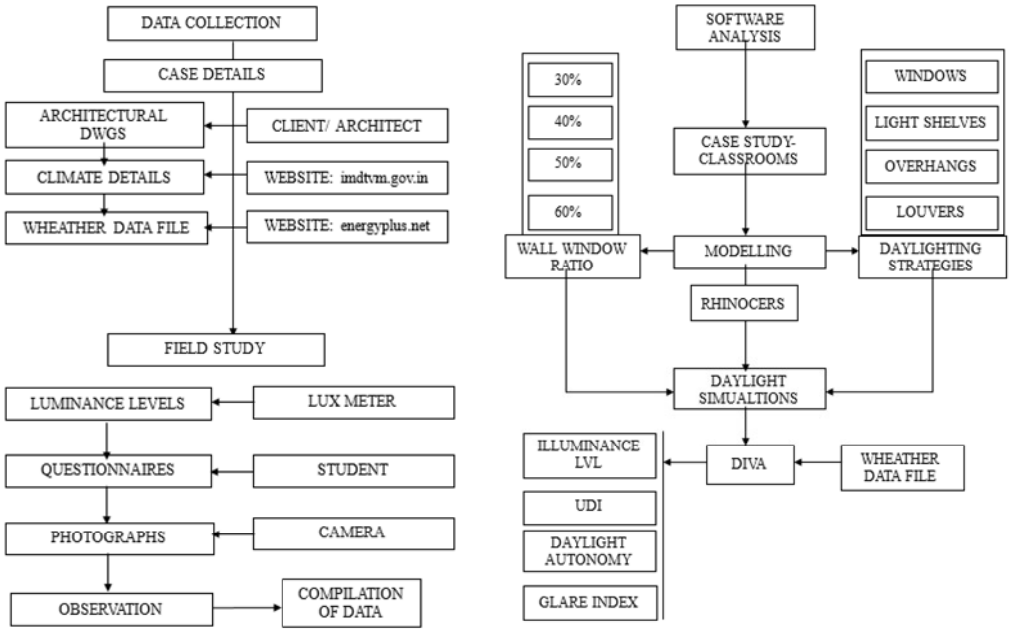

Figure 1. Flow chart showing steps of methodology
(Source: Author, 2018)

A detailed literature study was conducted for the better understand on the research area of study. The literature study has made the foundation base of knowledge for the thesis research project. The scope and limitation of the research study also derived from the literature study which was also found the research gap in the selected research area leads arrive into the research problem for the thesis study. The research problem refined in light of literature developed research questions for the research project.

RESULTS AND DISCUSSION

MESHS school Mampad, Malappuram buildings have been selected for evaluating the performance of daylight from the Malappuram district of Kerala state. A detailed field study was conducted on MESHS School Mampad for evaluating illuminance levels on the desks of selected classrooms. Lux values on each desk were recorded using a lux meter in order to understand the existing light levels of classroom spaces. A questionnaire survey also conducted among the students of MESHS School Mampad and their valuable feedbacks are taken to understand the relation between daylight and students performance. Computer based daylight modelling was done on school building to understand the daylighting performance by simulating different daylight metrics including daylight autonomy, useful daylight illuminance, discomfort glare probability etc.The school is located at Mampad town comes under Malappuram district. The school has both high school and higher secondary wing. The research is concentrated only on the high school wing of the campus which is a four storey building and contains a total of 26 classroom spaces.

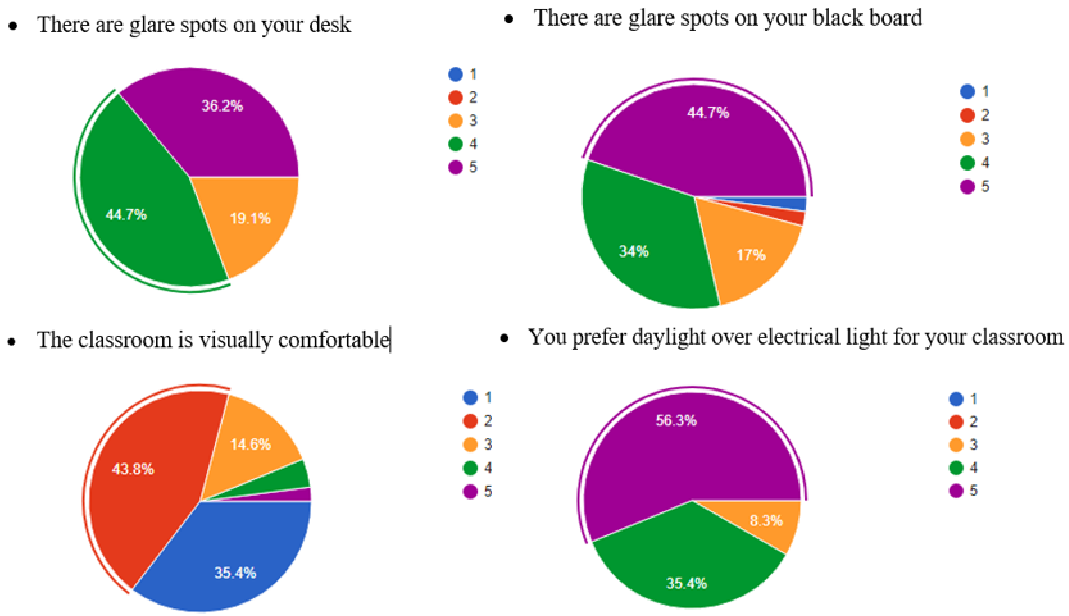

Figure 2. Lux level and luminance spots.
(Source: Author, 2018)

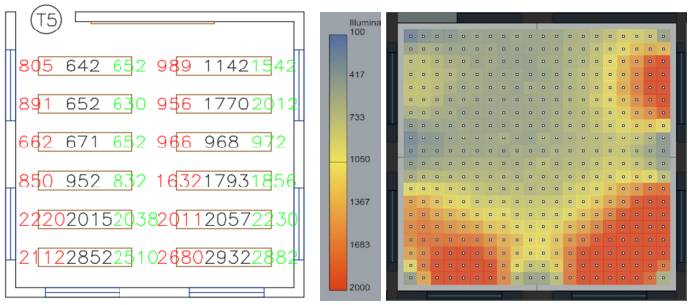

Figure 3. Lux level by manual readings (left), illuminance simulation result (right) of classroom T5
(Source: Author, 2018)

The classrooms which are selected for the study are located at the third floor of the building. Simulation of different daylight metrics is done using DIVA for Rhino software.

The illuminance level recorded using lux meter during the field study is compared with simulation of illumination levels.

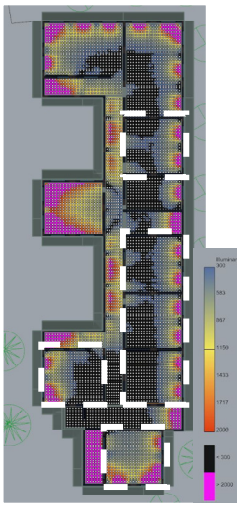

Figure 4. Illuminance levels ground floor (left) and first floor (right)
(Source: Author, 2018)

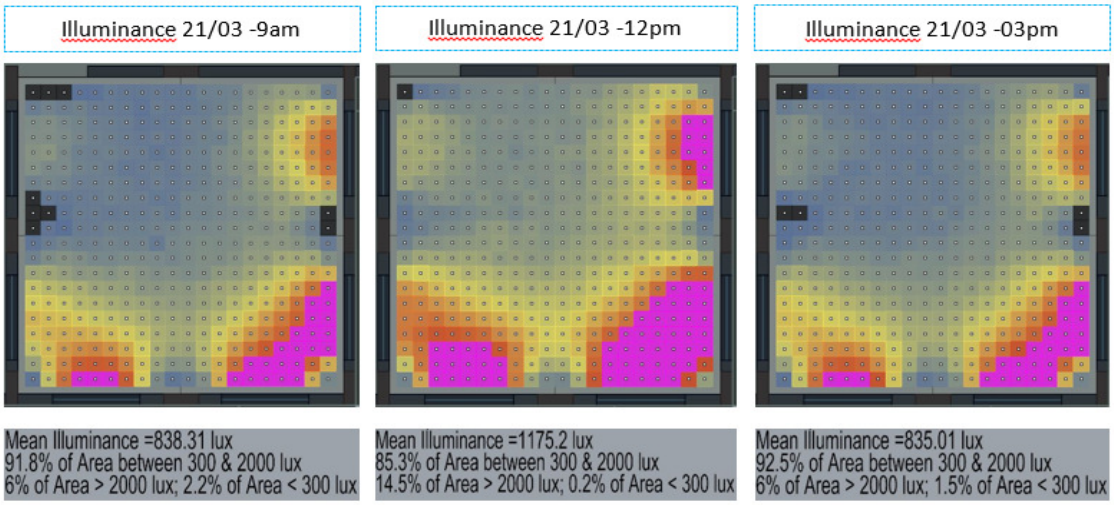

Figure 5. Illuminance levels simulations on 21st march of T5
(Source: Author, 2018)

Classroom T5 is having a daylight factor 2.8 which does not satisfies the need for a classroom as per standards. According to the standards 80% of a classroom should occupied with a daylight factor of minimum 2. From the figure 5 it clearly says that half of the classroom area is occupies with daylight factor of less than 2. The classroom is also does not satisfies the values of daylight autonomy and daylight useful illuminance which are of 58% and 54% respectively. Efficient design consideration for harvesting daylight should be implemented.

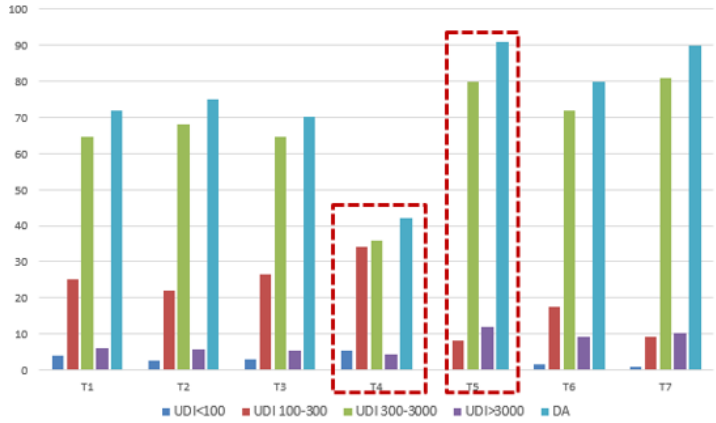

Figure 8. Bar chart comparing daylight metrics of different classrooms of third floor
(Source: Author, 2018)

It has been observed from above bar charts that the daylight metrics values such as daylight autonomy, useful daylight illuminance etc. does not vary much with the altitude of the classrooms.

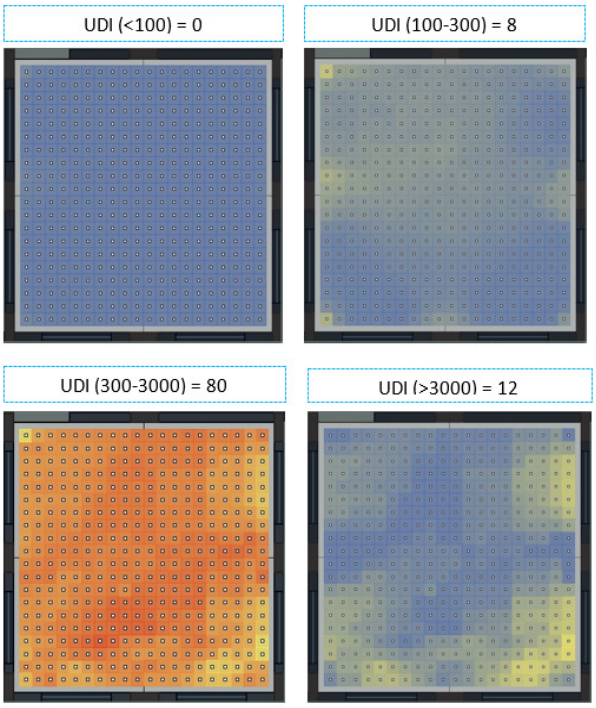

Figure 6. Useful daylight illuminance levels of T5
(Source: Author, 2018)

Daylight metrics of classrooms with different height are compared to understand the daylight performance variations with the altitude.

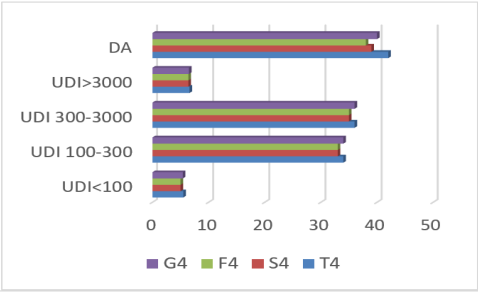

Figure 7. Bar chart comparing daylight metrics value with the height of the floor
(Source: Author, 2018)

Hence classrooms of the third floor have been selected for the further studies on daylighting performance. All the classrooms on the third floor have been simulated to understand the performance on different daylighting metrics.it has been observed from the figure 8 that classrooms T1,T2 and T3 are having similar daylighting patterns.

Classroom T4 is a problematic classroom with low level of daylight levels. Also classrooms T5,T6 and T7 are having similar daylight levels.

Hence classroom T1,T4 and T5 are selected for the further studies on daylighting performance through simulations.

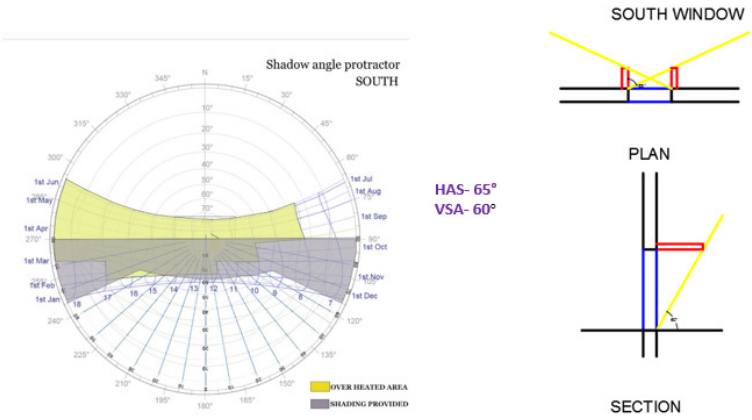

Figure 9. Shadow angle protractor and solution for facades
(Source: Author, 2018)

RESULT ANALYSIS

The analysis process is focused on the selected classroom T5. Proper daylighting strategies are tested and simulated to compare the results. Light shelf, overhang and louvers are the daylighting strategies selected for the simulation. The length of the slab projection is determined using shadow angle protractor method.

Table 1. Comparing daylight metrics value with different WWR on west facade of classroom T5
(Source: Author, 2018)

CLASSROOM T5	WWR(west)				
	DA	UDI<100	UDI 100-300	UDI 300-3000	UDI>3000
20	80	1	14	74	10
30	86	0.7	10	78	11
40	91	0	8	80	12
50	92	0	6	82	13
60	93	0	4	85	14
70	94	0	2	88	15
80	95	0	0	90	16

Useful daylight illuminance and daylight autonomy values have been found through simulations for different wall window ratios on east, west and south facades for classroom T5. From the Table 1&2 it is observed that 40% of wall window ratio is ideal for west faced and east facade.

Table 2. Comparing daylight metrics value with different WWR on east facade of classroom T5
(Source: Author, 2018)

CLASSROOM T5	WWR(east)				
	DA	UDI<100	UDI 100-300	UDI 300-3000	UDI>3000
20	85	0.7	12	72	10
30	88	0.5	10	75	11
40	91	0	8	80	12
50	93	0	5	83	13
60	94	0	3	86	14
70	94.5	0	0.5	90	15
80	95	0	0	91	16

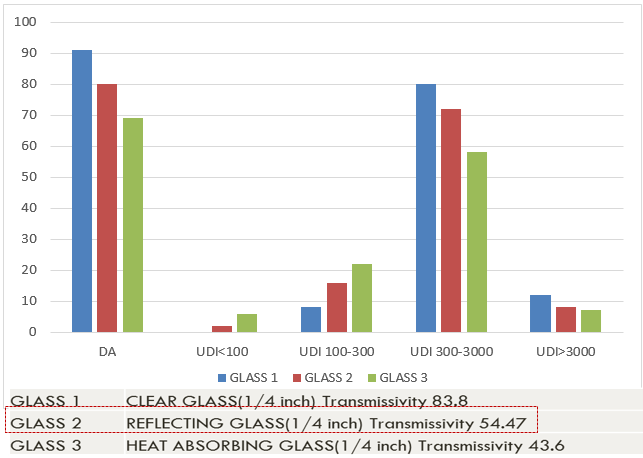

Figure 10. Bar chart comparing daylight metrics value with different glass on west facade of classroom T5 *(Source: Author, 2018)*

Table 3. Showing different scenarios of daylight interventions of classroom T5 *(Source: Author, 2018)*

SCENARIO	WWR EAST	WWR WEST	WWR SOUTH	GLASS TYPE	SHADE
1	40	40	40	GLASS1	OVERHANG
2	40	40	40	GLASS1	LOUVER
3	40	40	40	GLASS1	LIGHT SHELF
4	40	40	40	GLASS1	OVERHANG(S)/LOUVER(E,W)
5	40	40	40	GLASS1	LIGHT SHELF(S)/LOUVER(E,W)
6	40	40	40	GLASS2	OVERHANG
7	40	40	40	GLASS2	LIGHT SHELF
8	40	40	40	GLASS3	OVERHANG
9	40	40	40	GLASS3	LIGHT SHELF

Nine different combinations of daylight interventions shown in table 3 have been analyzed to improve the daylight performance on classroom T5. It has been observed from the figure 11 that scenario 5 is the ideal daylighting intervention for the classroom T5 with a daylight autonomy of 84 and useful daylight illuminance of 75.

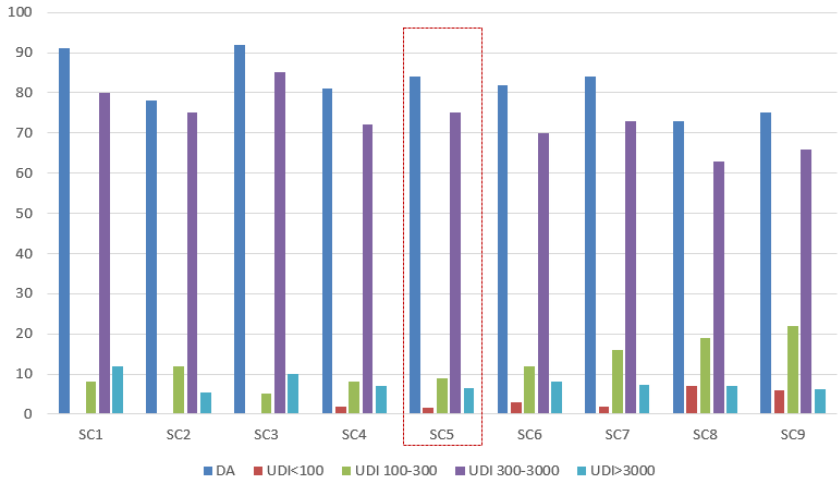

Figure 11. Bar chart comparing daylight metrics value with different glass on west facade of classroom *(Source: Author, 2018)*

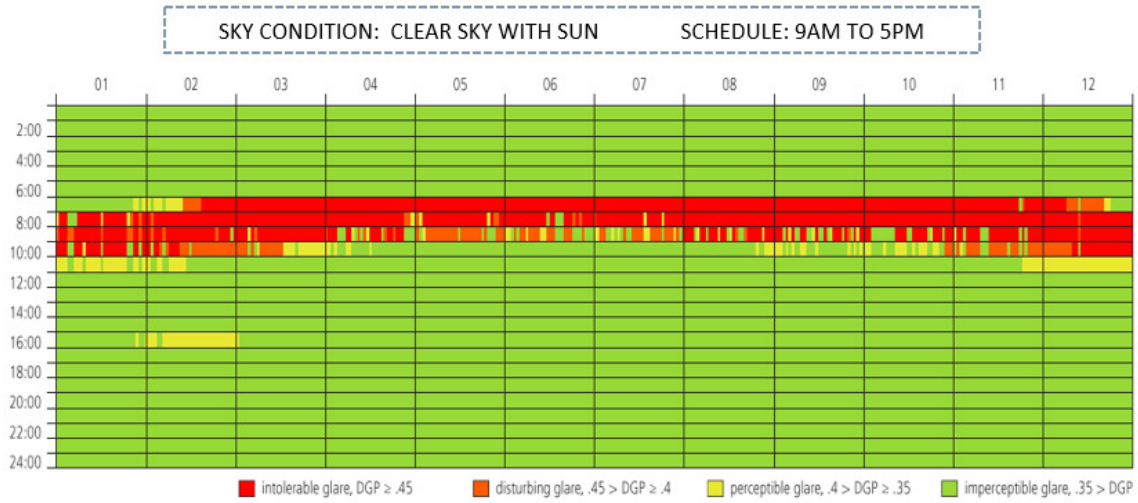

Figure 12. Showing annual glare data for a view of classroom T5 in existing scenario
(Source: Author, 2018)

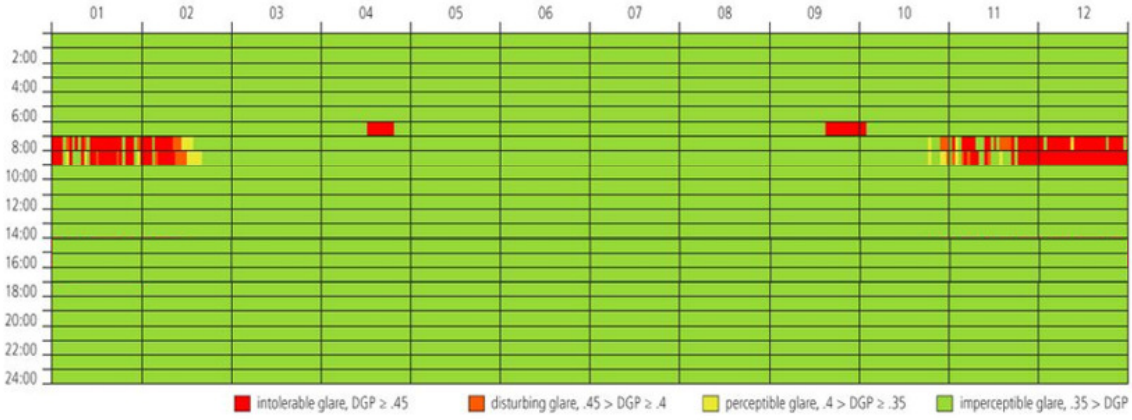

Figure 13. Showing annual glare data for a view of classroom T5 after interventions
(Source: Author, 2018)

Annual glare data analysis of the existing classroom T5 have been found through simulation to understand the existing glare problems in the classroom showed in figure 12. And it is observed that the classroom is facing glare problems throughout the year. Figure 13 shows the annual glare data for the classroom T1 after the interventions.

CONCLUSION

In the existing scenario Classrooms T1, T2 and T3 have windows on east and west sides with WWR 40% and 30%respectively. Existing daylight autonomy and UDI metrics have showed that the daylight harvesting needs to be improved in these classrooms using proper design strategies. In the existing scenario Classroom T4 has the lowest illuminance levels and daylight autonomy value. And the western facade of the classroom is shaded from sun by the adjacent classroom block. So daylighting strategies are applied for eastern façade of the classroom. Wall window ratio has been increased in east facade from 40% to 60%.Clear glass(1/4 inch) with transmissivity 83.8 has been used which allows more light to pass through into classroom interior. Light shelf strategies have used in east windows for a better distribution of light. Eight different combinations of daylight interventions have been analyzed to improve the daylight performance on classroom T4. It has been observed that light shelf with clear glass is the ideal daylighting intervention for the classroom T1 with daylight autonomy of 60 and useful daylight illuminance of 62.In the existing scenario Classrooms T5, T6 and T7 having good daylight autonomy and illuminance levels but there are areas which are potential for glare. Louvers are used in east and west windows to cut down direct sunlight entering to the classroom interiors. Use of reflecting glass (1/4 inch) with Transmissivity 54.47 also cut down the glare values. Nine different combinations of daylight interventions

have been analyzed to improve the daylight performance on these classrooms. It has been observed that the ideal daylighting intervention for these classroom provides daylight autonomy of 84 and useful daylight illuminance of 75.

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An Assessment Review of Building Professionals towards the Sustainable housing Developments in Nagapattinam Region

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Abstract: Indian Sub-Continent have a wide range of traditional Knowledge in its own, beyond that we all know that our population is 133.92 crores and we stand 2nd tall amongst the other nations in the world (World bank, Census bureau,2017). Current population growth rate leads to rapid urbanization in order to ensure that a populous country deserves a sustainable way of urban habitation. However developing an energy efficient and sustainable policy is highly impossible without knowing the region specific climate and values such as User's Demand and the existing economic conditions and housing customs and cultural specific. There are too many researches in the Field of Architecture and Civil Engineering Focuses on Users Comfort and Indoor Thermal Comfort, But, the actual situation and existing parameters of the region is well known by building Professionals such as Architects, Engineers, Planners, Developers, Promoters, Builders, Technicians and building industry workers. Here this article analyses the Nagapattinam Regional Conditions and their recommended series of sustainable and Energy efficient techniques and approaches familiar amongst the Region specific to housing sector. Moreover developing country and its need towards energy conservation and sustainable environment in passive manner will be achieved. Also this will helps to format guidelines for the Native professionals and the governing authorities by incorporating such approaches and techniques from designing itself will create a remarkable change in the society.

Keywords: Nagapattinam, professional's survey towards sustainability & Energy Efficiency, Assessment of Native Architecture, Approaches towards sustainability

INTRODUCTION

Nagapattinam is one of the oldest port town of Tamilnadu, India, which is familiar for its unique Built heritage with effective energy efficient design strategies and context specific. Now, it's fading away due various factors. After so many researches proven that these Vernacular houses are sustainable. Architects and Engineers started practicing in this region long ago but they never tried to incorporate such effective techniques in contemporary setting which leads to worst living conditions such as worst case damages of houses during all natural calamities and haphazard housing development in Nagapattinam region which loses its image and uniqueness of the region and heavy consumption of Electricity during peak summer. Even in such worst case scenario such as Tsunami 2004 and Gaja cyclone 2018 the traditional Core settlements of Nagapattinam holds less than 10% of damages and during peak summer the traditional houses holds average electricity consumption. Hence there is a need for the study amongst the building professionals of the region for developing a better residential setting for the region.

METHODOLOGY

This research aimed to explore the various techniques and different approaches of sustainability and Energy Efficiency in the Nagapattinam region through Documentation of the core Nagapattinam housing sector. Analyzing the available techniques using building professional's responses towards incorporation of such techniques in contemporary setting by survey. Existing Researches focusing on the comfort levels of the users but here this approach is from the end of building professionals what is possible from user end and what their actual preciseness are discussed elaborately.

SUSTAINABILITY AND SUSTAINABLE BUILDING PRINCIPLES

Over the next 50 years, while the world's population is forecast to increase by 50 percent, global economic activity is expected to increase roughly fivefold. Conventional demand studies suggest that global energy consumption is likely to rise nearly threefold and manufacturing activity at least threefold, driven largely by industrialization and infrastructure growth in developing regions (weight of nations, 2000). Sustainable practices around the world in construction industry focuses on three major promises. The initial direct focus is concentrating on environment and its load reduction the other two Economic and social level sustainability focuses on more of management which will be the focused solution for Sustainable developments for any new development and it is shown below in figure 1.

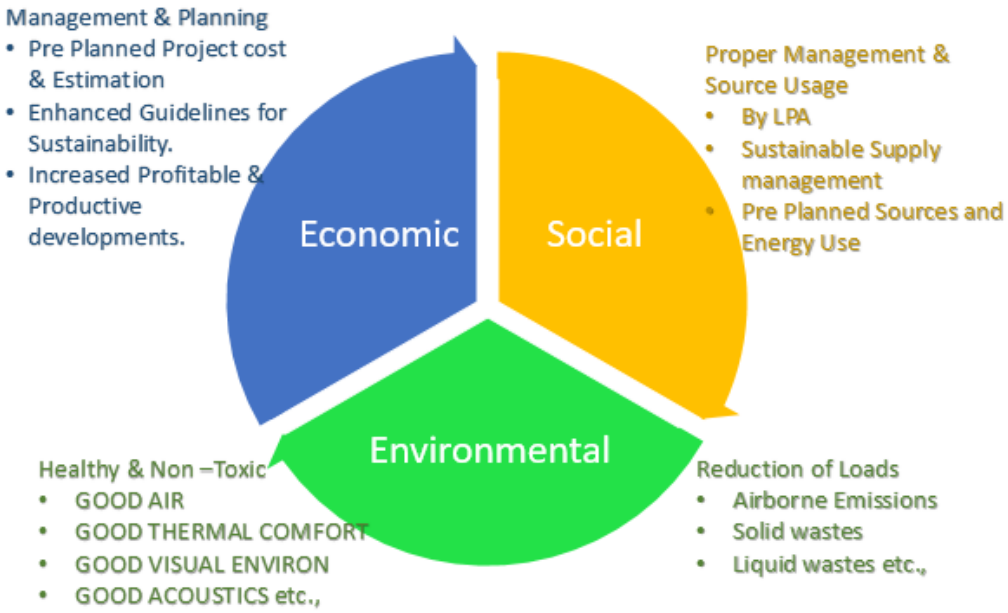

Figure 1. The Sustainability relationship matrix shows the Key Criteria's for sustainable solution in building promotions. (Source: Author, 2018).

Table 1. Principles for sustainable development in recent researches; Source: Author, 2018.

Title of the Journal Article	Published works sustainability solutions discussed	Authors, year
Sustainable Construction, Butterworth Heinemann, London UK	1. Towards Economy, good sustainable project management plans for short and long terms. 2. A clear statement about using resources appropriately both during construction and post construction maintenances. 3. Supporting communities by satisfying needs. 4. Project should enhance a healthy environment without spoiling its environments. 5. No materials in the construction used to threaten the other species around the environ. 6. minimised pollution by using materials, fossil fuels, transportations etc.	Halliday, S. 2008
Building a better quality of life, strategy for more sustainable Construction, Eland house, London, UK	1. Profitable meanwhile healthy competitiveness in promoting developments. 2. Satisfying clients with effect to their needs. 3. fair respect to clients, stake holders and Natural Environment, by virtue of using resources less, polluting environment less etc.,	DETR, 2000
Sustainable construction: Principles and a framework for Attainment. Published in	Discussed about four pillars. Social pillar, economic pillar, biophysical pillar & technical pillar.	Hill R C, BoWen P A, 1997. 15, 223

Construction Management. Economics	Developing environments for quality of life, protect and promote developments considering human health and safety both in living and working environments. Ensure financial affordability and sustainable management principles (supply chain management). Ensured waste management, appropriate use of water, energy, material and land. Prior impact of Assessment Activities for better construction of durability and Functional ensuring long term and quality.	-229.
Technology Development and Sustainable construction, journal of management engineering.	Minimizing resource use, maximising reuse of materials. Creating a healthy and non-toxic environment. Without compromising its quality.	Miyatake Y, 1996. 12, 23 – 27.
GBC'98 and GBC tool Build. Res. Inf.	Reduction in loads airborne emissions, solid waste and liquid waste. Reduced consumption of resources land, energy, water and materials. Improved indoor environmental quality and outdoor quality.	Cole R, Larson K, 1999, 27, 221-229.
Sustainable construction: green building design and delivery, 2nd edition, john Wiley and sons, Hoboken, NJ, USA.	Creating environments responsibly adhering resource efficiency and Ecological principles by proper management system.	Kibert C J, 2008.
Solar passive techniques in the vernacular buildings of the coastal regions in Nagapattinam, Tamil nadu, India – A qualitative and quantitative analysis. Energy and Building,	Bio-Climatic vernacular design strategies are sustainable and energy efficient. Proper Guidelines are mandatory to incorporate sustainable techniques of Vernacular buildings.	Shanthi priya R, sundhar raja M C, Radhakrishnan S, Vijiyalakshmi L, 2011.

The most of sustainable building principles are common to all regions however the major six sustainable principles for buildings are

- Optimized Site Potential
- Optimize Energy Use
- Protect and Conserve Water and natural resources
- Optimize Building Space and Material Use
- Enhance Indoor Environmental Quality (IEQ)
- Optimize Operational and Maintenance Practices

All can be achieve with an equal involvements of stake holders, building professionals and development authorities. So many researches proves that environments are sustainable and researches proven that various guidelines to the authorities but there is a less amount of research in the side of building professionals thought about the incorporation of Sustainability of their developing areas.

Sustainable Technique and Approaches in Nagapattinam Region.

The core settlement and neighboring early settled regions of Nagapattinam specifically houses were documented in which almost 16 unique characteristic features are identified as better solution adopted for the sustainability and energy efficiency which clearly states that these solutions are using optimal site potential and energy use. Conserving materials and resources, enhances indoor environmental quality and also maintenances less operational environment.

1.Thick Outer walls – Traditional Customized fire bricks of Nagapattinam sized 9 inch * 4 inch * 3 inch plastered mud, lime and traditional mud and Murom pushka entirely sized 1foot 3 inches outer walls.

Observation: thick outer walls eliminates sun radiation to a maximum of 6-8 hours which makes indoor comfortable during peak summers.

2. Row Housing – Most of the settlement does possess row housing with wall to wall constructions and the longer axis orients towards North –South this makes the extreme end houses alone needs thick walls rest of the houses were sophisticatedly comfort during summer and during rainfall seasons Observation: The walls don't get exposed which makes indoor even comfortable in Summer and rain don't disturb except the end houses therefore it remains comfortable throughout annum.

3. Linear Planning System – The Vernacular houses of Nagapattinam are linear in planning classification based on their needs. Observation: The orientation which reduces energy by placing common activities and daytime accessible areas in front and rear of the houses where they spent most of the time without using any active systems. Also they use most of daylighting and maximum opening in thinnai spaces for common activity.

4. Best Oriented Buildings – To a maximum extent the streetscapes are linearly in east west axis and the houses were oriented in North south axis due to the Local Warm humid Climate which makes indoor a better environment.

5. Small and Medium Sized Openings – All the traditional buildings the openings are very small because the linearly planned houses which possess a huge corridor to both extreme ends. Observation: Ensures cross ventilation in the houses and the rest of rooms holds a maximum of 20 to 30% opening which is sufficient for a warm humid climate of Nagapattinam.

6. Shaded Front and Rear Porches – Verandah in front of the houses with raised thinnai Space eliminates hot air transposing through building and also Observation: This porches provides shade to the indoor openings. Also this enhances direct cross ventilation to the longer axis crossing courtyards which enhances comfort levels to a degree above always.

7. Light Insulated Tile Roofing Pitched – Almost 80% of vernacular houses are pitched roof and pan tiled (pan tiles are country made native tile region specific axial cut in a cylinder shaped) arranged on wooden base. Observation: This is loose enough to evacuate the hot air in indoor environment to outdoor environment (Stack Effect).

8. Jallies and Jallie wall openings - Beneath roof and at corridors most of the houses possesses the jallies which creates Venturi effect. Observation: Also this opening ensures necessary light and wind to the passages and Activity spaces.

9. Courtyards – The Courtyards are Nagapattinam region is very familiar for its bridging of natural elements into building and also it reduces urban heat effects. Observation: Works with the principle of stack effect lot of researches in the same region proven that this gives maximum indoor comfort in all seasons.

10. Courtyards with Vegetation – Thulasi maadam in this region is very familiar and researches proven that, Observation: courtyards with vegetation reduces indoor temperature up to 4 degree Celsius from outer open environment.

11.Roof Lighting, light well / Skylight – Another interesting feature of vernacular houses in-between the pan tile / Mangalore tile roofs glasses were placed for indoor lighting to the rooms. Observation: Direct daylighting is used no Active energy needed and in this region Sun fall is always available more than 8-10 hours in day all through the year except worst case scenario, which is negligible.

12. Wind Chimneys – The natural clay made pipes and nowadays PVC pipes were used as chimney pipes for evacuating hot fumes out of kitchen. Observation: Nowadays and in early times we all know not just because of human metabolic activities alone room temperature never increases drastically kitchen use and activities plays a vital role which is reduced in an effective manner by this natural chimneys without active energy needs.

13. Wind Catchers – This region familiar for its unidirectional wind catchers which makes indoor environment even more comfortable in all seasons of the region. Observation: This wind catcher plays a vital role because of coast next to the settlement demands continuous air movement to enhance indoor comfort and maintains humidity level at optimal range.

14. Use of Local & Renewable materials cum Sources – Observation: The vernacular architecture is a unique blend with character of its own regional specific which shows all materials are taken from nearby surroundings which shows the region sustainable and Immortal.

15. Raised Plinth Level – More mandatory to the coastal region whenever there is a flood this saves indoor environment. Observation: As the sun strikes earth heats there the need for comforting indoor using Active systems demands energy which is delayed by this raised plinth and whenever there is wet during winter this raised plinth safeguards indoor.



Figure 2. The Sustainable techniques of native Architecture in Nagapattinam Neela Settlement
Source: Author, 2017-2018.

16. Gravity based Drain network – All residential sectors of core region does possess this gravity based drainage network. Observation: This always drains the sewage and excess rain water to the canal networks connecting to sea which makes entire region healthy. These Unique characteristic techniques of the analyzed Nagapattinam region are shown in pictures 1to 16 cumulatively captioned under Figure 2.

QUESTIONNAIRE SURVEY RESULTS

All the above specified Approaches and Techniques of vernacular Architecture in this Nagapattinam region is Proven as Sustainable and Energy Efficient ideas in various places around the world, with similar warm humid climate and also in other climatic conditions. Here the Survey is titled with "Building Professionals survey regarding vernacular houses of Nagapattinam region as a solution to contemporary Housing Setting" and before proceeding the survey a two lined statement is given for them and it is "In tradition we have a wide knowledge of building techniques and efficient strategic planning ideas but why doesn't we incorporate those essence to the contemporary developments to solve current energy issues of the nation." Apart from that all around the world buildings professionals started thinking of doing Environment friendly buildings considering highly energy efficiency and sustainability. Therefore this survey specific to a region will give a precise idea to the Nagapattinam region after successful implementation of this survey in LPA Nagapattinam this can also be used for other regions with similar specifications.

Q1: Are you familiar about Vernacular Houses of Nagapattinam Region?

Total Number of Respondents are 219	yes	No	Maybe
	163	08	47

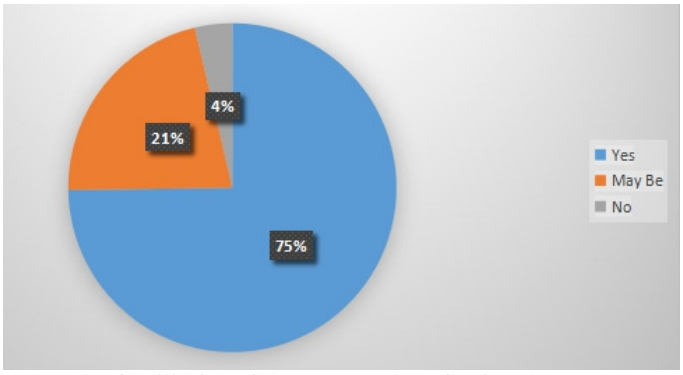

Figure 3. Shows the familiarity of the surveyed professional's percentage pie chart.

Q2: Are you a Building Professional of the above stated Nagapattinam Region Specify the below?

Total Number of Respondents are 219	Architects	Engineers	Promoters/Developers/ Contractors/Builders	Others Technicians, Building worker etc.,
	115	11	80	12

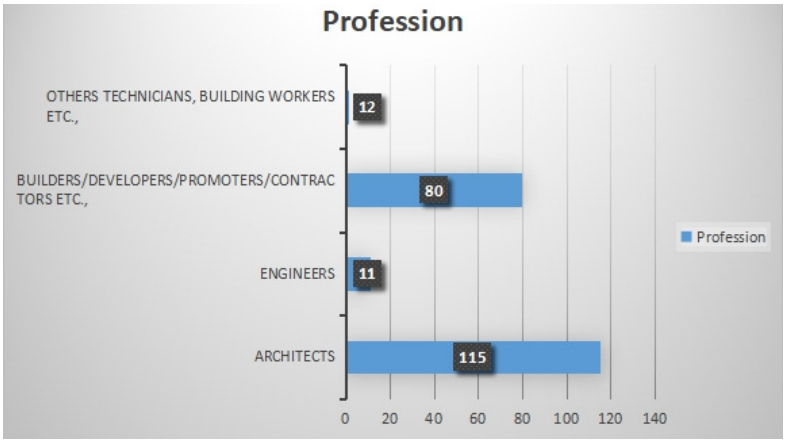

Figure 4. Bar diagram showing the surveyed professionals profession.

Q3: How long you had been working in construction industry?

Total Number of Respondents are 219	Less than 1 Year	1 year to 5 Years	5 to 10 years	Above 10 years
	57	57	57	47

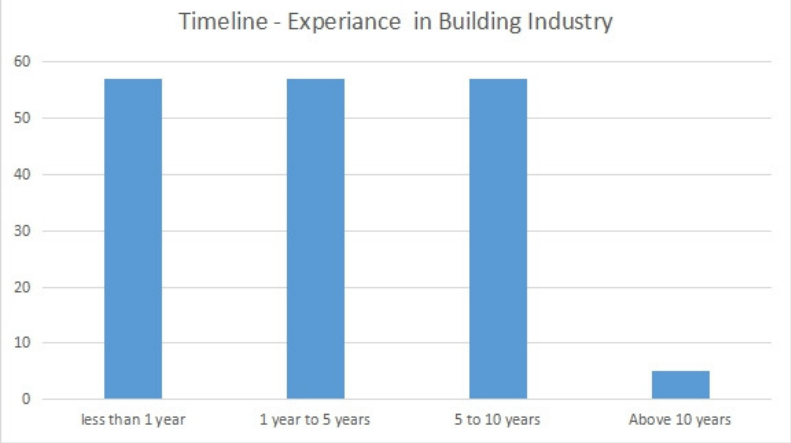

Figure 5. Bar diagram showing the surveyed professionals experience.

Q4. Have you seen these buildings in Nagapattinam Neela Streets housing's around Kayarogeswarar temple (Early Settlement in Nagai Region?)

Total Number of Respondents are 219	Yes	No	May Be
	182	0	25

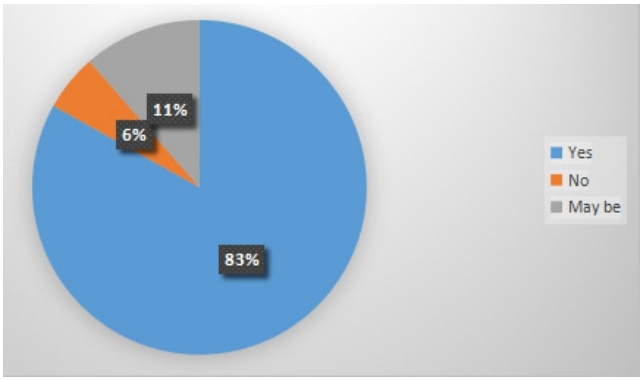

Figure 6. Pie Chart showing the surveyed professionals experience.

Q5. How do you Rate the vernacular houses of Nagapattinam with respect to sustainability?

1	2	3	4	5	6	7	8	9	10
-	-	-	-	-	12	37	47	68	55

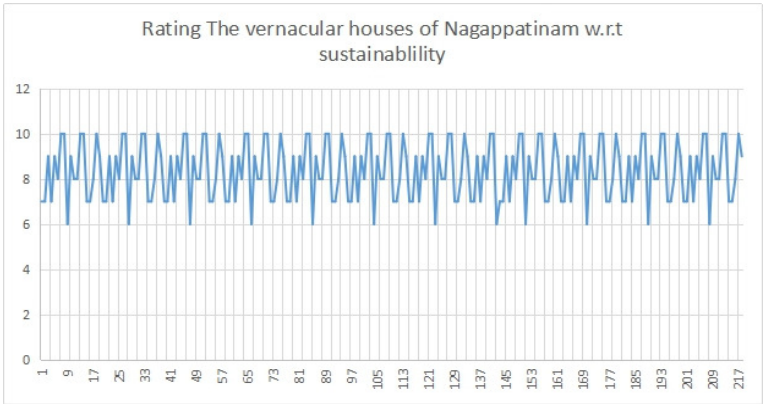

Figure 7. Chart shows the surveyed professionals rating towards sustainability.

Q6. Specify any one sustainable Architectural design feature of Nagapattinam houses

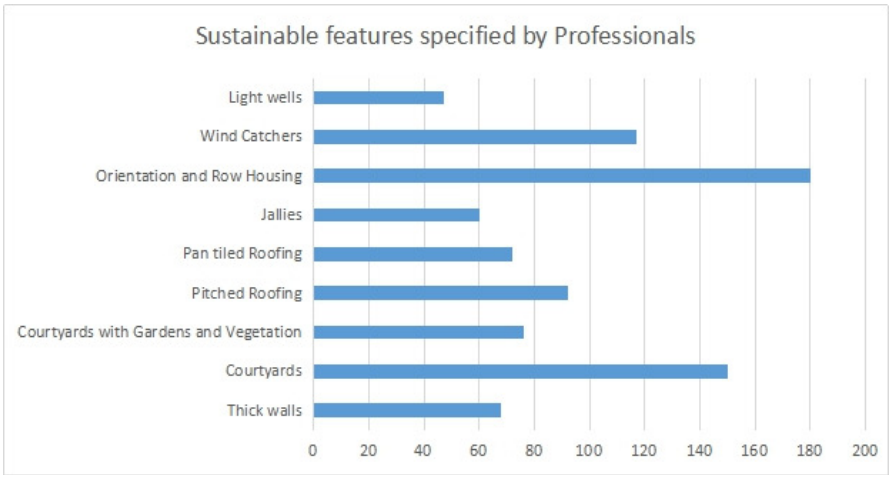

Figure 8. Chart shows the Sustainable Architectural design features available in study zone.

Q7. The traditional vernacular residences of Nagapattinam are highly energy efficient.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
59	160	-	-	-

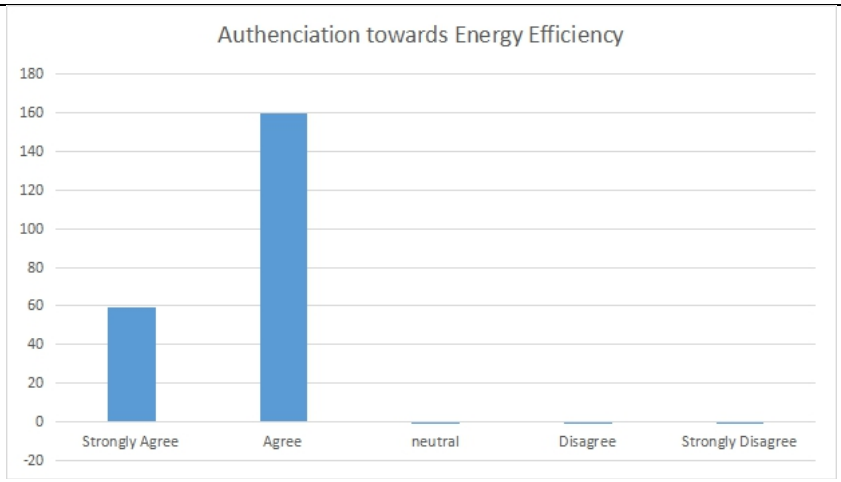

Figure 9. Chart shows the professionals consideration with respect to energy efficient.

Q8. Specify Energy Efficient Design features available in Nagapattinam houses W.R.T Passive Heating?

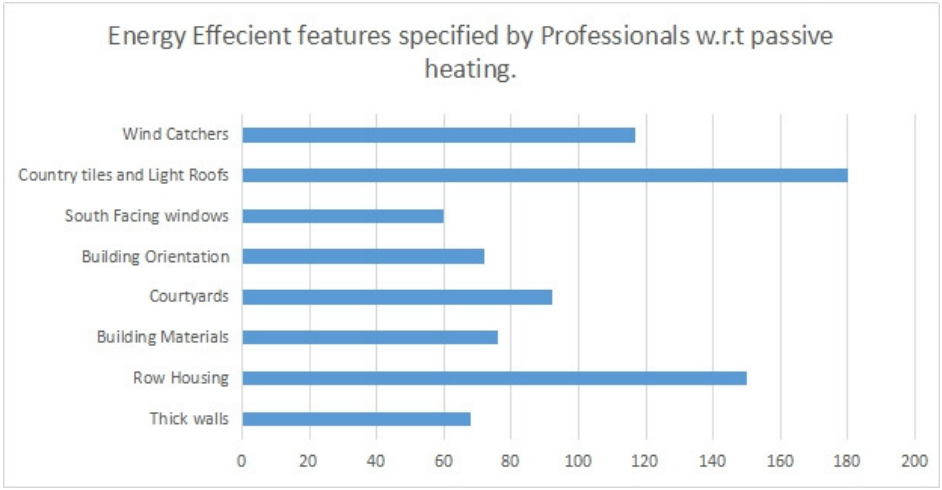

Figure 10. Chart shows the Energy efficient design features available in study zone.

Q9. Specify Energy Efficient Design features available in Nagapattinam houses W.R.T Passive Cooling?



Figure 11. Chart shows the Architectural design features available in study zone for passive Cooling.

Q10. Specify Energy Efficient Design features available in Nagapattinam houses W.R.T Passive Lighting?

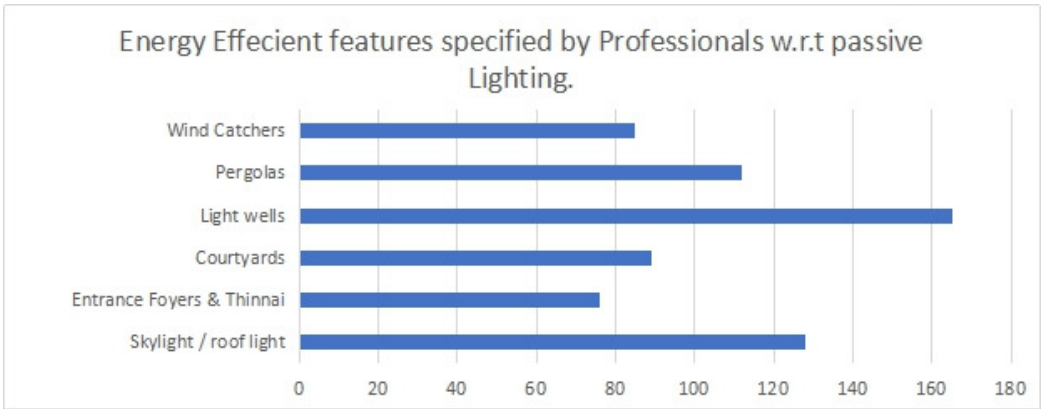

Figure 12. Chart shows the Architectural design features available in study zone for Passive Lighting.

Q11. Technical Energy efficient and sustainable solutions can be adhered to contemporary Context.

Total Number of Respondents are 219	**For Passive Heating, Cooling & Ventilations**				**For Passive Lighting**				**Inclusive of Architectural styles for sustainable Image of the Town**			
	Yes	182	No	31	Yes	1	No	68	Yes	150	No	69

Q12.Are the traditional houses are suitable to current scenario? If No please specify reason

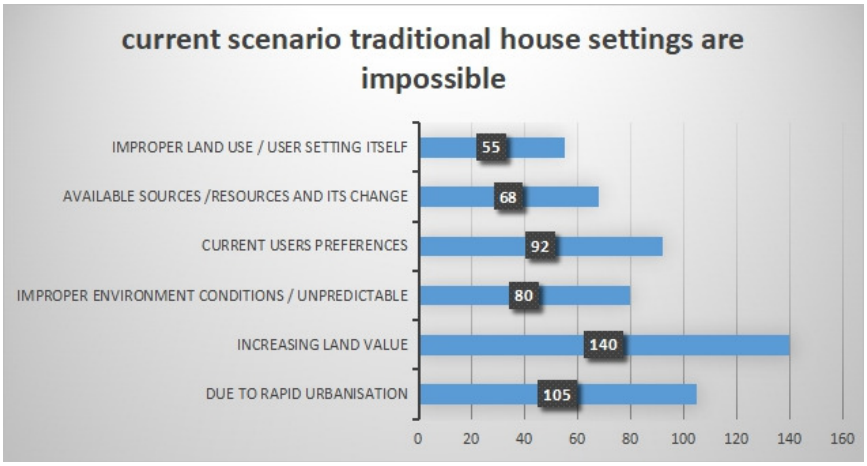

Figure 13. Chart shows the Architectural design features as solution for current scenario.

Q13. Can We Combine Sustainable and energy efficient techniques to solve current energy issues and to create better sustainable Environment?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
91	59	40	17	15

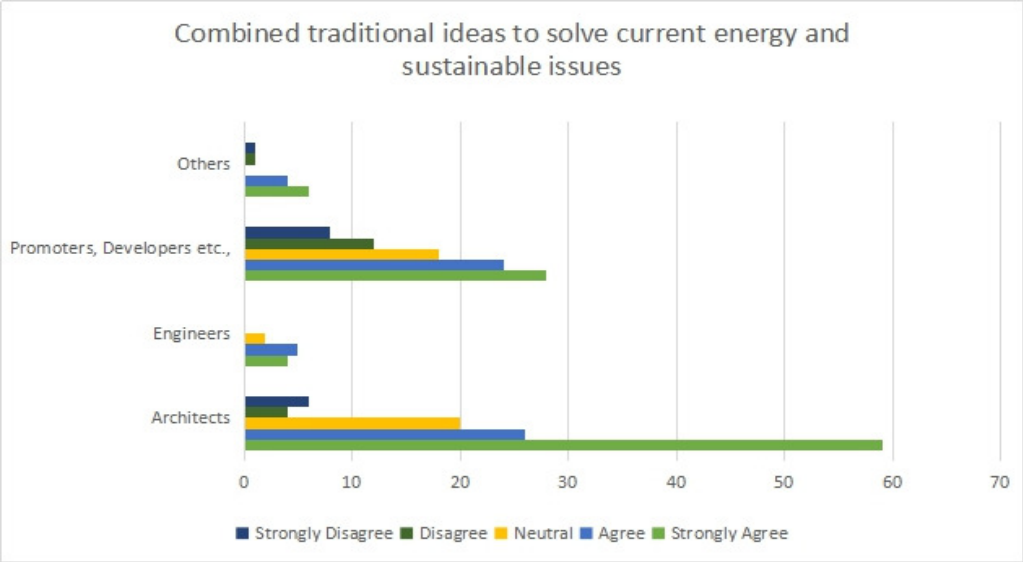

Figure 14. Chart shows the percentage of acceptance to incorporate vernacular design techniques to solvecurrent energy issues and sustainability in study zone.

Q14. Suggestions to incorporate Energy Efficient Technique in future residential designs of this Region?

Table 2. Suggestions for future residential developments towards Energy efficiency by Survey. Source: Author, 2018.

Sl.No	Energy Efficient Techniques Suggested	Professionals Nos
	Instead of thick walls Thick insulation materials	68
	Courtyards	180
	Extension of Roofs and Shading devices	42
	Wind catchers instead unidirectional preferable multidirectional	78
	Light wells/ Atriums	140
	Increased cross ventilation through planning	78
	Openings preferable in south and South west – medium sized	90

Q15. Suggestions to incorporate Sustainable Approach in future residential designs of this Region?

Table 3. Suggestions for future residential developments towards Sustainable development by Survey.Source: Author, 2018.

Sustainable Approaches Suggested	Professionals Nos
Integrating landscape / vegetation in indoor environs	180
More precise in materials selection w.r.t region	68
Raised plinth with proper and wide network considering vehicles and walkers at the same time.	58
Wind catchers	84
Linear housing Patterns	23
Increased Jallies for natural Venturi effect and stack effect.	97
Courtyards for stack effect	119
Retaining Traditional Architectural Forms and styles using Codes	108

CONCLUSION

This study concludes that the professionals and technicians from construction industry of Nagapattinam are very clear with their statement which is vernacular traditional buildings are sustainable and energy efficient. For sustainability and energy efficiency there are certain unique techniques are always available within their housing settlement such as Courtyards, courtyards with Vegetation, Passive lighting, Front and Rear Foyers, Wind Catcher Roof Chimneys and Jallie walls such traditional techniques needs to be reviewed and the local planning

Authority should frame a rigid code to practice in all upcoming residential developments, which will reduce Energy use considerably. Various Researches and its proven techniques shows that these techniques are energy efficient and sustainable beyond those professionals believe that this can be used to solve current Energy Issues.

Therefore this needs attention immediately from Development authorities of Zones and Region wise to promote such techniques as mandatory design element for developing any new residences from initial planning level itself. Not to follow all design elements in all residences but elements catering Renewable sources above 50% will be possible. This needs a quick start because of the growing rate of Indian population and rapid urbanization. This is not for Ornamental it becomes Inevitability at present. Incorporating traditional techniques are highly impossible in current scenario but it is always possible to observe the essence for the Traditional settlement which is purely for the betterment of Future Generations and their Energy Needs and for a perfect Sustainable Environment.

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Introducing responsive building facade in India for energy efficiency and sustainability

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Abstract: All parameters of human existence are influenced by building envelopes. They have manifold functions such as to resist and transfer structural and dynamic loads, to regulate the flow of matter and to satiate the aesthetical requirements on the inside and outside, each requiring their own mechanism. These myriad functions should be implemented without compromising on the user comfort requirements and energy efficiency. Responding to the limitations of static facades, over the past few decades, responsive facades are being developed as building envelope substitutes to meet the augmenting myriad of demands pertinent to energy consumption and efficiency, cost effectivity, user comfort and adaptation to changing environmental and climatic conditions. Responsive facades have an ability to adjust their behaviour by comprehending and learning from their surroundings. Therefore, the building envelope is no longer inert but dynamically transforms by benefiting from natural environmental conditions to regulate the internal environment by reducing its power demands. This paper encourages India to invest in responsive building facades for energy efficiency and sustainability. Various technologies that are used in responsive facade systems are identified, scrutinized and evaluated based on their advancement and implementation around the world. Responsive facade technologies are categorised as mechanical, electromechanical, information, material and passive technology on the basis of the structure, control and actuation used. Each of these systems are further enunciated with the help of literature case studies, tabulated and compared for analysing their benefits and shortcomings in order to encourage their use in India for specific climatic conditions.

Keywords: building envelope, static facades, responsive facades, climatic conditions, energy efficiency

INTRODUCTION

The vertical (facade) and horizontal (roof) components constituting a building envelope provide structure and stability to the building, shield it from direct external environment and help maintain comfortable interiors. According to studies, 20 - 60 % of the total energy utilized by a building is influenced by the architecture of it's envelope. (International Energy Agency, 2013). The limitations of a traditional static facade of a building envelope affecting its energy performance include a high rate of daylight admittance, high rate of heat transmission through conduction, convection and radiation, high rate of moisture migration and limited aesthetic expression, raising the need to upgrade its design and development. The visual performance and daylighting of a static facade could be enhanced by reducing the discomfort caused by glaring of windows, optimizing internal daylight levels, decreasing high energy demand for artificial lighting, and providing external shading screens. Building facades can be designed to be an intelligent system with the ability to customize the energy flow by regulation, attenuation, enhancement, entrapment and rejection. Additionally, an effective intelligent building facade should also be a medium through which the building can respond to an external environmental stimulus by resolving the issues of responsive architecture. To achieve such goals, the idea of a responsive facade as a methodically adapted entity has been proposed to overcome the limitation of existing traditional facades, which exploits the potential benefits of the use of advanced technology in the design of a multifunctional facade system.

WHAT IS RESPONSIVE FACADE?

The building envelopes are either static or responsive, independent or controllable or be composed of varied materials. Responsive facades are interactive in nature and are smart, intelligent and energy efficient, they dynamically modify the elements of the facade to manage the internal environment by responding to external environmental stimuli.

The characteristics of the building envelope are altered with the help of control systems that enable it to adjust itself to factors such as thermal resistance value, light level, glare, occupant comfort level, solar patterns, heat energy efficiency, thermal resistance and passive ventilation that are constantly altering. Researchers have shown that such modifications help enhance the facade performance by 40% to 65% when compared to the facades that are static.

WHY RESPONSIVE FACADES IN INDIA?

India is ranked fifth in the world for its large emissions of greenhouse gases (GOI, 2010) and is the fourth largest consumer of energy (EIA, 2013). Energy can neither be created nor be destroyed but can only be transformed from one form to another. But not all forms of energy can be utilised efficiently.The need of the hour is thus to conserve energy and achieve harmony between environmental sustainability, socio political sustainability and economic sustainability. The building sector contributes 35% of the total electrical consumption (Rawal et al, 2012) and also the number of buildings in India is projected to increase by five-fold by 2030. Thus design of efficient buildings is of significant concern and government is encouraging practices to reduce air-conditioning loads, artificial lighting, artificial ventilation etc. through solar heat control, natural ventilation, effective daylight and even passive solar heating in cooler climates. One pragmatic approach to facilitate climate control is by thoughtful design of the building envelope that consists of all the elements in the outdoor shell that facilitate maintain a dry, cool or heated indoor environment with intelligent interaction with the external environment. Presently in India, there are no high performance responsive facade systems to assure flexibility for power outages. Also, such facades are significant to maintain comfortable indoor environment.

CLIMATE AS AN IMPORTANT FACTOR

India is dominated by subtropical climate with very hot summers, humid rainy seasons and mild winters. With the advent of technology in building construction, the traditional vernacular design strategies for passive heating and cooling in different regions have been adopted in numerous ways to combat the external environment and climatic conditions.In cities like Kochi, Surat etc that falls under hot and humid climate, a double skin façade, roof garden, thermal energy storage, ice storage, etc. are adopted. In Moderate climates like in Bangalore and Pune, the responsive buildings elements are solar space, natural night ventilation and thermal mass activation. In Cold regions of north and north-east India, the most important principle in building design is thermal mass activation. When narrowed down to trends in facade design, there is a slow but very perceptible shift from the use of mere glass and stone cladding often seen across the country, towards the use of compelling facade materials like double skin façades, parametric designs, LED façades, and rain-screen façades. The bigger challenge of the building construction industry is to perform in spite of the inevitable harsh climatic conditions making static facade designs, even though built with energy conserving materials, insufficient. There is a dire need for our buildings and their facades to be designed responsive so as cope up with extreme weather conditions, soaring temperatures and changes in rainfall. Therefore, study is needed where we can relate the climatic aspects with the innovative techniques used worldwide to state their probable use in Indian context.

CLASSIFICATION OF TECHNOLOGIES IN RESPONSIVE FACADES

Table 1. Classification of technologies and identification of sensing, control and actuating phase

Technology	Mechanical Technology (Active)	Electro-Mechanical Technology (Active)	Information Technology (Active)	Material based Technology (Passive)	Passive Technology (Passive)
Sensing phase	User Requirement	Temperature Sensors Moisture Sensors Light Sensors Photovoltaic/UV Sensors	Network of sensors	Material- based sensing	(autonomous manmade structure) No sensors
Control phase	Hand-Operated	Central- Based Control System Building Management System	Network of micro controllers	Material- based controlling	No controlling technology
Actuating phase	Pulley system Cables system Cogs system Gears system	Motor-based Actuators Electrical-based Actuators Pneumatic-based Actuators	Material-based actuators Motor- based actuators	Material- based actuating Form-Changing Material Thermo-Bimetal	Natural phenomena moisture/ wind/ sunlight

		Hydraulic Actuators	Hydraulic actuators Pneumatic actuators	Material Phase Changing Material Electro active polymer Shape Memory Alloy Shape Memory Polymer	

The pre-existing responsive facade systems that were used over the past seventy years disclose the use of various control technologies, and are classified as manual switched systems, centralized control systems, decentralized control systems, material based or hand operated systems. Likewise the various systems using different sensors (central sensors, decentralized sensors, no sensor-present algorithms, central switches, material sensors) and the different actuating technologies (mechanical, electrical , pneumatic , hydraulic , material based) used are categorized for further comprehensive analysis and understanding of the technologies used in the responsive facades.

Also the progress and development in the responsive technology has led to the possibilities of various structural systems for the same including cable network, cable structure, structural glass facade/stick/curtain wall, space frames and self-loading structures. The goal for the structural growth of responsive facades is to develop a single light weight, self-loading envelope.

MECHANICAL TECHNOLOGY

With the onset of the common architecture slogan in the 1960s “Make a building as a system”, mechanical principles influenced design to be a mechanism meeting multiple purposes. Interdependent mechanical elements such as pulleys, wheels, hinges, rollers, cables and gears can change the magnitude, direction, and application point of forces. The direct legacy of industrial revolution was the implementation of these mechanical components (Decker & Zarzycki, 2013) cause movements in facade mechanisms by utilization of external forces (Schumacher, Schaeffer, & Vogt, 2010). The first responsive facade system consisted of an adjustable blind, hand operated with a mechanism of pulleys, cables and gears.

Penumbra system designed by Tyler Short in 2014 is a recent example of implementation of mechanical technology in the design of responsive facade. The Penumbra system offers a kinetic and mechanical solution that can improvise the otherwise static architectural components to shade the building facade for both high afternoon and low evening sun conditions.

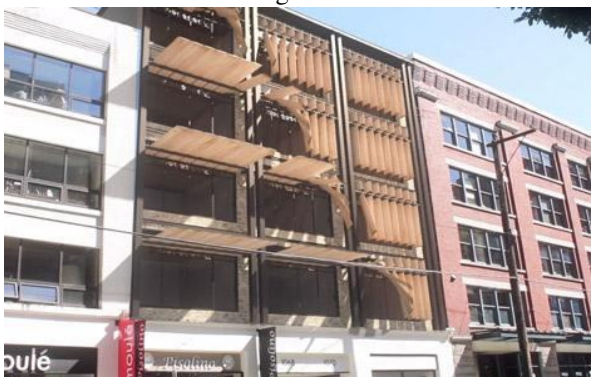

Figure 1. The vertical louvers swinging outwards
Source: www.dezeen.com



Figure 2. The hand operated mechanism
Source: www.dezeen.com

Here, the shading louvers which are the traditional static components rotate in three coordinal directions, both laterally and axially, according to the sun’s position. The system can be manual or computer-operated. Two interdependent gear and cog systems are actuated by the hand / computer operated mechanisms to convert a vertical configuration of louvers to horizontal.

ELECTRO MECHANICAL TECHNOLOGY

Electro mechanical technology is the integration of electrical components and controls with the mechanical technology. There are numerous examples of the use of this technology in responsive building facade systems around the world. The best example of a project that uses this technology is the Al-Bahar towers in Abu Dhabi, UAE.

Abu Dhabi experiences subtropical arid climate with the hot and glaring sun posing a huge challenge in shading the interior spaces while allowing for adequate daylighting. Responding to such harsh climatic conditions, the architects of the 145m tall Al Bahar Towers have developed a Mashrabiya shading system, taking culture clues from a traditional jaali like lattice screen called 'Mashrabiya', used for shading in traditional Islamic architecture. This shading system is a lattice of interlocking parametric triangular modular screens which open and close responding dynamically to the amount of sunlight incident and rotate around the building along with the sun's changing position. As the sun rises from the east in the morning, the screens along the east of the building begin to close. Through the day as the sun moves around the building, the strip of closed panels moves across the facade, performing their job of controlling solar gain. All the screens fold at night to reveal more of the internal facade. Sensors that open the units in case cloud and wind conditions change protect the whole system.

Each module comprises of stretched PTFE (polytetrafluoroethylene) panels coated with micro fibreglass. The interlocking geometric facade comprises of over 1,000 moving elements, controlled by a building management system to create a smart responsive facade. Like a secondary envelope, the giant lattice almost completely

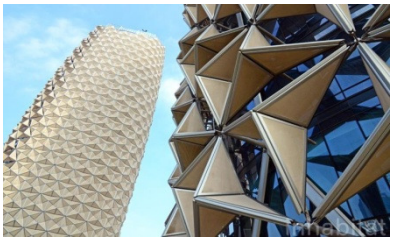

Figure 3. Close-up view of the facade
Source: www.inhabitat.com

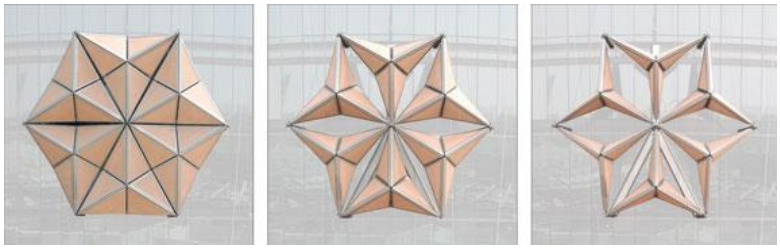

Figure 4. Comparison of shading units fully closed (left) and fully open (right)
Source: Council on Tall Buildings and Urban Habitat

surrounds the two towers by hanging like a curtain wall two metres away from the primary glass facade. In this way, using parametric models for the shading panels, the design can simulate their operation for different solar conditions throughout the year – varying solar angles and sun exposure. The south facing roof of the towers incorporate photovoltaic cells that generate about 5% of the building's energy needs, and also drive the system of computer controlled facade panels. It is estimated that this screening system cuts out approximately 50% of solar heat gain, effectively reducing the air conditioning load inside the building. Additionally, as the panels even in their closed condition filter some light into the building, they reduce the offices' dependence on artificial light. The twin towerssave a lot of energy that would otherwise have been required for cooling and lighting loads which can be calculated as a reduction of CO2 emissions of 1,750 tons per year. The result is a much more energy efficient architectural solution to office space requirements that is contextually and climatically relevant to the Middle East.

INFORMATION TECHNOLOGY

The idea behind information technology is a distributed control system to control the interwoven panels by the use of microcontrollers. The actuators are executed with the help of microcontrollers which help in processing and coding the data provided by the local sensors. Decentralized control systems are advantageous because of their independent reciprocation to the surrounding habitat, panel-wise effective time calculation of environmental data, straightforward substitution among multi-connected panels, inexpensive facade components, functional and compositional freedom. But the main drawback is that being a computer dependent system, their operations are susceptible to cyber security and computer failures.

Media TIC building which is located in Spain is designed by Enric Ruiz-Geli of Cloud 9 using this technology. The skin of this building is made out of Ethylene tetrafluoroethylene (ETFE) which is inflatable and lightweight. This envelope consists of air chambers that contracts or expands with the changing light. Each of these panels are embedded with UV sensors, soft body actuators, pneumatic pressure sensors, and microcontrollers that respond to UV rays or brightness from the sun. The motion of the facade is controlled by a digital sensor which tracks down the sun's movement all day long. It protects the occupants from direct sunlight by reducing the UV light penetration by 85 % while still allowing harmless light to pass through it. The sensors detect the environmental stimuli and pressurise air into the soft body with the help of microcontrollers. The opacity of the facade is dynamically regulated by this air as it causes deformations in the skin's geometry. Thus the entire facade can be controlled and managed by the simple movement of wind. This system is highly economic since no powered mechanisms are used to manage the motion of the air.

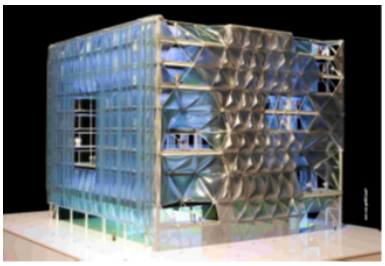

Figure 5. ETFE cladding
Source: Enric Ruiz - Geli cloud 9, 2007



Figure 6. South - east facade
Source: Enric Ruiz - Geli cloud 9, 2007

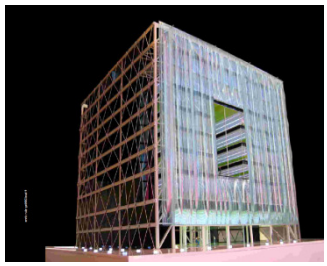

Figure 7. ETFE cladding when deflated
Source: Enric Ruiz - Geli cloud 9, 2007

This solar protected building uses about 2500 m2 of ETFE cladding which enables 20% energy savings. The anti-adherent skin consists of three layers of plastic separated by two air chambers that can be inflated or deflated as required. While the outermost layer of the skin is transparent, the intervening and innermost layers create shade with the help of their design patterns when inflated and joined together making it one single opaque layer.This helps in improving the thermal insulation of the building while allowing diffused light.

Table 2. Comparison of the various case studies and their technologies used

Project name	Penumbra		Al- Bahar towers	Media TIC Building
Location	A computer simulation		Abu Dhabi, UAE	Barcelona, Spain
Completion Year	2014		2012	2011
Architect	Tyler Short		Aedas Architects	Enric Ruiz Gell
Implemented technology	Mechanical Technology		Electro-Mechanical Technology	Information Technology
Type	-		Office	Media Building
Kinetic Elements	Shading louvers		PTFE panels	The anti-adherent skin
Reason for Motion	Manual		Sunlight/ UV radiation	Temperature, UV radiation, pressure
Materials	Wood		PTFE Fiberglass	ETFE ethylene tetrafluoroethylene
Control Systems	Hand operated/computer operated		Central control HMI and BMS	Decentralized Control/ Micro control

Sensing Technology	None - user's preference		Sensors - central based	Temperature Sensor, Network of sensors
Actuating Technology	Hand-Crank Contraption Gears and cogs System		Hydraulic actuators, linear actuators	Pneumatic-Based Actuator
Climate	Tropical climate		Hot and arid	Mediterranean Climate
Facade Structure	Suspended blades		Space frame	Space frame

MATERIALS THAT FACILITATE RESPONSIVE FACADES

Progress and in depth analysis of the inherent properties of materials, have helped facilitate and provide opportunities in the development of responsive facade systems. In this system, the material itself replaces the otherwise mechanical or electro-mechanical components. Molecular changes in the structure of the material that are stimulated by external signals such as chemical substances, electricity flows, magnetic field forces, temperature changes, and photons of light help operate the material based actuators. The factors that govern the motions of the material are generated by alterations in colour, electric currents, fluidity, volume and shape. Such intelligent interactive materials with shape memory polymers, phase changing materials and electro active polymers help building responsive facades. The actuators, sensors and the control systems are generated into the material itself, preventing the use of any external energy sources.

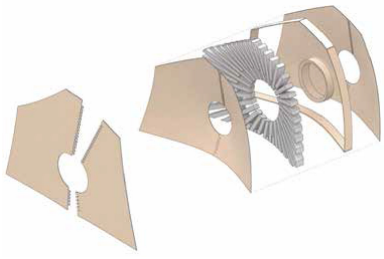

Figure 8. Exploded axonometric view of the module layers
Source: Kreig, 2014

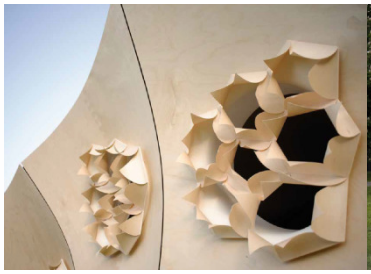

Figure 9. Hygroscopic aperture when relative humidity at 45%
Source: Kreig, 2014



Figure 10. Structure when it has 75% humidity
Source: Kreig, 2014

One prominent example of a project that uses this technology is the Hygroskin Pavilion. It explores the inter-relationships of the inherent characteristics of wood along with advancements in robotic manufacturing and computational morphogenesis. A meteor sensitive wood skin that naturally reacts to the humidity present in the air is developed. This responds by opening or closing without the aid of any industrial mechanism or external sources of energy.

These independent responsive apertures are embodied into the bigger, mechanised and fabricated multi component system of the pavilion to respond to changes in moisture content in the environment. Even the slightest of climatic changes will trigger the innate material movement of the skin causing it to react, thereby changing the relationship of the internal and external environment continuously. This leads to an exclusive convergence of spatial and environmental experiences.

The apertures are geometric elements that incorporate the hydroscopic actuators (wooden elements) into the polyurethane lattice. Each of these elements contributes significantly to the geometric value by taking the place of higher curvature of the cones within their centre area. This project thus achieves climate responsiveness by embedding responsiveness into the material without employing any external technical sensing aid, regulating devices or external energy control system. The wooden components that are hygroscopic react differently to varying humidity from 45% to 75%. They are calibrated exclusively to suit the typical moderate climate of that particular region of Central Europe.

PASSIVE TECHNOLOGY

In passive technology, natural resources like the moving wind, flowing water, and sunlight are directly used to eliminate the dependency of a facade system on manual and electrical power sources.



Figure 11. Aluminium panels rustling in the wind
Source: extechinc.com



Figure 12. Charlotte Parking garage
Source: extechinc.com



Figure 13. Wave like movement is created
Source: extechinc.com

One of the facade systems using this technology is of the Gateway Village Parking garage in Charlotte, NC. The 260 feet long and 6 stories tall parking garage has 80,000 small aluminium plates animating the entire length of the structure to reveal the wind currents. It is a pure poetic experience to walk in the interior of the garage as reflections of the aluminium plates project mesmerising shadows akin to rustling trees onto the walls. 50 percent of the open building is shaded by the motion of this light, durable, amorphous and fluid-like facade. It also reduces the need for expensive HVAC systems by providing good natural ventilation. The open design allows car emissions to be dispersed outside, as abundance of natural light and air flows through the parking facility, creating positive impact on the environment. It helps maintain a comfortable temperature within, by acting as a light barrier. Analysis of the above case study gives us the benefits of responsive facades that are passive - their independence from mechatronics, minimalist presentation of artwork and ever changing aesthetic expressions provided by environmental variables.

Table 3. Comparison of the various case studies and their technologies used

Name	Hygroskin pavilion	Charlotte Parking Garage
Location	Orleans-la Source France	Charlotte, North Carlino
Completion Year	2013	2000
Architect	Achin Menges	Ned Kahn
Implemented technology	Material Technology	Passive technology
Type	Pavilion at Institute of computational design-Stuttgart	Parking Garage
Kinetic Elements	The floral shaped outlets.-Elevation Elements	Façade Elements
Reason for Motion	Environmental- relative Humidity	Wind
Materials	Veneer composite	Aluminium Panels
Control Systems	Material Based technology	No Control
Sensing	Material Based technology	No controls

Technology		
Actuating technology	Material Based technology	Wind
Climate	Humid Subtropical	Humid Subtropical
Facade Structure	Self loading	Cable net
Facade Structure	Self-loading	Cable net

CONCLUSION

In this paper we have discussed about the importance of facade design to control the building energy performance, present trends in facade design in India and pointed out the necessity to develop climate responsive designs over static facades. Different technologies in responsive facade design and their implementation around the world have been studied and analysed for their probable use in Indian context. The case studies clearly justify the undeniable benefits of the use of responsiveness in facade design I.e. its ability to perform under extreme climatic conditions, improved thermal insulation, higher values of energy conservation leading to reduced CO2 emission levels, reduced annual and peak energy demand, ever changing aesthetic expressions provided by environmental variables and exhilarating spatial and environmental experiences. Thus, for energy efficiency, sustainability, and benefits beyond, responsive facade systems need to be integrated in India.

ACKNOWLEDGEMENTS

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Studying an Active Street Edge

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Abstract: Urban public streets have always been an integral part and parcel of city life. Throughout history, streets have showcased cities' cultural, social, and economic contexts. Recent researches on public streets have brought into light their declining value in terms of physical design and use. Thus, in this context of dramatic change in the use of public streets it becomes necessary to investigate and evaluate the actual use of modern city streets, how and why they are used, particularly in terms of their physical deterioration and/or improvement. Therefore, an opportunity exists to study and examine the interrelationship between physical patterns of contemporary public streets and people's activity patterns. This paper relates to urban public spaces, particularly street edges, and to the relationship between the street edge design and the extent and character of outdoor activities in Indian scenario. The paper tries to identify and list down architectural design principles for creating a better outdoor environment along the street edges. Case studies with varying cultural contexts were selected and analyzed through field observations and activity mapping. The results were analyzed and the factors that contribute to an active street environment were identified and listed out here. Analyzing this relationship will add insights into and complement the application of urban design theories and promote sustainable urban regeneration in the context of public streets and their planning process.

Keywords: physical pattern, activity pattern, street edges, activity mapping, sustainable urban regeneration

INTRODUCTION

Street edges are one of the main parameters deciding an active city environment. They provide active engagement opportunities for people to walk and participate in a versatile and varied city life. It is the zone that one walks along when you are in town and these are the frontages that you see and experience close up and therefore intensely [1]. This is where you enter and leave buildings where the indoor and outdoor life can interact [1]. A major problem cited by the city dwellers in the present day streets are congestion, noise, pollution etc. This has degraded the quality of street edges and made them less inviting. The paper aims to study an active street edge and the activities happening there so as to find out the relationship between the physical quality of the street edges and the diversity of outdoor activities.

SCOPE & LIMITATIONS

The study covers the physical quality of the street edges and their relationship with the activity patterns in the streets. The study is limited to commercial streets only and examines only the physical parameters of the street edges.4 live case studies were chosen based on varying enclosure level of the streets and analyzed to get the desired results. Due to time limitation only activities at certain time intervals have been taken into account for activity mapping of the live case studies.

METHODOLOGY

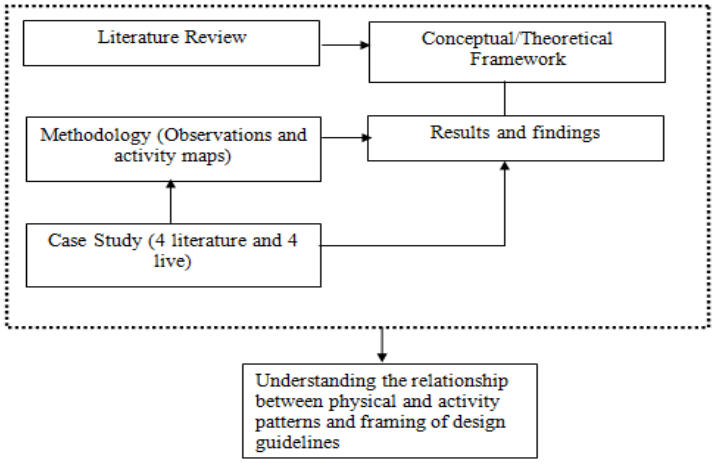

Figure 1. Research Process

Source: Author

Literature review was done firstly to get a theoretical framework for the procedure. Live case studies were done through field observations and activity maps. The results obtained were compiled to frame a set of architectural design guidelines for creating an active street edge.

LITERATURE REVIEW

INTRODUCTION

Principal theories of urban spaces were studied to get clarity on their definition, characteristic importance, values and their relationship with people and place. Based on the principles of activity and physical dimensions of a place, a conceptual theoretical framework for this research will be proposed.

PLACE THEORIES

Place Theories of Canter (1977), Punter (1991) and by Montgomery (1998) were studied initially.It gave an understanding about the place components and the inter-relationships between them.

ACTIVITY PATTERN AND TYPES

Different activity types were noted down for the study based on the studies of Carmona (2010) and Jan Gehl (2010)

PRINCIPLES OF ACTIVITY PATTERN

The following principles of activity pattern were selected to define the study framework based on passive and active engagement types.

Place Components	Principles			
Activity	Types of Activity	Necessary	Active Engagement	Population density
				Pedestrian flows and movements
				Vitality and Diversity
		Optional		People attractors
				Cultural and Social events
		Social	Passive Engagement	people watching
Physical Setting	Density			
	Mixed use			
	Human Scale			
	Permeability			
	Connectivity			
	Imageability and legibility			
	Landmarks			
	Enclosure			
	Complexity			
	Architectural style			

Table 1. Study Framework (Source: Author, 2018).

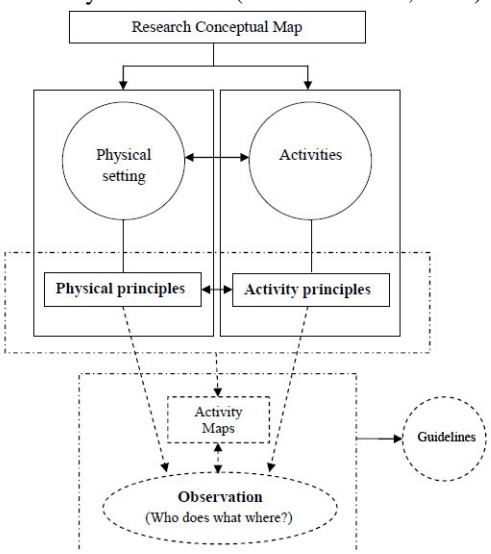

Figure 2. Conceptual framework map
Source :Author, 2018

CASE STUDY SELECTION

4 live case studies have been chosen for the study based on increasing enclosure levels starting from a very high degree of enclosure to a lesser one. The Case studies were analyzed to draw the conclusions and frame a set of design guidelines for creating an active street edge.

LIVE CASE STUDIES

Jew Street, Mattancherry
Princess street, fort kochi
Sector 17 street, Chandigarh
Mall road, Manali

GENERAL OBSERVATIONS, MAPPING AND ANALYSIS

CASE 1: JEW STREET, MATTANCHERRY

Jew Town is the narrow street between Mattanchery Palace and the Pardesi Synagogue.The street edge taken for the study is from the Jew town road to the Pardesi synagogue. Activities observed and the physical quality of the street edges was noted down for the study.

OBSERVATIONS

Main activities noted along the street edge were as follows:

Necessary Activities: Customers looking for goods, articles, items i.e. shopping activities. People visiting synagogue for religious and tourist intentions. Optional Activities: People walking down the street, sitting down on the steps for resting, photographing the place etc. Social Activities: People watching other people, shopkeepers interacting with customers, conversations among people.



Figure 3. Street view showing users activity and schematic street section
Source : Author

PHYSICAL QUALITIES OF THE STREET EDGE

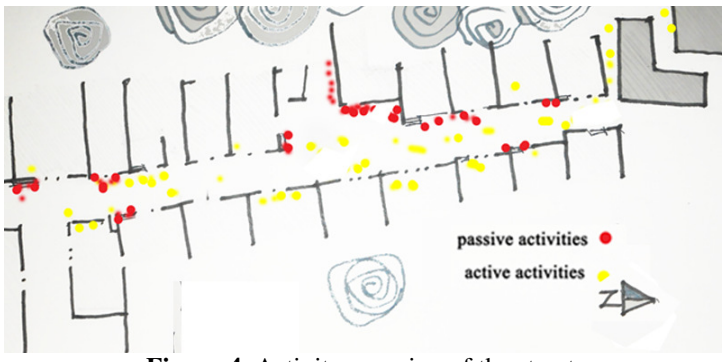

Figure 4. Activity mapping of the street
Source : Author

The Street is built in a human scale of 2:1, giving an enclosure to the street. The steps lining along the shops acted as spaces for resting and communication. The flooring pattern changes as one enters the street from tarred

road to stone flooring. Antiques and other items were displayed outside allowing visual access and improved spatial quality. The street being a completely pedestrian stretch further adds on to the spatial quality.

ANALYSIS

The scale of the street is an important factor in deciding the spatial quality of the street. Flooring or tile patterns, change in colour, texture etc. adds on to the physical quality and helps people relate to the space better. Possibility of encouraging optional and social activities along street edge by means of steps, sidewalk pavements. Visual transparency of the street edge like use of glass facade, multiple opening etc. allows both direct and indirect communications to happen between people-especially between shopkeepers and customers.

CASE 2: PRINCESS STREET, FORT KOCHI - OBSERVATIONS

Princess Street is one of the earliest streets to be constructed in Fort Kochi, Ernakulum.

Main activities noted along the street edge were as follows Necessary Activities: Customers looking for goods, i.e. shopping activities, dining activities along the eateries and side walk cafes. Optional Activities: People walking down the street. Social Activities: People watching other people, shopkeepers interacting with customers, conversations among people near the side walk cafes

PHYSICAL QUALITIES OF THE STREET EDGE

The Street is built in a scale of 1:1, giving a mild level of enclosure to the street. Either side of the street has buildings of European architecture with British, Dutch, Portuguese and French sensibilities. Use of glass façade in the lower portion of the buildings.



Figure 5. Street edge view showing users activities
Source :Author(2016)

ANALYSIS

Outdoor cafes and eateries can markedly increase the level of social and recreational activities. Vertical façade rhythms made walls more interesting and walks appear shorter. Visual transparency encouraged street edge vitality. Narrow units and multiple entry exit points provided many points of exchange in and out. Open windows on the lower and upper floor of the buildings ensured “eyes on the street” [4].

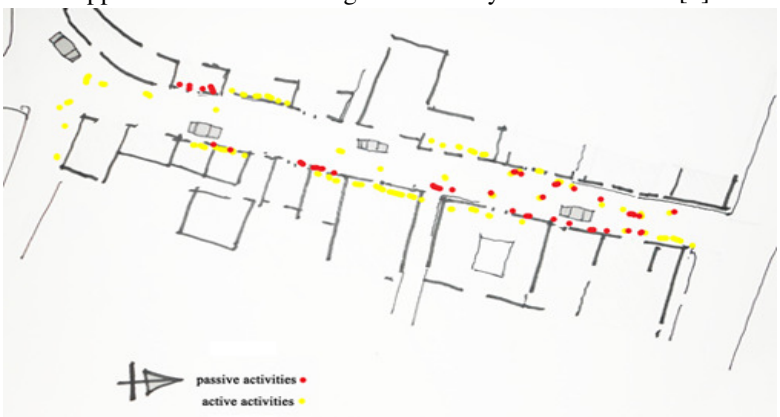

Figure 6. Activity mapping of the street
Source :Author

CASE 3: SECTOR 17, CHANDIGARH

Observations: Main activities noted along the street edge were as follows. Necessary Activities: Customers looking for goods, i.e. shopping activities. Optional Activities: People walking down the street, sitting on the benches. Social Activities: Conversations among people, gatherings etc.



Figure 7. Street edge view showing users activities
Source : Author

PHYSICAL QUALITIES OF THE STREET EDGE

The Street is built in a scale of 1:1.5, giving a lesser level of enclosure to the street. Tree lined avenues; street furniture, changing floor patterns gives some level of physical quality to the street edge. Monotonous building façade.

ANALYSIS

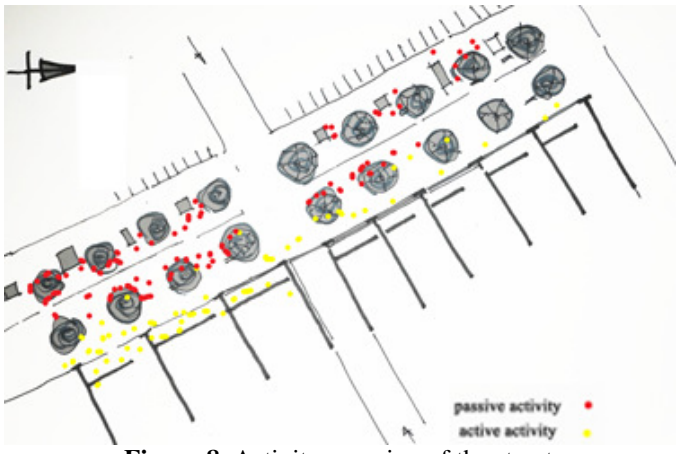

Figure 8. Activity mapping of the street
Source : Author

Presence of street furniture, paving, vegetation etc. adds on to the spatial quality of the street edges. Vertical articulation of building façade helps break down the scale. Scale confusion is created due to the larger scale of the building façade [5]. Activities being differentiated make the setting appear dull and boring.

CASE 4: MALL ROAD, MANALI, OBSERVATIONS

Main activities noted along the street edge were as follows: Necessary Activities: Customers looking for goods, i.e. shopping activities. Optional Activities: People walking down the street, sitting on the benches, steps. Social Activities: People watching other people, Conversations among people, gatherings etc.



Figure 9. Street edge and user activities, Mall road Manali
Source : Author

PHYSICAL QUALITIES OF THE STREET EDGE

The Street is built in a scale of 1:2, giving a very less level of enclosure to the street. Continuous variety in the architectural character. Street furniture, changing patterns of tile flooring, level differences etc added to the physical quality of the street edge. Inbuilt seating space for recreation , Paved interlocks cement blocks, Shrubs planted along the center line of the street.

ANALYSIS

Seating and supplementary devices incresed the staying activites along the street. Changing patterns of flooring encouraged walking along the street edge. The fully pedestrianised street stretch helped in making the street a self inviting street for the visitors.



Figure 10. Activity mapping of the street
Source : Author

STREET	SCALE/ENCLOSURE	ELEVATION	INTENSITY OF ACTIVITY
1)Jew street,Mattancherry 	2:1 		• Activities are more warm and intense • Sense of Intimacy created by enclosure • Informal activities are more • Vibrant and interesting
2)Princess street,Fort Kochi 	1:1 		• Activities are cool and less intense • Vibrant and interesting
3)Sector 17,Chandigarh 	1:1.5 		• Activities are cool and less intense • Activities are more formal • Dull and boring
3)Mall road,Manali 	1:2 		• Activities are more warm and intense • Informal activities are more • Vibrant and interesting

Table 2. Comparitive chart
Source :Author

PARAMETERS	JEW STREET	PRINCESS STREET	SECTOR 17	MALL ROAD
DENSITY	Medium level	Low level	Low to high depending upon time of day	Very high –all times of the day
MIXED USE	Commercial and residential	Commercial and residential	Only commercial	Commercial and residential
PERMEABILITY	Both physical and visual	Both physical and visual	Both physical and visual	Both physical and permeable
CONNECTIVITY	In and out	At the road ends	From all sides	In and out
IMAGEABILITY& LEGIBILITY	Jewish synagogue and the setting	The street edge and the vegetation	Lack of imageable element.Visual scale dominates.	The setting, mountains, etc.
ENCLOSURE	Highly enclosed	Medium enclosure	Low level	Low level but the ambience makes it an enclosed space.
ARCHITECTURAL STYLE	Mix of traditional kerala with colonial influence.	Colonial Dutch British style	Monotonous contemporary style	Diverse style from vernacular to contemporary.

Table 3. Compartive analysis with research parameters (Source-Author)

FINDINGS AND INFERENCES

In all the four cases Scale proved to be a crucial factor in deciding the activity types along the street stretch. Greater enclosure levels responded well to the human scale (case 1, 2). In case 3 and 4 avenue planting, lamp posts, vertical articulation helped in breaking down the scale. In case 3 the outdoor paved area are frequented by lesser people due to scale confusion. Visual transparency along the ground floors by means of glass facade, multiple entry- exit points supplemented staying activities. Variety in flooring patterns and changing them at regular intervals made the walks along the edges interesting. Outdoor cafes (as in case 2), street vendors (case 4) encouraged the recreational and staying activities along the edges. In case 3 there was a clear cut demarcation between the necessary activities and optional/recreational one whereas in case 4 it wasn't. The case 4 street appears to be a more active street when compared to case 3. People generally preferred to stay in those areas where people are. Demarcation between activities can make the street appear boring (case 3).

GUIDELINES FOR AN ACTIVE STREET EDGE

Vertical façade articulation- Architecturally articulating the street façade by means of cornices, details, textures, colours etc. i.e bringing a continuous variety in detailing.

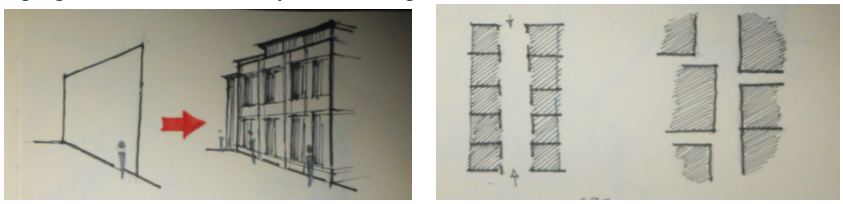

Figure 11. Facade and Configuration; Source-Author

Multiple entry-exit points along the ground floor-Increasing the visual transparency and encouraging permeability at an eye level. Changing patterns of flooring along the street. The flooring pattern along a particular street stretch should be such that it should be able to accommodate different user groups. Strip pattern for individual users and wider pattern for grouped users.

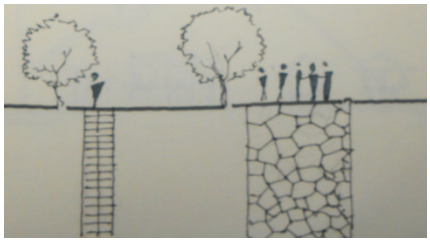

Figure 12. Street furniture Source- Author

Provision of street furniture-railings, seats, sculptures, lamp posts etc. The street furniture used at a particular street stretch shall be uniform in character and design and should enhance the authenticity of the place.

- Avenue planting, lamp posts etc for larger scale streets.
- Encouraging mixed use in streets with ground floor commercial and upper residential.
- Provisions of Side walk cafes and proper allocation of street vendor units.
- Encouraging pedestrianized Commercial Street stretches.
- Lighting of the streets should be designed in such a manner so as to ensure that there is no glare or light spilling onto the surrounding areas.
- Incorporate visual elements that engage all types of user groups both young and the elderly.

Contemporary design practices should not affect the authenticity and the heritage value of a particular street.

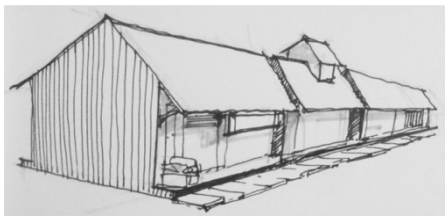

Figure 13. Fascade design; Source- Author

Blank street façade can be made interesting by employing street art that can serve to interpret the historic or the cultural importance of a particular area.
Locate street furniture and other outdoor accessories so that they will not hinder the pedestrian route.

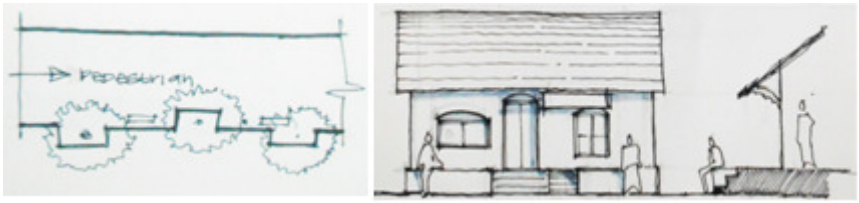

Figure 14. Street Frontages ; Source - Author

Signages to commercial buildings should not undermine the historic character of the building.
Street furniture like benches etc should face that side of the street where human activity happens

CONCLUSION

Active streets with soft edges have a significant influence on the activity patterns and the attractiveness of the city space. The aim was to study such active street edges and to find out the relationship between the physical quality of the street edges and the diversity of outdoor activities. The results have showed that an increase in the physical quality of the street edge results in an increase in the amount of social and recreational activities. Encouraging different user groups to stay along the street edges by converting such streets into pedestrianized streets has increased the staying activities. Design diversity attracts higher number of people to a particular street and increased the potential for passive activities. The scale of the street and the enclosure levels directly affects the kind of activity happening there. The number of people using the street is not a major parameter in deciding the street quality. The results can be used to devise planning strategies for active streets in future.

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A study on indoor air quality of naturally ventilated classrooms in NIT-Trichy

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Abstract: The study discusses and analyses exposure to carbon dioxide and particulate matter in the naturally ventilated classroom spaces of NIT-Trichy. Real time monitoring of IAQ during winter is held and perceived air quality is understood and compared against prescribed standards for analysis. The air movements inside classrooms were studied and relationship between opening configuration and pollutant concentration with respect to the relative time spent in the environment were infered. The rates were found within the permissible rate at 50% occupancy of classrooms which indicates the potential to cross acceptable limits under unfavorable outdoor conditions.

Keywords: IAQ; Classrooms; Carbon dioxide and Particulate matter

INTRODUCTION

In today's world, people spend most of their times indoors in various micro environments. Human health and comfort is largely dependent on the property of air existing indoors because the duration of exposure associated with it has considerable effects on performance and well being. According to the World Health Report (2002), deteriorative air stands causes 2.7 % of the total ailments over the world. In India, an estimated half a million women and children die of air pollution indoors every year. India's student population with age between 18-23 is 1,41,537 pupils in 51793 higher education institutions under MHRD. (MHRD 2015) Chakravarthy, S., et al. (2002) reported that of the 855 children that was studied in urban and rural Tamilnadu, 18% were identified with respiratory trouble (including asthma) while only 5% were ' diagnosed' asthma. Particulate matter is elemental in causing asthma. Outdoor air quality seemed to get considerable attention and identification in studies while that of indoors had far less recognition in terms of the necessity to be studied, at least until last decade. Unacceptable levels of indoor air quality can be particularly damaging to sensitive groups like infants and juveniles, the aged and those with heart and blood vessel and pulmonary issues like asthma. While there are reports on IAQ of office spaces and academic spaces, there are not many studies on the same. (Datta, A., (2017))

BACKGROUND

Inhalation is the major route of exposure to indoor air pollutants. (Chithra, V.S., Nagendra S.M.S., (2012)) Good IAQ contributes to a beneficial student environment as well as teaching and non-teaching staff performance along with adding a sense of comfort and wellbeing. These elements help any institution in its core purpose– education for students (EPA). United States Environmental Protection Agecy (EPA) states that understanding and controlling common indoor contaminants can lower the risk of indoor health problems, as adverse effects from indoor air pollutants can shoot up fairly short after encounter and/or, potentially, anytime during the lifespan. Occasionally, investigations of human encounter with air pollutants indicate that indoor levels of pollutants may be two to five times (and occasionally more than 100 times) higher than outdoor levels. These levels of indoor air pollutants are of particular concern because most people spend about 90 percent of their time indoors. This study aims at analyzing the conditions in naturally ventilated lecture halls of Lecture Hall Complex inside the National Institute of Technology, Trichy campus. The intent of the investigation is to examine the grade of indoor air in the specified classrooms and to quantify the presence and accumulation of pollutants attributed by occupancy in lecture halls.

EXISTING LITERATURE

VENTILATION

Natural forces such as winds and thermal buoyancy force propel external air across openings carefully constructed for the same. Air, given the disparity in internal and external air density, building envelope apertures such as windows, entrances, wind towers, etc. resulting in ventilation. (NCBI, 2009) Wind driven (wind-

induced) cross ventilation occurs with pressure difference at windward and leeward side. Clements-Croome, D.J., et al, (2008) note that the fundamental components of ventilation inside a structure are (1) ventilation rate, the proportion of external air let inside the volume, as well as its quality, (2) airflow direction, the comprehensive air administration pattern in a building, typically from dirt-free stretch to unclean spaces, (3) air distribution or airflow pattern, ensuring that outdoor air is distributed indoors efficiently and the airborne contaminant generated indoor is removed effectively.

INDOOR AIR QUALITY

The quality of indoor air (IAQ) draws attention to the grade of air both inside and surrounding buildings and structures particularly emphasizing on wellness and comfort of the structure's inhabitants. (US EPA) Good indoor air quality (IAQ) management includes not only air-borne pollutant control but also administration and supply of sufficient exterior air and establishing admissible temperatures and relative humidity. Delivering external air to each part of the space efficiently along with removing airborne pollutants generated indoor in an efficient manner ensures acceptable indoor air quality. (NCBI (2009)). Chithra, V.S., Nagendra S.M.S., (2012) attained a negative linear association of pollutant gathering structure with wind velocity. Scattering occurred with higher wind movement, thinning the surrounding accumulation, in turn steadily reducing the internal levels of concentration.

Efforts to avert or react swiftly to indoor air quality issues can eventually lead to immediate and longer-term health issues for students and faculty such as cough, irritated eyes, headache, and hypersensitivity and, in much more atypical instances, hazardous situations like Legionnaire's disease or carbon monoxide poisoning (EPA). Those particularly ill-protected to the effects of indoor air pollutants are people with asthma, allergies or chemical sensitivities, respiratory diseases, suppressed immune systems (due to radiation, chemotherapy or disease) and contact lenses (EPA). Declined comfort as well as efficiency of building users that triggers absenteeism and concentration loss is to be tagged on poor quality of indoor air (Chithra, V.S., Nagendra S.M.S., (2012)).

EDUCATIONAL BUILDINGS

Theodosiou, T.G., and Ordoumpozanis, K.T., (2008) state that due to high classroom occupancy density (in close proximity to 1.8 m2/pupil) during working hours, there is an enhanced ventilation necessity and visual environmental standards to guarantee a surrounding that can ensure good mental and health conditions. The quality of the air in classes is of particular concern to students, especially to those who are sensitive to poor air quality (Jurado, S.R., et al. 2014). Norback, D., et al. (1990) investigated and established the link between VOCs, respirable dust, and personal factors for sick building syndrome (SBS) extensiveness and occurrence in six elementary schools. On an average presence of CO2 in all fields overshot 800 ppm, indicative of deficiency in ventilation along with insufficiency in air supply. While the indoor VOC concentration increased at high room temperatures, lower ventilation and high air humidity levels enhanced respiratory dust. Dijken, F.V., et al. (2005) indicated poor IAQ in schools with CO2 levels being all above 1000 ppm in 10 out of 11 classrooms studied. CO2 rates exceeded 4000 ppm and ventilation rates were found to be below 0.5 l/s per person in investigations conducted in schools in the United Kingdom by Coley, D.A, Beisteiner, (2002). Chithra, V.S., Nagendra S.M.S., (2012) found that during periods of occupancy of the classroom PM accumulation were substantially on a higher note than that during periods of vacancy. Human activity may have been an important component in the level of coarse particles, since no considerable indoor source for particulate emissions existed (smoking, cooking). In the classrooms, PM concentrations were mostly on the upper hand than reported national ambient standard for air quality. J.M., Daisey, et al. (2003) suggests strong positive associations between CO2 mixing ratio and ventilation level in classrooms in an educational centre in the US where asthma and 'sick building syndrome' were reported.

POLLUTANT CLASSIFICATION

The level of carbon dioxide found indoors is a frequently used method, referred to as an IAQ indicator for inefficient ventilation systems (Lin and Deng, 2003). CPCB (2010) identifies particulates (PM) as a crucial indicator of pollution in most Indian cities. Coarser (>PM10) concentrations of suspended particulate matter (SPM) are chiefly irritants and may not have direct effects on human health. High PM exposure was found to be linked with increased death rates along with mentionable respiratory issues (WHO, 2003) Major sources of the above identified pollutants are unpaved roads, ground, road dust, construction work, bakeries, hotels open eat-

outs, vehicular exhaust and other emissions, along with occupational density of spaces and respiration henceforth.

CLIMATE

LOCATION

The location can be categorized under warm-humid zone. The location, Tiruchirapalli (10°46′N, 78°43′E, 88 m AMSL), is in the state of Tamilnadu, India, by the National Building Code of India 2005. The months of October to November have highest wind speed with North-East monsoon occurring during the months of September to November.

CLIMATE DATA

The average outdoor wind speed at the location is 7 m/s- 8.5 m/s blowing from ENE and WNW. The study was conducted in the month of November where the average wind speed is 8 m/s.

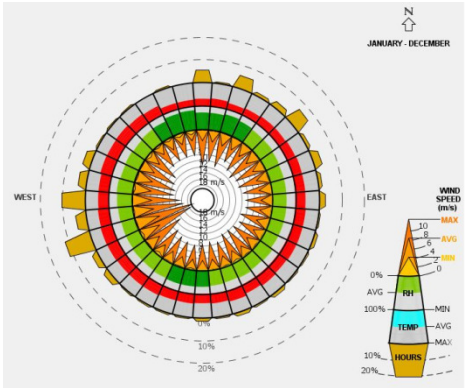


Figure1. Annual wind-rose diagram, Trichy
Source: Climate Consultant 6.0

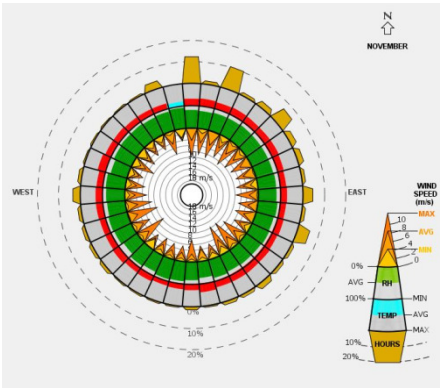


Figure2. Wind-rose for the month of November, Trichy
Source: Climate Consultant 6.0

BUILDING

The building, due to its distinct shape, has rooms spread out in various directions along with a large central courtyard. This, however, ensures better wind movement through all of the classrooms with minimal obstruction. The highlighted classroom which are on different floors of the building were taken for this particular study predominantly considering its orientation.

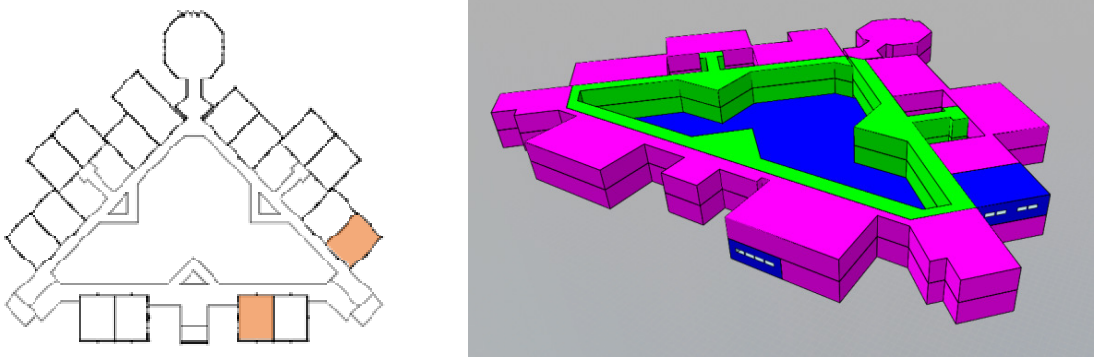


Figure3. Lecture halls selected for the study in plan
Source: Author, 2018

CASESTUDY

BUILDING

Lecture Hall Complex of NITT campus was selected for the purpose of study considering the non conditioned space with working plane height at 0.75m. Even though the operable area for each window is 0.9 m2, the window panes are mostly jammed leaving an effective operable area of less than 40% of actual operable area by design. The typical layout of the lecture hall with position of lights and fans has been marked with the points at which the readings were taken. The classrooms are typically occupied from 8.30 AM to 4.50 PM with an hour's break for lunch and 10 mins each after first two hours in the forenoon and afternoon. Once occupied, the occupancy pattern doesn't change much as students are seated throughout the lectures.

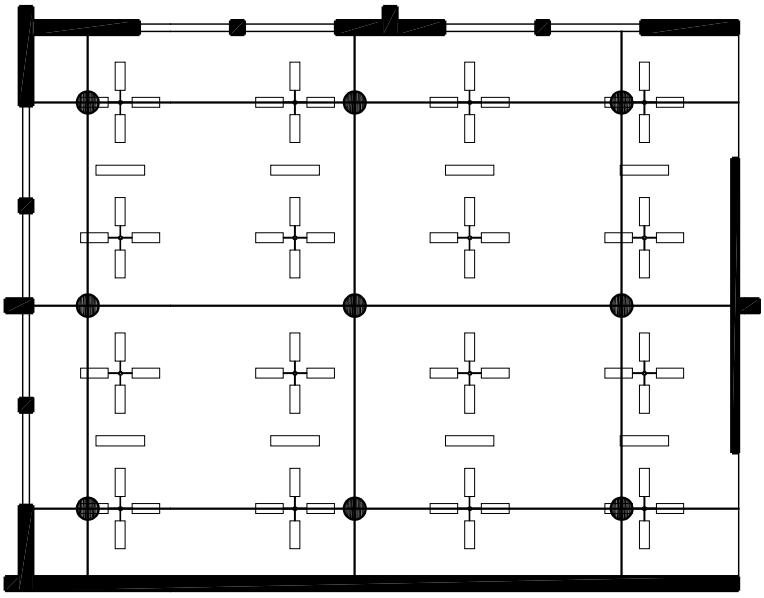


Figure4. Typical layout of a lecture hall with position of lights and fan along with the 9 various points at which measurements were taken
Source: Author, 2018

Table1. Quantitative data of two lecture halls (Source: Author, 2018)

Specifications	Lecture hall Ground floor	Lecture hall First floor
Occupancy (Vs Max)	28 (80)	35 (80)
Area	100.32	100.32
Volume	331.06	331.06
Area of openings	2.7 m2	2.7 m2
Operable area	0.9 m2	0.9 m2

STANDARDS REGARDING POLLUTANT CONCENTRATION

CO2

Concentration of CO2 provides good indication of occupational density along with ventilation rates, for indoor CO2 is predominantly generated mostly by human metabolism. Indoor CO2 build up is attributed to inefficient or unreliable ventilation system operation. Further, building shows symptoms of SBS if the CO2 concentration exceeds 1000 ppm, upper permissible limits being 800 ppm.

PARTICULATE MATTER (PM2.5, PM10)

Standards for particles with a nominal aerodynamic diameter > 2.5 µm and </= 10 µm (PM10- PM2.5) is as follows. Particles that are less than or equal to 2.5 µm are called PM 2.5, which is a sign of fine particles, has a concentration limit of 15 µg/m3 . PM10 , thoracic coarse particles or coarse-fraction particle, has 50 µg/m3 as the permissible limit (National Ambient Air Quality Standards (NAAQS). The minimum ventilation rate in the breating zones as per NBC 2005 states outdoor air rate, Rp, of 7.5 cfm/person or 3.8 l/s-person

WIND SPEED

The minimum wind speed for desirable indoor comfort and efficient ventilation is 0.2 m/s while the maximum comfortable speed is 1.5 m/s. The average wind speed during study was around 0.2 m/s- 1.2 m/s blowing at an angle of 125˚ to 140 ˚ from normal.

FIELD SURVEY

QUANTITATIVE STUDY

To arrive at an understanding, the actual as well as perceived IAQ is assessed and the impact of openings in achieving recommended IAQ is explored through simulation. By assessing evaluated indoor air quality of classrooms against prescribed standards, the influence of openings as well as influence of fans in achieving IAQ is studied. Readings were taken in the two different lecture halls before and few hours after the spaces were occupied. At both times, reading were taken with fans switched on as well as switched off for proper study. Hand-held Indoor Air Quality monitor (IAQ 3007R) by Rave Innovations which measures PM10, PM 2.5 and CO2 concentrations simultaneously was used. Simultaneously, using anemometer wind speed was measured in various points denoted.



Figure5. Image of an IAQ monitor (IAQ 3007R)
Source: RAVE INNOVATIONS, 2018



Figure6. Lecture hall in the ground floor

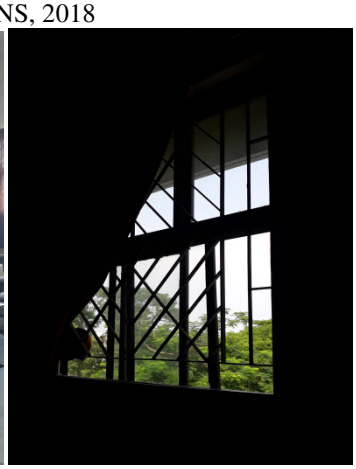


Figure7. Typical opening configuration of windows
Source: Author, 2018

The readings for L I (Ground floor) were taken in the morning soon after the halls were opened for lectures, before being occupied and 2.5 hrs after being occupied. The reading for L II was also taken once in the morning, before the space was occupied and after wards, when the space has been occupied for 3 hours. The points of measurement were taken considering the occupancy pattern of class as well as the distance of each point from the indoor air source, i.e., the windows and fans. However, the days preceding that of study saw unusual storm

which is estimated to have cleaned up or settled outdoor dust resulting in influencing the pollutant concentration. Similarly, wind data measured had strong deviation from the projected weather data. The study has helped analyses the role of fans in inducing desirable wind movement inside the space even though supply of outdoor air was less.



Figure 8. Jammed window panes blocking air inlet
Source: Author, 2018



Figure 9. Lecture hall in the first floor
Source: Author, 2018

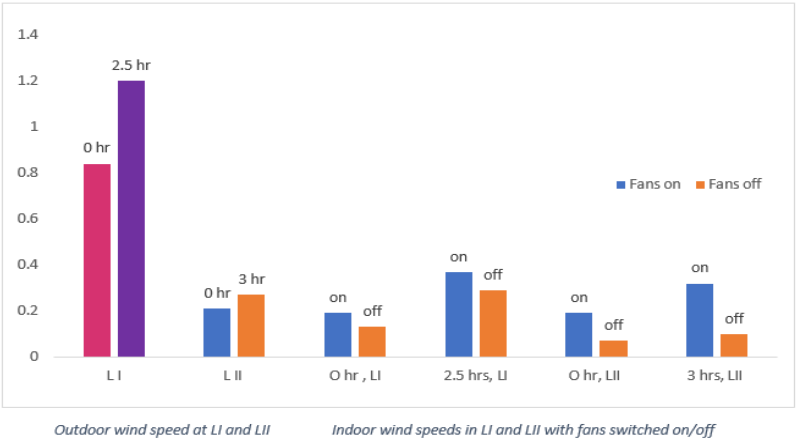


Figure10. Outdoor as well as indoor wind data measured at both lecture halls with fan switch on/off
Source: Author, 2018

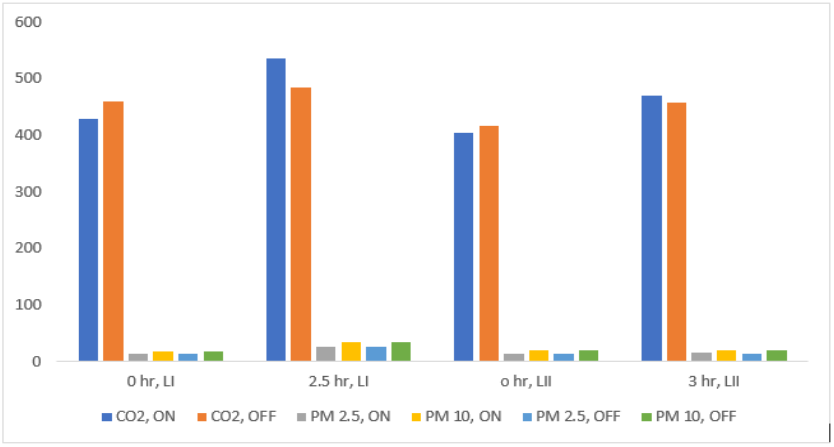
Table2. Equations to arrive at various IAQ parameters, Source: Minimum standards of ventilation for residential buildings

Volumetric flow rate of fresh air through the room is calculated using	ACPH, Air change per hour	Ventilation rate per person is calculated using
$Q = E \times A \times Vwin$	$N = 3600 \times q/Vol$	$Rp = (ACPH \times D \times H)/60$
where, Q = Volumetric flow rate of fresh air through the room (CFM) E = Effectiveness coefficient of openings with values between 0 and 1 (E = 0.5–0.6 for perpendicular winds and 0.25–0.35 for diagonal winds) A = Area of inlet openings in sq.ft; Vwin = Wind velocity in ft/min	where, N= Number of Air changes per hour (ACPH) q = Q = Volumetric flow of fresh air through the room Vol = volume of the room (cu.ft)	where, Rp = Ventilation rate per person (CFM per person, L/S per person) ACPH = Number of air changes per hour D = Occupant density H = ceiling height (ft)

The ventilation rate achieved with the particulars pertaining to the lecture halls signified major inefficiency. The ventilation rates arrived at through calculation was less than 0.1 at all conditions. The desired number of air changes per hour was not achieved in any of the cases under both the lecture halls. Readings from the instruments indicate pollutant concentration which is well within the limits. Relationship for the indoor and outdoor concentration of gaseous pollutants is given by

Indoor concentration = Outdoor concentration + (Pollutant generation rate/ Ventilation flow rate) (NCBI, 2009) which implies, with higher outdoor concentration, higher is the indoor concentration. Also, it indicates higher ventilation rate would imply lower indoor concentration with respect to generation rate. However, with a

measured outdoor wind speed of 0.2 m/s to 1.2m/s, it could be said that neither the orientation not the configuration of openings of the study spaces, due to various mentioned reasons, were suitable to let in enough outdoor air as well as perform as efficiently as anticipated in ensuring good ventilation. The indoor air velocity readings fell short of the desired limits by a large margin.



ON: Fans ON; OFF: Fans OFF; CO2: Carbon dioxide; PM 2.5, PM 10: Particulate matter of size 2.5-10

Figure11. Pollutant level trends chart indicating CO2, PM2.5, PM 10
Source: Author, 2018

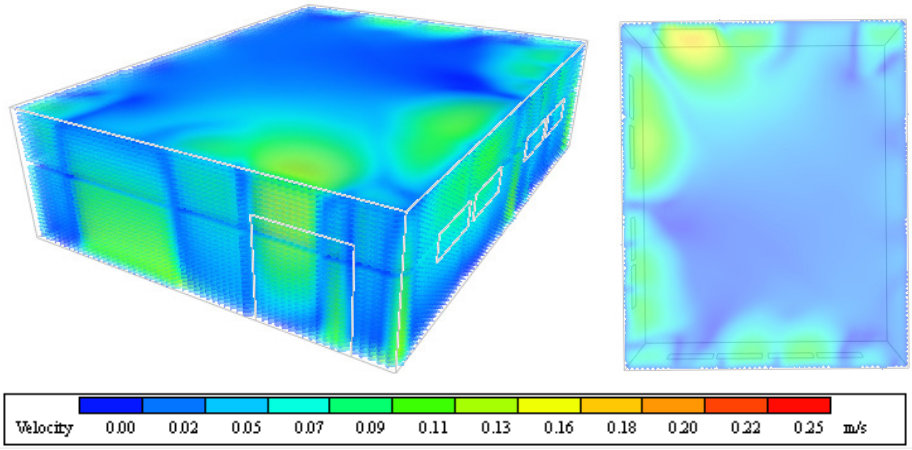


Figure 12. Plot of wind velocity, Ground Floor lecture hall and First Floor lecture hall respectively
Source: Author, 2018

The plot of particle tracking traces the movement of contaminants and particles inside the lecture hall. The plot shows settling of particles towards the centre of the hall effectively validating the measured data as well. It was found that the concentration of pollutants were higher towards the centre as compared to the other measurement points inside the class.

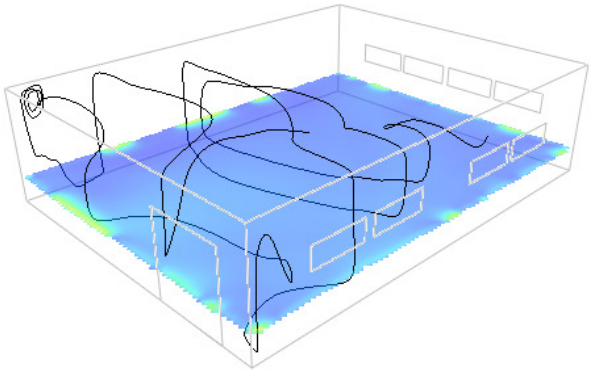


Figure 13. Plot of particle tracking in the lecture hall on first floor
Source: Author, 2018

SUBJECTIVE STUDY

The perceived levels of comfort in an environment are as important as the actual/measured data on variables. The sense of control one has over a space largely influences their perception of comfort. Freedom to open/close window shutters, control over the speed of air movement by switching ceiling fans on/off, air movement preferences, health and comfort etc. were questioned with the help of a Likert 5 point scale questionnaire. From the survey, it was found that 100% of the population found fans desirable while inside the hall at any given time and 60% found the prevailing indoor wind speed as well as the comfort levels as lower than desired. While asked, 20% of the sample ascribed lack of comfort to poor air quality. 50% of the sample suggested improper ventilation rates of which, 10% had difficulty in concentrating during lectures and that the symptoms prevailed for few days. 10% of the population had irritated eyes which lasted for few hours from period of occupancy, of which 100% ascribed the causative as dusty indoors. Of the 80% who recognized windows as operable, only 50% had made any effort in the past to optimize openings to suit the necessity while 35% had never tried moving the panes. However, 70% of the sample size preferred open windows to closed while 60% of the total sample would rather have the curtains pulled at all times. This could be due to hindrance in thermal or visual comfort.

CONCLUSION

The study aimed at analyzing the indoor air quality of two comparable naturally ventilated lecture halls varying only in levels and orientations. It was found that even though the outdoor wind speed was high, desired wind speeds were not achieved indoors in either of the class rooms. While the hand held instruments denoted pollutant concentration within the permissible limits, even with all the fans working in full blast, more than one indoor reading point indicated no wind movement inside lecture halls. This is of particular concern with students spending a good share of daily routine in this indoor environment. Deserving attention has to be given to this issue in order for this environment to fruitfully cater to its prime function of arranging for a healthy learning environment. An immediate solution to this situation could be improving the functionality of the openings by removing any obstruction on designed operable area and utilizing the operable area to full potential.

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Study of natural ventilation in a residential apartment on windows and openings based on CFD

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Abstract: Natural ventilation significantly improves thermal comfort in the hot and humid climate. By using computational fluid dynamics, wind flow can be simulated to accurately design spaces that provide the required flow and velocity. This study is on the improvement of indoor conditions by optimizing the window and opening design for natural ventilation in residential apartments. The case study is on an apartment complex at TNNLU, near Dindigul, Tamil Nadu which is a hot and humid climate. The case is checked for the need for natural ventilation duration of the year and CFD simulation of air movement due to natural wind outside is compared with various changes in window type and opening to know the average wind velocity in major spaces like Living, bedroom, kitchen. First measurements of air velocity, temperature, the relative humidity inside and wind velocity are measured outside to get boundary conditions. Realizable k–ε turbulence model is used for solving the steady-state pressure based numerical simulation with Ansys Fluent 19.2. After those simulations of different options of window type, size and spacing are carried out and results are compared to recommend the best option for natural ventilation for a single unit of an apartment

Keywords: natural ventilation, windows, CFD, passive cooling

INTRODUCTION

Human beings spend most of their lives indoors and residential spaces take the major portion of it. Today most of the new residential buildings are moving towards multi-storied apartments. High-density residential construction will lead to the deterioration of residential wind environment, thereby resulting in wind currents, wind shadow areas, poor ventilation, and other adverse weather conditions, which considerably affect the thermal comfort of people.

Utilization of natural ventilation to provide proper cross ventilation will lead to a reduction in power consumption. As air-conditioning technology has advanced from 1902 and AC systems became commercially viable among a large population of middle-income group, today's architectural design approaches tend to encourage sealed indoor areas that seldom open towards the outside surroundings. The design approach has changed in a way that will lead to poor air quality, increased cooling load, and increased use of artificial means to achieve comfort.

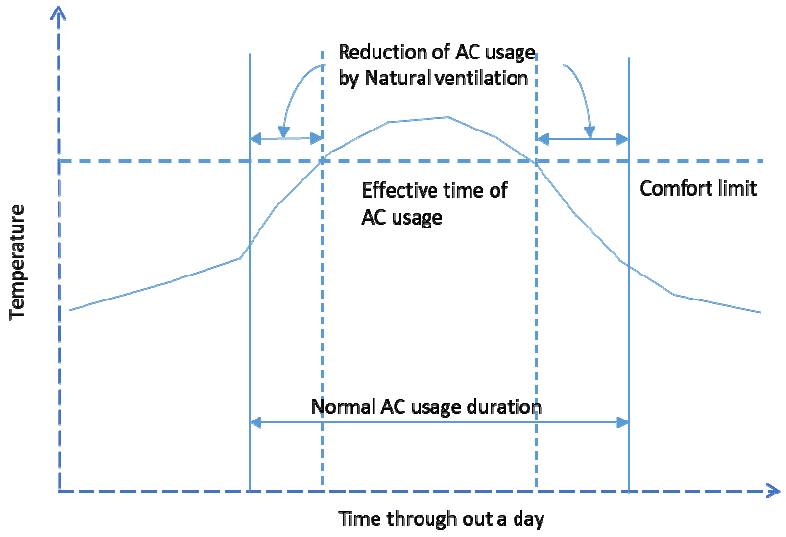

Figure 1. Relation between natural ventilation and AC usage
(Source: Francis W.H. Yik Yu Fat Lun, 2009)

The two dominant drivers causing natural ventilation (or air movement) flows are buoyancy and wind. Stack ventilation uses buoyancy while single sided and cross ventilation uses wind velocity. Design for natural ventilation involves many factors, like regional climate (monthly average wind velocity and wind direction), site layout (massing of the building, orientation, and zoning), and space planning (shape of the room, size of openings, location, window type).

Studies have found out that that there is significant relation between wind and layout, form, the direction of buildings. A staggered layout leads to better air movement in interior spaces but a macro level study on the influence of surrounding buildings on exterior wind movement pattern and velocity. Implementation of wind velocity from the CFD results to the interior level energy modeling will lead to more accurate prediction of Indoor wind environment and occupant thermal comfort. This project involves simulation of residential high-rise buildings to find indoor wind environment, using the pressure coefficients on the facade. Natural ventilation can support thermal comfort and reduces the AC usage period even in a harsh hot humid climate (figure 1).

Literature study

Kang, Ki-Nam Song et al, (2013) identified from measured factors for natural: a-T, RH, g-T and wind velocity. Based on correlation statistical analysis with user comfort voting, wind velocity showed the greatest relationship. The subject felt more comfortable with the wind at 0.41 m/s velocity.

Wang et al, (2007) said that factors like opening sizes, building, and opening orientation, shading elements play a major role in design for hot and humid climatic regions. Y.W.Fung et al (2014), studied 5 parameters of ventilation mode, window type, orientation, WWR and area of space. Natural ventilation performance (cross or single-sided ventilation) represented by MAA (mean age of air), is most affected by the change in ventilation mode from single-sided to cross ventilation.

Chaobin Zhoua et al, (2014), devised three-levels of design approach, block level(orientation and space), building plan level(corridor, common space), and unit level(openings-size, spacing) to achieve better natural ventilation. The optimized design by introducing wind corridors showed improvement in AA of less than 6 min for 90% of floor area compared to 30 mins for 50% conventional design floor area. Abdelsalam Aldawoud, (2016). Made modifications for various models in terms of WWR of inlets and outlets to find effective design type of window which performed well in cross ventilation. The Author also found that the wind velocity is directly proportional to the size of inlets and outlets. He found narrow inlet and large outlet as the most effective design. The studies showed that wind can be used to increase comfort levels. In this paper, factors like window size, spacing for a single flat will be varied to find the optimum setting for natural ventilation in terms of wind velocity, cross ventilation and uniform flow of wind.

METHOD

This study uses field measurement of wind velocities inside the flats, outside measurements of wind velocity and direction and CFD simulation which uses ANSYS Fluent 19.2 software. The field measurement is compared with the CFD simulation to validate the results. This study focuses only on wind driven ventilation and not on buoyancy driven. The results are also compared with alternatives of different window types. The opening size of windows is changed to know which will be suitable for enhanced wind velocity inside the livable spaces.

Field measurement

The case study was done on stilt + five-floor multi-story apartment in Tamil Nadu National Law University, Tiruchirappalli, 10.74°N, 78.59°E. The climate is hot and humid. The measurement was taken on November 21st and it was selected to cross-compare with the simulation results only. Hotwire anemometers which had the resolution of 0.01 & accuracy of ±3% reading +1.6% FS for wind velocity and resolution of 0.1 & accuracy of ±1 C for temperature was used to find the wind velocity, air temperature along with a handmade wind vane to find direction of wind also with the live weather data for accuracy.

The block E was selected among 6 to conduct the field measurement. The block was chosen because the wind was blowing from the North direction and it will be able to measure the outdoor measurement at respective height. The measurements were taken on floors 1, 3, and 5. The flat 6 on the 3rd floor is selected as representative for comparison. Also, average wind velocity due to atmospheric boundary layer will be achieved on the middle floors. This is important because the meteorological data take average wind velocity at the 10m

height of unobstructed area which will be used for simulation purpose. Also, the meteorological station is around the 15km radius. The measurements were taken at Centre of the room at 4 points per room and an averaged was used to compare with simulation. The readings were taken 1.5m above finished floor level. During recording all the doors except toilets were open and all the windows where open. The windows were sliding

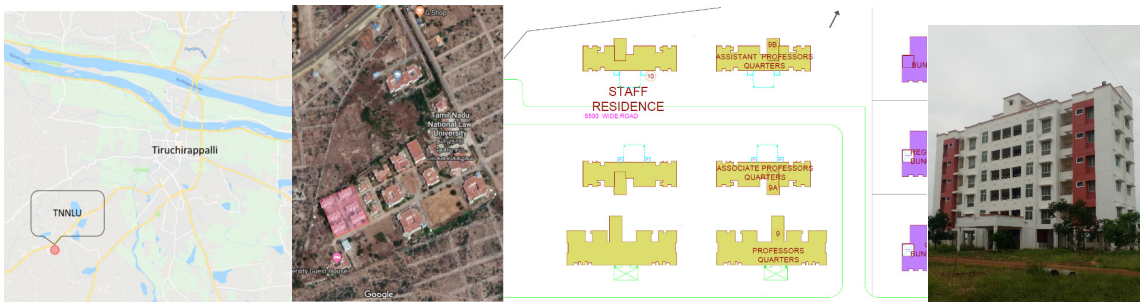

Figure 2&3. Key plan, Site, selected building for the study
(Source: Google maps, TNNLU,2018)

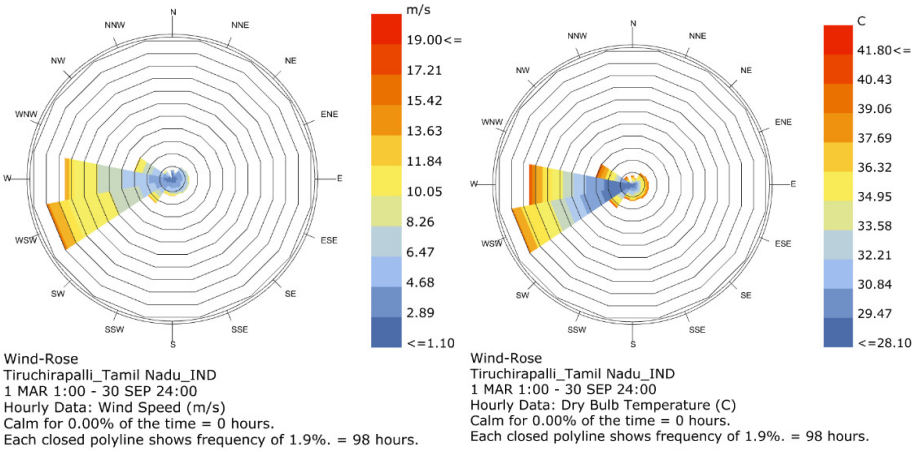

Figure 4. Wind rose analysis with conditions greater than 28□C

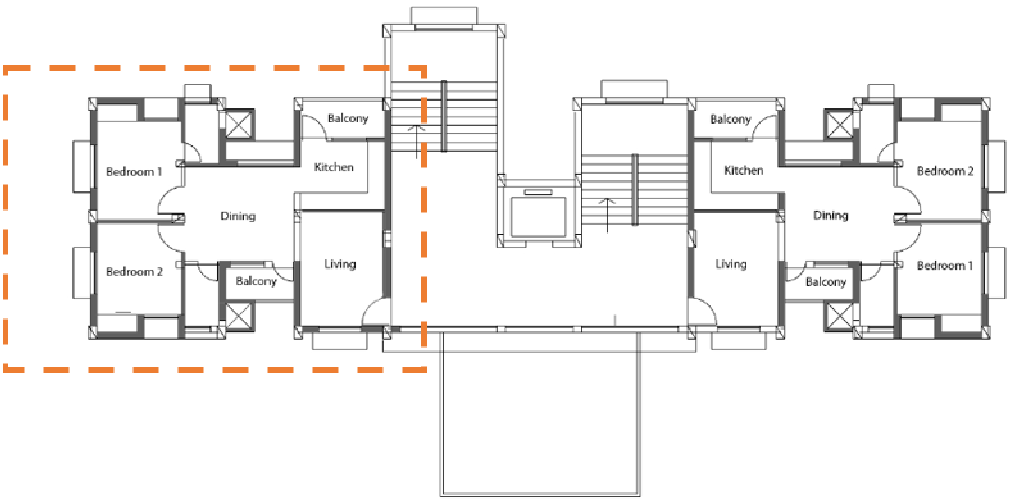

Figure 5. Building Plan
(Source: epw file from ISHRAE and analysis from Grasshopper, honey bee)

type with two panes for 1200*1300 and three panes for 1500*1300 & other bigger sizes.

Annual wind condition

The natural ventilation in terms of wind-driven mode mainly depends on the predominant wind direction and velocity at the location and the performance of the ventilation in apartments can change based on the time, day and season. So annual weather data has been analyzed to know first when natural ventilation mode can be utilized for thermal comfort of occupants. The NBC 2016 states that occupant is comfortable indoors up to 28°C with no or low wind movement. The weather file has been analyzed using honeybee software. In that conditional statement was set to show the wind rose diagram of Tiruchirappalli when dry bulb temperature goes above 28°C. Also, wind velocity beyond 1m/s was considered since lower outdoor velocity won't be helpful for wind driven ventilation indoors.

CFD model

Based on several literature studies realizable k-ε model has been chosen for this wind simulation since it produced better results in terms of accuracy with robust calculations. Ansys 19.2 fluent was used for simulation. The model was designed using Space Claim. First, a model with effective openings due to sliding windows was created with all doors except toilets was created and another model with the assumption of casement window as created with larger openings. The first model will be verified with the measurements.

Boundary conditions: The windward distance and leeward distance were set as 5H and 10H from the model for the domain. The height was set 6H and the sideward gap was set as 3H (H is the height of the model). The mesh settings were set as minimum element size of 0.2m and mesh model was based on the proximity of model detail.

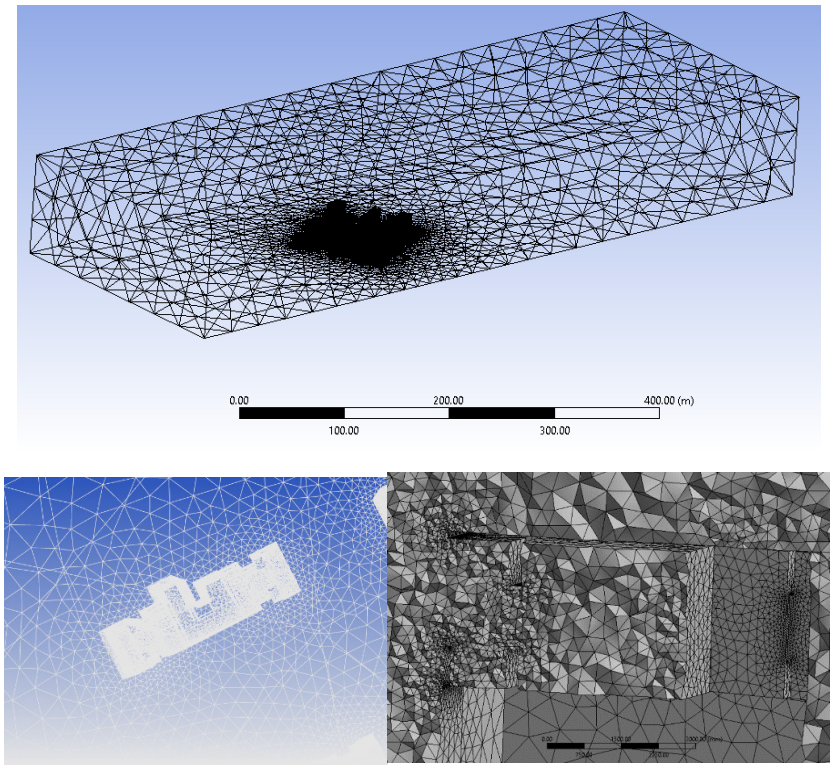

Figure 6. Boundary condition and Meshing of the base model
(Source: Author)

So more detailed the model is denser the mesh will be as we can see in fig.6.

The meshes were composed of tetrahedron meshes with fine mesh settings. U/Uref = (H/Href) k U is wind velocity at H height and Uref is reference velocity at Href reference height usually 10m. k is roughness coefficient which depends on the surface profile of land, here it is considered as suburban (0.25) Inlet wind velocity was set as 3.5m/s the same as recorded with the instrument.1000 iterations were set as maximum limit

and the input also considering the Atmospheric Boundary Layer. A roughness coefficient of 0.2 was considered. The wind direction of the recording was from Northwest and same was simulated for the base case.

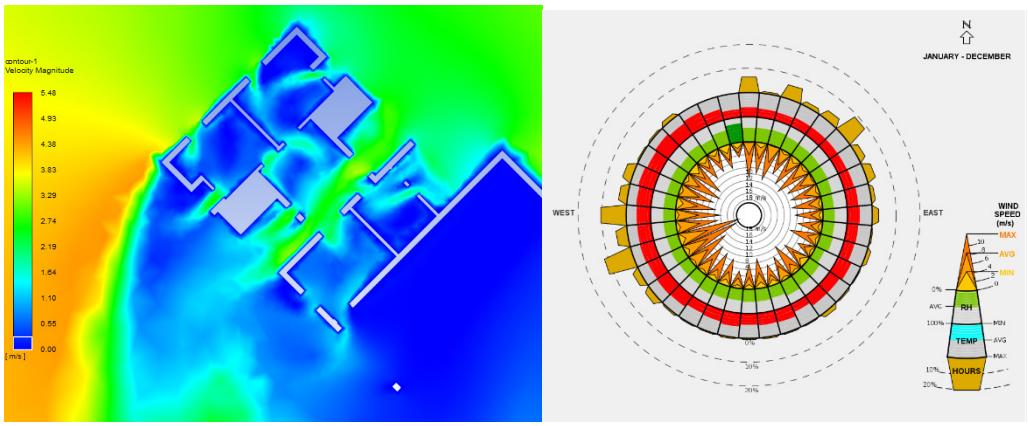

Figure 7. Simulation of base case A with wind from the north side
(Source: Climate consultant 2018)

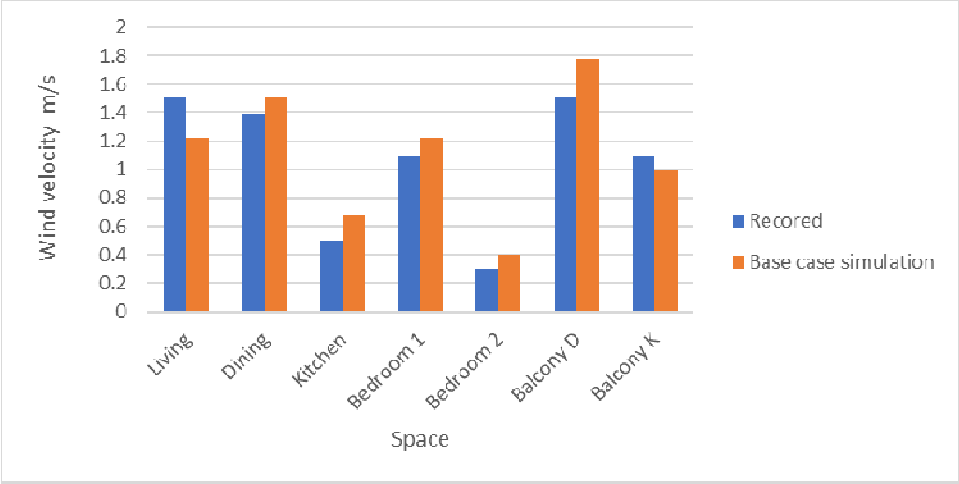

Figure 7. Comparison of wind velocity of Measurement and base case simulation at North windward direction

The wind velocity of the recorded and simulation showed almost similar results with deviation from 7 to 22% between them. The comparison shows that CFD simulation can be validated for further design changes for improvement.

The Base case was simulated with wind from predominant wind direction (West) which is 260 from the north.

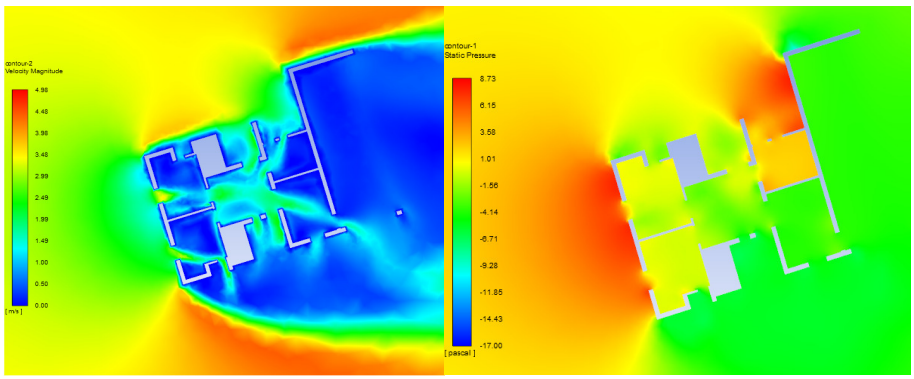

Figure 8 a. Base case with side window configuration B– wind velocity and pressure simulation

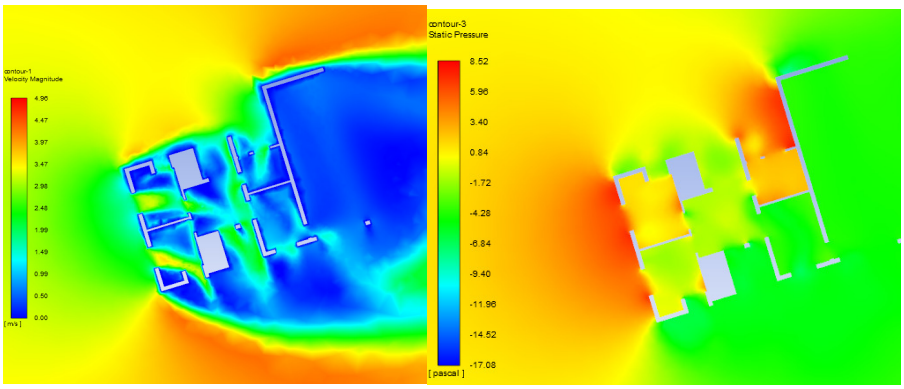

Figure 8 b. Full Frame size open window (Casement) configuration C – wind velocity and pressure simulation
(Source: Author, 2018)

Table 1. Results of wind velocity in m/s*(Source: Author, 2018)*

	Living	Dining	Kitchen	Bed 1	Bed 2	Bal D	Bal K
Base case (B)	1.51	2.21	0.51	1.49	0.92	1.41	1.32
Frame opening (C)	0.86	1.73	1.34	2.70	2.31	2.24	1.63
Changed opening (D)	1.28	1.83	1.81	1.83	2.51	1.89	1.51

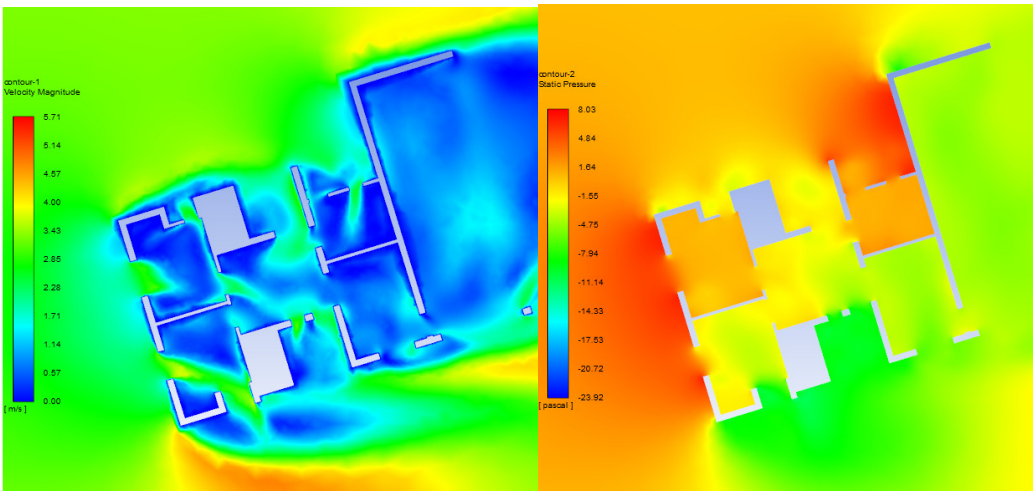

Figure 9. Modified opening size of windows Configuration D - wind velocity and pressure simulation
(Source: Author, 2018)

RESULTS AND DISCUSSION

The base case was simulated with wind from predominant wind direction 260° from the north (WEST) and the input of 3.5m/s was given as inlet velocity of air. The windows which were of 3 pane sliding type (1500*1300mm) and 2pane sliding type (1200*1300mm) were considered to be open on the left side as observed by occupant behavior.

The results showed that in Bedroom 1 there was an irregular movement of air where the average wind velocity was 1.49 with a max-3.48,min-0.4m/s. This shows no uniform flow of air movement. The bedroom 3 had sufficient wind movement only in one corner. The dining room had uniform movement with average winds

velocity of 2.2m/s. The kitchen had wind movement only near the door area. The living room had surprisingly good wind velocity of 1.51m/s. The base case did not have proper ventilation in bedroom 2, kitchen and bedroom 1.

Table 2. Window configuration of Configurations B, C, and D*(Source: Manoj, 2018)*

	North	Sill	South	Sill	West	Sill	Panes
Living B C D			1000*1300 1500*1900 1500*1300	800 200 800			3 CW CW
Dining B C D	1200*1300 1800*1900 1200*1300	800 200 800	1200*1300 600*1300 600*1300	800 800 800	-	-	3&2 CW 3&2
Kitchen	600*1300 1200*1300 600*1300	800 800 800	-	-	-	-	2 CW 2
Bedroom 1	600*1300 1200*1300 600*1300	800 800 800	-	-	1000*1300 1500*1300 1500*1300	800 800 800	2&3 CW 2&CW
Bedroom 2	-	-	600*1300 1200*1300 1200*1300	800 800 800	1000*1300 1500*1300 1200*1300	800 800 800	2&3 CW CW

The next configuration C had considered maximum opening possible in the fenestration by changing the window type form sliding to the side opening casement window. Table 2 shows the openings in each room. The results show that Living room had average wind velocity of 0.86m/s with almost uniform distribution around the space where has dining room had 1.73m/s which are lower than the base case B. The increased wind velocity was due to the reflected wind coming from the staircase with larger window size. Bedroom 1 had high wind velocity of 2.7m/s and bedroom 2 had 2.3m/s average and some points had above 3.5m/s which was not needed since it will disturb some user activities. The results show higher values but changing the window type to casement for all the sizes will not be operationally feasible. So another configuration D was made with a mix of sliding and casement window. The living room was changed to casement type and dining room had base case sliding type and the 1800*1900mm size window as changed to 1200*1300mm. The kitchen had sliding pane opening on the right side. In bedroom 1 north side opening was reduced to 600*1300 and west side as casement type. In bedroom 2 both openings were reduced to 1200*1300 casement type. The west side opening was moved towards the left for 300mm to increase the uniform distribution of wind. The results showed the most uniform movement of air among all the configurations (B, C, and D). The living room had a uniform velocity of 1.28m/s. Bedroom 1, Dining and kitchen and around 1.8m/s. Bedroom 2 had 2.51m/s velocity due to change of west

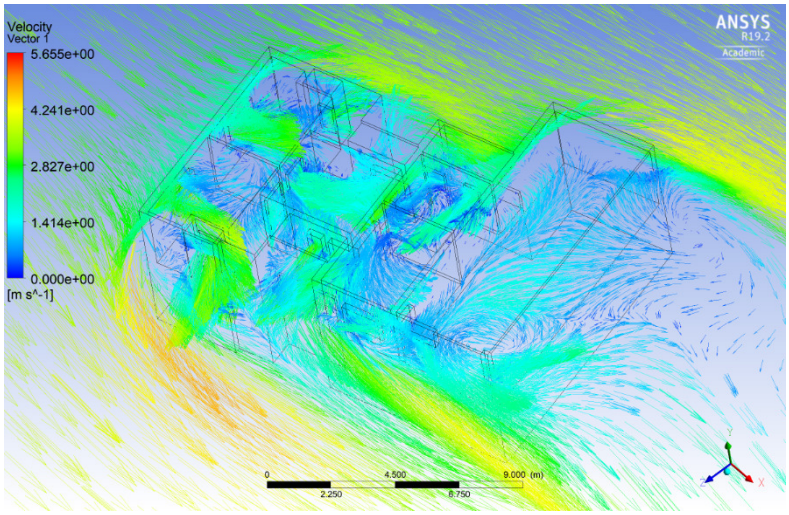

Figure 9. Wind vectors of configuration – D
(Source: Author, 2018)

opening placement towards the north. The configuration had fewer spaces with low movement of air.

CONCLUSION

The study involves analysis of measurement, simulation of the CFD model of an apartment flat, comparison of them and different configuration for finding better wind distribution and wind velocities. The measurements compared with base case showed a little variation of wind velocity values. The simulation of the base case with predominant wind direction showed that there can be improvements made with the opening arrangement and 2 more cases were simulated to find the best option. The D configuration had a more uniform distribution of wind. The study was restricted to only window type and spacing of openings of the apartment. Further study has to be made in terms of building orientation, block-level influence, and new design elements introduction. This study shows how minor changes in design lead to more comfortable conditions in terms of wind movement in the hot and humid region.

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Pragmatic Utopian Lighting Design: Classifying a modern architecture movement within the umbrella of sustainable design, and identifying its parallel lighting movement

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Abstract: This paper reviews ideologies of a sustainable design movement called 'Pragmatic Utopia' and presents a parallel lighting movement of the same name. Pragmatic utopia is a term coined by architect Bjarke Ingels of the world-renowned architecture firm Bjarke Ingles Group (BIG) to describe an architectural style that seeks a perfect world through design tempered by reality. The paper aims to identify and learn from what has been observed about pragmatic utopia so as to inspire practicing lighting designers.

Keywords: pragmatic utopia, sustainable lighting design

INTRODUCTION

Pragmatic utopia is a movement that emphasises on socially, environmentally, and economically sustainable design. BIG (Ingels, 2009) argues that architecture is entrenched in two equally unfertile approaches. First, the utopian approach originating from philosophy, mysticism or a fascination of computer visualizations so detached from reality that they fail to become anything other than eccentric ideas. Second, the pragmatic approach of building well organized but predictable high performing boring boxes. Therefore BIG derived a third approach wedged in the small but very fertile overlap between these two approaches called 'pragmatic utopia.' Semantically, pragmatism and utopianism are two contradictory concepts: pragmatism advocates behaviour dictated by practical consequences than theory or dogma; utopianism describes a perfect world that often conflicts with reality. Based on these definitions, pragmatic utopia is the marriage between a practical approach to reality, and the ideal of trying to create a sustainable life for future generations. While the traditional approach to sustainability is an exclusive approach that settles for a compromising lowest common denominator, pragmatic utopia is an inclusive approach that ties together conflicting differences (Ingels, 2009).

PRAGMATIC UTOPIAN LIGHTING DESIGN – THE FUNDAMENTALS

Pragmatic utopian lighting design (Dugar & Lewis, 2014) fundamentally expands on the current set of criteria for sustainable lighting – social, environmental and economics – by focussing on human (animal) biology and interaction. Socially sustainable lighting will include criteria beyond visual function and performance, and focus on satisfaction, pleasure and delight through greater sensory stimulation (Willey, 2006). Stimulation is a psychological need that increases the satisfaction of performing mundane tasks by increasing attentiveness, reducing fatigue, altering perceptions of time, and promoting a positive outlook from the human perspective by providing visual interest (Dugar, 2016; Winchip, 2005). The social impacts of design are of course driven by architectural concepts. Though more and more, lighting is addressed earlier on projects, and with advancement in research there are real opportunities for lighting to positively influence public space and human health. Additionally, social responsibility entails an interest in the greater good of society by designing spaces with public access that promote positive social interactions for all demographics.

Environmentally sustainable lighting will include criteria beyond stringent energy codes and LEED credits, and focus on human health (Fehrenbacher, 2006). If humans are not exposed to sufficient amounts of light in the right wavelengths at the right time of day, their biological clock becomes desynchronized with the solar day, which may result in a decline in physiological functions, neuro-behavioural performance, and sleep (Brainard, Rollag, & Hanifin, 1997). LED technology provides the opportunity to design with 'dynamic white' electric lighting systems that can shift colour temperature in alignment with daylight (Ellis, Gonzalez, Kratzer, McEachron, & Yeutter, 2013). Paired with well day-lit spaces, these conditions have shown improved recovery time in hospital patients (Cornelissen & Knoop, 2008). Although more conclusive research is needed before circadian lighting can genuinely be implemented with predictable results, the potential for supporting human

health in the built environment is real. The instigation of the WELL design guidelines shows the time has now come for a more human-oriented approach to lighting design.

Economically sustainable lighting will include criteria from two different perspectives. The first is an obligation to discuss openly with architects and owners the potential increase in the initial investment in sustainable systems (luminaires and controls), as well as the projected cost savings and life cycle costs due to a reduction in energy consumption over time. The second perspective focuses on lighting as a sustainable profession (Rea, 2009). Sustainability of the lighting profession will be determined by its ability to define, articulate, and deliver lighting designs that simultaneously meet the needs of the visual environment and preserve the natural environment (Loeffler, 2007).

PRAGMATIC UTOPIAN LIGHTING DESIGN – THE IDEOLOGIES AND THEIR LIGHTING PARALLELS

A varied set of theories and practical project examples in architecture and urban design have been used as an inspiration for identifying some of the core ideologies of pragmatic utopia (Chodikoff, 2008; Dugar, 2016; Ingels, 2009; Zabetas, 2007). Parallels are then drawn to the lighting industry with project examples that reinforce these ideologies.

Ideology # 1 – Methodically riposte nature

The first ideology of pragmatic utopia is to methodically riposte nature. BIG's design proposals for the Rødovre and Escher Towers in Copenhagen are examples of building forms generated as an answer to natural forces. The Rødovre Tower has building forms that maximize daylight and minimize overheating and glare. The towers are oriented towards the sun and the design optimised for passive solar heat gain. Sunlight is also ensured for the terraces of all apartments from morning to evening. Offices, on the other hand, occupy the north facades as they do not need sunlight because of excess heat and glare, but still need diffuse daylight. However, as the east and west facades risk considerable overheating in the summer months, the building volumes lean towards the south. The Escher Tower consists of a building form with three-square towers merged into one so as to withstand vertical stress from gravity loads and horizontal stress from wind loads. The central tower is straight while the two peripheral towers shift location in plan between ground floor and penthouse, causing the volume to flip 90 degrees; thereby providing structural stability. Riposting nature therefore generates structurally impossible-looking architectural forms.

Parallel in lighting # 1

The nexus of health, energy and technology have raised serious issues about the psychophysiological effects of light on the body and the need for natural light in the lit environment for improved functioning of the human biological systems. While it is impossible for electric light to exactly replicate natural light, the intent should be to design balanced luminous environments that are synchronised in the best possible manner with the innate biological systems of all living beings occupying the spaces. The application of the first ideology of methodically riposting nature with appropriate design and technologies can result in lit environments remodelled on nature. The sculptural redesign of Andronikos Hotel on the Mykonos Island by KLab architecture provides an impression that the building has burst forth from the island's natural rocky landscape. Light filtering through the bamboo canes and miniature glass windows, and out from under the furniture generates a sense of serenity and intimacy. The deep blue and pure white colour scheme based on the natural beauty of the Aegean Sea and desert-like landscape respectively has positive biological effects: blue has a calming effect on the endocrine system that secretes hormones directly into the circulatory systems to target distant organs; white has a relieving effect on stress symptoms and positively affects the lymphatic system, stomach and joints. 4000K LED lighting is discreetly integrated into the sculptural forms so as to amplify these colours to their best advantage. Additionally, a small number of 3000K downlights and spotlights add warmth similar to a sunlit space. Advanced lighting control technologies seamlessly interconnect natural and electric light as well as provide user-specific control.



Figure 1. Andronikos Hotel, Mykonos
(Source: Vandoros & Paraskevopoulos 2017)

Ideology # 2 – Enterprisingly utilise resources

The second ideology of pragmatic utopia is to enterprisingly utilise resources. BIG's design proposals for Little Denmark in Copenhagen and Zira Zero Island in Baku, are examples of where architecture orchestrates the flow of artificial and natural resources. Little Denmark and Zira Zero Island are heated and cooled by heat pumps connected to the surrounding landscape. Solar thermal panels integrated into the architecture create a steady supply of hot water, while photovoltaic panels on strategically located facades and rooftops power daytime functions. Grey and storm water are collected and led to treatment plants to be recycled for irrigation. The solid parts of the wastewater are composted for fertilizer. The wind is harvested through offshore wind farms to provide carbon-neutral power supply. Therefore a whole new range of liberating aesthetics in architecture is triggered where the costs incurred for sustainability can be regarded as an investment rather than an expense.

Parallel in lighting # 2

The emerging trend in the ever-evolving sustainable design arena is to create net-zero energy buildings. While there is a general consensus on the importance of adopting advanced lighting technologies, investment costs, payback periods and reliability are impeding factors that have led to various levels of acceptance of these technologies. The application of the second ideology of enterprisingly utilising available resources to achieve better performance can justify these investments. The Traverso-Vighy Zero Energy Building (TVZEB) in Vicenza is an experimental building that blends seamlessly into the surrounding nature and provides visually designed spaces geared to utilise renewable energy and resources that correspond to its use and context. Conceived as a "daylight funnel", the building design maximises sunlight exposure during the winter and totally excludes direct radiation during the summer. All south-facing inner surfaces are clad with special mill-finish aluminium with over 90 per cent reflectance that maximises overall daylight use and winter sun reflection deep into the working space. An efficient DMX-controlled LED lighting system with three different colour temperatures (4000K, 6000K and Amber) supplements and emulates the dynamic daylight spectrum that penetrates the building envelope.



Figure 2. Traverso-Vighy Zero Energy Building, Vicenza
(Source: Chemollo & Castagna 2012)

Ideology # 3 – Sensitively acclimate paradoxes

The third ideology of pragmatic utopia is to sensitively acclimate to paradoxes. The Helsingør Hospital designed by BIG is an example of architecture that has adapted to contradictory requirements. Helsingør is designed so that patients are able to enjoy the beautiful views of the surrounding landscape without being exposed to the public. There is clear visibility for the hospital staff to be able to monitor the patients without creating a 'big-brother' atmosphere. Although it operates like a hospital with total control to the staff on who would be where and when, it provides an intimate sense of freedom and the safety of a home to its patients. An open-air atrium over two levels brings daylight to the interior from various directions. The result is a prescription of diagnosing architectural paradoxes, which understands the daily dilemmas of users and owners.

Parallel in lighting # 3

A very significant issue within intelligent spaces is lighting that is capable of adapting to future conditions based on user requirements. The application of the third ideology of sensitive acclimation in the form of adaptive lighting with intuitive controls can result in the replacement of fixed lighting with flexible components. The Swarm System from Zumtobel is an adaptive lighting management system configures itself by means of sensors such as ultrasound and light to record the positions of the luminaires in a space, which then enables fast and easy adaptation to changing situations within spaces such as offices, streets or roadways. In a typical office situation during full occupancy, basic room lighting ensures appropriate luminance distribution, while supplementary light allows for individual visual tasks and indirect lighting of the ceiling. In the case of partial occupancy of specific workplaces, reduced basic lighting in these areas minimises energy consumption. Through this mutual communication with each of the luminaires in the vicinity, an intelligent light cloud is formed, creating a pleasant atmosphere in the immediate surroundings based on the available daylight and electric light. In a typical street or roadway lighting situation, when vehicles enter a specific area or zone, the integrated sensors transmit signals to the neighbouring luminaires, which then successively increase the light level, thus accompanying the vehicles. This results in an efficient and energy-saving lighting management system, which

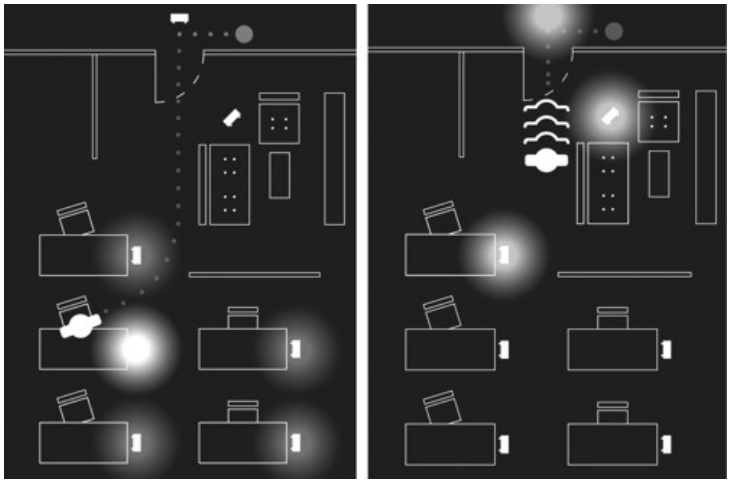

Figure 3. Zumtobel's *Swarm* System
(Source: Zumtobel 2015)

reduces operating costs, provides maximum visual comfort and individuality.

Ideology # 4 – Discreetly integrate history

The fourth ideology of pragmatic utopia is to discreetly integrate history. BIG's design proposal for the Vilnius World Trade Centre 1 is an example of modern architecture integrated with their respective historically significant sites. The challenge when integrating a mixed programme for the Vilnius World Trade Centre 1 into a historically fragile context was how to straddle between architecture and urbanism. Skyscrapers were definitely not an option next to the heritage baroque city of Vilnius. The initial idea of mapping downtown Vilnius onto the site created a series of separate buildings cut off from each other by streets and squares. The pattern was inverted by turning the streets into buildings and the blocks into parks to create a network of

separate functions fused together to form a whole. The building form is like a patch of the baroque city's organic pattern, starting with the conference centre at the centre and various programmes reaching outwards.

Parallel in lighting # 4

The lighting of heritage buildings can become an issue using conventional light sources and luminaires, which generally tend to be too large and cumbersome to be able to integrate with the architectural fabric. The principal task is to highlight the architectural details so that these buildings can be viewed and celebrated after dark. The application of the fourth ideology of discreetly integrating advanced lighting technologies can protect the architectural integrity of these buildings. OVI's lighting design solution for the Rookery building in Chicago more than adequately demonstrates that size and precision are no longer issues for solid-state lighting. Completed in 1888, the 12-storey building's distinctively dark red masonry facades were left unlit making it visually disappear at night. The use of standard luminaires seemed impossible, as every window condition on the building is unique with over 100 irregular ledges. Another critical issue was to prevent harm to the masonry by not penetrating the historic building fabric. A custom miniature 14.4 Watt LED luminaire with a telescopic mounting arm was designed to accommodate different ledge conditions and allow for lockable field conditions and aiming. The luminaires are positioned on every third level to graze the facade and detailing around the window frames with a soft glow. Discreet mounting to the granite windowsills instead of the façade, together with polyurethane feet, minimise direct contact with the historical ledges. The 'Rookery-red' finish of the luminaire blends with the façade, while the micro-optics eliminate glare for the tenants and minimise light



Figure 4. Rookery Building, Chicago
(Source: Sundin & Peiniger 2014)

trespass into the night sky. The overall power consumption for the façade lighting is less than 2.4kW.

Ideology # 5 – Objectively fraternise societies

The fifth ideology of pragmatic utopia is to objectively fraternise societies. The Sjakket Youth Club designed by BIG in working-class Copenhagen neighbourhoods is an example of architecture that has consorted with the social fabric. In a culturally homogeneous population, these neighbourhoods comprise a major population of foreign-born students coming from non-Danish ethnic backgrounds. Social problems such as poverty, unemployment, drug abuse and ghettos have persisted with the immigrant and ethnic minority groups in this area. Thus began the mandate for establishing outlets for creative and physical activities in this potent mixture of youth culture and immigrants. The design process was to refurbish the area without gentrifying its raw beauty and alienating the original occupants. The building uses interesting material palettes that are sampled from the best materials of all the resident cultures so as to reflect the true diversity of the areas. BIG's design proposal for the Slussen in Stockholm is another example where the unique three-dimensional form of the urban space is transformed to accommodate people instead of cars. The urban infrastructure of cars, buses and trains is to be transformed into a social infrastructure to support the free flow of public life from the city to the water. Therefore architecture is evolved from the belief in quality of life and human interaction as the infrastructure for a sustainable city.

Parallel in lighting # 5

Apart from providing visual comfort and safety, the scope of lighting design also involves reviving and rejuvenating urban spaces. Social interaction is an often-neglected yet essential component in such urban design projects. The application of the fifth ideology of objectively fraternising through lighting that affects social interaction can rejuvenate the urban fabric at large. Broken Light is an immersive experience developed by Daglicht & Vorm. The project uses light as art to reflect the fiery past of Katendrecht, a neighbourhood of Rotterdam. Broken Light rejuvenated and transformed the look and feel of Atjehstraat, a street that until a few years ago was rife with crime, by creating a social sculpture. It exists as an interior, cathedral-like space for the street's residents, who literally and figuratively have welcomed it into their neighbourhood. Static and tight beams of light rise up along facades as tall columns, which are balanced by pools of light reflected on the ground. The light motifs, inspired by flowers and birds, look like graffiti from above and are experienced as pools of light and dark by pedestrians. The optical system and luminaires are custom-designed to vary the size, pattern and intensity of the light projections to customise space between windows, creating glare-free street



Figure 5. Broken Light, Rotterdam
(Source: Teunissen, Wilschut & Ijzendoorn 2014)

lighting. The vertical and horizontal projections of light are operated by a single-lamp luminaire mounted on a six-metre high pole. Additional road lighting is provided by a standard luminaire mounted on the same pole by means of an additional bracket.

Ideology # 6 – Imaginatively explore regulations

The sixth ideology of pragmatic utopian design is to imaginatively explore regulations. BIG's design proposals for the Tøjhuset and Battery projects in Copenhagen are examples of architecture that has stretched the limits of building codes. The master plan for these projects called for high-density residential and mixed-use developments. The city building code defines an equation for how tall a building can be, proportionate to its proximity to the nearest neighbours. The ingenious design process applied for both these projects was to establish phantom images of the maximum building envelope by measuring the distance to all neighbouring buildings. The resulting expressive volumes, which comprise additional square metres of space although of abstract origin, were so much more similar to the neighbouring buildings that they were lauded both by the city architects and the clients. Therefore instead of ignoring or complaining about rules and regulations, architecture free from any stylistic straightjacket can be generated within the constraints of rules and regulations.

Parallel in lighting # 6

Adhering to stringent codes and standards is a key issue in the lighting design process, as projects must meet a series of performance requirements. This is typical specifically for renovation projects where older buildings no longer meet the required technical indoor climate, electrical engineering, lighting and safety standards. The sixth principle of imaginatively exploring the regulations can be used as an opportunity to lend existing architecture a new identity through lighting. The exposed concrete architecture of the Kongress am Park convention centre in

Augsburg was over four decades old and in desperate need of a facelift. The building underwent complete renovation, which included the refurbishment of all concrete elements and an up-to-date lighting scheme. The brutally rough and monotonously desolate grey concrete surfaces became an excellent canvas to provide a wide range of striking scenarios using state-of-the-art dynamic LED lighting designed by d-lightvision, a lighting

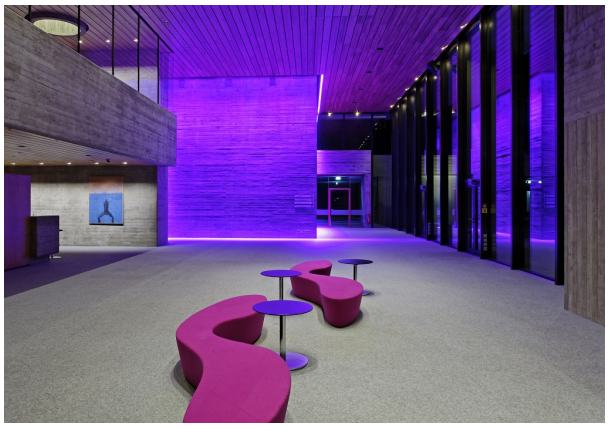

Figure 6. Kongress am Park Convention Centre, Augsburg

design practice based in Munich/DE. Coloured light is applied to define room depth as well as render the room surfaces subtle eye-catchers. Apart from meeting technical standards for different interior spaces, the renovated lighting atmosphere changes from emotionally driven to sober and practical, depending on how the spaces are used. While the daytime lighting concept is to reveal the form and textural quality of the concrete, the nighttime concept is to render inner sections of the building visible to the outside world. Spectacular compositions of warm and cool colours create interest and suspense, capturing onlookers' attention and inspiring an emotional response.

Ideology # 7 – Opportunistically mutate ideas

The seventh ideology of pragmatic utopian design is to opportunistically mutate ideas. BIG's design proposals for the Clover Block in Copenhagen and the People's Building in Shanghai were competition entries for lost causes. The Clover Block, originally designed as a mega perimeter block of affordable housing around a football field, was then resurrected as a perimeter building to protect the Khalifa Park against extreme desert conditions in Abu Dhabi. The People's Building, originally designed as the Danish Pavilion for the Shanghai Expo, was then scaled up to become a landmark building for the People's Republic of China. Thus there arises a new career path in architecture – overcoming accidental challenges through the mutation and migration of old ideas.

Parallel in lighting # 7

Factors such as the commoditisation, the global macroeconomic situation, energy efficiency regulations and government actions limiting certain profligate uses of energy sources will require lighting professionals to increasingly act as energy and investment advisers besides their normal role as visual environment advisers. The profession itself will thrive when lighting professionals start positively influencing the global market as collaborative advisers for energy savings without sacrificing visual quality. The application of the seventh ideology of opportunistically mutating the lighting professionals' role as advocates for sustainability can help open new markets for their products and services. Lighting service agreements (LSA) that leverage advances in technology and lighting science by bundling in products and services at very little or no delta cost can add value to the lighting professionals' work. For example, an LSA leasing commercial LED lighting would provide threefold benefits: one, tenants would get state-of-the-art equipment without the capital expenditure or risk of a new technology; two, companies leasing the lighting equipment would gain predictable revenue streams with higher gross margins over time; and three, lighting professionals would bring about a flurry of innovations around the purchase paradigm along with significant energy savings.

CONCLUSION

People are fatigued by urban sprawl, degradation of environmental quality, and decaying safety and sociability in their neighborhoods, as the status quo of sustainable design does not seem to be meeting public expectations (Kasperzyk, 1991). As economies and environments continue to evolve and change, careful design and conservation can improve human lives and prepare urban centres for a resilient and positive future. The process of achieving pragmatic utopian lighting design is to first seek a buy-in from the owner and the rest of the team by considering fundamental criteria at project kick-off: socially, environmentally and economically sustainable lighting. Then it is important to establish the primary ideology that is relevant to the project from any of the above-mentioned seven ideologies. Then by applying one ideology, an interconnected chain of ideologies is triggered, which is analogous to the carbon ring: the end result of one ideology leads to the start of another. Finally, a back-check has to be done to evaluate the implementation of the primary ideology at relevant project milestones.

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Revitalizing Kukrail Rivulet/Nala, Lucknow to Provide Environmentally Sustainable and Socially Inclusive Space

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Abstract: Human sustenance is dependent on water which can also be termed as "elixir of life". The four main civilizations that flourished were along the rivers namely; Indus, Nile, Yellow, Euphrates and Tigris rivers. Natural water bodies that are the "natural heritage" to us, is not only a source of water supply but also an important resource for the flourishing of any settlement. But in present day urban growth and expansion, the location of natural water bodies is taken as liability by the architects, planners and policy makers, rather than an asset or a resource. Thus, leading to extreme problems in contemporary urban settlement like flash floods, lack of storm water management, deteriorating state of water bodies and lack of drainage and sanitation facilities, etc. Due to lack of planning and infrastructure, vast area of cities is unutilized or misused, thus polluting the water bodies and its surrounding. Thus, taking approx. 9km patch of Kukrail rivulet/nala in the urban periphery of the Lucknow city as the area of study where the rivulet is in deteriorating condition and redefining its image in the city. So as to provide environmentally sustainable and socially inclusive public space for recreational activities to the residents of the locality as well as to the city. The aim of this paper is to redefine the image of Kukrail as nala/sewage drain to the natural rivulet/stream. And that can be achieved by cleaning the water of the Kukrail rivulet and city drains of that locality falling in it by adopting an environmentally sustainable treatment process and developing the land area of rivulet bank and berm in an environmentally friendly and socially inclusive public space for recreational activities.

Keywords: Kukrail Rivulets/ Natural Streams, Revitalization, Sustainable, Recreational public space, water bodies, ecosystem, constructed Wetland Treatment

INTRODUCTION

Human sustenance is dependent on water which can also be termed as "elixir of life". Water is one the most abundantly available resource on planet earth, yet just 2.5 percent of it is accessible as clean water and rest of water is saline. The four main civilizations that flourished were along the rivers namely, Indus, Nile, Yellow, Euphrates and Tigris rivers. Evolution and development of human settlement across the world is basically dependent on three parameters-

- Physical environment
- Geographical location
- Socio economic environment (Bindu & Razak, 2015)

Water sources play a crucial part in the development of social, cultural, financial and physical environment in any settlement. In present day of urban growth and expansion, the location of natural water bodies is taken as liability by the architects, urban planners and policy makers, rather than an asset or a resource. Hence, the deteriorating state of the water bodies has led us to the protection and revival of natural water bodies of the cities. Water sources such as sea, ocean, rivers, lakes and ponds etc. are not only source of water to the surrounding habitat but these are the "natural heritage" to us, which have seen the development and decline of many civilizations and cultures in its surrounding. The rivers and its tributaries (chain of natural streams) had influenced the cultures all around the world and had been the part of our lifestyles. As we are trying to conserve the built heritage of our ancestors to know the glorified past of human settlements, we need to conserve these natural heritages too. So that our future generations could learn about the harmony and balance that our ancestors have developed between the built space and nature and could enjoy the healthy environment. But in today's scenario, we have interfered a lot in the balanced system of these natural heritages to fulfil our greed of development and disturbed the balance of nature.

Due to extreme exploration of natural resources and the rapid growth in the population, city needs more and more land, to meet this requirement, the city boundaries have to be broken which effects tremendously on the basin of natural drainage system. This impact on natural drainage pattern causes the extreme problems on contemporary urban settlement like urban floods, improper drainage, shortage of sanitation and the mismanagement of storm water. These are the basic problems of today's urbanization, which directly affects the living standards in a specific neighborhood causing disastrous effect on the natural basin.

As a result, vast area of cities is not in proper use as it should be. The water bodies are also getting polluted which has the great impact on environment. In India, water pollution has been taking place on a large scale for a long time. Both surface and ground water bodies are polluted to a great extent. According to a report of NEERI about 70 per cent of the available water in India is polluted. The picture of water pollution of every river i.e. the main sources of use is gloomy. About 12 per cent of people get clean water while rest 88 per cent quench their thirst from polluted water derives from ground water sources such as wells, tanks, etc. and surface water sources like lakes, rivers and natural streams/channels.

Most of the developed cities in the world are settled on the banks of the water bodies and have flourished; these may be an ocean, sea, river, lake etc. Most of the ancient civilization like Indus Valley and Egyptian had settled down and developed on the bank of rivers (Indus, Nile). This shows the role of water bodies in early human settlement. Water bodies both natural and manmade had crucial in shaping of spatial pattern & built form in human habitat. These water bodies provide a security to the inheritance habitats and also mark the territory and edge of the city which is the very important and impulsive significant in urban planning or urban settlement of that era.

Water bodies have functional and aesthetical role, where functional role is fulfilling daily requirement of water for consumption and various purposes like religious and recreational activities, transportation needs, etc. Whereas, aesthetical role adds excitement and vibrancy to the surrounding. Apart of these benefits, there is an ecological benefit also to the environment, which all together contributes to social and economic benefits to the habitants.

Lucknow is a very fast-growing city with increasing population; there are many reasons which are responsible for deteriorating state of the water bodies in the city. As the urbanization process accelerates in some parts of the city, the results could be even worse. Fresh water is critical to nature and human communities, but it is threatened by overdevelopment, polluted runoff and global warming leading changes in the extent and distribution pattern of the water bodies in and around the city. Thus, taking Kukrail nala/rivulet basin in Lucknow city as the area of study. So, the purpose of this study is to identify those issues which have led Kukrail rivulet turn into a nala and find environmentally sustainable solutions for its restoration and rejuvenation of the space providing a healthy recreational space.

LUCKNOW CITY

Lucknow is a largest metropolitan and capital city of Uttar Pradesh. It is headquarters of the all Districts and Divisions, with population of 2, 56,239 in 1901 and 28, 80,108 in 2011. After Kolkata and Delhi, Lucknow holds the status of third largest city of northern region of the country. Lucknow is a hub of cultural and artistic activities, making it a multicultural neighborhood. In medieval period, Lucknow was ruled by the Nawabs. Thus, making it important in terms of social, cultural and administrative aspects throughout the era.

Lucknow has almost uniformed tropical climate, situated in the upper Gangetic plains of the country. Lucknow city lies at 123 M. above MSL, between the coordinates of 26°30'N - 27°10'N and 80°30'E - 81°13' E. City is situated on banks of River Gomati, which flows through the district dividing the present city into two parts Cis-Gomti and Trans-Gomti regions having their lateral slopes towards the river. Cis-Gomti region consists of old settlement of the city and is densely populated area, whereas Trans-Gomti region holds mainly the new settlement. Total area covered by the city is 2528 Sq. Km. Gomati is a tributary of Ganga. It is a perennial river, fed by many small and big rivulets and streams within the Lucknow city itself and carries storm water from the catchment area to the river.

As per survey reports of LMC (Lucknow Municipal corporation) only 494 lakes and ponds were listed in 2006, whereas, 964 lakes and ponds were listed in 1952. There is 46% of decline in area of water resources in Lucknow due to unplanned urbanization of the city. Among the remaining ones, most of them are in

deteriorating state carrying the city waste and sewage. City has around 20 drains which carries storm water from their catchment area in the monsoon season and in dry season carries city sullage to the River Gomti. Among these drains, Ghazi Uddin Haider canal and Kukrail rivulet are the biggest one. Ghazi Uddin Haider canal was constructed by the Nawabs to carry water from River Ganga to the river Gomti, the canal lies in the Cis-Gomti region in the eastern side of the city. Kukrail rivulet lies in the Trans-Gomti region flowing through the various settlements in the region and discharges in the upstream of the river. During the dry season, most of the sullage of the city is carried by them. Apart from rivers, canals and rivulets, it has many small and big lakes, ponds like Kathuta Lake, Bharwara Lake, Butler Palace Lake, Bakshi ka talab, etc. These water bodies are not only the source of water supply to the city but also help in maintaining the microclimate of surrounding and have great religious and cultural importance among the people of city. City has a vivid range of flora and fauna.

KUKRAIL RIVULET (AREA OF STUDY)

Kukrail rivulet is fourth order tributary of Gomati River. Its basin covers an area of 86.75 Sq. Km (approx.) and first order streams are mostly dominating the basin. It is situated in the region of Gomati River in the Central Plain of Ganga. Area experiences the composite climate receiving moderate to heavy rainfall in the monsoon (Jun.-Sept.). Sometimes, there is a situation of flood in the Kukrail basin region due heavy rainfall.

Kukrail rivulet/nala with a length of 28 kms. Originates near the village Asti, after its entrance into Lucknow it runs in a narrow bed enclosed by steep banks. When it approaches to Gomti River, its banks recede to a narrow strip and we get the moist tarai land of Bastauli and Shaikhpur Kasaila on either side of the Faizabad Road. It joins the Gomti just below the city of Lucknow.



Figure 1. Kukrail rivulet in urban area of Lucknow city
(Source: Google earth, 2018)

The rivulet got its name from the Kukrail forest as it flows through it. Kukrail forest region is known for its Gharial Rehabilitation Centre which was established on a 10-hectare land in 1975 with the main objective of ex situ conservation of gharial (Gavialis gangeticus) the sole surviving member of the Gavialldae. This Centre, has also undertaken activities for conserving number of species of turtles. With total protection provided to the entire 10-hectare area of the Centre, conservation of native flora and fauna was automatically ensured. Gharial Rehabilitation Centre is located in the East Block of Kukrail Reserved Forest adjoining the Kukrail Picnic Spot. With increasing colonization, now it is very close to urban habitat of Indira Nagar.

The area has good biodiversity of fauna which include- rhesus monkey, jackal, fox, common mongoose, small Indian mongoose, blue bull, Five striped squirrel, common house rat, Indian mole rat, House mouse, Porcupine, Hare, Brown shrew, various snakes like- cobra, python, common Krait, Rat snake, Water Snake. Many species of fishes, viz., Chilwa, Katla, Mirla, Mangur, Rohu & Girai are found in the nearby Kukrail rivulet/nala. Kukrail rivulet is a natural water channel occupied by irrigation department. It is clean and clear until it enters the vicinity of urban settlement, from where it starts getting polluted and carries the sullage of the surrounding neighborhoods, polluting the River Gomti.

Study area lies between Kukrail picnic spot phase-II to its confluence in Gomti River covering an approx. Length of 9.0 kms. Water of Kukrail rivulet is clean till green hut in Kukrail picnic spot phase-2, where religious activities also take place but as soon as it enters the city, it starts getting polluted through various

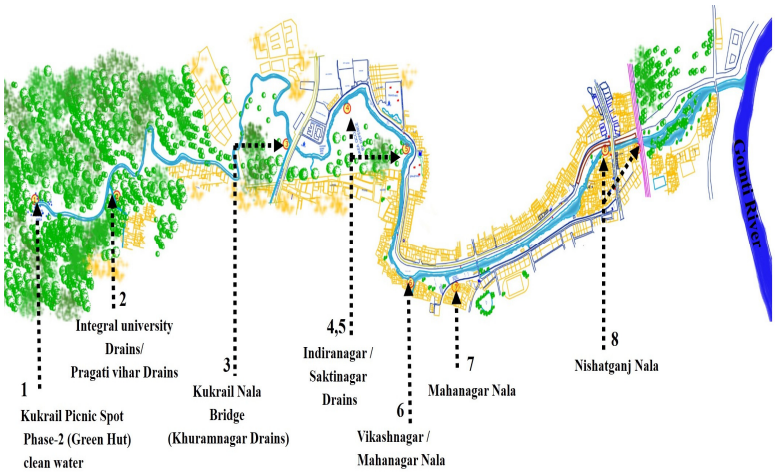

Figure 2. Identified sewage drains inlet points in Kukrail rivulet
(Source: Bundela, 2018)

sewage drains draining into the rivulet. There are 7 major sewer drains identified which drains into the Kukrail rivulet at various points and polluting it.

Despite of these sewage drains other sources of pollution to the Kukrail Rivulet are pollutants from slums and other unauthorized settlements on the banks of Kukrail rivulet and dumping of wastes from the surrounding Habitants.

Table 1. Physico-chemical properties of Kukrail rivulet *(Source: Anjum & Kumar, 2018)*

Name of tests	CPCB Norms	Results in Wet season	Results in Dry season	Remarks
DO (mg/L)	-	6.2 - 9.0	3.4 – 6.0	-
BOD (mg/L)	30	0 – 92.4	78 – 120	Polluted during dry seasons
COD (mg/L)	250	0 – 53.2	46 – 97.1	Within limits
pH	5.5 - 9.0	7.21 – 7.87	7.1 -7.87	Within limits, moderately alkaline
Turbidity	-	2.15 – 9.50 @ 200 NTU	3.0 – 55.0 @ 200 NTU	-
TDS		147 – 640	277 - 740	Higher near points of sewage drains

APPROACH TOWARDS REJUVENATION OF THE KUKRAIL RIVULET/ NALA

Revitalization will not only improve the quality of the environment but also help in socio- economic and cultural development of the neighborhoods in the vicinity of the area. This will cherish the ecosystems in the area and help in flourishing of the different species of flora and fauna. As we can see the revitalization of Cheong-Gye-Cheon, Seoul, Korea has increased the number of species up to 1000% times and reduced the urban heat island impact in the region. It has provided a center for recreational activities in the middle of the city. Similarly, Kukrail rivulet improvement will also upgrade the quality of living in the area.

Adopting constructed wetlands for waste water (sewer water) treatment will not only help in reducing carbon footprint involved in the treatment of sewage water as compared to mechanically operated STP's which requires high amount of energy for its operation leading to high carbon footprint involved with it and which has adverse effect on the environment.

CONSTRUCTED WETLAND TREATMENT SYSTEM

"Constructed Wetland (CW) treatment systems are artificially developed systems which utilize the properties of naturally available vegetation and microorganisms in water to clean the contaminants in waste water."

CWs treat the sewage water utilizing profoundly compelling and naturally stable structures; it utilizes plants, microorganisms, daylight to change wastewater in greenery enclosures to reusable water. The components of the

constructed wetland (CW) treatment plant are natural which incorporates physical filtration and sedimentation, organic take-up, change of supplements by microbes that are anaerobic and aerobic by nature, plant roots, and in addition compound procedures (precipitation, assimilation and disintegration) that refine and treat the sewage water. This system generally doesn't use machinery except water pumps to supply waste water to the system (if there is a difference in level of CW and water source), chemical compounds are also not used and the assortment of the characteristic components that does the water reusing and decontamination make CW exceptionally powerful. These are designed in such a manner that it becomes the integrated part of the existing green spaces having constrained space around the location of setup. Thus, making it unquestionably successful, temperate and enduring than regular sewage treatment frameworks.

CWs provide an environment friendly solution for treating waste water and convey as important monetary advantages for developing nations by creating arrangement of aqua-culture. CWs are effective in reducing contaminates by 98% such as biological oxygen demand, chemical oxygen demand and other chemical components (compounds of phosphorous and nitrogen) and suspended solids in waste water.

CWs have a rich microbial population in order to achieve the biochemical change of contaminations, are important, and self-continuing. CWs likewise have essentially cut down the average lifetime investment and regularly reduce the monetary expenses than conventional treatment systems (ITRC, 2003). CWs require less maintenance and workmanship.

CWs treatment process constitute of following components waste water, medium (gravel, sand and soil) for growing of plant species, vegetation, microorganisms, etc. To increase the dissolved oxygen level in the waste water, effluent is allowed to flow through gravel bed and sometimes aerators are also installed and the treated water coming out is odorless. Vascular and non-vascular plant species are the important parts of the CWs. Algae formation in the CWs are also useful as photosynthesis by them increases the level of oxygen in water. Particular types of trees like Bamboo is planted to avert soil disintegration, give great ground cover and help set up an eco-framework by pulling in fowls. Bamboo discharges enormous amounts of oxygen in the climate and is anything but difficult to develop. Likewise, its underlying foundations consequently go about as a sifter to tidy up the water.

A CW treatment system acts as a zoo for the microorganisms. Microorganisms incorporate bacteria, yeasts, fungi, protozoa, rind algae. Microorganisms help in breaking of organic components in the sewage water. Sewage water contains both dissolvable and insoluble organic substances. Microorganisms utilize these substances as a "nourishment".

Constructed wetlands give territory to a rich assorted variety of spineless creatures and vertebrates. Invertebrate creatures, for example, creepy crawlies and worms. Add to the treatment procedure by dividing waste and devouring natural components. On the way of their functioning CW treatment system can be divided into two types:

- SFCW - Surface Flow Constructed wetlands
- SSFCW - Subsurface Flow Constructed wetlands

To treat 1Cubic meter of water approximately 10 sq.m. area is required to develop constructed wetland.

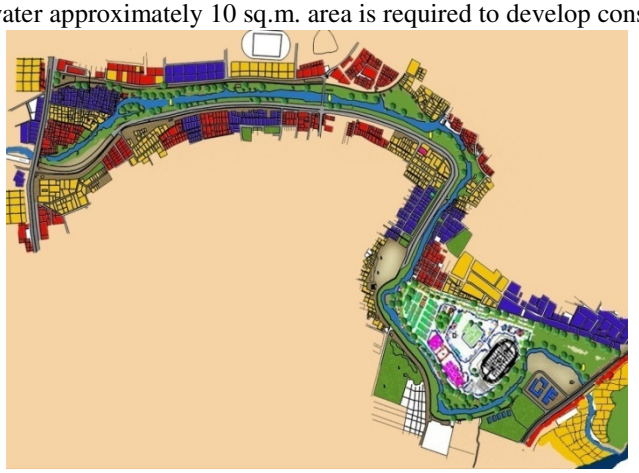

Figure 3. Conceptual proposal for the revitalization of the Kukrail rivulet
(Source: Bundela, 2018)

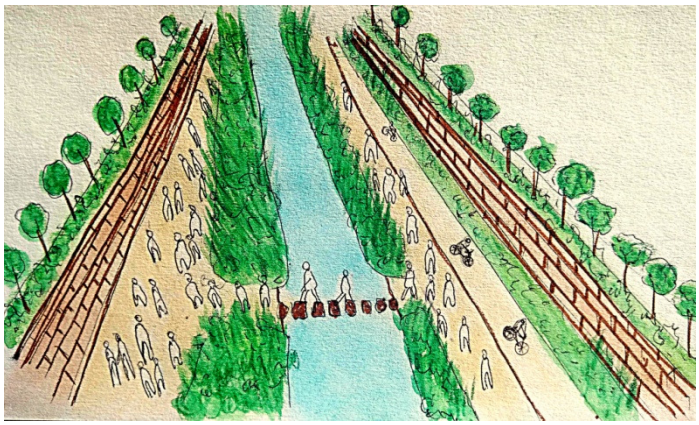

Figure 3. Conceptual section for the revitalization of the Kukrail rivulet
(Source: Bundela, 2018)



Figure 3. Conceptual proposal for the revitalization of the Kukrail rivulet
(Source: Bundela, 2018)

CONCEPTUAL LAYOUT FOR THE REVITALIZATION

Vibrant activities can be developed along the Kukrail rivulet/nala for public use, which includes pedestrian lane, waterfront parks, boating, markets, and some activities for the revenue generation, etc. For social integration and cultural development, development of land along the Kukrail rivulet/nala is necessary, as it can change the character of the city.

The revitalization project will consist of following stages:

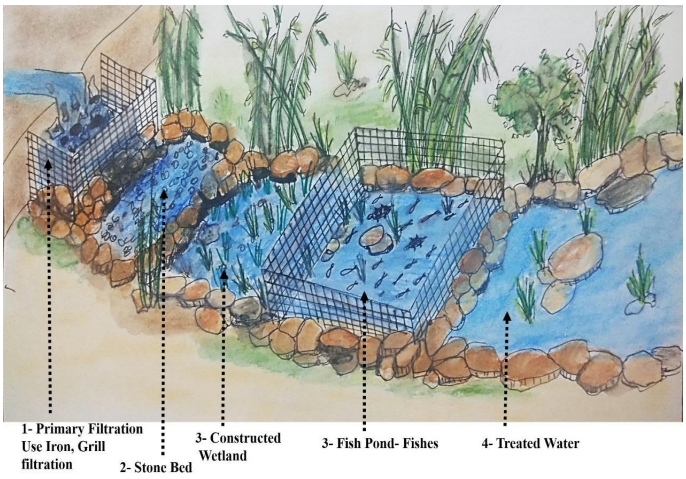

Figure 3. Identified sewage drains inlet points in Kukrail rivulet
(Source: Bundela, 2018)

- Water Supply and management Plan
- Sewage Improvement
- Section Plan
- Bridge and adjacent roads Plan
- Landscape and amenities Plan
- Recreational activities and socio-economic development Plan
- Natural Heritage Restoration Plan

CONCLUSION

Revitalization will have following benefits like Sedimentation will be reduced, Erosion of banks will reduce, more nutrients will be available for plant growth, Contribution to Aquatic habitat by woody and leaf debris, Overall biodiversity is increased Improvement of ground water recharge, Filtration of excess nutrients and chemical pollutants Visual diversity and beauty, Safe corridor and better habitat for wildlife, Urban heat island effect is reduced, Adverse effects of air and water pollution is reduced, Economic growth of location will increase.

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Building Performance Evaluation: A descriptive study of a Modern Passive vernacular house

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Abstract: This study targets the affordable housing sector, considering the case study of a farmhouse located in Narayanaghatta on the outskirts of South Bangalore. The study aims to use the SVAGRIHA manual of Self-assessment for energy efficiency and passive controls to assess the performance of a newly constructed building. SVAGRIHA is jointly developed by GRIHA Council and TERI for a simplified, easier and inexpensive rating system. The SVAGRIHA Manual consists of 14 criteria, each awarded with distinct points surmounting to a total of 50. The rating will be on a 1-5 star basis depending on the number of criteria satisfied by the building. A detailed holistic model was developed using the packages of REVIT, Sketchup and DIVA tools to simulate the energy and lighting performance .The building uses passive vernacular construction. Predominantly, CSEB (Compressed stabilized Earth blocks), Athangudi Tile flooring, refurbished wood from old buildings, Mangalore tiles for roofing, and filler slab for ceiling have been used. This study's main objective is to act as a guide for preliminary analysis in design as well as a post-construction stage by using the manual for assessment.

Keywords: Building Performance Evaluation, Green Rating, SVAGRIHA, CSEB, Sustainable living

INTRODUCTION

High-rise buildings and compact apartments in the city centre are sights of pollution and congestion. Newer technologies have increased the speed of construction but decreased the quality of life. High congestions lead to urban heat islands increasing thermal discomfort. More individuals' intend to move to greener, peaceful outskirts to escape this monotonous Cityscape. The conscience to lead a cleaner-greener life, giving back to the society and earth is growing popular.

Construction industry contributes majorly to carbon emissions and energy consumption. India ranks highest in energy consumption amongst Asia pacific region (Bin S, 2008). Majority (73%) of the energy consumed in residential buildings is used for lighting (28%) and ventilation controls in India (BEE, 2008) .Naturally ventilated buildings are thermally more comfortable and energy efficient. Passive construction Techniques rightly moderate the outside environment keeping the indoors pleasant.

Rating systems for buildings help check the construction practices and evaluate the extent of impact caused by a building. GRIHA is one such home grown rating system. It has many variants. The current study is carried out in one such home constructed in the outskirts of southern Bangalore by a 4 member family. They wanted to create a Farmhouse which is sustainable and green. The project was perpetrated by Masons Ink studio, an earth construction concern. The house not constructed with the intent of being GRIHA certified yet passive construction techniques are used in terms of material selection and design. Also being a farmhouse, produces its own organic crops and provides for animal husbandry. This enhances the chances of renewable energy production through recycling waste within site. The aim of the paper is to evaluate this building with the SVAGRIHA self-assessment tool to check its rating and provide a brief report on how to use the tool. This tool has been formulated for quick appraisal during design stage as well as construction stage.

LITERATURE REVIEW

SVAGRIHA is a new variant introduced by TERI and griha council. It is aimed at becoming a design-cum-rating tool for architects. It consists of 14 criteria with simplified calculators for examining the compliance and also provides recommendations to improve. It is targeted at constructions less than 2500 sq.m. Comprising of individual residences, small offices, schools, motels, commercial buildings etc. The process for application involves:

1. Registration
2. Certification fee

- Online submission of documents: should consist of –Narratives, certificates, Drawings, Test reports, documentation etc.

3. Evaluation process:
   - Minimum points in each category should be achieved

Criterion number	Name	points
1	Reduce UHIE and maintain native vegetation cover on site	6
2	Passive architectural design and systems	4
3	Good fenestration design for reducing direct heat gain and glare while maximising daylight penetration	6
4	Efficient artificial lighting system	2
5	Thermal efficiency of building envelope	2
6	Use of energy efficient appliances	3
7	Use of renewable energy on site	4
8	Reduction in building and landscape water demand	5
9	Rainwater harvesting	4
10	Generate resource from waste	2
11	Reduce embodied energy of building	4
12	Use of low-energy materials in interiors	4
13	Adoption of green Lifestyle	4
14	innovation	2
total		50

Figure 1. Categories for evaluation
(Source: SVAGRIHA)

The facility is ground plus one structure with total built up area of 271 sq.m situated in a site area of 5000 sq.m. Location: 12°50'18.1"N 77°43'33.6"E.
Some of the notable materials used for construction are:

- Wall – CSEB Blocks (U value =2.02 W/m2.K), Rammed earth (U value = 0.3- 0.7 W/m2.K) (TERI)
- Floor- Athangudi tiles (U value =), oxide flooring ,Terracotta tiles ,stone floor
- Roof- Mangalore tiles wood truss (U value = 1.37 W/m2.K)
- Ceiling- filler slab U value = (3.36 W/m2.K) (A. Madhumathi, 2014)
- All wood used are refurbished from older constructions (window-door frames, stairs, railing, pillars)

Climate

Bengaluru falls under moderate climate (NBC 2016).The fig 3&4 show Feb to May as overheated (above 28ºC with RH < 30%) and Nov to Jan as under heated periods (below 22 ºC with RH > 50%). May 4th is recorded being the hottest day of the year. Humidity levels are predominantly low for most part of the year indicating dryness .The wind wheel diagram Indicates predominant wind direction as the east and west for 20% hours. North and south directions experience very little to no wind movement. North east and south west being monsoon winds are experienced during the rainy months. May to October predominant westerly winds. November to April predominant easterly winds.

METHODOLOGY



Figure 1: north elevation Revit model

Source: Veena N, 2018



Figure 2: east elevation

Source: Veena N, 2018



Figure 3: west elevation

Source: Veena N, 2018

Data collections: Involved site visits and primary data collection through photographs and interviews. Majority of information was availed from drawings (CAD, electrical drawings, specifications drawing, as built drawings, etc.)(Masonsink, 2018)**Simulation**:In order to determine the energy consumption pattern of the building a baseline model is developed from the characteristics acquired from the building survey. The geometrical layout of the facility and photographs are shown in below figs 1, 2 &3.
The fig4. ShowsSun path along theoverheated period between Feb and May. Horizontal plane roof receives maximum direct sunlight.Provision of sloped roof is good in minimizing the surface area. East façade is well buffered with shaded terrace. The Autodesk insight is a tool, inbuilt in Revit for energy analysis of design. The tool generates an interactive report with graphs and sliders to understand how the model works with various settings by changing the range. It represents the energy consumed in kWh/m2/yr. or USD/m2/yr. The Sketchup and DIVA simulation results are separately shown in appendix

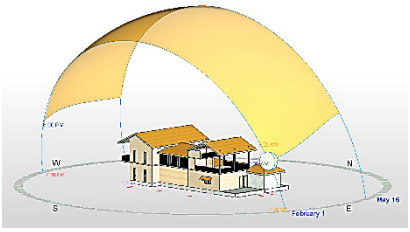

Figure 4: sun path diagram

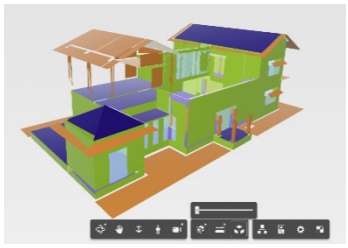

Figure 5: Insight model

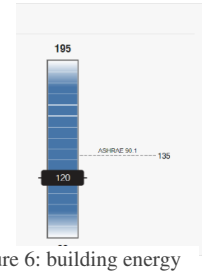

Figure 6: building energy consumption

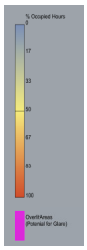

Figure 7 DIVA daylight availability calculation for ground floor

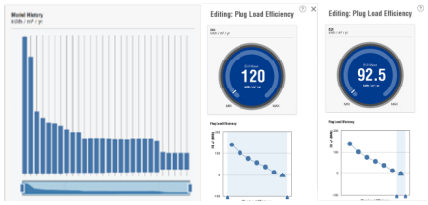

Figure 8: decreasing energy use with various passive controls from 120 to 92.5 kWh/m^2/yr.

SVAGRIHA compliance report:

CRITERA 1: Involves preserving of native vegetation and reduction of paved surfaces in the site. It consists a total of 6 points and minimum points to be achieved are 3 .The facility has scored 3 points by having >50% area under soft scape and planting of only native trees/ vegetation.

Part 1: Reduction of Exposed hard paved surface on site

To calculate the total paved area in the site:
= Site area – (building footprint + landscape area) Eq 1
Total paved area = 4980.3– (424+ 4427.6)

= Soft paved area + hard paved area under shade>50%
Total paved area (as per eq 1)
= 4427.6+ 128.7> 50%
= 128.7 sq.m

Site Area	Number of trees
Less than or equal to 250 sq.m.	2
Between 250 sq.m and 750 sq.m.	3
Site area greater than 750 sq.m.	3+1 for every additional 250 sq.m.

Table 1: Tree ratio

Source: SVAGRIHA

The site did not have existing matured trees before construction.
–Newly planted trees are native and exceeding the prescribed ratio.

CRITERA 2: Deals with incorporating passive architectural techniques in the design. Different list of recommendations are provided for each climate. Bengaluru falls under moderate climate and table

Moderate climate passive strategies
Light colored external surfaces
Design according to site topography
Design of openings according to local wind patterns
Internal distribution of spaces to be carried out such that buffer spaces like store rooms, staircases, toilets etc. are located on the eastern and western facades
Ventilators

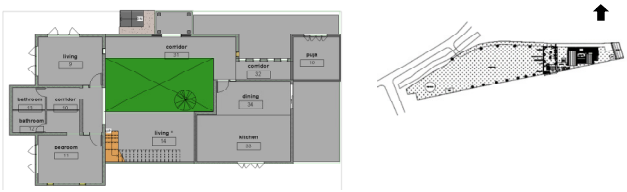

Figure9: (above) Plan of ground floor, (below) East and west façades with minimal opening and well shaded by buffer zone between exterior and interior spaces, (above) Site plan

Source: Veena.N, 2018, Masons Ink

2 shows the recommendations. It also encourages active low energy systems such as earth berming, Passive downdraft systems etc. to reduce the energy consumption for cooling or heating.The site is linear with mild slope towards west. The building has been carefully positioned along the narrow end, keeping broader area for farming activities and ease of irrigation. The western side is well shaded by a sit-out leading from the kitchen. The Pooja room is made out of stone which has high thermal mass, reducing the effect of western sun. The east side though consisting of Living and bedroom spaces are well protected by extended balconies on the wall above. No active heating/cooling systems have been used. Overall points in the criteria 4, Achieved= 2.

CRITERA 3: Controls the fenestration design. It helps in maximising daylight availability indoors while minimising glare and heat gain.A set of 4 calculators are available for this criteria for calculation of various parameters.The calculator is available only after registration. Hence alternative methods with Revit and DIVA are used for obtaining the same. There is a mandatory requirement for the building to fulfill 60% WWR as per ECBC.Overall points 6, Achieved= 2.

Part 1: Reduction in direct heat gain through the fenestrations:

Calculator 1: Insolation

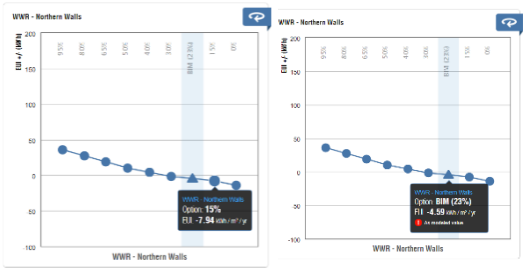

Figure 10: Base case scenario and designed scenario

Design Case: In design case, to calculate the total direct heat gain through the fenestrations, enter the area of windows on each façade in each cardinal orientation. Base Case: In the base case, the overall window area of the project is equally distributed across all the facades and then heat gain is calculated.(SVAGRIHA)The same can be obtained using Revit Insight model's Interactive graphs to vary and attain the two scenarios.

Actual/ BIM modelled scenario represents the fenestrations areas as represented in the design. Northern façade has 23% .western side 16%, eastern façade14% and southern facade 13%.Base case scenario represents where all the fenestration areas are equally distributed amongst the facades (16% on each façade). This figure shows the difference in heat gain in base case and designed case for north facade. Similar graphs are available for other cardinal orientations.The design case is not performing as well as base case. Hence fenestration design can be improved.

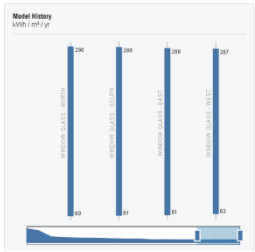

Figure 11: (left) Base case and designed model respectively

CALCULATOR 2: SHGC

Base case scenario is where SHGC value of the glass panels are between 0.6 – 0.64 (as pre ECBC). BIM model scenario where SHGC value of the glass panels are between 0.8 – 0.85 (as perdesign).A total of 4.68 kWh/yr. is saved.

Calculator 3: adds the total heat reduction due to insolation and SHGC, summing up to 5.97 kWh/yr.Thisis 46% of base case which gives 3 points for moderate climate.

Calculator 4: Daylitspaces–are calculated using ECBC method of calculation, to identify the total daylit spaces in the living areas. The percentage of daylit spaces as compared to living areas should be ≤25%. [SVAGRIHA].The average illuminance level required for living spaces in a residence is considered as 200 lux (SP 41) and DIVA simulation shows for this lux level.85 % of floor area falls under daylit zone corresponding to 2 points. For plans showing the day lit spaces refer appendix.

- Calculate Total no. of lamps fluorescent or CFL = 42
- Watts =36W
- No of led ceiling mounted lamps=13
- Watts =9.5 W
- Total watts = 42 * 36 + 9.5 * 13
- =1635.5 W

Total floor area = 271 sq.m

		Clear Glass			Tinted Glass		
Frame Type	Glazing Type	U-Factor (W/m^2-°C)	SHGC	VLT	U-Factor (W/m^2-°C)	SHGC	VLT
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, vinyl, or fiberglass frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40

Table 5:

CRITERIA 4:

Controls artificial lighting in terms of lighting power density. Total points available are 2, Achieved-2.The ECBC method is used to calculate the watts allowed. First step is to identify the allowed lighting power density for different spaces which is then multiplied with the gross lighted area of the space designed (from floor plans). The LPD values are well below the prescribed levels shown in table 2.

CRITERIA 5:

Deals with conduction of heat through building envelope. The thermal efficiency of the building is evaluated by the following heat gains, the SHGC of glass, U value of glass, Lighting Power Density level, and EPD level and People occupancy. These values can be manually calculated from previous Criterion or another way is to check the Revit Load summary report. Spaces can be assigned and grouped into HVAC zones and non-HVAC zones and Revit calculates the total amount of heating and cooling loads for different spaces based upon their volumes and areas. The thermal efficiency of the envelope should meet the standards as prescribed inFig20.The cooling load density considers total cooling load divided by occupied analytical area in the building. It consists ventilation, Power, Lighting, latent and sensible loads hence a good alternative. The cooling load is lesser than 115 W/sq.m for Bengaluru residential category hence achieves 2 points.

Building Summary

Inputs	
Building Type	Single Family
Area (m^2)	271
Volume (m^3)	773.10
Calculated Results	
Peak Cooling Total Load (kW)	**26.1**
Peak Cooling Month and Hour	May 4:00 PM
Peak Cooling Sensible Load (kW)	22.9
Peak Cooling Latent Load (kW)	3.2
Maximum Cooling Capacity (kW)	26.1
Peak Cooling Airflow (L/min)	78,401
Peak Heating Load (kW)	**3.2**
Peak Heating Airflow (L/min)	36,848
Checksums	
Cooling Load Density (W/m^2)	96.35
Cooling Flow Density (LPS/m^2)	4.83
Cooling Flow / Load (L/(s·kW))	50.08
Cooling Area / Load (m^2/kW)	10.38
Heating Load Density (W/m^2)	11.72
Heating Flow Density (LPS/m^2)	2.27

City	Threshold				Points awarded
	Residential		Commercial		
	higher than sq.ft./1R	lower than W/sq.m.	higher than sq.ft./1R	lower than W/sq.m.	
Allahabad	225	165	200	190	1
	300	125	275	135	2
New Delhi	275	135	225	170	1
	325	115	275	135	2
Mumbai	325	115	275	135	1
	400	95	350	110	2
Pune	300	125	275	135	1
	375	100	325	115	2
Hyderabad	300	125	250	150	1
	350	110	300	125	2
Chennai	275	135	250	150	1
	350	110	325	115	2
Bengaluru	275	135	250	150	1
	325	115	300	125	2
Kolkata	300	125	275	135	1
	375	100	325	115	2
Chandigarh	275	135	250	150	1
	350	110	300	125	2
Jodhpur	275	135	250	150	1
	350	110	300	125	2

Table 5 hot water requirements

Source: SVAGRIHA

CRITERIA 6:

The criterion evaluates the building based on its 3 key appliances and their BEE ratings- Air conditioners, fans and geysers. This criterion could not be evaluated as electrical fixtures were not installed at the time. It has totally 3 points.

CRITERIA 7:

It encourages generation of energy on site to meet the future needs of the proprietors. Total points are 4 and the building achieved 4 points.

Part 1: Renewable energy system for electricity generation.
The renewable energy to be installed should meet the minimum threshold standards mentioned in the tool. For PV panels the typical size used for residences are 65"x 39"x1.4" (l x b x d). As a thumb rule, 10 Sq.m area is required for 1 Kw capacity solar system and generates 1600 – 1700 Kwh of electricity per year. To identify the angle and direction for mounting the PV Panels for optimum energy output throughout the year solar irradiance figures can be used. Thefacility is provided with 2sq.m of PV panel.

Irrigation system	efficiency
Surface	30-40 %
Sprinkler	60-70%
Drip irrigation	80-90%

Table 7: low flow rates of fixtures

Source: TERI

Part 2: Solar Water Heaters In case of solar water heaters, certain benchmarks are established for requirement of hot water per day for different building typologies. These are mentioned in the table 4. The installed water heater is 150 LPD suitable for a 4 member family home hence meeting the requirement.

CRITERIA 8:

Since the tool encourages soft scape, it also considers the sustainable approaches for its water demand. It has two parts, for landscape as well as plumbing fixtures. A total of 5 points can be achieved. The building gains 2 points in this criteria.Part1:Reduction in building water demand- by using low flow fixtures.

Part 2: Reduction in landscape water demand. This can be achieved by planting more of native vegetation and reducing the area for lawn. Using efficient irrigation system also help minimize wastage of water. The building

$$(\text{l.p.d}) = \frac{\text{Plant Factor x EvapoTranspiration Rate (m.p.d) xCanopy area (sq.m) x 1000}}{\text{Irrigation system efficiency}}$$

achieve more than 40% from base case in surface irrigation. To find the water demand of the landscape following equation can be used:



Figure 12: Rooftop showing the solar water heater

Source: Veena.N

For design area:
For surface irrigation= 0.4 x 0.0004 x 4427.6 x 1000/0.35
=2024lpd
For sprinkler = 0.4 x 0.0004 x 4427.6 x 1000/0.65
=1090lpd
For drip irrigation =0.4 x 0.0004 x 4427.6 x 1000/0.85
=833lpd
For base area: For surface irrigation= 1 x 0.0004 x 4427.6 x 1000/0.35
=5060lpd

CRITERIA 9:

Encourages Rainwater harvesting to be incorporated to meet the daily water demand. The excess water is appreciated if allowed to recharge the ground water level and maintain. The stored water must be covered and maintainedhygienically. The criteria demands ≤75% of total water requirementfor the project for 2 days should

be covered by the RWH collection. The thresholds to be assumed for calculating water requirement is as follows:

- –Residential – 140 lpcd(GRIHA, SVAGRIHA)
- Avg rainfall in Bangalore 970 mm annually
- Daily average = 2.7 mm
- Total roof area used for rain water harvesting = 276 sq.m
- run-off coefficient of the surface 0.9 for smooth pavements and roofs

Rainwater harvested = daily average rainfall (for the location) x surface area x run-off coefficient of the surface
Rainwater harvested = 0.027x 276x 0.9
=6.70 cu.m
=6700 liters
Per capita = 6700/4
=1675 lpcd
2 days equivalent demand =140 x 4x 2 =1120 liters

Harvested quantity is exceeding the threshold. Rainy filters are installed in RWH outlets meeting the mandatory requirements. Achieves - 4 points.

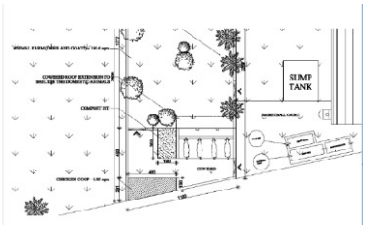

Figure 13: Site plan

Source: Masons ink

Criteria 10

Fig13 showsSite plan and dedicated space for bio gas plant. However it wasn't installed at the time of evaluation. The farm waste and cattle refuse can be fed to the biogas plant to generate energy. Some of the several biogas plants available in the market to choose from are TERI TEAM digester, ASTRA digester (CEPT), TIDE etc. (GRIHA, SVAGRIHA): Achieves - 4 points.

Criteria 11

Part1: PPCthe use of pozzolona mix cement is encouraged so that fly ash (a pollutant) mixed with ordinary cement reduces the embodied energy of cement. Fly ash is a waste byproduct from thermal power plants and its reuse reduces air pollution. Ordinary Portland cement was used in this project. However a number of other materials used are of less embodied energy.

Part 2: Reduction in embodied energy Materials that require high energy from extraction of raw material to final installation of products are called high embodied energy material. Using of materials locally sourced and that involves less processing encourages energy and cost saving. The calculation shows that around 30% reduction in embodied energy than base case scenario.

D.C. E.E. = (Area L.E.S X E.E. L.E.S.) + (Area R.S. X E.E.RCC) + (Area L.E.W X E.E.L.E.W.) + (Area R.W. X E.E. C.B.) Eq.5
D.C. E.E. = (76 x 590) + (227 x 140)) + (730 x 46).) + (684 x 550)
= **4, 86,450**
B.C.E.E = (Area S X E.E.RCC) + (Area W X E.E.C.B.) Eq .6

B.C.E.E = (684 x 2141) + (216 x 730.)

= **1,620,000**

Where;

- D.C.E.E. = Design Case Embodied Energy
- Area L.E.S = Area under Low-Energy Slabs
- E.E.L.E.S. = Embodied Energy of Low-Energy

Building element	Unit	Energy per unit (MJ)
Walling systems		
Burnt brick masonry	m^3	2141
SMB masonry	m^3	550
Steam cured block masonry	m^3	1396
Roofing systems (for 3.6 m span)		
Reinforced concrete slab	m^2	730
SMB filler slab	m^2	590
Composite panel roof	m^2	560
Ribbed slab roof	m^2	490
Brick masonry vault roof	m^2	575
SMB masonry vault roof	m^2	418
Mangalore tile roof	m^2	227
Ferroconcrete tile roof	m^2	158

Table 6 embodied energy of various materials

Source: B.V.V.Reddy

Slabs

- Area R.S. = Area under Remaining Slabs
- E.E. RCC = Embodied Energy of Conventional RCC slabs



- E.E.L.E.W = Embodied Energy of Low-Energy Walling
- Area R.W. = Area under Remaining Walls
- E.E.C.B = Embodied Energy of Conventional fired clay Bricks
- Area S = Total Area under Slabs

- Area L.E.W = Area of walls under Low-Energy Walling

Criteria 12:Talks about using low embodied energy materials. The materials used for floor are a combination of terracotta tiles, Athangudi tiles, Cement Oxide floors and natural stones. No vitrified tiles or highly polished stones have been used. The walls are exposed and are lime plastered in the interiors. No synthetic wall paints have been used in the building. All the wooden frames, shutters, wooden stairs, truss, Pillars are refurbished wood from old houses.

This adds a new life to the material and interiors.

Criteria 13:

Emphasizes the need to follow a green lifestyle even by the layman. This includes his responsibility in choosing a sustainable site, in terms of proximity to services, provisionof dedicated spaces for maintenance staff, help in creating awareness in society or indulge in organic farming. Totally this criteria provides 4 points, of which the building gets 2 for their initiative.

Cement based oxide floor	4.8	227
Stone floor	0.44	45
Terracotta	2.7	114
Ordinary Portland cement	6.4	-

Table 7 embodies energy of materials

Source:ECBC

Part 1:

A key part of sustainable living is equal distribution of resources. It is applicable for spaces as well. This criteria calculates the per capita space available and it should be within the threshold range .

Figure 14Lime plaster walls, exposed brick walls and refurbished wood, oxide and terracotta floors



- For residential between 12.5 to 50 sq.m are / person,
- For commercial between 5 – 10 sq.m. Area/person
- For nursing homes -100 sq.m area/person
- For schools 4 – 8 sq.m area/ person
- For hotels -35 – 60 sq.m area/ person

The calculations leads to 67.75 sq.m per person which is exceeding the threshold value. The ideal number of people would be 6 members for an area of 271 sq.m to meet the threshold.

Part 2:

Recommends reduction in usage of private vehicles by occupants for day to day needs. This depends on the selection of site .Minimum of 7 out of 11 services are required to be located close to the building. The average distance travelled by a person should be 2100 km/annum. Limitation the services are not mentioned in the manual, hence they are assumed.

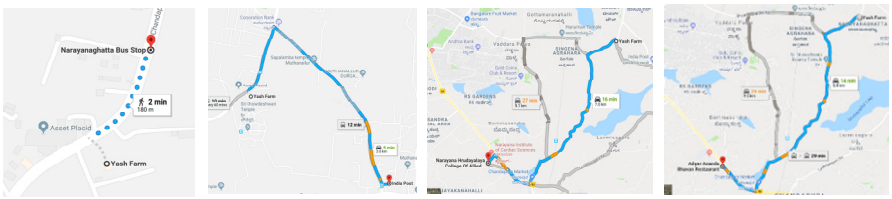

Fig15. Bus stop, Post office, Hospital and restaurant respectively showing the distance from the building.

Part 3:A number of staff work in a facility for its maintenance and service like maids, drivers, etc. Dedicated space for their rest and toilet facilities are required.

Part4:Bringing social awareness to the neighborhood regarding environment friendly lifestyle is also given importance. This could be done through print media (brochures, pamphlets, banners, etc.) or social media or any means of promoting green lifestyle.

Basic services	In km
Bus stop	0.18
Railway station	4.7
Bank	0.55
Post office	2
Market	5.2
Shopping complex	6.6
School	3.5
restaurant	6.4
hospital	7
Police station	6.6

Criteria 14:

The last criteria is dedicated to some unique innovation initiated by the project apart from the already existing criteria in improving its performance. It contains 2 points. No particular innovative measures are taken other than the ones mentioned in previous criteria

Conclusion:

The manual is an easy to use tool for architects. A thorough run through the criteria can give better insights while designing. Thecurrent building shows that sustainable practices without the intention to be certified can perform below power with respect to GRIHA criteria. Though most criteria have been addressed by the clients and designer, the design requires scrutiny in its deign intentions quantitatively. The facility has earned 31 points of total 50.Two of the criteria were un- addressed due to limitations. Gets a rating of 2 stars.

Acknowledgement

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Re-imagining a more Sustainable Bangalore Using Urban Indicators

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Abstract: The study examines whether the current trend in development of Bangalore is sustainable in the context of planning, resources management and utilization. The objectives of the study are select urban indicators to evaluate the city's sustainability, prioritize them with appropriate background knowledge, analyze assets and liabilities within the select indicator groups based on the context of the city, suggest appropriate citywide policy measures. With the above objectives in mind, indicators are selected to examine sustainability across environment, inclusivity, mobility and institutional framework, with the economy as an overlay across all indicator groups. The urban indicators considered in this paper would act as a tool to guide decision makers, community members and stakeholders to participate, plan, propose strategies, monitor and create policies to "Re-imagining a more Sustainable Bangalore Initiative." The outcome of the study will help fulfill the goal of developing a sustainable Bangalore through the design of policies, tools, and strategies essential for planning.

Keywords: Re-imaging Urban Cities, Sustainable Urban Centre, Bangalore.

INTRODUCTION

Urbanization is happening at a rapid pace especially in developing countries. According to the UN, over 54% of the global currently reside in cities, adding another two and a half billion by the year 2050. Ninety percent of that increase is expected to come from Asia and Africa. In India, about 30% of its population resides in its cities, and at this projected pace of growth, India will soon be 75% to 80% urbanized, matching that of the developed world. Urbanization brings about significant economic, social and environmental changes both in local and global scale leading to significant irreversible changes in the earth's carrying capacity.

Discussions on sustainability gained worldwide recognition and momentum after the Brundtland Commission report of 1987; the term Sustainable Development was coined and defined then. Earth Summit of 1992 acted as a catalyst to stir up development and initiatives by the local governments at city level (Saha, 2009). Agenda 21 addressed the importance of sustainable indicators to aid in decision making at the local, regional and national levels (Kitchin, Lauriault& McArdle, 2015). Since then, many local authorities adopted them through formal commitments or had begun urban indicators projects, occasionally accompanied by benchmarking to aid in evidence-based decision-making (Saha, 2009).

INDIA-AN OVERVIEW

India is the second largest country in Asia with an area of 3.29 million square.kilometers. It has 22 major languages and several religious beliefs. For centuries, the land had preserved its unity in diversity. For the context of this study, the overview of India is looked through the lens of sustainability and its three main pillars. To better understand the challenges and strengths in its journey of sustainability, the overview is provided under the category of Socio-Cultural, Economy, and Environment.

Cultural sustainability (or) Human Capital. World Economic Forum (WEF) cites that India scores very high on Greendex International Report on sustainable living. Greendex study highlights the eco conscious behaviors of Indian consumers (Chitra, 2017). Culturally there is an aversion towards wasting food, favors thriftiness in the form of reuse and hand-me-downs and favors selective hoarding so that things could be of use someday. It is very common to find people across all income groups in Indian households taking bucket baths, hand wash dishes, line dry clothes, use gently used clothes as a duster and grow their food even if it is a small platform on top of a kitchen sink.

The recent trends in interpreting cultural information with emphasis on ways of life has resulted in a greater awareness of alternative knowledge and methods to cope with the environment. This has led to a growth in knowledge recognized as a basis of sustainable development, with a potential to develop global knowledge

networks (Chand, 2006). Foundation of all the efforts towards the sociocultural aspect of sustainability is educational reform that leads to greater awareness.

At a macro level, Human Development Index (HDI) developed in the 90s' can serve as a measure to promote human development, ensure freedom and augment social capital within the country. The real impact of these indexes on decision making within the country is not a visible one, and with India's ranking so low, any significant improvement will still be marginal in its overall ranking. It would be a motivating factor if the country is compared and rated based on its progress and improvements year on year as opposed to ranking where developed and developing countries are rated in the same platform. At the national level it is critical to examine how India could use its existing indices to better integrate with the policies and programs, while engaging cities to be a part of the national agenda towards sustainability through shared a purpose and vision.

Developmental Sustainability (or) Financial Capital. Current demography of the country shows that 50% of Indians are under the age of 25, and most of them are digital natives. That means India is coming into the same "demographic dividend" that China enjoyed as its baby boom generation moved through the workforce and drove economic growth in the 1980s, '90s and early 2000s (Magistad, 2016).

According to McKinsey's India's Urban Awakening report, to keep pace with the developement India will have to build 700 to 900 million square.meters of residential and commercial space every year. In transportation infrastructure, country has to build 20 times the capacity that it has achieved in the past decade in addition to the 19,000 to 25,000 kilometers of road lanes to be built every year. In other words, a city of the size of Chicago needs to be built every year to keep pace with the development (McKinsey, 2010). The country needs about 1.2 trillion dollars in capital investments for infrastructure towards Indian cities over the next twenty years (McKinsey, 2010). This type of financial need and growth is unprecedented for the nation and a call for action-oriented area based planning through collective intelligence is crucial.

Environmental Sustainability (or) Natural Capital. India only supplies 105 liters of water percapita to its people against the benchmark of 150 liters of water percapita. On an average only 30% of sewage is treated and the share of public transportation nationally is only 30%, against the benchmark of 50% (McKinsey, 2010). According to Ministry of Environment, Forest and Climate Change, India has over 20,000 known mineral deposits and about 87 of them are exploited. Geological Survey of India has estimated India's coal reserve to be 8% of the world's reserves. There are two identified biodiversity hotspots in the country, and over 45,000 plant species identified. Although the annual rainfall is high in India, and is spread over four months of monsoons, Indian rivers carry 90% of its water during the months of June through November; only 10% of the river flow is available for the other six months. In order to keep pace with development, country should mandate eco-sensitive urbanization through land development decisions, policies and climate action plans.

GETTING TO KNOW BANGALORE

Meeting the growth ahead, Indian cities will require a more in-depth understanding of the contextual issues to facilitate appropriate urban policies and practices (Reddy &Balachandra, 2013). The city of Bangalore caters to a large number of diverse populations and the responsibility of the provision of municipal services rests with numerous local government and parastatal agencies.

The city of Bangalore is located in southern part of India in the state of Karnataka. Once known as "Pensioners Paradise" and "Garden City of India" is now the IT Capital and the Silicon Valley of India. In 2014, Bangalore was officially declared the hub of the $150 billion information technology (IT) sector that contributes to nearly 10% of India's GDP (Menon, 2017). The Government of Karnataka expects Bangalore to be home to 2 million IT workers by 2020.

Decades of rapid urbanization have paved the way to a most commonly found mindset in Bangalore, which is 'let's grow our city now and clean them up later'. This mindset can prove to be disastrous and a very costly means to develop our cities. Encouraging planned growth is crucial. At the same time, it is unsustainable to pursue planned growth without worrying about environmental consequences, and not consider its growth implications. Most of the discussion around sustainable development focuses on environment, social/equity, and economic equally in the same platform. In the process of giving importance to human centric development, cities have somehow forgotten that without a suitable environment to live in there cannot be a sustainable economy and society. This paper will consciously select indicators in all three aspects of sustainability with equal importance in addition to institutional sustainability.

Bangalore Local Planning Area has grown spatially since 1949 from 69 square.kilometers to 1219 square.kilometers in 2017. The draft Master Plan of 2031 expects Bangalore urban to grow further to 2190 square.kilometers with an estimated population of 18-20 million by 2031. There are 42 planning districts and 198 wards in Bangalore. Each ward has a population ranging up to 200,000 people. Bangalore has active Resident Welfare Associations (RWAs) or Neighborhood Associations (NAS) and councilors are elected in every ward to represent the community; RWAs serve as a platform for the citizens to voice their opinion on infrastructure improvements at the community level at times RWAs take up larger issues like demolition of illegal structures, use of electronic metering and privatization of water.

In June 2017, city of Bangalore was selected as the seventh city in the state of Karnataka to be on the list of smart cities. While the city Master Plan provides zoning and Land Use guidelines, the Smart City mission will focus on implementation of projects. Timing couldn't be apt to streamline coordinated efforts to make city's urban development inclusive and sustainable.

DETRIMENTS OF SUSTAINABILITY - A MASTER PLAN EVALUATION

While there are several detriments towards Sustainable Bangalore, the one that tops it all is the Master Plan of the city of Bangalore. It has always been a Land Use and Zoning exercise and not a sectorial planning document. Master Plan is updated every 15 years and is a significantly long period for a Master Plan document to stay unrevised, considering the rate of urbanization. The city transforms itself at a decadal growth rate of 45%-65%. The detriments of sustainability listed below highlight select issues in the Master Plan.

Residents find no relevance to the Master Plan. Unless people are part of advocacy groups or a strong Resident Welfare Association (RWA), city residents do not see any connection to the Master Plan. So they remain disengaged.

CAUSE

The process of Master Plan preparation is not a participatory one. Historically, Master Plan preparation is commissioned to an external agency either out of state or overseas and the Bangalore Development Authority's (BDA) lack of in-house capacity has led to a poor perception on the ability of local planning authority.

EFFECTS

Discrepancies in existing and proposed Land Use Plan; for example Commercial Land Use approved in Master Plan 2015 is downzoned in Master Plan 2031 as Residential. The overall percentage of such conversion of former commercial Land Use to Residential Land Use across the city in the Draft Master Plan 2031 is as high as 35%.

This type of disconnected planning and non-participatory efforts needs to be addressed through collective intelligence, participation and planning. The city of Bangalore must come up with a shared vision, purpose and bring everyone on board for collective action towards "Re-imaging a more Sustainable Bangalore."

SHARED PURPOSE THROUGH URBAN INDICATORS

Role of indicators in measuring Bangalore's sustainability is crucial for engaging citizens, assessing existing condition, policymaking, and implementation. Cities are complex systems, and they need multiple measures.Good indicators help simplify complex and hard to understand information to provide a bigger picture of existing conditions across sectors and at various levels. For the indicators to be effective in the city of Bangalore, it is best to consider the following attributes in an indicator.

- Be user and community-driven
- Identified based on priority
- Comprehensive
- Reliable and easily understood
- Measurable
- Cost-effective
- Flexible and adaptive to accept changes

Indicators are selected based on the context of the city of Bangalore. Since there is a definite disconnect among city residents, and the Master Plan; indicators are grouped under four broad areas of

sustainability introduced in the Draft Master Plan 2031. They are ecological sustainability, social inclusion, mobility, and institutional sustainability. This study has not included subjective indicators to assess 'quality of life' as that would result from fulfillment of psychological needs of people and is hard to measure. If the city with an estimated population of 12 million citizens have to be on board; it is only possible by speaking the same vocabulary of sustainability and measuring what the citizens can relate to and cross learn from.

ECOLOGICAL SUSTAINABILITY

Following are six indicators selected to measure the city's ecological sustainability.

- Access to green space and green cover per capita
- Number of good air days using PM2.5, PM10, No2 and So2 reading
- Number of hospital admissions for asthma cases
- Total number of vehicles inspected for emission
- Reduction in number of lakes and tanks and impact on biodiversity
- Illegal discharge of sewage water and clean up cost.

Urbanization in Bangalore had increased by 125% from 2000 to 2014 (Figure A1). Green cover in Bangalore has reduced from 45% in 1999 to 8.4% in 2014. State of green cover in the city is sad, as there is one tree for every seven person in the city. With growing population there is growing number of vehicles and this results in a huge amount of suspended particulate matter. As of March 2017, there were 6,700,000 registered vehicles in Bangalore and the average annual increase in vehicles is reported to be 8%. Estimated total emissions in 2015 from vehicular traffic are 196 tons of CO per day based on Urban Transport Model built for Revised Master Plan 2031. As a result of air pollution, traffic police and children are severely affected in the city. A study conducted by Clean Air India Movement (CLAIM) in schools of Bangalore claims the prevalence of asthma in children less than 18 years of age has been on the rise from 9% in 1979 to 25.6% in 2009. Hospital admissions of children with asthma have increased from 4% to 11% in 20 years based on the research published by Dr. Paramesh, pulmonologist (Paramesh, 2002).

This apart, water pollution is all time high in Bangalore. There is a heavy inflow of sewage, municipal waste, and effluents into the lakes of the city. Polluted lake waters indicate decreased dissolved oxygen to support life. Surface water pollution is high and this contaminates groundwater resources. There is a direct correlation between increased urbanization, vehicular traffic, air pollution, and related health hazards.

Though the indicators selected may not paint a holistic picture, measured indicators would aid in creating awareness in the area of air pollution, green cover, water pollution, and biodiversity.

Social Sustainability. Indicators selected under social sustainability to measure inclusive growth in the area of housing, water, energy and waste are listed below.

- Households below poverty line
- Share of income spent on energy
- Water consumption per day
- Percentage of people with potable water supply
- Share of waste and waste water recycled

Though there is overwhelming demand for housing due to population growth, estimated slum population in Bangalore is about 8%-14% and a total of 576 slums have been identified by city. Unlike Mumbai, Bangalore is not perceived to be a city of slums. There is a huge demand supply mismatch when it comes to housing for all income groups. Per census 2011, total residential units in the city were 2,104,000 units and an additional 218,000 units were vacant. Estimated housing stock as of 2016 is 3,039,000 units. Nearly 60% of the city's population depends on rental housing. Total housing demand is estimated at 5,700,000 units for the year 2031; this is double the existing housing stock within a decade. As infrastructure is interrelated, with an increase in housing units there is an increased demand for safe drinking water, electricity and waste disposal. Number of households with tap water (both treated and untreated) access within the premise is 66%, electricity access is 98% and toilet access is 95%.

MOBILITY

Productivity of a city has a direct correlation to its mobility and physical access to jobs. Population projection of 2031 estimates 60% of people in the age group of 25-59 and infrastructure related to mobility would play a major role in tapping the productivity of its residents. In 2008, Department of Urban Land Transport (DULT)

initiated the first study to identify series of indicators essential to track interventions towards urban mobility. There were many indices formulated to measure congestion, travel time, road safety, walkability, VMT, cycling and so on. Public safety and mobility are interrelated. When the city is perceived as safe, there is an increased trust in the government and government provided services. Of the reported crimes in the year 2010-2012, 41.5% were property related crimes and crime against women is 3.8%. There is no safety assessment similar to CEPTED for approval of plans. Indicators selected for this group are listed below.

- Amount of waiting time at intersections
- Total number of cars during peak period
- Traffic related deaths
- Number of street lights and cctv cameras

Institutional Sustainability. Technology cannot substitute governance. It can complement city's substantive teleonomy (Ortiz, P., 2018). City of Bangalore should strive to establish shared vision of what the city should be, formulate goals and select appropriate technologies to help achieve the goals. If the city's social fabric has gaps and inequalities efficiency will be jeopardized (Ortiz, P., 2018).

City GDP growth rate and employment growth rate has stayed over 6% since early 2000. Unemployment rate at 14%, city GDP was $83 billion in 2011 with an expenditure percapita of Rs.2721 per month. Strong governance structure requires participatory residents. A closer look at Bangalore neighborhoods reveals that the city has strong Resident Welfare Associations (RWAs) or Neighborhood Associations (NAS) in every ward or municipal jurisdiction. Currently RWAs serve as an informal mechanism of feedback loop for grievance redressal (Figure A1). With the recent order issued by the Mayor to the wards of Bangalore, it is now a mandate for the ward committees to conduct monthly meetings in every community in the first Saturday of every month starting December 2018 at the ward office.

Indicators selected to help measure institutional sustainability are listed below.

- Unemployment rate
- Total revenue and sources
- Expenditure per capita
- Percentage of basic needs financed through debts
- Number of active RWA
-

CONCLUSION

The National Disaster Management Association (NDMA) has identified 32 seismic zones in the country and Bangalore is in zone 29, with a maximum potential of 6.8 Ms scale earthquakes. Probabilistic analysis had been carried out for 48 cities by computing ground acceleration over 500, 1000, 5000 and 10,000 years. According to the report, Bangalore is relatively the safest among other cities as there is no major threat of natural calamity.

Though the need for Bangalore's preparedness for natural calamity or disaster is limited, it is essential to not let externalities from urbanization pose a significant challenge. The rate at which the lakes and wetlands are being encroached, water bodies contaminated, and air quality unchecked, the city is prone to high risk for man-made disasters.

Indicators selected within ecological sustainability, inclusive growth, mobility and institutional sustainability are chosen to help the city intervene in the health, well-being, and increased productivity of its residents (Figure A2). For the select indicators to fulfill the characteristics of attributes stated earlier and gather accurate measurement for informed decision-making; there has to be a formally established feedback loop. Unlike cities of the western world, the sheer size of the city of Bangalore and its population of over 12 million could pose a challenge to receive timely feedback and monitoring, unless communities are engaged and made part of the system.

Government's inability to manage urban challenges is most often the result of lack of capacity and that of ignoring the assets and liabilities of the city during the planning process. Proposals to develop newer cities or newer projects that disconnects from the existing ones are a result of the inability to connect the knowledge and the infrastructure base. In order to avoid repeating the mistakes of the past and build on the assets of the city; it is important to identify, formalize the informal best practices in the city, and strengthen them. Sustainable development is by no means an environmental movement directed solely by the government but is a community movement facilitated by the government. With this notion, the "Re-imagine a more Sustainable Bangalore"

could be an initiative that is envisioned as a ground up movement that has a potential to engage all stakeholders of the city and be truly sustainable.

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APPENDIX

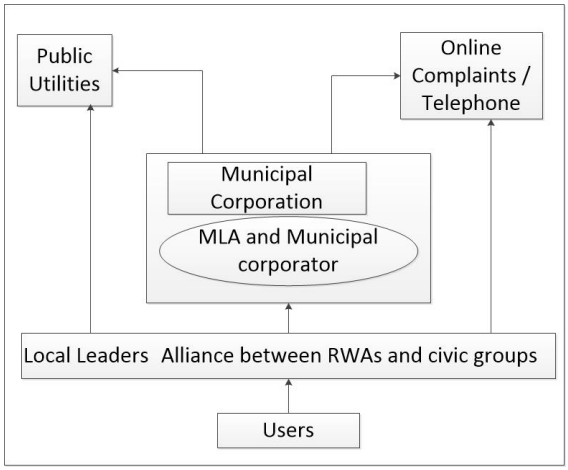

Figure A1. Typical grievance redressal mechanism found in the neighborhood



Figure A2. Sustainability Indicator groups selected for Re-imagine a more Sustainable Bangalore Initiative

Kerala Traditional Architecture -A Testimony to Sustainable Architecture

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Abstract: A traditional architecture of a region is the one that evolved with time and that talk about the local cultural, social, economic and environment friendly life of the people of the place. Kerala is one of the states in India famous for its culture and natural beauty, where the traditional architecture are world famous for its sustainability, climate responsiveness, local and natural material usage and its age. The objective of the paper is to study the sustainability aspects of Kerala traditional architecture and analyze its significance in the modern world. The methodology of the study is based on the comparison of the strategies of sustainability from literature with the real life study of traditional buildings in Kerala. The major strategies considered were site and land use, health and wellbeing of the occupants, materials and energy. The buildings were selected in a single geographical zone, Kannur, of Kerala to limit the study. Two residential buildings, more than 100 years of age were visited and studied. The result focus on study of the construction of a traditional building to its existence till date. The construction techniques to materials to its climate responsiveness are studied in detail. The paper concludes with the learning of traditional architecture and integrating the study to the contemporary architectural works.

Keywords: traditional architecture, sustainable development, modern

INTRODUCTION

The sustainable development concepts are gaining more relevance now days, as the traditional buildings are vanishing in our natives. The scenario is the same in Kerala, India. But the contemporary architecture of the region to certain extend has become mere copying of an alien concept about architecture from west to our land. They work predominantly for the mechanically operated environments. This has eradicated the local traditions and given birth to a faceless urban development. Discussions are happening among environmentalists to reduce the over exploitation of ecology and natural resources, but sadly a mere failure is faced by them in most of the cases as development and human made spaces are in trend today. This over exploitation of natural resources is a threat to our existence. Human being are forgetting the words of a great personality, Mahatma Gandhi, that - “Earth has enough to satisfy every man’s need but not his greed.”

Building constructed of cement, steel and bricks are most of the times solids that does not breathe and always needs to cut break to let air in. They are environmentally unsound. They also lack the passive and natural environment controlling system that again consumes energy.

Our practices today at times ignore certain facts about our traditional architecture. Influenced from the non-regional characteristics of the contemporary practices and forgetting the knowledge in traditional architecture have caused the formulation of unsustainable architectural practices (1). Traditional architecture always represented the right harmony between the need of living, natural environment, spaces and use of materials (2). Using these elements from traditional buildings, contemporary architecture could be formulated as continuity to the culture, building adaptability to climate and sustainable architecture. A building should be a livable in all sense. They should be capable of energizing human rather than causing any building illness. Sustainable architecture is a solution, where it helps in creating indoor and outdoor spaces but connects with nature too.

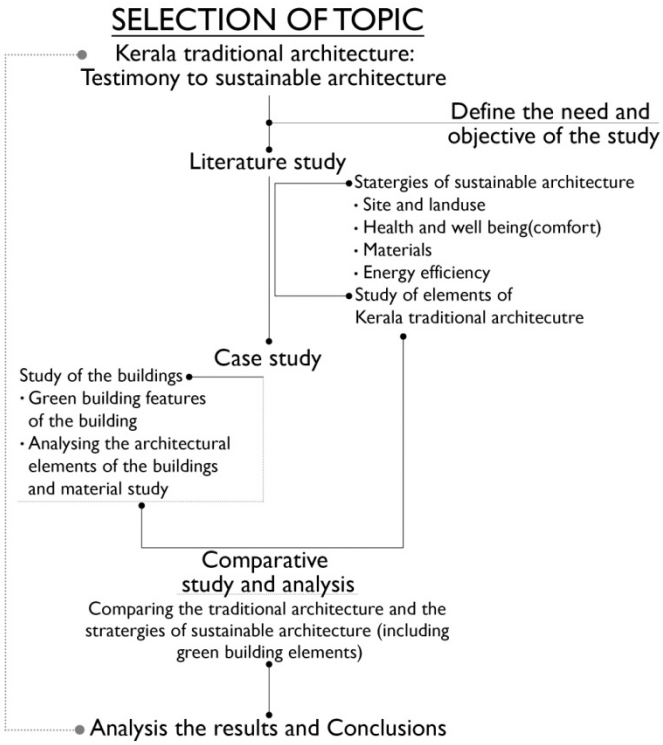
The traditional architecture evolved through the trial and error method of construction where human constructed houses suiting his climatic environment, his daily need, and other physical activities. They have evolved by satisfying humans ‘basic need’ for a shelter rather than satisfying ‘his ego’.

The intention of the study is to discover the values of traditional architecture through exploring Kerala traditional architecture. The analysis of the study will be based on the literature works on the strategies of sustainable architecture and also the characteristics of climate responsive architecture for Warm humid climate. The major scope of the study is to enlighten the young modern world of architects about certain set of

architectural practices, elements and components of traditional houses to evolve a sustainable modern world of construction.

METHODOLOGY

This research paper aims to create an understanding that Kerala traditional architecture is a demonstration to sustainable architecture in Kerala.



Strategies of sustainable architecture

It is estimated that by 2056, the global statistics will change drastically. Global economic activity will increase five times than present, global population will increase over 50%, and global energy consumption will be increased approximately three times, and global manufacturing activity will be increased three times the least (3). Building industry is one of the most intensively energy used sector.

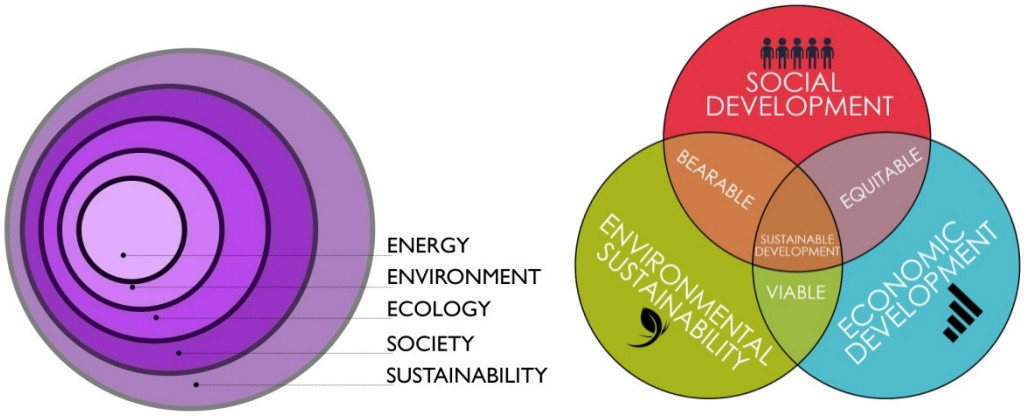


Figure 1. Concepts and dimensions of sustainable development

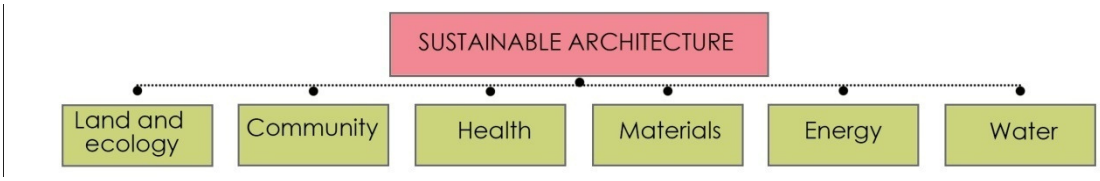


Figure 2. Elements of Sustainable architecture

This causes humongous issues like global warming and climate change, pollution, over exploitation of resources, depletion of renewable energy sources etc. Sustainability fundamentally affects the way an individual lives. "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This is definition of sustainable development is quoted in the Brundtland commission report - Our common future. In the Book "Sustainable housing principle and practices, Edward and Turrent explains the concept as the development that accommodate the careful, efficient and beneficial treatment of society, ecology, environment and energy. In many researches the dimension of sustainability of are summarized into three: Social, economic and environmental (3, 4)

Deriving from the concepts of sustainability Paola Sassi has written book on 'Strategies of Sustainable Architecture' considering the major issues in the building industry and its adverse impacts. Buildings has to be designed and built to contribute positively to the sustainability agenda, economically, environmentally and socially (5).Sustainable design for a house, can the explained with the sustainability in land use, community developments, human wellbeing, and usage of material, energy and water.

Table1. The framework for strategies and dimensions for Sustainable architecture (4, 5)

DIMENSIONS	CONCEPTS	ELEMENTS	CONCEPTS
Environmental sustainability	_Protecting the land, flora and fauna. _Reducing pollution _Protecting and enhancing biodiversity _Efficient use of resource _Focusing on energy efficiency	Land	_Select sites that can cause low ecological damage _ Build on previously used and derelict land _Protect local and existing natural habitats and introduce new planting
		Water	_Minimizing the need for water and use water efficiently with less water fixture and systems _Recycle used water and harvest rainwater _Reduce the use of mains drains.
Social Sustainability	_Social progress of a community _Recognizing human needs _Working with local communities	Community	_ Recognizing and enhancing the social capital _ Providing basic needs _ Enhancing the quality of life _ Ensure a quality public environment
		Health	_ Physical comfort levels _ Keeping the living environment pollution-free _ Restorative environments

Economic Sustainability	_Maintenance of steady and high growth in economic _Ensuring employment for all _Increased profitability and productivity	Materials	_Minimizing the need for materials _Use locally available materials _Design reused and recycled materials _Select new materials that do not pollute the indoor air. _Material disposal and waste minimization – Include recycling provisions in buildings.
		Energy	_Reduce energy requirements: use passive design techniques _Use energy efficiently with efficient equipment and systems _Use 'green' energy sources

Location: climate and topography

The study area is one of the northern districts of Kerala, Kannur 11.86°n latitude and 75.35°e longitude. The characteristic Kerala architecture results from the geographical, climatic, and historic factors. The architectural character in the traditional buildings of Kannur evolved in response to the climate of the region. The sample chosen for the study are old traditional residences in Kannur, as human being spend approximately 65% of life inside residences (survey by university of California). The selected residences are more than 100 years old and occupied till date.

One of the case studies was old ThrikkaikunnuKottayam palace in front of Thrikkaikunnu temple, Kannur and the residence was constructed around 1849. It's in 35 cents of land and accommodated around 20 families earlier and ended with a family of 6 people today. The other study was on PullambilTharavadu, in the Pullambil region of Kannur district. It is more than 100 years old (year of construction is not known) on 3.5 acres of land with around 2 acres of farm and other vegetation.

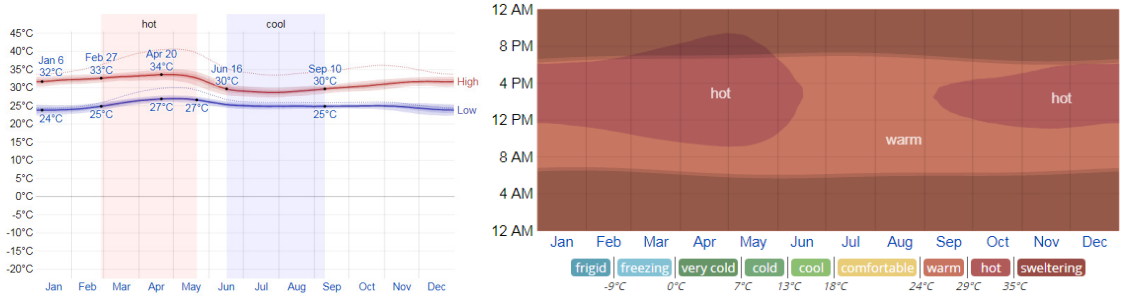


Figure 3. Average high and low temperature and Hourly temperature data with comfort conditions (Source: https://weatherspark.com)

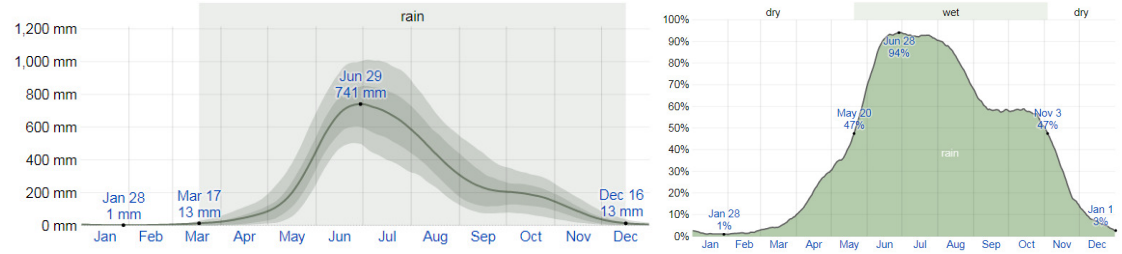


Figure 4. Monthly rainfall in kannur and Daily chance of rainfall (Source: https://weatherspark.com)

The base for humidity comfort level is on the dew point, this can determine the comfort level in human based on the amount of evaporation from human skin. The comfort conditions are muggy, oppressive and miserable 85% of a year.

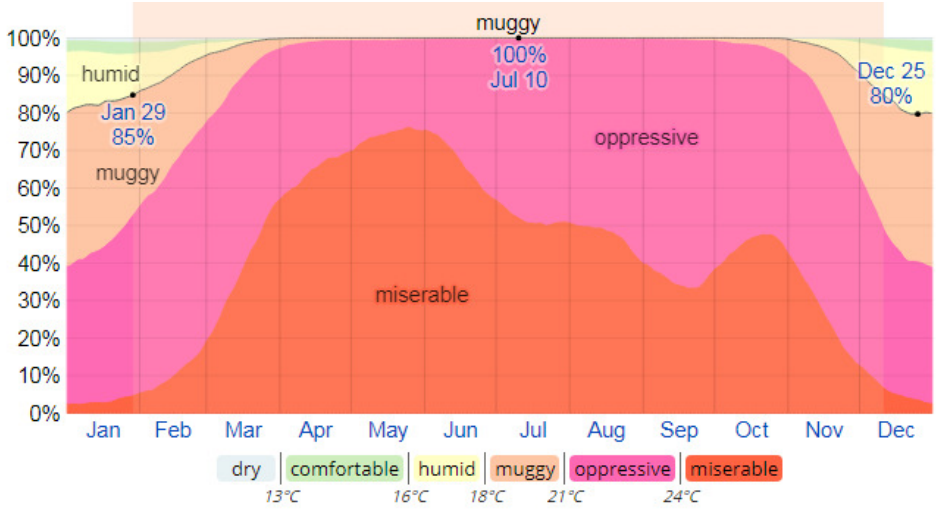


Figure 5. Humidity comfort level for the region
(Source: https://weatherspark.com)

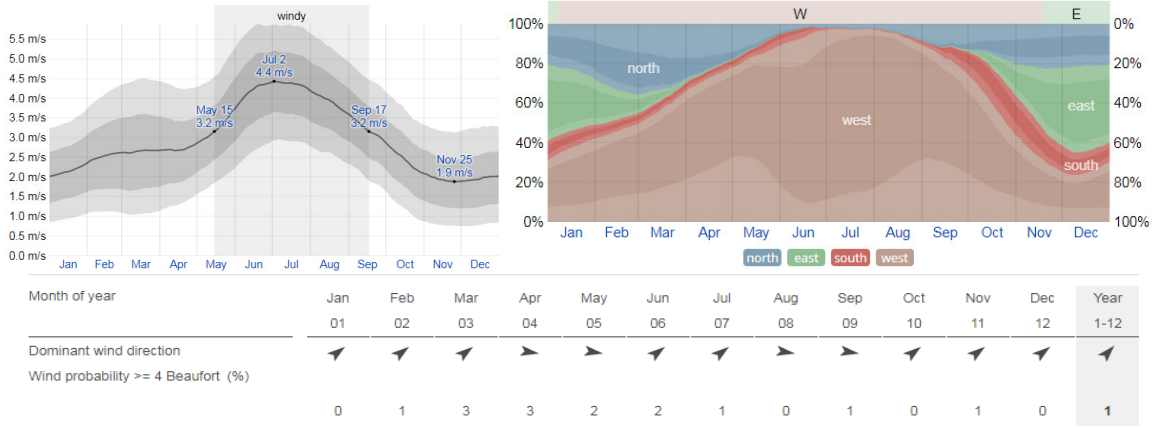


Figure 6. Average wind speed and wind directions
(Source: https://weatherspark.com)

The hottest day of the year is in April, with an average high of 34°C and low of 27°C. The coldest month of the year is January, with an average low of 24°C and high of 32°C. Kannur is a region with heavy rainfall annually, with an average rainfall of 3350mm in a year. The wettest day in a year is June with 94% chance of wetness. (Fig.6) shows hourly average wind vector (speed and direction) at 10 meters above the ground. The average wind speeds of more than 3.2 meters per second, where the wind is dependent on topography and other physical factors.

SUSTAINABILITY OF KERALA TRADITIONAL ARCHITECTURE

Environmental sustainability: Land use and Water efficiency



Figure7. The site development 1.Thrikkaikunnu residence 2.Pallumbil residence



Figure8. Sources of water 1.Thrikkaikunnu residence 2.Pallumbil residence

Architecture in Kerala was based on 'Vastushastra' where the building is designed and the spaces are oriented in the cardinal directions. The residential plots are primarily square. Planning of the residences begins with the division of the plot follows determination of the cardinal directions or squaring the site.

The traditional residences of Kerala with a courtyard and all the other spaces positioned around it are 'Nalukettu'.

As West and South of the plot receives the highest heat, the spaces for morning use are place away, and mostly kept in North, East, North East and North East. And spaces for night uses are in the other directions.

The residences (Tharavdu) were constructed in large plots where in most case the residence accommodated more than five families and the buildings occupied less than 30% of the land and the rest of the plot accommodates large farm land, cow shed, guest houses and other amenities.

The residential plots were self-sustained.

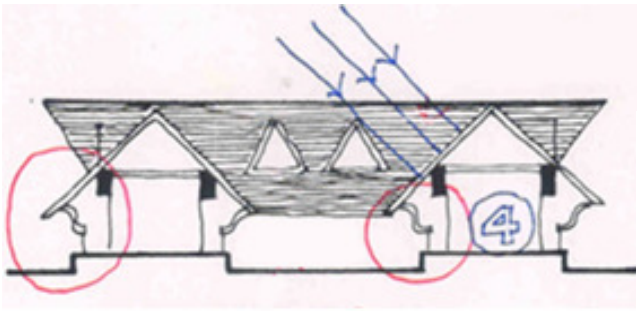
The water sources for the whole site is made in the plot itself, or uses natural sources which serve all indoor and outdoor uses of the residence.

Social sustainability: Community development and human well being

The residences of Traditional Kerala were designed to support the social life too. The verandas and courtyards were the major spaces in these houses for the social gatherings and treats. The major feature of the residences were the absence of compound walls, which opened the plots to other people, work in farms, feed cattle etc. indeed promoted the social relationships.



Figure9. Space for meeting and gatherings
1. Thrikkaikunnu residence, veranda 2.Pallumbil residence, courtyard



Courtyard play a crucial role in climate control by the stack effect of moving hot air up and the pressure difference suck cool air in.

Figure10. The stack effect in the courtyard
(Source: http://archiestudio.in/regional_heritage_-_kerala)

The human wellbeing in the residences can be well explained with the environment friendly and climatically responsive design. This technique develops an organically breathing building.

Climatically responsive traditional architecture of Kerala (6, 7)

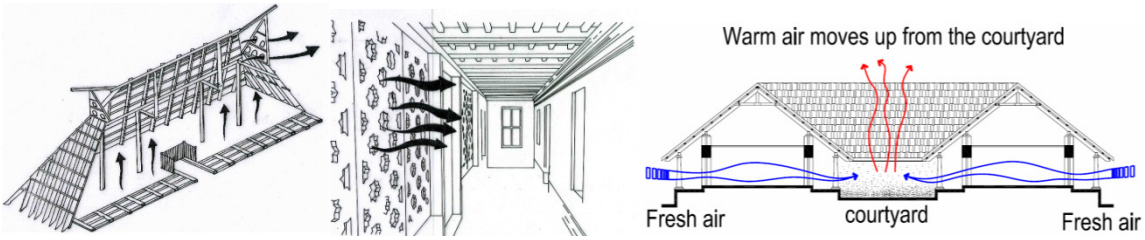
- The orientation of building is crucial in the traditional buildings, as people believed in Vastu rather than architecture. But the intention behind the orientation of the buildings and the planning was to take advantage of the wind and to restrict heat gain.
- Dampness is eliminated with high plinths
- Verandah and internal courtyard protects the building from rain and sun.
- Pitched roof prevented water penetration to the building. The overhang of the roof helped in keeping water from walls also.
- The clay tiles and thatches on the roof cool down faster owing to its low thermal mass.



Figure11. Gable roof, tiled and over hung

1. Thrikkaikunnu residence 2.Pallumbil residence

- Pitched roof with gables created an attic space for the residence, which were functionally storage spaces and climatically a space insulator and gables enhances ventilation to allow warm air to escape.
- Openings are fewer towards the exterior and more towards the courtyard taking in less radiation and facilitating air circulation (stack effects)
- The use of Jallis prevents the entry of direct sunlight to the rooms, but allows air movement.



(a) **(b)** **(c)**

Figure 12.(a) The insulating attic (b)Venturi effect through Jallis
(c) Stack effect in courtyards

- Walls are painted in light colors so that it reflects the radiation.
- Walls have rough texture causing self-shading for walls.
- The walls made of porous laterite helps cool the building. The thickness and thermal properties of the material prevents radiation from penetrating.
- The green cover in the site create a pollution free environment for the residents

Economic sustainability: Material usage and Energy efficiency

The materials used in these residences are all of least embodied energy as the transportation factor is nil. The materials used in the construction on residences like laterites, rubble, lime, oxide, tile/thatches, natural stone are acquired from the site itself or the nearby regions. The major materials, laterite is porous and breathes itself. They have low U-value that the transmit heat slowly.



Figure 13. The construction materials used in the buildings

The major highlight of the materials is the durability of the these materials to the extent that the building exist unworn and undamaged for more than 100 years, which is a never expected life expectancy for today's residences. The traditional architecture of Kerala demonstrate an example of social upliftment or empowerment as the materials like terracotta tile, natural stone, ornamental elements are all created in the small scale units of craftsmen.. "Perunthachan", the master carpenters were the architects of the old traditional buildings of Kerala.

Evident energy efficient design elements in the building are C-shaped ventilation tile to take hot air out and the



Figure 14. The c-shaped tile and glass tile in the roof

clear glass tile to let sun light inside the room (especially in kitchen).The climate responsive design factors like the veranda, gable roof, courtyards, jalli walls and white lime plastered walls prevent the heat in the indoors, inturn reduce the usage of mechanical conditioning systems. These factors create a harmonous environment for human and nature and they follow the principle of life "Give and Take".

CONCLUSION

Ignorance of traditional architecutre and techniques has led to the loss of knowledge of the human to create a comfortable living space for themselves that are environmental friendly and also energy efficient. Therefore preserving, learning and practicing the traditional or vernacular architecture is important for the future generation in terms of sustainability. Traditional buildings are designed and constructed based on the knowledge aquired for the culture and lifestyle of the locals. They use less resources and local materials to maintain thermal comfort in the buildings in particular climate zones. They are ecologically sensitive and environmental sound. They satisfies all the specification for sustainable architecture.

Acknowledgement

I had great help and good guidance from some respected persons for preparing this research. I would like to show my deepest gratitude to Prof. SubashVarma, TKMCE, Kollam, for his support and guidance for numerous consultations. I am thankfull to those who directly and indirectly help me through the project, especially to my senior advisor Dr. Dili A.S., TKMCE, Kollam. My sincere thanks goes to Dr. A. MeenatchiSundaram, NIT, Trichy for his support and encouragement for writing this paper. I should also express my appreciation to many people, particularly my classmate for their valuable comments and suggestions.

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Assessment of Daylight in Residential Architecture– A Study of Apartments in Chennai

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Abstract: In a day, the light comprises of all the direct and indirect sunlight which consists of diffused sky radiation and direct sunlight reflected by the buildings and landforms. Within an interior space, daylight is enormously affected by the fenestration of that building. Effective daylighting improves the comfort of a user, his health and satisfaction by reducing the lighting and cooling loads. Despite use of glass, using daylight in modern building can be challenging. Glare and uneven light distribution can cause discomfort for the user and pose challenges to effectively light the spaces. Most frequently, electrical lighting is used to balance lighting in spaces negating any potential energy savings. For existing buildings, the available methods to provide effective daylight are limited by the existing constructions and configuration. This paper aims to evaluate the potential of daylight inside interior spaces under clear sky conditions - the intensity of internal illumination in residential apartment building from available outside external illumination in various apartments in different parts of Chennai city. The natural and electrical lighting in low rise apartments present in coastal areas of Chennai is studied. Comparative analysis has been done for these buildings.

Keywords: Daylighting, Chennai, Apartment building, Illuminance, Illuminance meter, Illumination level, lighting controls.

INTRODUCTION

In a multi-storied apartment, daylight, a non- depleting and one of the most significant resources received from sun, is an important aspect since the illumination received by the lower stories is less when compared to that in the higher stories. Due to the necessity of conservation and reduction of energy usage in recent years, daylight has been incorporated as one of the most basic aspects in designing a building. Direct solar illumination is not a part of daylight design since it creates discomfort due to glare and heat. Hence only sky radiation is considered for illuminating interior spaces of a building.

Owing to the varying positions of the sun throughout the year, it is difficult to predict the daylight that enters a building. Hence with changing geographical locations the intensity of sunlight and its distribution cannot be constant.

METHODOLOGY

This research examines some of the low-rise apartment buildings in Chennai – in areas such as Mylapore, Alwarpet and Raja Annamalaipuram. In each apartment, one flat is studied indoor and outdoor regarding how daylight enters the flat – the Illuminance is calculated using the Konica Minolta illuminance meter. Internally, in each room the illuminance, both at the centre of the room and near the openings/windows, with and without electrical lights are determined. These values are compared with one another.

Chennai – The Study Area

Chennai is located along the Eastern coastal plains of Tamil Nadu with an average elevation of about 6.7 metres with its highest point being 60 metres. Featuring a tropical wet and dry climate, since it lies along the coast on thermal equator, extreme variation in the seasonal temperatures are prevented and hence throughout the year weather is most likely hot and humid.

Average Minimum and Maximum Temperatures

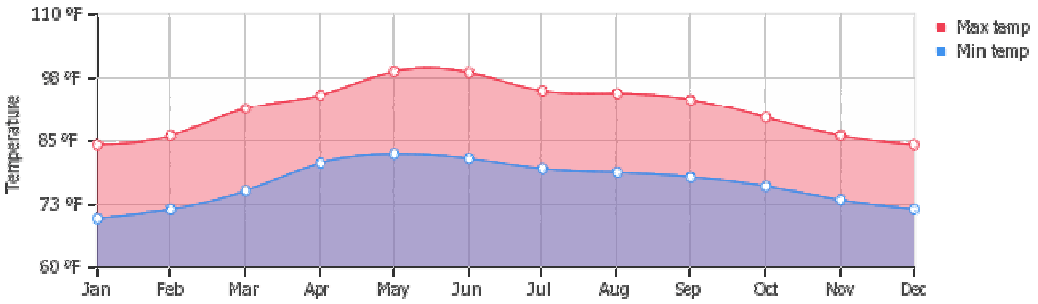


Figure 4. Average temperature in Chennai
(Source: An image from https://weather-and-climate.com)

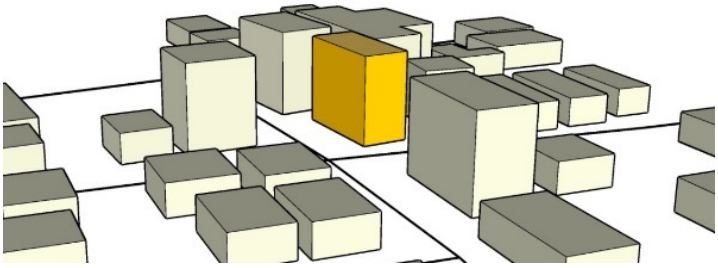
Average annual maximum temperature is: 91.4° Fahrenheit (33.0° Celsius)

Average annual minimum temperature is: 77° Fahrenheit (25.0° Celsius)

APARTMENTS STUDIED

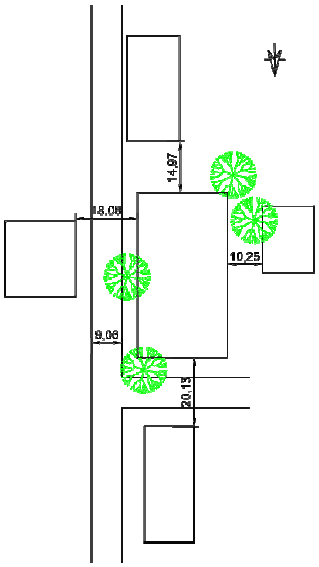
1. Park Villa Apartments

LOCATION: No.14, East Abhiramipuarm 1st Street, Alwarpet, Chennai – 600018



This is a four storied apartment with two units in each floor. The area of each unit is **1250 sq.ft.** Each unit consists of a hall, a kitchen, 3 bedrooms and 2 overhung balconies.

Figure 5. Context of the apartment



This east facing apartment is surrounded by equally tall buildings in east, north and south direction and a two storied building to the west side of the apartment. The surrounding trees provide shade to the apartment.

The width of the street is **9m.**

The building has an average clearance of about 15.75 metres around it, ignoring the presence of trees.

Streets run alongside the east and north directions, hence more daylight comes from these two sides.

The balconies facing the south, are potential to bring enough daylight into the hall and kitchen, but they are mildly shaded by the neighbouring building.

Illuminance was calculated using the Illuminance Meter (Unit – lux or k lux). The following measurements were taken at around 2 pm – 3pm in the afternoon.

Figure 6. Distance from the surrounding apartments
(Source: Author, 2018)

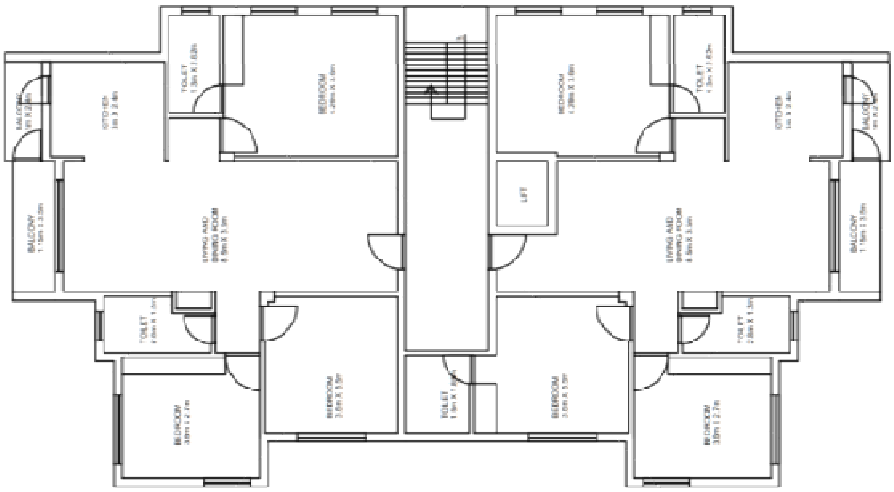


Figure 7. Third Floor Plan (+9m from ground level)
(Source: Author, 2018)

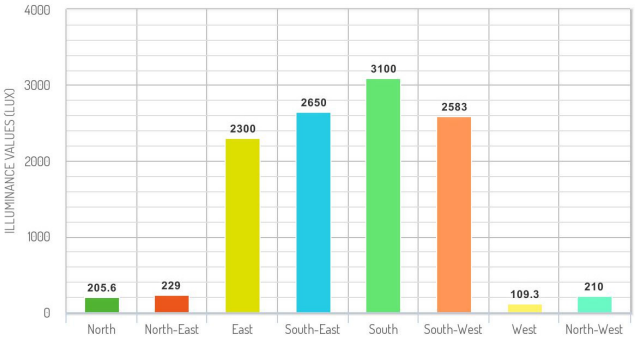


Figure 8. Natural lighting outside the building
(Source: Author, 2018)

The illuminance in the North , North-East, West, and North-West directions is lower when compared to the other directions, due to the presence of trees. In the entrance of the apartment, the illuminance was 1361 lux.

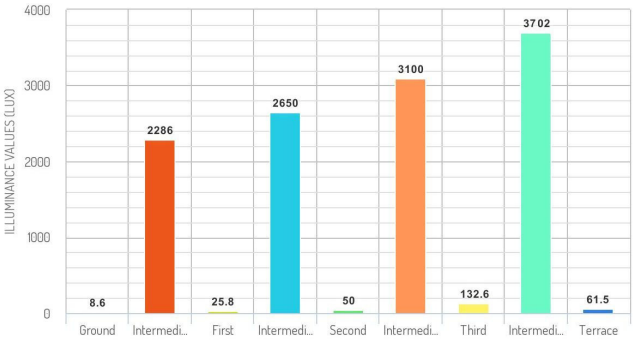


Figure 9. Lighting in the landings of the staircase
(Source: Author, 2018)

Due to the presence of openings in intermediate landings, the amount of daylight entering is higher compared to that in the respective floors. With increase in height, the quantity of light entering increases due to the absence of obstructions in the exterior.

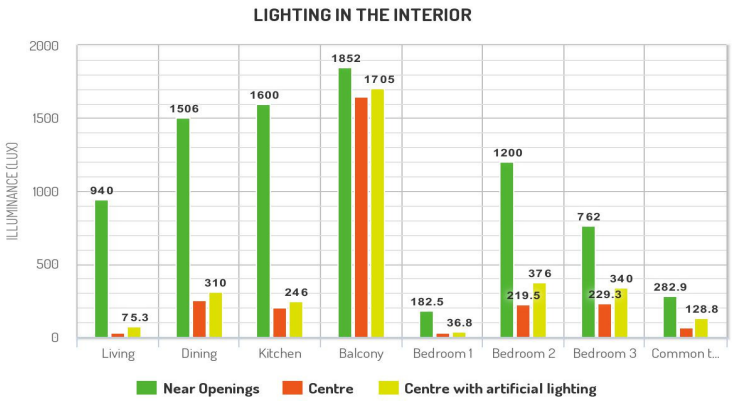


Figure 10. Lighting in the interior *(Source: Author, 2018)*

There is an extreme contrast in the values near the openings when compared to that in the centre of each room. Almost all the rooms receive more than enough daylight except for the bedroom located in the south-west direction (due to the presence of trees). Since the rooms are quite large in size, the illuminance value decreases with the increase in distance from the openings.

Table 1. Surveyed Details taken and Code index for Case 1.

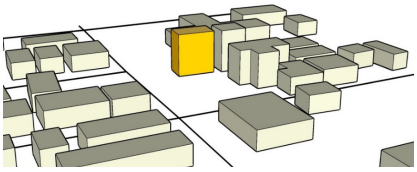
ROOMS	LUX AS PER NLC	AVAILABLE LUX
Living room	50	75.3
Kitchen	200	246
Bedroom 1	50	36.8
Bedroom 2	50	376
Bedroom 3	50	340
Common toilet	100	128.8

Table 1. Surveyed Details taken and Code index for Case 1.

In this apartment, the lighting levels in the kitchen, living area and the bathroom are in par with that in the national lighting code, India. Hence, the lighting available in these rooms are sufficient with the presence of electrical lighting. But, in the bedrooms the available lighting with electrical lighting is too high. Therefore, curtains are used to cover the windows in order to reduce the lighting in the rooms.

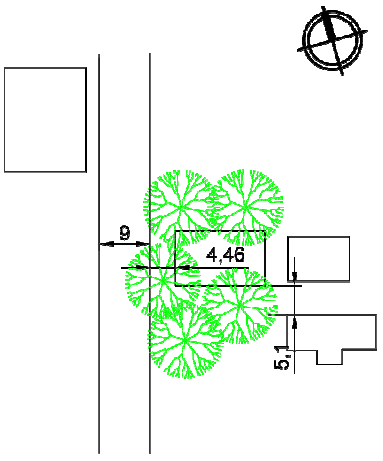
2. Seshachalam Apartments

Location:Bheemanna Garden Street, Sriram colony, R.A.Puram, Chennai – 600028



This is a two storied apartment, with two units in each floor. Each unit is a 3 BHK flat. The area of each unit is **1450 sq.ft**. Each unit consists of a hall, a kitchen, 3 bedrooms, a storeroom and a balcony.

Figure 11. Context of the apartment. *(Source: Author, 2018)*



This north facing apartment is surrounded by equally tall building on the south direction and a two storied building to the east side of the apartment. The dense tree cover provides ample shade to the apartment.

The width of the street is **9m.** Streets run alongside the east-west directions, hence more daylight comes from these sides.

This building is north-south oriented, hence it has a possibility of receiving maximum amount of day light, but due to the tree cover the flat on the ground floor doesn't get sufficient amount of sunlight as it is expected to receive.

The balcony facing the west, are potential to bring enough daylight into the hall and dining, but they are shaded by the trees.

Figure 12. Distance from the surrounding apartments
(Source: Author, 2018)

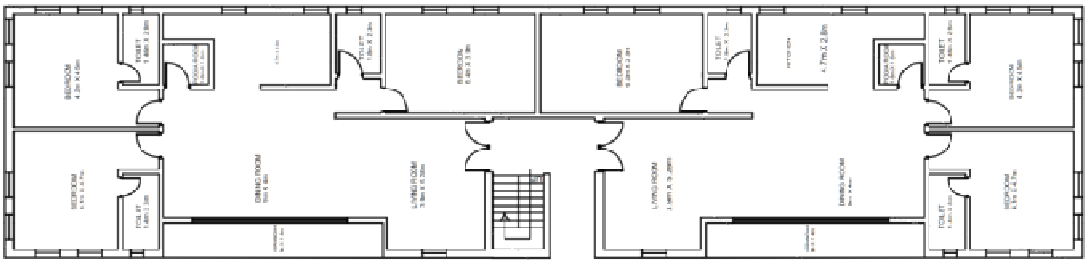


Figure 13. Ground Floor Plan
(Source: Author, 2018)

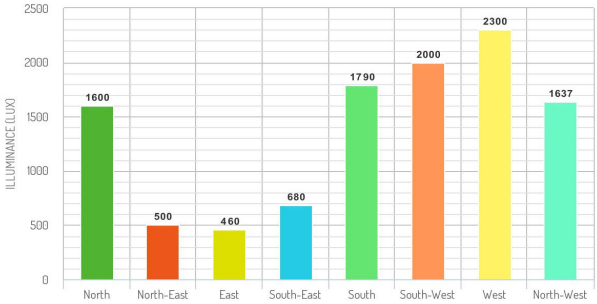


Figure 14. Natural lighting outside the building
(Source: Author, 2018)

The illuminance in the exterior is low, due to the presence of trees.The illuminance at the entrance of the apartment was 870 lux

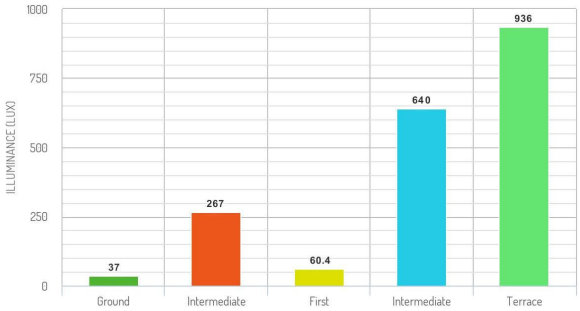


Figure 15. Lighting in the landings of the staircase
(Source: Author, 2018)

Due to the presence of openings in intermediate landings, the amount of daylight entering is higher compared to that in the respective floors. With increase in height, the quantity of light entering increases due to the absence of obstructions in the exterior.

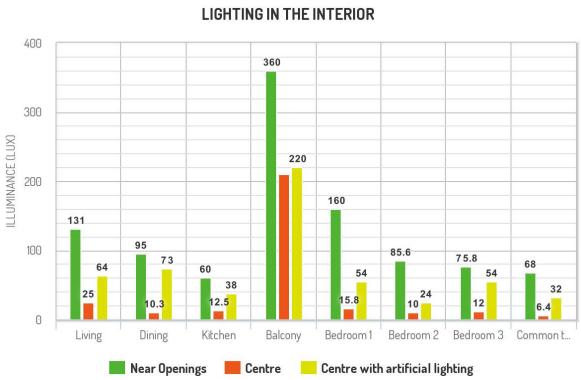


Figure 16. Lighting in the Interiors
(Source: Author, 2018)

There is an extreme contrast in the values near the openings when compared to that in the centre of each room. This difference in the quantity of light varies with different times during the day, depending on the position of the sun. The bedroom facing the east direction receives more daylight than the other bedrooms due to the absence of obstructions. The rooms in the south, west and north directions receive comparatively less amount of daylight due to the presence of trees.

Table 2. Surveyed Details taken and Code index for Case 2.

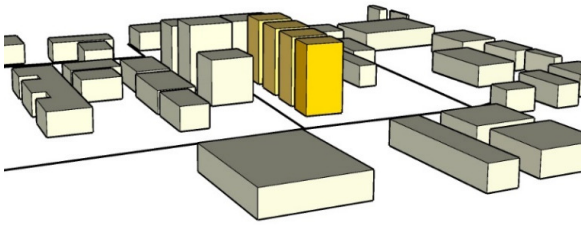
ROOMS	LUX AS PER NLC	AVAILABLE LUX
Living room	50	64
Kitchen	200	38
Bedroom 1	50	54
Bedroom 2	50	24
Bedroom 3	50	54
Common toilet	100	32

Table 2. Surveyed Details taken and Code index for Case 2.

In this apartment, the lighting levels are sufficient in the living room and two of the bedrooms when compared to that in the National lighting code, India. Whereas, in the kitchen and in the bathroom, the lighting levels are insufficient. On that account, a more effective lighting system can be introduced.

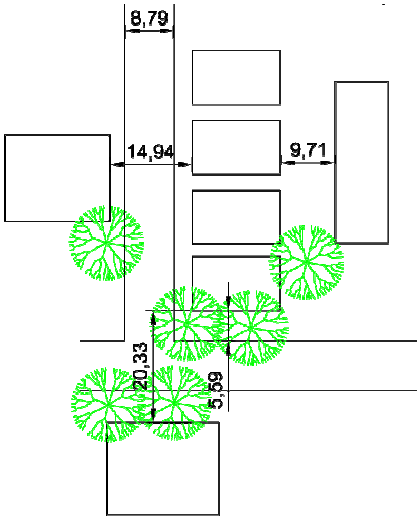
3. Kaveri Apartments

Location:Brindavan Street, Mylapore, Chennai – 600004



This is a four storied apartment building block, with two units in each floor. There are four such blocks. Each unit is a 2 BHK flat. The area of each unit is **855 sq.ft.**

Figure 17. Context of the apartment
(Source: Author, 2018)



This south facing apartment is surrounded by equally tall building on the south direction and a two storied building to the west side of the apartment with ample space in between. The tree cover provides shade on the south negating the effects of harsh sunlight to the apartment.

The width of the street is **10m.**Streets run alongside the east-west directions, hence more daylight comes from these sides.

This building is north-south oriented, hence it has a possibility of receiving maximum amount of day light, which might reduce the amount of electricity usage. The balcony facing the west, has potential to bring enough daylight into the hall and kitchen.

Illuminance was calculated using the Illuminance Meter (Unit – lux or k lux).The following measurements were taken at around 3 pm – 4 pm in the afternoon.

Figure 18. Distance between the surrounding apartments
(Source: Author, 2018)

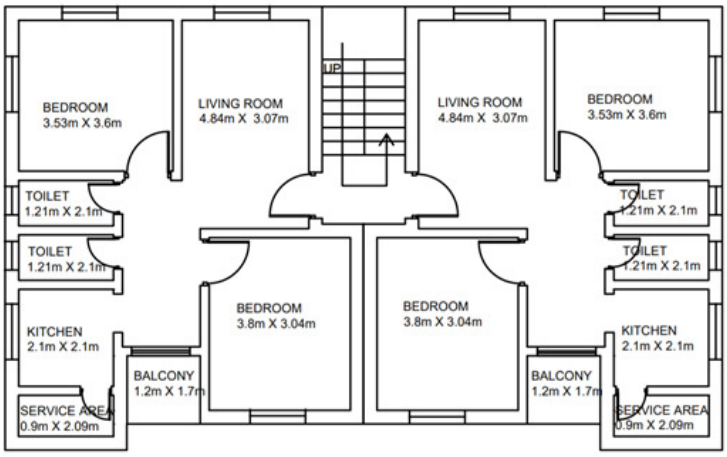


Figure 19. Second Floor Plan (+6m from ground level) *(Source: Author, 2018)*

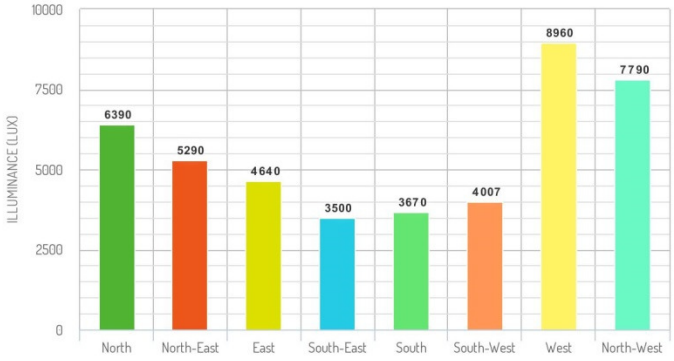


Figure 20. Natural lighting outside the building
(Source: Author, 2018)

The illuminance in the exterior is high to the positioning of the apartment.The illuminance at the entrance of the apartment was 4.64 k lux.

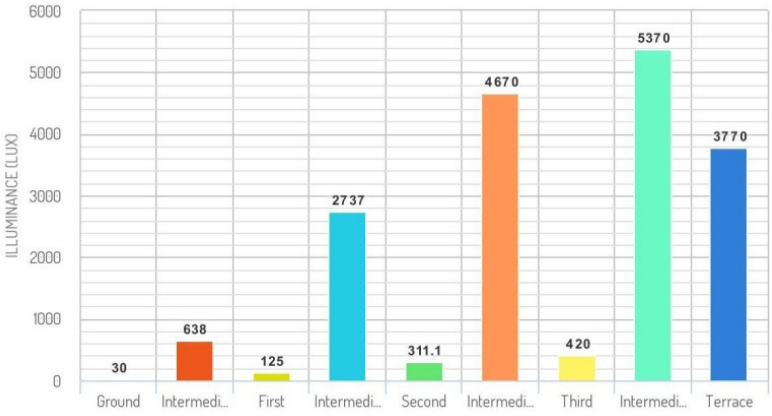


Figure 21. Lighting in the landings of the staircase
(Source: Author, 2018)

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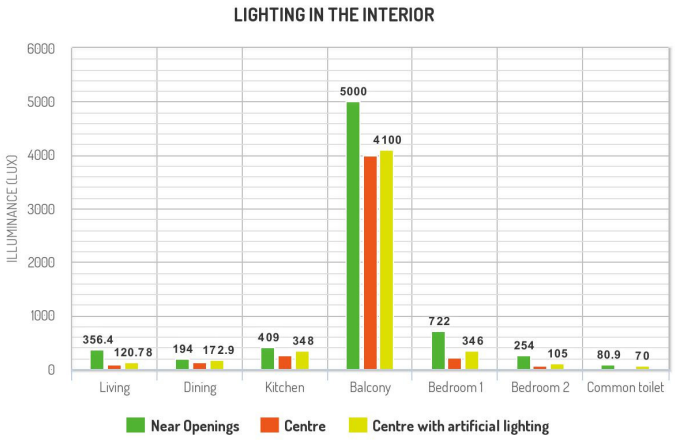

Figure 22. Lighting in the Interiors
(Source: Author, 2018)

There is not much difference in the values near the openings and in the centre of each room. This is because, the amount of daylight entering the building is less in almost all the four directions, due to obstructions like trees and neighbouring buildings. Also, the size of the balconies is not large enough to let in light into the other rooms. The living room, dining room and kitchen do not receive enough daylight due to obstructions on the west, north and east directions.

Table 2. Surveyed Details taken and Code index for Case 2.

ROOMS	LUX AS PER NLC	AVAILABLE LUX
Living room	50	120.78
Kitchen	200	348
Bedroom 1	50	346
Bedroom 2	50	105
Common toilet	100	70

In this apartment, the lighting levels are sufficient in all the rooms except for the bathroom when compared with the National lighting code, India. Lighting levels in one of the bedrooms is higher than required. In the common toilet, the lighting is inadequate. Hence, a better system of lighting should be introduced in these rooms.

COMPARITIVE ANALYSIS: Observation from the Three Buildings

Opening Percentage in Each Apartment

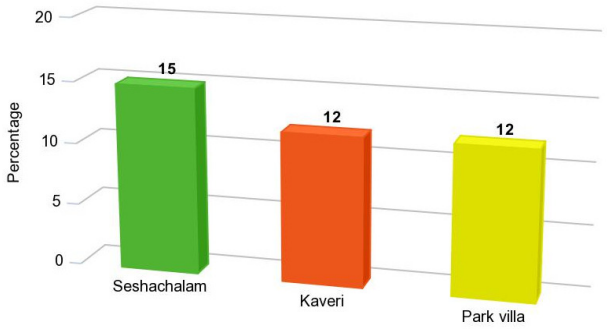

Figure 23. Comparative analysis of the three buildings
(Source: Author, 2018)

The minimum opening percentage that should be provided in an apartment for providing sufficient daylight is 8% and all the three apartments mentioned above have satisfied these criteria.

Lighting in the Centre of the Rooms without Electrical Lighting

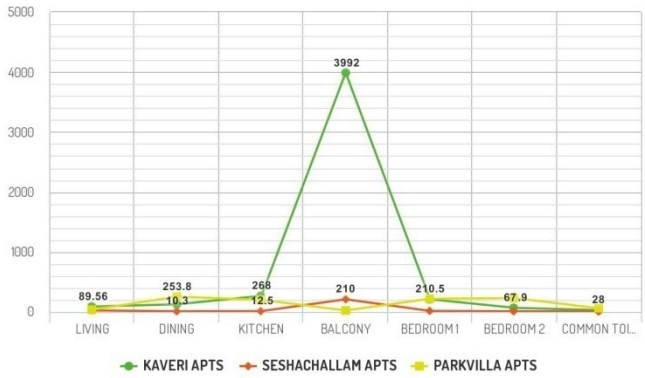

Figure 24. Lighting in the centre of the rooms without electrical lighting
(Source: Author, 2018)

There is a vast difference between the illuminance value in the balcony of Kaveri apartment and that of the other two apartments. This is because, the balconies of the former are facing the south direction, and the balconies in the latter are facing the north and east directions with obstructions like trees and neighbouring buildings.

Lighting in the Centre of the Rooms with Electrical Lighting



Figure 25. Lighting in the centre of the rooms with electrical lighting *(Source: Author, 2018)*

There is not much difference in the illuminance values with and without electrical lighting. The only notable difference is in the balcony of Park Villa Apartment, which has good electrical lighting.

CONCLUSION

The amount of daylight entering the building is comparatively less in the lower floors, and increases as the building goes up – various reasons are, vegetative cover, buildings around it(mostly individual houses which are two storied)Apartments with larger setback area tend to bring in more daylight and ventilation. Also, to reduce the effect of harsh sunlight from the east, south and west directions, a cover of trees would help.

The prevention of undesirable side effects due to daylight in an interior space is as important as providing that space with enough daylight. This can be provided artificially if not available naturally. Making these electrical lighting controls efficient improves the energy efficiency of the building making it quite sustainable.

Three types of controls are commercially available to reduce energy intake:

- Switching controls: when there is adequate sunshine, the on-and-off switch controls the electric lights.
- Stepped controls: multiple levels of lighting control, based on needs.
- Dimming controls: persistently alter electric lighting by regulating the power input to luminaires to balance the illumination level given by sunshine.

The daylighting conditions in various low-rise residential apartments were analyzed and assessed and the above inference was obtained. The above discussed techniques can also be integrated in future developments to reduce energy considerably for Energy.

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Piezoelectric effect: Converting pressure exerted on Architectural elements by human movements into electric energy

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Abstract: The ever-increasing need for energy has reached its historical peak in the current scenario. The future of our planet depends on the methods by which we satisfy these needs. At present, there exist a myriad of renewable energy sources such as solar, wind, etc. Yet, the energy demands remain high and there is an urgent necessity to meet these demands. When humans move, walk, or exercise, they utilize the chemical energy from food and convert it into kinetic energy of movement. As the Law of Conservation of Energy states, "Energy can neither be created nor be destroyed". So, this kinetic energy that helps humans move is converted into pressure that is exerted on the surrounding architectural as well as non-architectural elements. What if this pressure is used to produce electric energy? A rapidly growing concept in this aspect is the piezoelectric effect that converts pressure to electricity. Thus, it becomes possible to produce electric energy using human movements. The piezoelectric effect will provide a valuable source of renewable energy that is both sustainable and efficient. Further in this research, an analysis is done to map the human movements in different spaces at NIT, Tiruchirappalli institutional campus and to identify the ideal spaces from where piezoelectric energy can be harnessed by the architectural elements to meet the current energy demands. These spaces may be general and not necessarily specific and confined to NIT, Tiruchirappalli institutional campus.

Keywords: Architecture, Renewable, Piezoelectricity, Movement, Kinetic, Electrical, Energy, Behaviour, Observation

INTRODUCTION

Energy is defined as the capacity to do work. This work is highly significant in today's world. It is this work that helps us move, gives us light, provides heat in cold climates and keeps us cool in hot climates. So, from where do we get the energy to carry out such work? The chemical energy of food is converted to kinetic energy that helps humans move. We get light, heat and cooling from systems that are powered by electric energy.

In most cases, electric energy is obtained from the burning of fossil fuels in large power plants. Fossil fuels are formed by natural processes which may take hundreds to thousands of years to occur. Although these are renewable sources of energy, they can be renewed only in the long term. Another concern is the environmental impact of burning fossil fuels. The burning of fossil fuels leads to the emission of large quantities of carbon dioxide which is harmful to the atmosphere. It is the major cause of Global warming and Global climate change. This raises a need to identify sources of energy to help reduce the dependence of humanity on fossil fuels.

Advances in technology have led to outstanding inventions and innovations in this field. Today, there exist devices that can harness energy from the Sun, Wind, Ocean waves, etc. Albeit, the world is still largely dependent on fossil fuels as its primary source of energy. Newer sources of energy can help reduce the consumption of fossil fuels, but to stop its usage is a highly difficult task.

USING KINETIC ENERGY AS A SOURCE OF ELECTRICITY

Energy loss to surroundings

As mentioned earlier, the chemical energy of food is converted to kinetic energy that helps humans move. The law of conservation of energy states, "Energy can neither be created nor be destroyed, it can only be transferred from one to another". So, what happens to the kinetic energy that helps humans move? What does this energy get converted into? This kinetic energy is lost to the surroundings in the form of heat and sound. In addition, it also exerts a force that acts upon the surface in contact with the body. Theoretically, this can be put as follows,

Kinetic Energy → Heat + Sound + Force on surface

Harnessing the lost energy

Now, what if we use the force that acts upon the surface to produce electric energy? The idea is to convert the kinetic energy of human movements into electric energy. How can this be done? The kinetic energy of human movements can be converted into kinetic energy of the surface or a system. This kinetic energy can then be harnessed as electrical energy.

A simple example would be a bicycle generator. Here, a person pedals (kinetic energy of human movement) the bicycle and as the wheel moves (kinetic energy of the system), it moves the generator which converts the kinetic energy into electrical energy. This electrical energy, with the help of a converter and inverter, can be changed from direct current to alternating current and can be used to power a light bulb. Another example from daily life is a traditional feature phone, the kinetic energy that we exert on the buttons of the mobile phone gets converted into electronic signals (electrical energy) that powers the phone on and makes it work as we want it to.

PIEZOELECTRIC EFFECT

Piezoelectricity or the piezoelectric effect refers to the electrical energy produced from the pressure exerted on a material. Piezoelectric materials such as quartz are capable of producing an alternating current when subjected to vibration under favorable conditions. This was first demonstrated by the Curie brothers, Pierre Curie and Jacques Curie in 1890.

A common example of the piezoelectric effect is a simple gas-stove lighter. The lighter holds in it a piezoelectric crystal fixed to a spring and a hammer. When we apply force on the hammer, it transfers the pressure to the piezoelectric crystal through the spring. The piezoelectric crystal then produces a high voltage between two metallic points, which results in a spark due to the ionization of air. This spark, when exposed to a combustible gas, produces a flame.

The piezoelectric effect can thus be used to convert the kinetic energy from human movements to electrical energy. Piezoelectric crystals can be fixed to surfaces that come regularly in contact with humans. These crystals can be connected to a converter and inverter if required, and then to a storage bank, which shall store electrical energy for future use.

A SCHEMATIC MODEL OF A PIEZOELECTRICITY GENERATOR

Working principle

Piezoelectric crystals, when subjected to pressure are capable of producing high voltages of electrical energy (as seen in Fig 1 and Fig 2). The converse is also true.

Working procedure

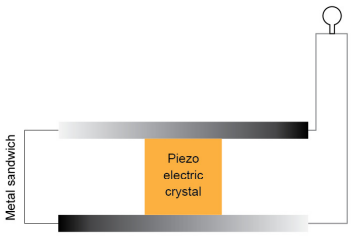
When a force is acting upon a piezoelectric crystal, it deforms. As it deforms, it tries to regain its original shape, and in this process, it converts the pressure exerted on it into an alternating current. This can then be converted to direct current and stored in a storage bank for future use. Thus, in this process, kinetic energy from human movements is converted into electrical energy and is used to power electrical equipment (as seen in Fig 3). The amount of electrical energy produced differs depending on the type of piezoelectric crystal used. Generally, the amount of energy produced is not very large, but it is enough to power small devices like charging a mobile phone or lighting a small bulb.

Magnitude of energy produced

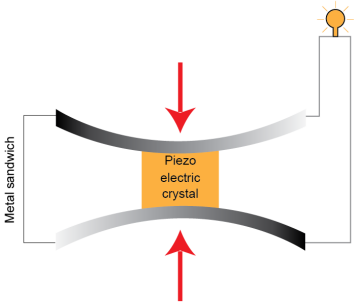
A 1 cm3 quartz crystal, when subjected to a force of 2 kN, is capable of producing a voltage of 12,500 V.

Necessity

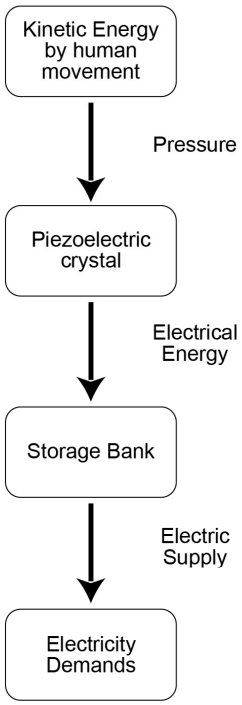
There are many places in the world even today, where electricity is long sought. In such places, even a small amount of energy produced by these piezoelectric crystals would be of immense use, leading to greater development. Moreover, piezoelectricity does not cause harm to the environment and is an environmentally friendly technique. Also, it is an easily renewable source of energy, unlike fossil fuels, making it a sustainable approach to producing electricity.



(Fig.1) Piezoelectric system at rest



(Fig.2) Piezoelectric system under pressure



(Fig.3) Conversion Process in a Piezoelectric System

LOCATING A PIEZOELECTRIC SYSTEM

The location of a piezoelectric system plays a significant role in determining the magnitude of electrical energy that is produced. Piezoelectric systems can be connected to the flooring, as the floor receives maximum pressure from human movements through footsteps. Being a fairly new approach, not much research has been done to integrate piezoelectric systems in floors. Although, there have been instances where such systems have been tried and tested successfully.

In large urban locations, such as plazas, squares or even streets, the use of piezoelectric systems can help supply sufficient energy to street lamps and other electric requirements. On an average, humans take about 7000 steps in a day. If we can use the kinetic energy of these movements by multiple users at such urban locations, large quantities of electricity can be produced. The location of the piezoelectric system should be such that it comes under maximum pressure from human movements. The system should generally be located at crowded locations, where the number of footsteps per given time is relatively high.

A research was conducted at National Institute of Technology, Tiruchirappalli (NITT) University Campus, to determine ideal locations for installing piezoelectric systems. The main aim of the research was to identify crowded locations which have a relatively higher number of footsteps per given time. This will help determine an ideal location at which maximum electrical energy can be produced by the piezoelectric system. These locations may be specific to NITT Campus but can also be generalized in terms of the typology of the space considered. And, thus the inferences of this research may apply to any university campus in general.

RESEARCH METHODOLOGY

At first, a preliminary survey was conducted to identify major activities and gathering locations within the university campus. The survey consisted of questions to analyze the usage of four different types of spaces within the campus. These included public plazas, eateries, sports activities and streets. Such spaces generate maximum crowding at various times. The survey helped in understanding the amount of time spent by an individual at each space and the intensity of the activity carried out in the space.

The next step was behavior observation. This involved mapping activity and behavior patterns. Three different approaches were undertaken to map the behavioral interaction of humans with certain selected spaces.

These approaches include,

- Individual-Centered Approach
- Space-Centered Approach
- Physical Trace Observation

Individual centered approach

In this approach, certain individuals were selected and their day to day activities were mapped in two ways. One on a working day and other on a non-working day. The survey was used to identify and select samples for observation. The major user groups were identified in the survey. These users were divided into four strata and a stratified sample was selected from each of these strata. The daily activities of these samples were mapped to give a fair idea of the major activities performed by the campus users.

Space centered approach

In this approach, certain locations were selected based on the responses in the preliminary survey. A space from each - public plazas, eateries, sports activities and streets – was selected. The daily activities in each of these spaces were mapped on a working day and a non-working day. This helped in identifying major crowding times and major gathering locations in the space which received the maximum number of footsteps for a given time.

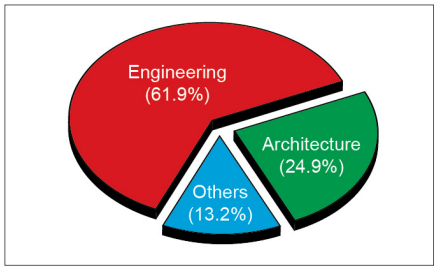
Physical trace observation

The four spaces analyzed in the Space Centered Approach were studied for physical trace observation. In this approach, the spaces were visited when not in use, and any physical traces left behind by human activity were identified. These may be footmarks, erosive flooring or some kind of accretion. This helps to give an idea of the spots that are majorly used. These spots can serve as ideal locations to install piezoelectric systems.

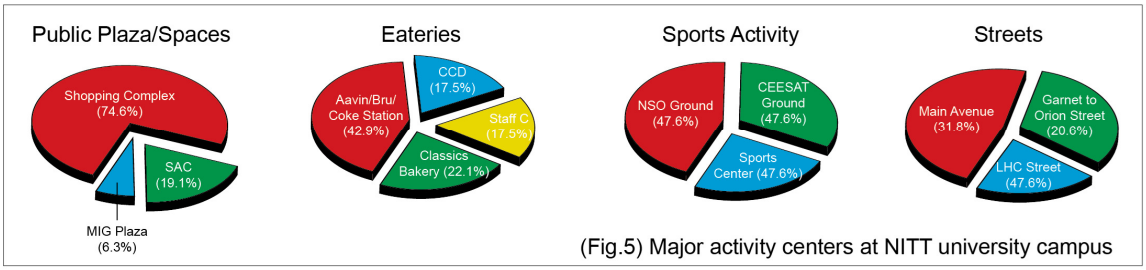
ANALYSIS AND FINDINGS

Survey report

The preliminary survey was useful in identifying major crowding locations and the time spent by various individuals at these locations. The survey was conducted among various classes of users. The responses were recorded from a variety of samples as shown in Fig (4). A total of 126 samples were surveyed. The four different categories of spaces as mentioned before were put forth to the samples and the samples were asked to choose their most visited space from each category. The results of this are as seen in Fig (5).



(Fig.4) Variety of Surveyed samples



(Fig.5) Major activity centers at NITT university campus

BEHAVIOUR OBSERVATION

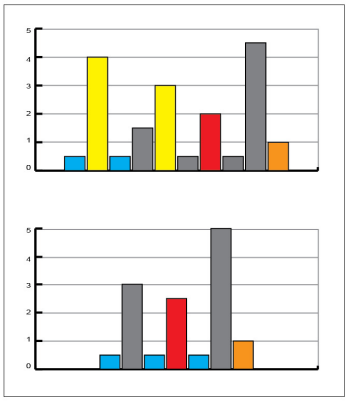
Individual centered approach

The survey helped to establish different clusters of users based on their type of activities and major locations used. The major users are students, staff and other residents of the university campus. Taking the clustered sampling approach, the student cluster was selected to be studied. The student cluster was selected since they are the most active users of the university campus and are much larger in number than the other clusters.

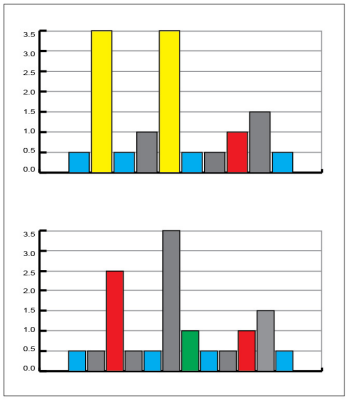
Further, the student cluster was categorized into four major strata based on the type of activities carried out. They were – Engineering (Male), Engineering (Female), Architecture (Male) and Architecture (Female).

A sample was selected from each of these strata (stratified sampling).

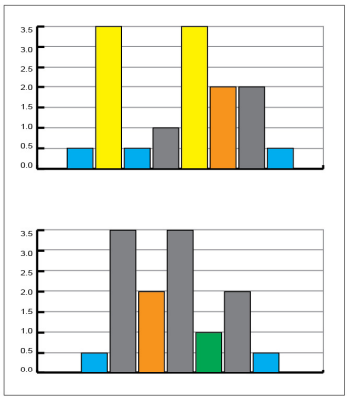
These samples were studied, and their daily activities were mapped to identify major activity centers and the



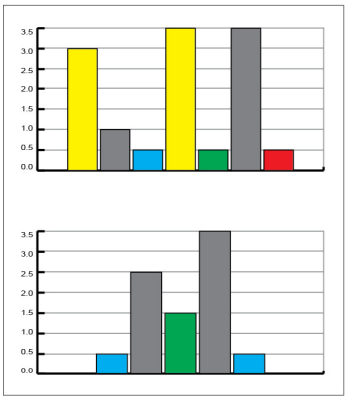
(Fig.6) Stratified Sample 1



(Fig.8) Stratified Sample 3



(Fig.7) Stratified Sample 2



(Fig.9) Stratified Sample 4



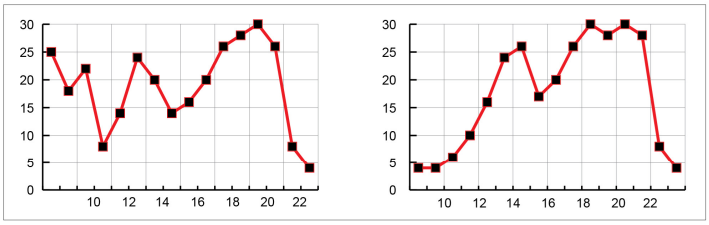
time spent doing the respective activity. The results of this approach can be seen in Fig (6), Fig (7), Fig (8) and Fig(9).

A general observation is that the samples spend most of their time at hostels and classrooms. The next space that is most used by the samples observed are spaces enabling sports activities, eateries and public plazas, respectively.

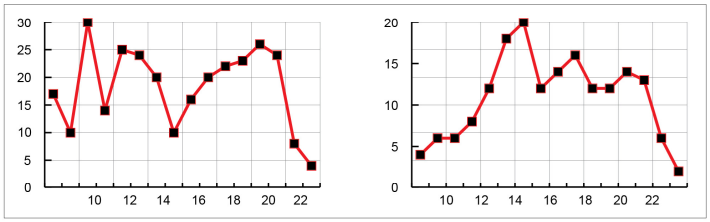
The first stratified sample is a student of Engineering (Male). As seen in Fig (6), it is observed that this sample uses spaces enabling sports activities regularly. Compared to the other samples, sample 1 keeps switching between spaces more often, which implies that sample 1 uses the streets within campus a lot more than the others.

The second stratified sample is a student of Engineering (Female). From Fig (7), it can be seen that this sample dines at eateries and spends time at these spaces relatively more than the others. Sample 2 does not move from one space to another as often as sample 1, which implies relatively lesser usage of streets.

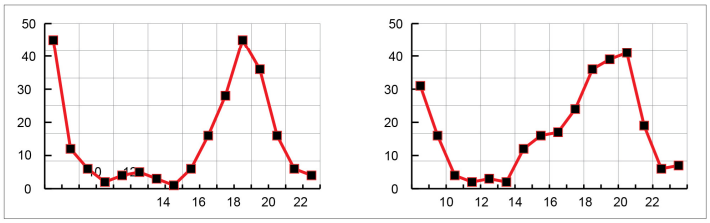
The third stratified sample is a student of Architecture (Male). As seen in Fig (8), it is observed that sample 3 uses spaces enabling sports activities, and also is a regular user of public plazas and spaces. Similar to sample 1, this sample also keeps switching between spaces a lot more than the others, indicating relatively higher usage of streets.



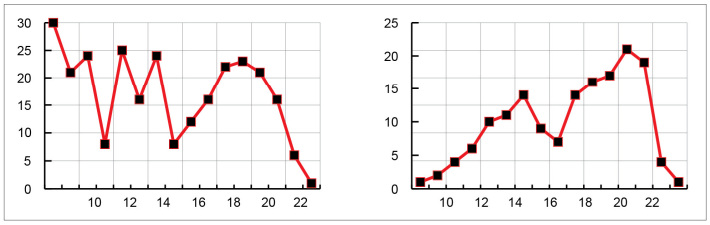
(Fig.10) Public Plaza - Shopping Complex



(Fig.11) Eateries - Aavin/Bru/Coke Station



(Fig.12) Sports Activity - NSO Ground



(Fig.13) Streets - Main Avenue

The fourth stratified sample is a student of Architecture (Female). From Fig (9), it can be seen that sample 4 regularly uses public plazas/spaces and spends about an hour in that space every time. Similar to sample 2, this sample does not switch between spaces as often, indicating relatively lesser usage of streets.

Space centered approach

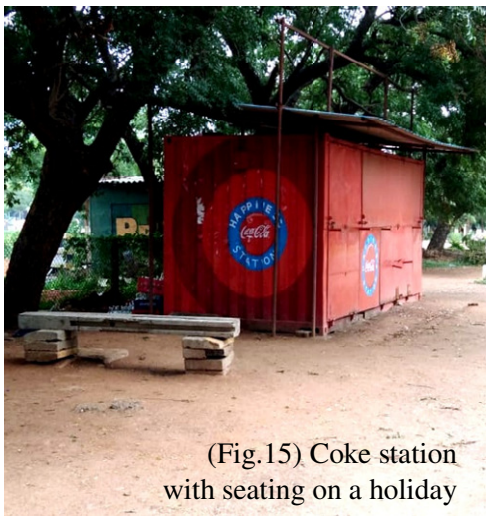
Based on the survey response, a space was taken from each category of spaces. The spaces that were most used were selected and observed to map user patterns. The user patterns of each space are seen in Fig (10), Fig (11), Fig (12) and Fig (13).

In general, it is seen that all these spaces, other than those used for sports are crowded between 08:00 hrs - 08:30 hrs, 12:30 hrs – 13:30 hrs, 17:00 hrs – 21:00 hrs during weekdays and 12:00 hrs – 14:30 hrs, 16:30 hrs – 21:30 hrs during weekends. Places used for sports activities are observed to be crowded at two different times on both weekdays and weekends, 06:00 hrs – 08:00 hrs and 17:30 hrs – 21:00 hrs. This indicates the time of maximum activity in these spaces. Maximum piezoelectric energy can be harnessed at these times.

Note: In the above graphs, X-axis represents time in hrs and Y-axis represents the crowd. The graph on the left represents a week day and the graph on the right represents a weekend.



(Fig.14) NSO Ground jogging/running track



(Fig.15) Coke station with seating on a holiday



(Fig.16) Shopping Complex on a dull



(Fig.17) Street lights that can be powered by piezoelectricity

Physical trace observation

The locations were visited when not in use to identify any physical traces of activity, to decide appropriate locations for piezoelectric systems. From the observation (as seen in Fig.14, Fig.15, Fig.16 and Fig.17), the cycle parking of the Shopping Complex, the counters of shops at Shopping Complex and Coke Station, and the Jogging track of NSO Ground have several physical traces which indicate higher levels of activity. These

locations are seen as ideal spots to locate piezoelectric systems. These locations would generate large quantities of energy, as the footfall at these spots is maximum.

INFERENCE

The piezoelectric effect provides us with a highly useful new source of energy. This effect helps us to convert the kinetic energy of human movements into electrical energy that can be used to power small devices. This source is both renewable and sustainable. Although, it is not very reliable, as energy production varies with activity patterns. However, with the integration of a power storage unit, it can provide a stable discharge of electricity.

The research shows the following spaces are best suited for location of piezoelectric systems.

- Public plazas – to light the surroundings
- Small-scale eateries – to provide electricity to run the space
- Sports center – to use high levels of activity to generate electricity
- Streets – to power street lamps

The following spaces within NITT university campus are expected to generate high voltages of electrical energy by the use of piezoelectric systems, and it is recommended to test such systems in these spaces as mentioned. As per the analysis, it is seen that maximum power can be generated between 10:00 hrs – 13:30 hrs and 16:30 hrs – 20:30 hrs.

- Shopping Complex – Cycle Parking and customer side area near shop counters
- Coke Station – Customer side area near counter
- NSO Ground – Jogging Track
- Main Avenue – At regular intervals along pedestrian pathways

Advantages of piezoelectricity

- It provides us with a new source of energy in a world where our resources are rapidly depleting.
- It provides us with a resource of energy that is both renewable and sustainable.
- It minimizes the loss of energy to surroundings by converting the kinetic energy of movement into electrical energy.
- It encourages public participation and user involvement in the production of electrical energy.
- It shows people the value of each watt of electrical energy.
- It helps to increase activity levels of people in general, by putting forth a certain value for each activity performed.
- Disadvantages of piezoelectricity
- A piezoelectric system requires high installation cost.
- The amount of energy produced is very low and can only be used to power small equipment.
- A piezoelectric system requires high maintenance, thereby increasing maintenance cost.
- Variation in activity levels will vary the amount of energy produced. If a food outlet dependent on piezoelectricity is having a dull day, it will have very low electrical energy to power its systems.
- Low power generation raises a need to store power when generated but not required. This increases storage cost.

FUTURE ASPECTS

Researches on piezoelectricity have gained pace in the last decade or so. The urgent need to find newer sources of energy has triggered technology enthusiasts to create a deeper understanding of piezoelectricity.

Since the quantity of energy produced is low, most researches are aimed at finding ways to extract maximum energy from this method. Piezoelectric crystals are being closely examined to identify their properties that bring about this effect. In the future, piezoelectricity is expected to play a major role in energy production.

This is seen as a potential replacement for other non-renewable sources of energy.

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Vaikuntaperumal Temple: The Pallava's path on Sustainable Architecture

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Abstract: The Temples are the oldest building typology of south India, which are still active in use. As a fruit of experiments over centuries temple architecture has evolved with set of rules for the zoning of site, use of spaces, selection of materials, measurements and so on. They are the only structures which do not have any foreign influence on its style, so they are more vernacular. Pallava dynasty has an important role on the evolution of dravidian temples. They were the first to introduce Rock cut temples, monolithic structures, multi tired sanctums. Vaikuntaperumal temple in Kanchipuram is the pioneer to have multi tires, pillared prahara and circumbulatory (pradikshana) path very next to the sanctum (garbagriha). This research attempts to identify the sustainable character of the temple by conducting field study using Hygrometer, Light meter, Anemometer, Surface Thermometer and software's.

Keywords: temple architecture, sustainable design, thermal comfort, user perspective, learning from past, field study.

INTRODUCTION

Temples are the oldest building typologies that have been so vernacular with no influence of foreign styles.They have a set of byelaws,design principles and spatial organisation which have been framed from the experiments happened over centuries. ThiruParameswaraVinnagaram or VaikuntaPerumal Temple is a temple dedicated to Lord Vishnu, constructed in the dravidian style of architecture, the temple is a pioneer to have pillared pradhikshana path around two others inner prahara very near to the sanctum. This is the first temple to have three levels and each with a Vishnu statue in different posture. The important event timeline of the timeline is briefly elucidated below.

8th century - The main temple constructed with sandstone was built by Nandi Varma PallavaMallan

14th century - Vaikuntavalli, Andal and Hanuman idols were installed in mahamandapam.

15th century - Gopuram and Arthamandapam were constructed with granite by Vijayanagara.

DESIGN PRINCIPLE

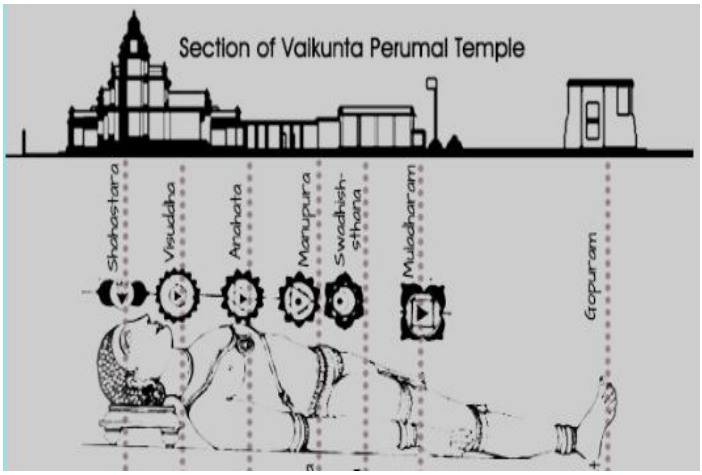


Figure 1. Symbolic Representation of Temple

- The symbolism is that the human body is a temple in which the Antaryamin resides.
- The analogy is extended to explain the various parts of the body as being representations of the different portions of a temple.
- The forehead is said to represent the sanctum; and the top of the head, the tower.
- The space between the eyebrows, the Aajna chakra, is the seat of the divinity.
- The finial of the tower corresponds to the unseen Sahasrara located above the head.

Spatial Organization

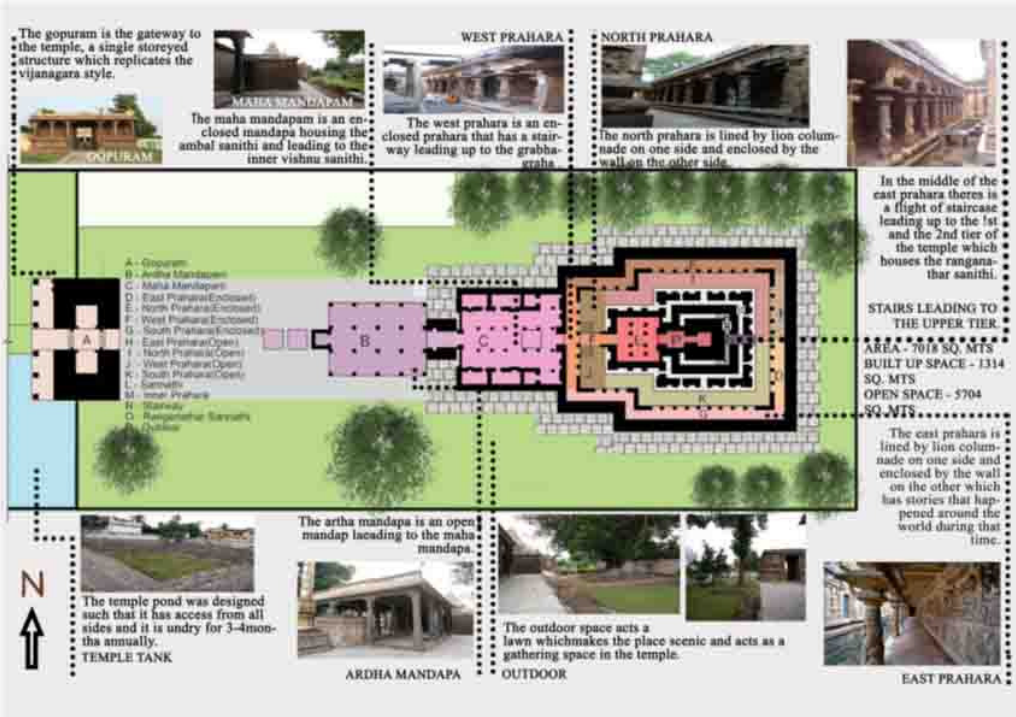


Figure 2. Spatial organization and site plan

Resource Management

The temple tank was initially the source of water for the temple. The temple tank is designed in such a way that it has access from all the sides and the topography of the site thus making it a natural storm water drain. The temple consumes 1000 liters of Fresh water per day for its maintenance.

Waste Management

- A very less amount of grey water is generated, and this is discharged into the garden space within the temple complex.
- There is no production of black water in this temple complex
- Wastes like Paper plates, dry flowers, plastic covers & food wastes are disposed into corporation garbage bins

Material Study

The primary building materials were sandstone and granite. They have high thermal lag, better heat capacity and thermal resistance. This specific type of sand stone was preferred due to its ease of sculpting. It was taken from the fresh water basins around Kanchipuram. Later structures were designed with granite as sandstone was found ruining. Some sandstone was plastered with lime. All the above materials were found to have acquired from within 40 kms.

PASSIVE STRATEGIES AND FIELD STUDY

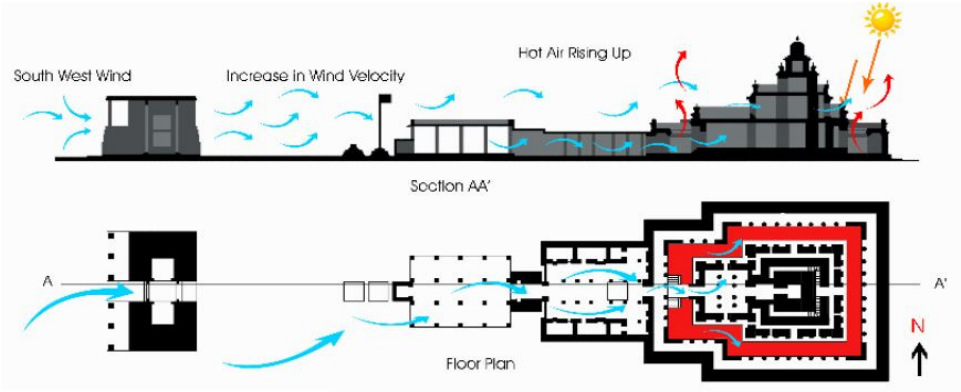
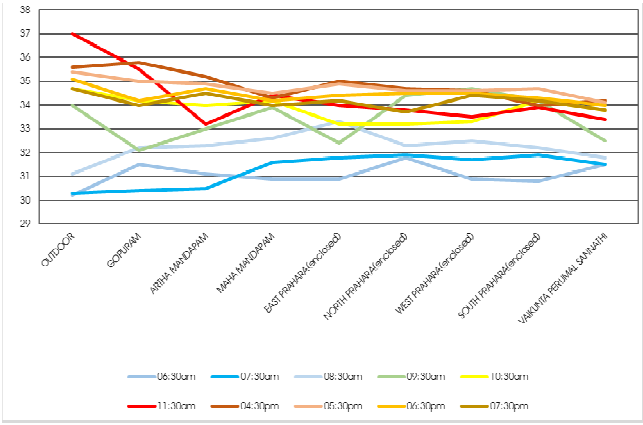


Figure 3. Wind movement induced through Passive strategies

The efficient use of Stack effect and Venturi effect for Air circulation, thick wall with statues act as a barrier for heat gain, and Southern and Northern fenestrations don't allow direct sunlight into the structure.

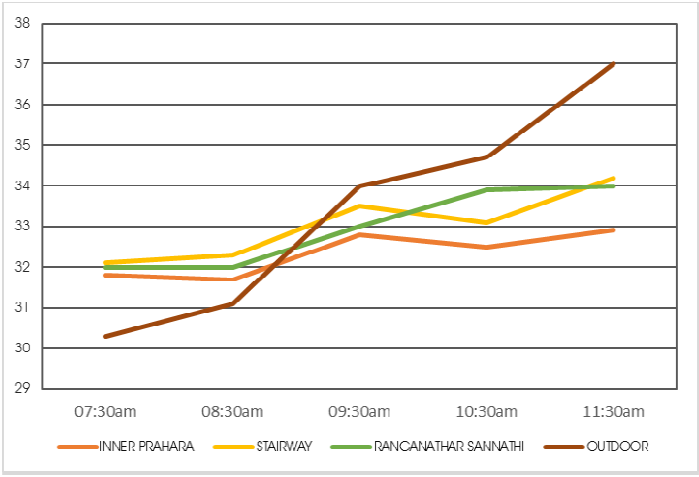
Temperature Analysis

Field study conducted with Hygrometer is analyzed with the graph below.



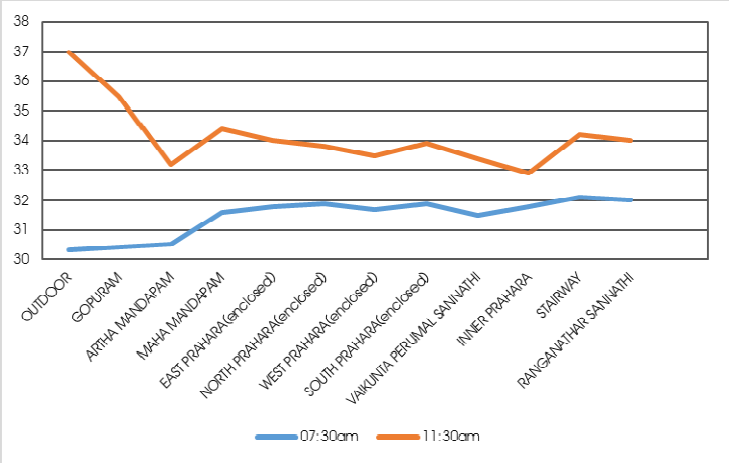
Graph 1. Over all Readings taken at various points on working hours

From the above graph, the readings are segregated for selected points within the main temple structure.



Graph 2. Readings within the main temple structure.

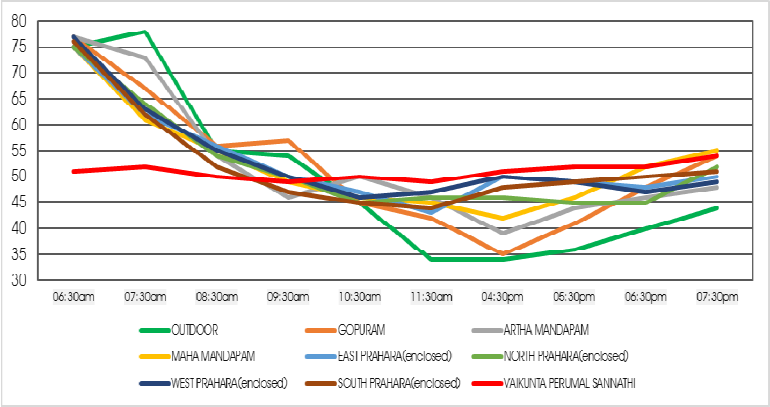
Though the Outdoor air temperature varies, spaces within the structure remain almost constant. From the Graph 1, the Outdoor maximum and minimum air temperature is compared with other spaces.



Graph 3. When Outdoor air temperature is maximum and minimum

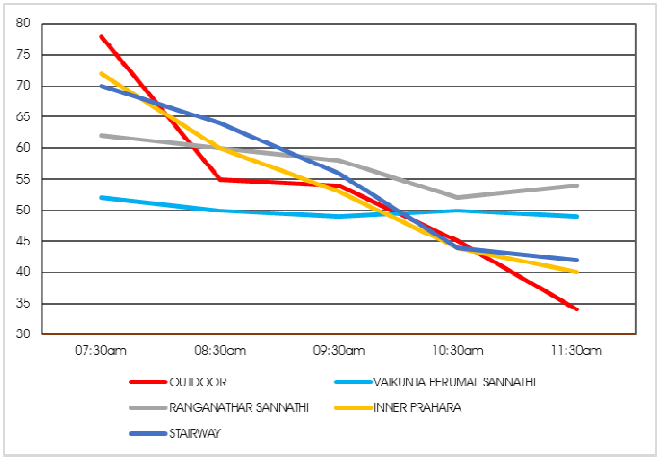
Spaces within the main structure tend to balance air temperature, and VaikuntaPerumalSannathi remains constant throughout the day.

Relative Humidity Analysis

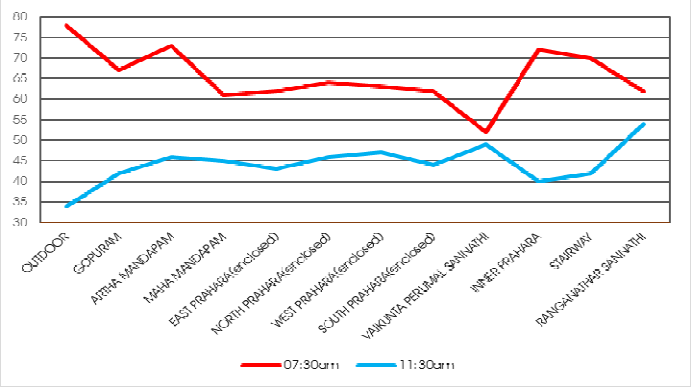


Graph 4. Over all Readings taken at various points on working hours

From the above graph, the readings are segregated for selected points within the main temple structure.



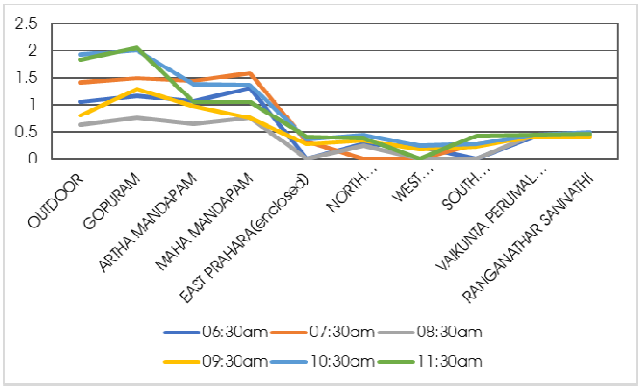
Graph 5.Readings within the main temple structure.



Graph 6. When Outdoor relative humidity is maximum and minimum.

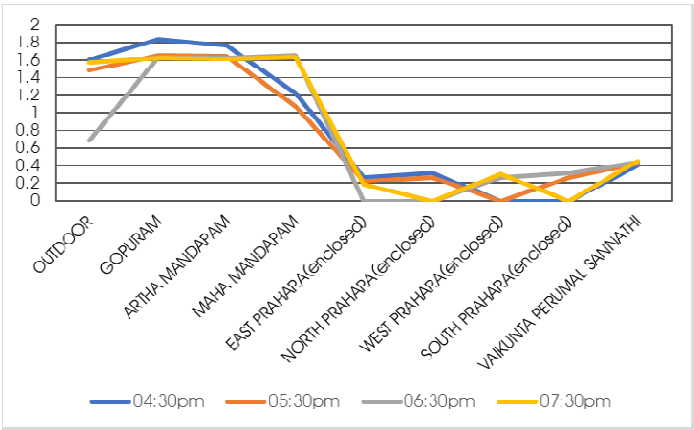
Wind Flow Analysis

Field study conducted with Anemometer is analyzed with the graph below.



Graph 7. Over all Readings taken at various points in the Forenoon

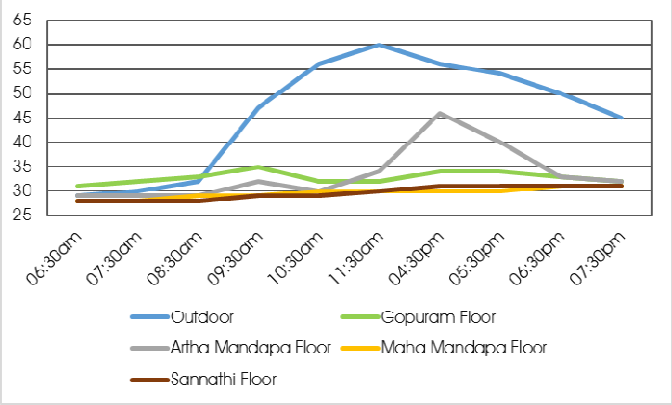
VaikuntaPerumalSannathi in ground floor maintains constant relative humidity, RanganathanSannathi (First floor) has slight variations along with varying outdoor relative humidity, and Stairway and Inner prahara has fenestrations contact with Outdoor, hence these places vary with Outdoor relative humidity. From the Graph 4, the Outdoor maximum and minimum relative humidity is compared with other spaces. Spaces which are in contact with outdoor open space have similar relative humidity, and VaikuntaPerumalSannathi has smaller fenestrations and surrounded by inner prahara and Stairway.The enclosed prahara has no fenestrations and wind flow is very low within the prahara, the stack effect takes place in the Open circulation space, Venturi effect takes place at Gopuram, and ArthaMantapa has no walls and wind flow easily.



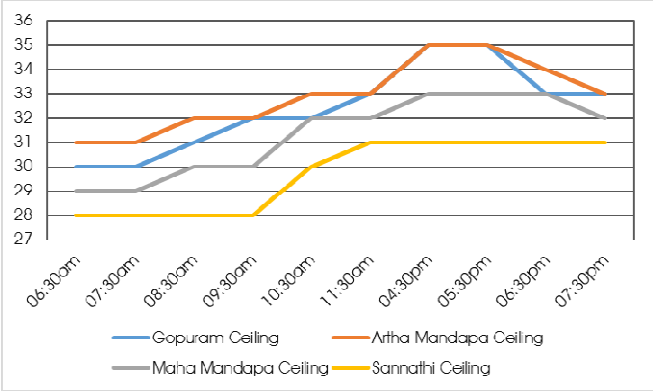
Graph 8. Over all Readings taken at various points in the Afternoon

From the above Graph 7, wind flow at 7.30 am is plotted below.

Field study conducted with Surface thermometer is analyzed with the graph below.



Graph 9. Floor Surface Temperature of Various Spaces



Graph 10. Ceiling Surface Temperature of Various Spaces

Gopuram has wind velocity higher than Outdoor wind velocity; the wind is being thrusted into gopuram which increases the velocity of the wind, which is known as Venturi Effect. The Open circulation path around the main temple structure, receive direct sunlight throughout the day and the floor gets heated up which causes the air in contact with the floor to get heated up, this hot air rises and create vacuum, this draws air from the MahaMantapa which is in contact with ArthaMantapa. This happens because of stack Effect.

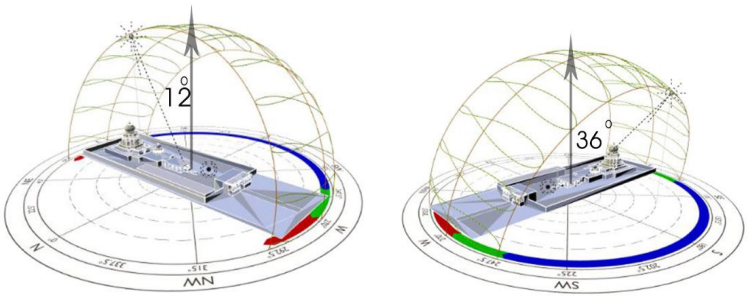
In the first floor, RanganathanSannathi has fenestrations which allow air to pass through.

Surface Temperature Analysis

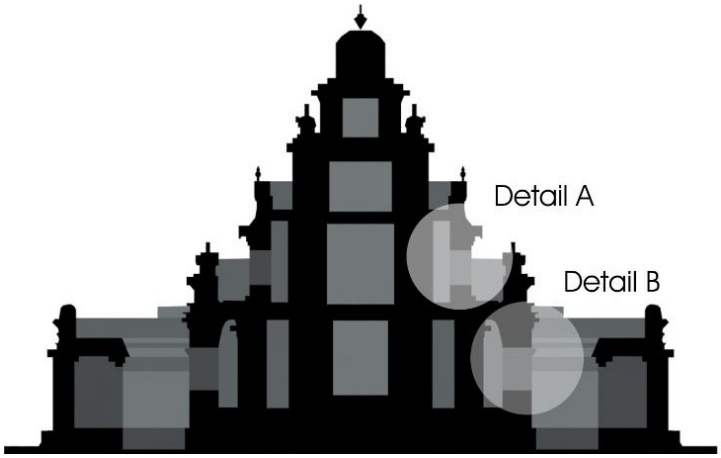
Outdoor Floor surface temperature reaches 60 degree Celsius in the noon, ArthaMantapa floor surface temperature raises in the afternoon as direct sunlight falls on the floor, and Spaces within the main structure has constant floor surface temperature.The ceiling is constructed with granite and sandstone which has thermal lag of 7.2 hours, hence the ceiling surface temperature starts to increase in the evening. The East and southern outer wall receives more direct sunlight and surface temperature increases, and the inner walls remain constant because of thick walls and self-shading statues.

Shadow Analysis

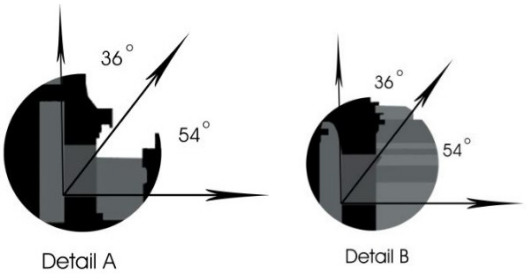
The summer solar angle (Northern angle) is 12-degree inclination and winter solar angle (Southern angle) is 36-degree inclination from the perpendicular axis of the temple location. These angles represent the required shading angle for the shading devices.



Maximum Southern Solar Angle Maximum Northern Solar Angle

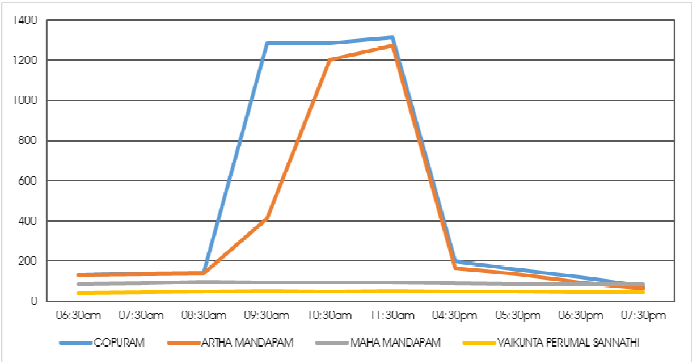


Section along North South Axis



First floor fenestration has shading device with required angle, no direct sunlight enters the structure, In the ground floor, wall thickness acts as shading device and no direct sunlight enters the structure.

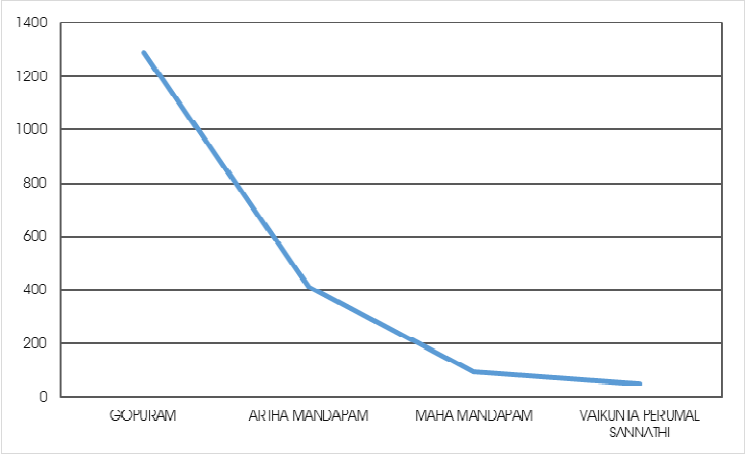
Field study conducted with Lux meter are analyzed with the graph below.



Graph 11. Lux level at various spaces as we enter the temple

Lighting Analysis

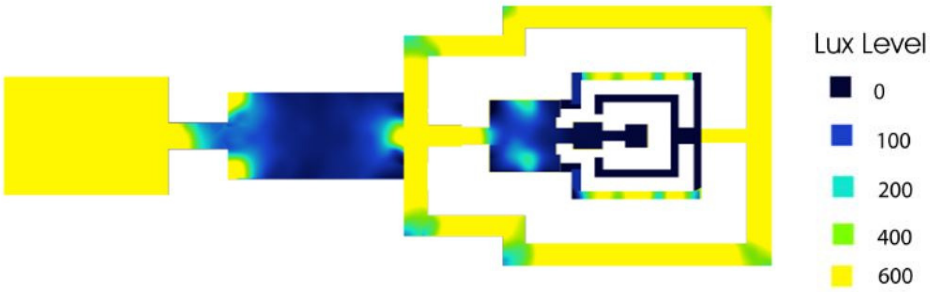
Lux level decreases as we enter and reach main deity,For example, at 9.30am Lux at various spaces as we enter the temple.



Graph 12. Lux level at 9.30am at various spaces as we enter the temple

VaikuntaPerumalSannathi remains dark throughout the day; Lux levels are managed in such a way to regulate concentration of visitors towards the main deity.

Software analysis of day light using Sefaira



Day light analyzed for equinox (September 21) shows the decrease in day light lux level as we enter and reach the main deity.

CONCLUSION

Vaikunta Perumal temple is a master piece in pallava's architecture. It is sustainable in many aspects like, site selection, design strategies, material selection and resource management. This also shows the level of knowledge they had towards, energy efficiency, human thermal comfort, sun angle, wind movement theories and psychological effects created by daylighting.

On the aspect of design, it still satisfies the modern day activities and it acts as a building with various functions and activities. The vernacular way of building is sustainable in many aspects and the term sustainability may be new to the Tamilnadu, but it was maintaining and balancing the three pillars of sustainability right from its long past.

Acknowledgement

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research. Any error in the paper is our own fault and should not impair the reputation of the professional. This research is a part of our curriculum in the Sustainable Architecture M.Arch master's program.

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Analyzing the Bequest Values associated with the Building Materials and Construction Techniques in the Built Heritage of Chettinadu region

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Abstract: Chettinadu region has a unique character and identity which reflects the traits of a country's people (Chettiars), environment, and society. Especially, the materials used for construction are environment-friendly and the principles are followed by generation of people. A field study in the region of Chettinad investigates the building materials used in traditional houses. The traditional houses of Chettinadu have its unique tradition in many ways, especially in the different indigenous materials used and this paper focuses on bringing out its inherited values. It is important to study in detail about the home-grown building materials as it influences the qualities of the houses and comfort of people. The analysis of the study provides an insight into the cultural, spatial and characteristics of building materials in the built heritage of the Chettinad region.

Keywords: Chettinadu region, built heritage, indigenous materials, construction technology, climate responsive architecture

INTRODUCTION

Chettinadu, a region known for its cultural heritage, a hometown of Nattukottai Chettiyars who are known for their prosperity in banking and business. The ancestries of Nattukottai Chettiars are people who were successful merchants and bankers, popular for their houses from the 18th century and there is a close link between its architecture and culture. There are around 10000 to 15000 houses standing for its richness, culture, affluence and architecture. One could see the influence of other parts of Tamil Nadu also. The houses depict the owner's power, wealth and reputation. These types of rare, culturally rich houses are recognized and nominated by UNESCO World Heritage Site in 2014.

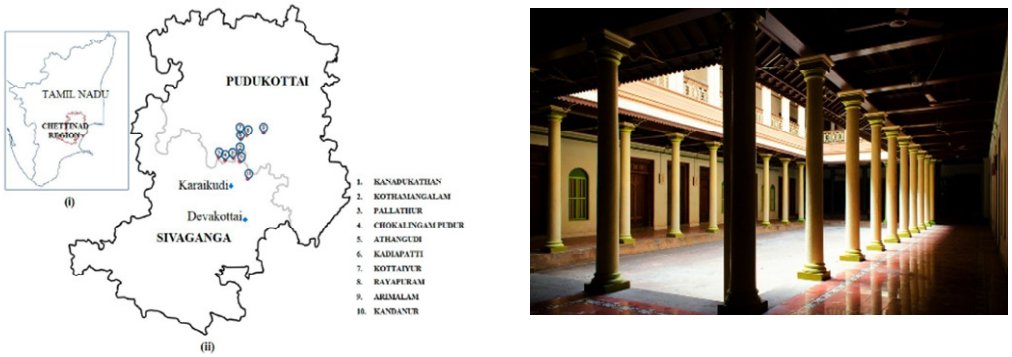


Figure 1. Map showing the Chettinad Region (Source: Author 2018)

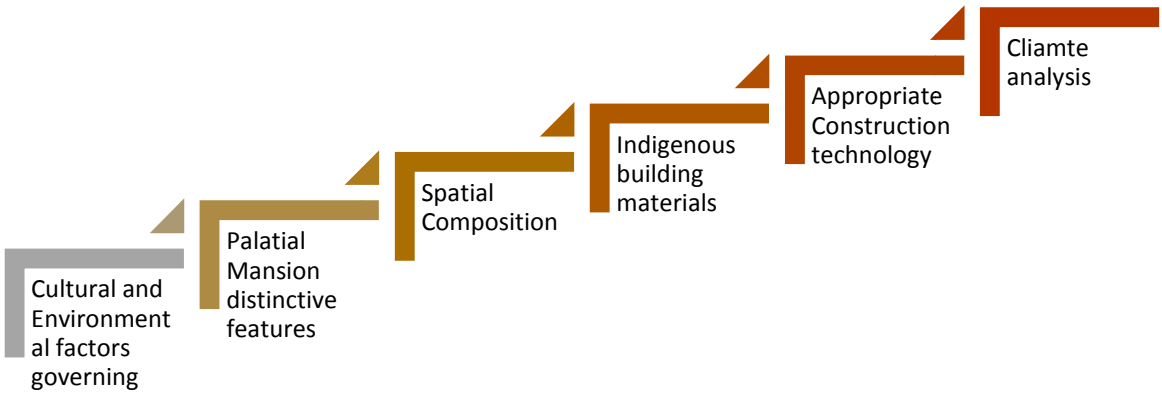
Karaikudi (Chettinad) in Tamil Nadu is located 9°N to 10°N latitude in a hot and semi-arid area because of which architecture suiting to such climate became vital. Majority of the year in Karaikudi has a high amount of moisture. This leads to less scope for evaporation causing both physiological and psychological discomfort. These palatial houses are therefore designed with natural and passive techniques and materials that provide a comfortable indoor environment. The principles used in the construction are evolved connecting the architecture to building types, materials and construction technology.

SCOPE

This paper discusses in detail about the vernacular concepts that were evolved in the Chettinadu architecture, where indigenous building materials not only had a cultural significance but improved the thermal performance of the buildings. Therefore, various spaces, building materials used and the construction technology will be mapped against the climatic conditions of the Chettinad region, and qualitative analysis will be mapped out.

METHODOLOGY

The following steps will be taken as the methodology of the paper.



CULTURAL & ENVIRONMENTAL INFLUENCES OF CHETTINADU HOUSES

As Chettiars of that time travelled a lot, lot of other traditional influences are seen in their houses which contributed to its uniqueness also. To mention with, Gothic domes and arches, huge windows, pergolas and artistic decorations were brought by those merchants along with money and materials. As a result, specific, stylish city plans were adopted by their villages bringing in orthogonal roads, precise water management systems, modern techniques and creativeness maintaining the harmony and culture of Tamil Nadu. Some of the huge houses depict the power of people and have 3 or 4 big courtyards, high ceilings, reception halls, verandahs and around 40 rooms, highlighting the western influence along with the Tamil architecture.

These palatial Chettinadu houses were built between 1840 and 1935. They are with several courtyards measuring approximately 400 to 450 m² in area. Middle of the courtyards is exposed to the sun, surrounded by pillars, with a veranda connected to different rooms. People lived as a joint family because of which they required huge areas for combined living and also to conduct different activities.

Indoor thermal comfort is ensured by passive architecture approaches; especially space utilization – open space, closed space and semi-open spaces were providing an apt living environment in all seasons and all times of the day. Narrow streets helped opposite houses and their balconies provide shadow to each other along with the overhangs.

CHETTINADU PALATIAL MANSIONS DISTINCTIVE FEATURES

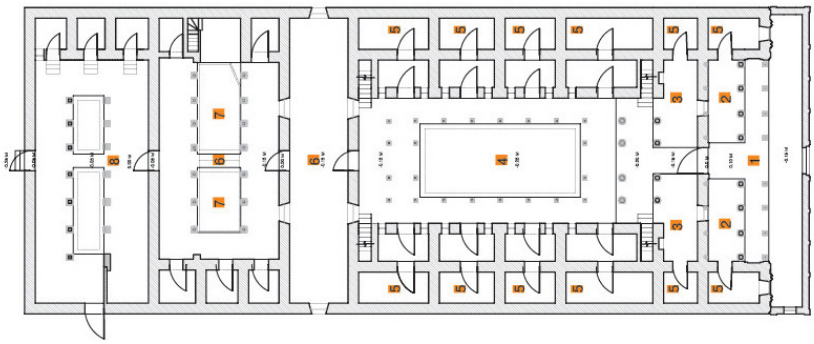


Figure 2. A typical floor plan of a Chettinad Palatial Mansion (Source: Sudarsanam, 2013)

The structural design of Chettinadu houses stands apart for its huge halls and courtyards. Those spaces were decorated by Belgian glasswork, intricate wooden work, stunning ceramic tiles, different types of stones, decorated iron and wooden pillars and other different materials uniting ethnicity to European style.

Those huge houses have a two storey small towers at both the ends of the front elevation. The front door in the First Street and back door in the second. Big rectangular house structures between the streets occupy huge areas and are divided into different portions - veranda – thinnai to receive the guests, business rooms on either side of the verandas leading to indoor courtyards normally used for festivities, elevated sitting areas, main courtyards, double rooms in series from the main courtyard, small courtyard and surroundings for prayer, sleeping, cooking and exclusive spaces for women. The main doorsill shows a series of courtyards in a straight line, and they narrow down to the back door. Later two storey structures were expanded both vertically and horizontally with numerous courtyards and halls to provide space for guests during marriages and rituals.

The large outer Thinai- raised platforms on either side of the central corridor are for male guests. Storeroom / gigantic granaries/accountant or kanakkupillai rooms/men's well are led from the thinnai. Then comes the beautiful, decorated teak main door with a picture of Goddess Lakshmi and its bottom – vasappadi having the 9 gems – navaratna buried. There are normally four courtyards, the first with pillared corridors and individual rooms having triangular slots for the lamps, the second for dining, third for women and the fourth - nalankattai for the kitchen, behind that would be female well and grinding stones.



Figure 3. Features of a Chettinad Mansion (From Left to right: Thinnai, Kanakupillai room, Courtyard) (Source: (N, 2015))

SPATIAL COMPOSITION

The following spaces mentioned are present in a typical Chettinadu construction house.

- ***PATTAGASALAI*** – This space composed of the central space is elevated taking care of the sanctity and it is for usual rest, secret transactions and also for ritual events.
- ***MULTIPURPOSE CENTRAL OPEN SPACE*** – This is a semi-public and business place situated in the rooms also serves as the first stage of private spaces for required introverted scheduling. This is also used as a festive space for ceremonial purposes whenever required.
- ***FRONT VERANDA*** – Front thinnai is used by the men to hold informal discussions and also to receive visitors and guests. The veranda is also used for business such as pawning. Such use limits the movement of visitors within the house.
- ***MUTTARAM AND PATTAGASALAI*** – One of the salient features of the Chettinad houses that emphasise the introverted nature of planning is the muttaram (main courtyard) which is surrounded on the sides by aisles with roofs sloping down into the court. The main courtyard is used for drying paddy and the aisles are used for chatting and sleeping. The pattagasalai (inner thinnai) is used by men for sleeping and for discussing family matters. The aisles Lead to the ullarai and veliarai (secret cellars). During festivities, the muttaram was used as the wedding space in the earlier phases of planning. The aisles surrounding the courtyard were used for seating, while the pattagasalai seated the melakarar (musicians).
- ***KALYANA KOTTAGAI*** – This is primarily used as the main living space but gets converted into the wedding hall during marriages. The central double- storeyed hall is used as the thirumangalyamedai (marriage stage) and seating place for women during muhurtams. The high ceiling and the polished granite columns provide the required grandeur to the place. The surrounding aisles are used for keeping the seervarisai (dowry) and by the melakarar (musician). The area has direct access to the bhojana hall so that the guests could proceed to the dining hall as soon after the muhurtham.
- ***SERVICE AREA*** – These comprise a double courtyard with 4kitchens in the front and 4 store rooms (2 metres on each side). The corridor spaces around the courtyards are used as preparation spaces during

festive occasions. The circulation of the cooks is restricted to the service areas. The courtyards which open to the sky resolve the problem of lighting and ventilation and clear off the smoke and other pollutants from the kitchen. There are steps to the first floor where the whole plan is repeated.

- ***SERVICE YARD*** – This comprises a central courtyard divided by passage around which is the service thazhvaram. A well (keni) which is located in the courtyard is used by the woman and the servants. On both extremes are spaces meant for storage of unimportant materials and vegetables.
- ***DOUBLE COURTYARD SPACE*** – At normal times when the main bhojana hall is not used, the double courtyard and the space surrounding it is used as the main dining space and the side rooms are used as storage spaces. During festivities, space gets transformed into a preparatory space; the food prepared in the kitchen is stored in the adjacent room to be served in the bhojana hall. The courtyard space could be used as a waiting space and also for hand washing.
- ***BHOJANA HALL*** – This is a dining space common to the two houses having an entrance from the street. It has a central courtyard surrounded by aisles with roofs sloping into the courtyard. The open courtyard provided both lighting and ventilation and enhances the quality of the space. The area has accessibility from the washing and preparation areas of both houses and can thus cater to a very large crowd of about 150 people, reflecting the self-sufficient nature of the Chettiars.

Traditional construction techniques & materials specific to chettinadu region

Orientation: The entrance of the house is normally in the east because of which the central courtyard brings the main ventilation. The garden on the west side brings fresh air into the house supporting warmness in the house. The absorbed heat is discharged through the courtyard during the night like a thermostat controlling the temperature. The courtyards extract more air as there is low pressure and surrounded by rooms.

The longer sides are oriented towards the North and South, which receives lesser radiation, compared to the East and West facades. The figure below shows the plan of a conventional Chettinadu residence, where experiments were carried out using a data logger. The spaces in blue indicate areas of lower temperature i.e. the courtyards, as they receive maximum cross ventilation, the transition spaces in yellow (higher temperatures) and the rooms along the north and south corridor in red (highest temperature). (Radhakrishnan S, 2011)

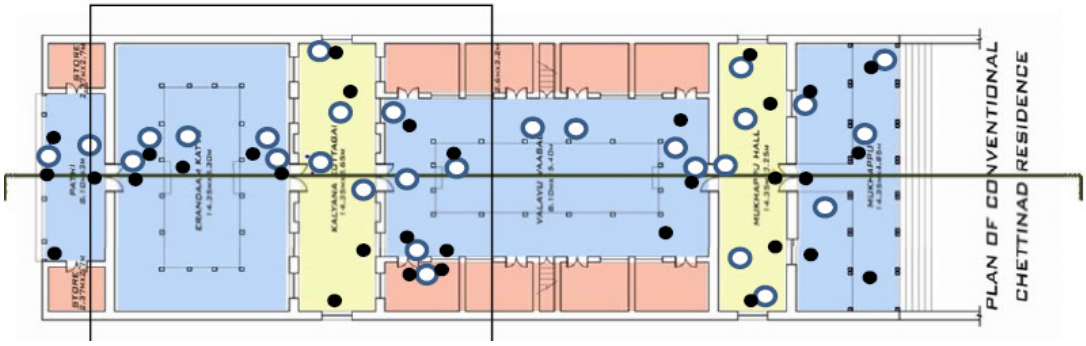


Figure 4. Plan of a typical Chettinad House showing different thermal zones
Source: S. Radhakrishnan R. P., 2011

Walls & Wall coatings: Chettinadu plaster has lasted for years and centuries and is well-known for its soft surface and concrete look. This plaster is made of seashell lime and eggs. Plastering is the final step of completing the wall. The bricks on the wall are covered with layers of white lime mortar and ended with lime plaster ensuring smoothness, hardness, brightness and coolness.

The external walls, in particular, are 0.46– 0.6 m thick; work based on the thermal mass principle acting as a thermal battery that retards the heat gain. The time delay is known as a time lag. The thicker the plastering material is the longer the heat waves passing in. The cyclical reduction in internal temperature compared to the external is well-known.

According to the Energy Conservation Building Code 2017, for Warm & Humid climate, the allowable U-factor is 0.4 W/m m²K. Therefore the U-value we achieve is more stringent than that. Also, there is a time lag of 11.29 hours, which will block away from the thermal radiation during the daytime, thus maintaining cooler temperatures indoors during the night.

Table 1. U - Value and Thermal Lag of a typical Wall assembly

S.No	Material (Outside to Inside)	Thickness (m)	Conductivity (K)	U- Factor (W/m²K)	Time lag (hours)
1	Lime plaster with egg finish	0.005	1480	0.135	0.12
2	Lime mortar	0.05	1440	0.013	0.89
3	Brick wall	0.35	2400	0.001	9.27
4	Lime mortar	0.05	1440	0.013	0.89
5	Lime plaster with egg finish	0.005	1480	0.135	0.12
Total		0.46		0.297	11.29

Table 1. U - Value and Thermal Lag of a typical Wall assembly Source: Author 2018.

Floorings: Aathangudi tiles are one of many popular handmade decorative cement floor tiles, made of sand, cement and baby jelly, prepared with only bare hands, clean glass and mould through a fascinating process. There are no special machines, and even some designs don't even need the mould. The surface of these tiles is extremely polished by this simple technique. The mixture (lime mortar or cement mortar) up to a thickness of 1.5 " is uniformly spread to ensure that the tiles are properly placed, and the tiles are properly packed with hand. Besides being environmentally friendly and completely natural. Terracotta tiles make the room cooler compared to other flooring types and their appearance improves with the use of “the tiles have an intangible cooling effect". The ingredient's composition is the trick. The special characteristics of Aathangudi tiles are Eco-friendly and do not reflect, radiate or warm.



Figure 5. Making of Aathangudi tiles (Source: (S. Radhakrishnan R. S., 2014))

Courtyards and Clear Storey: Courtyards act as microclimate modifiers for controlling high temperatures, directing winds and adjusting the humidity level.

Key benefits of courtyards are,

- Reduce heat gain by self-shading and thermal breaking
- Block high angles of summer sun and allow low angles of winter sun
- Similar to a cool air reservoir
- Heat sinks at night, though natural convective cooling occurs.

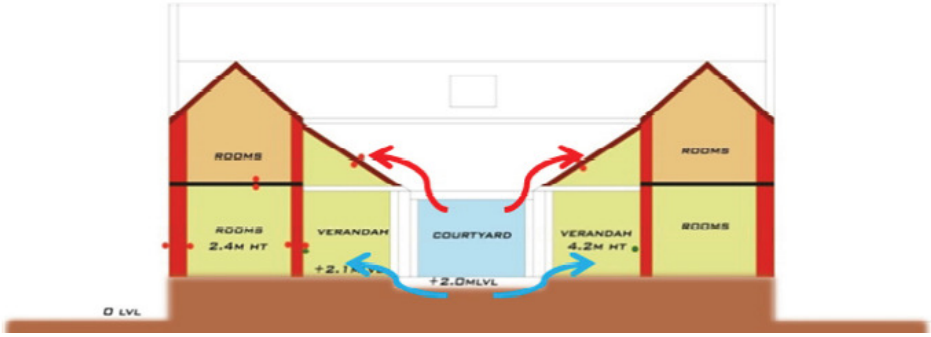


Figure 6. Section through the courtyard (Source: (Radhakrishnan S, 2011))

Some houses have storey instead of courtyards ensuring lighting to the central space. Storeys have a high ceiling boosting the stack effect. This ensures that the hot air is escaped during the night and space is kept cool. The section below shows the cold air entering the rooms adjacent to the courtyard, which receives maximum ventilation through cross-ventilation and the hot air rises up through the stack effect.

Ceilings – Machu (False ceiling): The false ceiling of height 0.9 – 1.3 m is done below the roofing. It is a loft-like structure running in wooden beams and used as a store. Transfer of heat is reduced in the process.

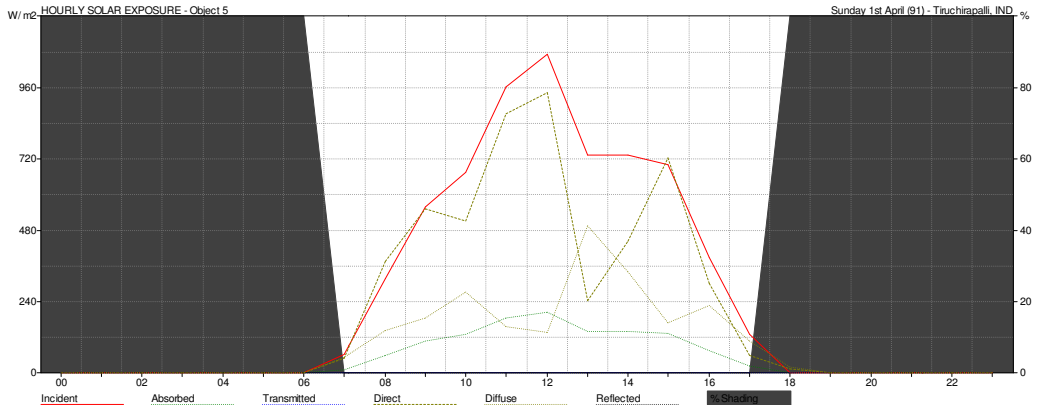


Figure 7. Solar exposure graph for Chettinad region (Source: Ecotect)

The above Solar exposure graph shows that the roof receives the highest amount of Incident solar radiation; 1080 W/m² from 6:00 am to 17:00 pm, the peak being from 11:00 am to 13:00 p.m. Thereby, the Machu provides a thermal buffer from the heat directly entering the living space.

Roofs: The flat roof prevents the horizontal surface from adding any heat during the day. It's made of wood, a bad heat conductor. The horizontal surfaces act as a shield to protect the inside from the outside. A temperature zone is created by the heat sink of the courtyard.

The pitched roofs of the houses are built using country tiles aligned on wooden bars; the wooden bars are on the wooden logs connected to the wall. Double-decker system is used to keep the interiors cool and the chajjas served as sun breakers.

The ground floor has the roofing with mud mortar, mud bricks and Calicut tiles. Roofs have a central provision for rainwater gathering and air cooling.



Figure 8. Roof section showing movement of air flow (Source: (N, 2015))

The big rectangular mansions run across the streets East / West and North / South, enabling sloping roofs and terrace roofs. Chettinadu roofs have the plaster known for its fine blends of natural color.

MATERIALS

1. The foundation is made of Rubble masonry combination of stone, mud and mortar and type of foundation is step foundation.
2. Flooring is done with local Aathangudi tiles, but its colour is attained by the use of imported paints brought from Italy. Manufacturing is done with a glass plate and dry cement. The mezzanine floor and the central courtyard are tiled. Some part of the central courtyard is covered with mud tiles.
3. The wall is constructed with backed bricks which were plastered using sand and lime mortar, and fibre roots which were used as a bonding agent and a coat of egg white were done to give a silky-smooth finish for the walls.
4. The Bricks were produced using locally available red soil. These bricks helped in maintain thermal comfort inside the house.
5. The pitched roofs of the houses are built using country tiles aligned on wooden bars; the wooden bars are on the wooden logs connected to the wall. The ground floor has the roofing with mud mortar, mud bricks and Calicut tiles.
6. The construction materials were from different places proving the wealth and proximity of the people.
    - Decorative items and furnishings
    - Marble from Italy
    - Wall-to-wall stained glass and mirrors from Belgium
    - Crystals from Europe
    - Chandeliers and teak from Burma
    - Crockery from Indonesia
    - Decorative items and furnishings from East Asian countries and Europe
    - The woodwork and stonework from Houses in Frances and other European destinations.
7. Walls have egg plastering that doesn't peel. This mixture is created with egg white, an extract of unripe medicinal fruit (From the mountains of kadukkadi) and lime grind. The wall lasts a lifetime; remains glossy smooth and cool even after one hundred years. This plastering over the baked brick wall keeps the inside of the house cool throughout the hot and humid Indian summers.
8. Special ceiling roofs with copper plates soldered with a special variety of aluminium. Artistic patterns are created using vegetable dye on these plates. These materials are completely biodegradable in addition to their energy - efficient use behaviour. Chettinad's traditional materials reflect a profound understanding and reaction to the local environment and climate.

CLIMATE-CONSCIOUS DESIGN PRINCIPLES

Karaikudi is located in the Tamil Nadu State district of Sivagangai. The river Thenar flows across southern Karaikudi. At 10.07 ° N 78.78 ° E Karaikudi is located. It has a mean height of 82 meters (269 ft). The Karaikudi terrain is predominantly flat. Rocky areas are found in the surrounding area of the town of Karaikudi and the rock intensity is more west of the town. Cultivation is not much possible as it has red laterite soil. The maximum average temperature is approximately 34 ° C (93 ° F) and the minimum average temperature is approximately 24 ° C (75 ° F). The average annual rainfall in Karaikudi is approximately 920 mm (36 inches).

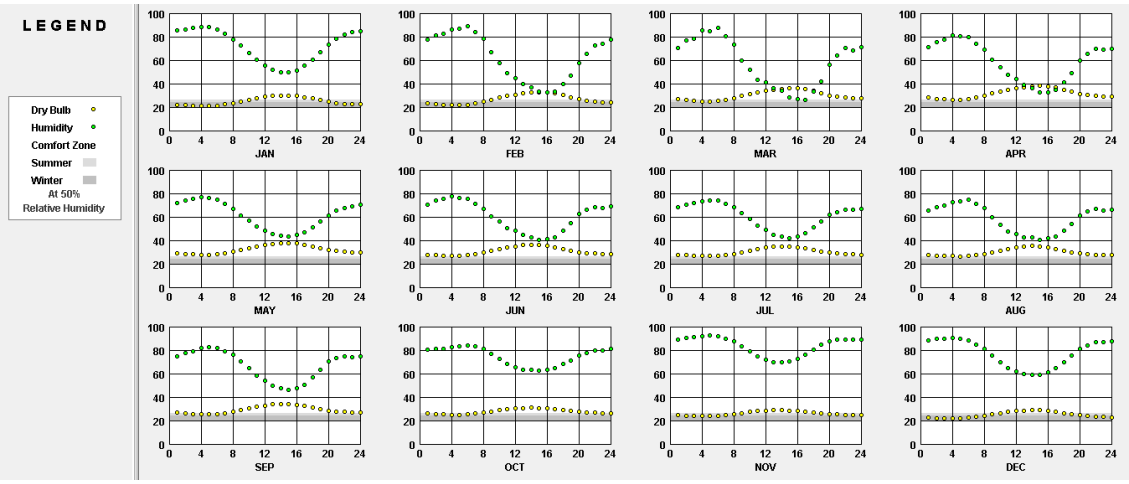


Figure 9. Temperature of Humidity graphs for Karaikudi (Source: Climate Consultant)

The yellow curve shows the "Dry bulb temperature" and the green curve shows the "Humidity" and the grey bar shows the comfort zone. From this, one can infer that for almost all the months, the optimum thermal comfort cannot be achieved without proper architectural planning inside the building. Therefore, to tackle the higher temperature, the use of optimum orientation, mass walls, plastering, double roof, play an important role. To tackle the high levels of humidity, placement of courtyards, cross ventilation and clear storey help in talking out the heat by stack effect.

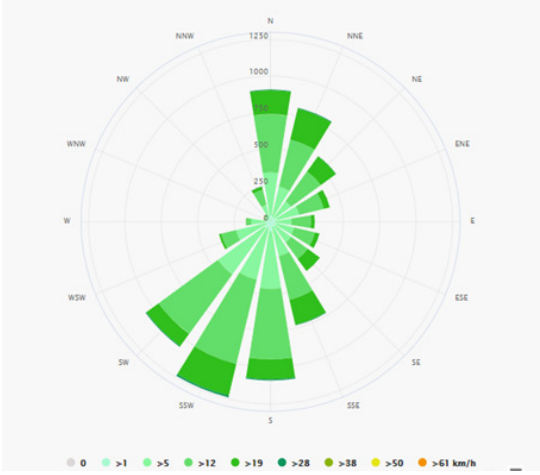


Figure 10. Wind Rose diagram for Karaikudi (Source:Ecotect)

The wind rose diagram indicated that the predominant wind flow is through North-South throughout the year. Therefore, the courtyard receives maximum wind flow throughout the year. The winds flowing from either North/South flow through the length of the plan and take away the hot air.

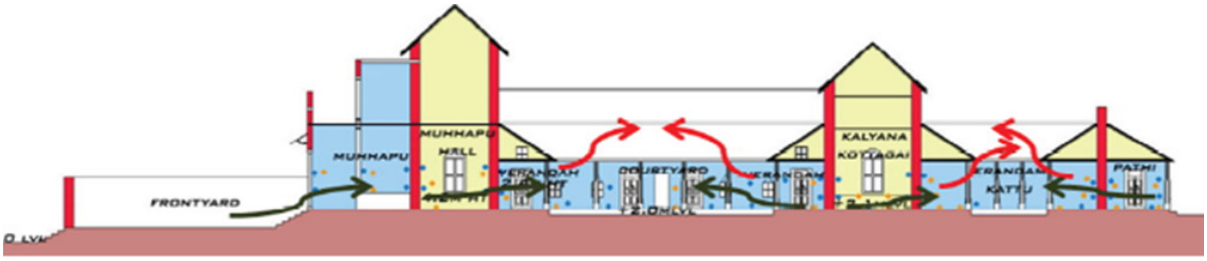


Figure 11. Longitudinal section along all courtyards (Source: (Radhakrishnan S, 2011))

The sun path of Karaikudi demonstrates that buildings adjusted towards the east-west axis and the North and the South facades are longer. The wall is aligned with the road axis, running from north to south with important openings of the houses facing each other on the east to west. The compound wall ensures overall consistency with the various villages in the region. The building's height does not exceed two levels, the ground floor and the first floor. Therefore mutual shading between the buildings, keeps a part of the building/ courtyards shaded throughout the day. The first diagram shows the Sun path on April 1st, 8:30 am and the second diagram shows the Sun path on April 1st, 5:30 pm.

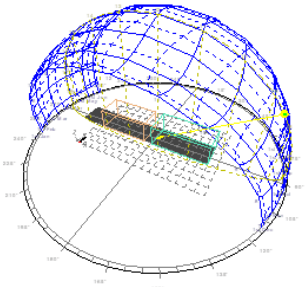


Figure 12 Sun path of Karaikudi on April 1st, 8:30 a.m. (Source: Ecotect)

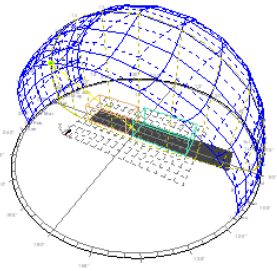


Figure 13 Sun path of Karaikudi at April 1st, 5:30 p.m. (Source: Ecotect)

Figure 12 & 13. Sun path table

The psychometric chart shown below, states a loss of strategies to be followed in order to achieve optimum thermal comfort. The design strategies are listed as follows,

- Sun shading of windows (33.1%) – Uses of arches and recessed windows
- High thermal mass, Night flushed (0.3%) – High thermal walls
- Direct Evaporative cooling (1.6%) – Semi-open spaces
- Two-Stage Evaporative Cooling (2.5%) – Double / Triple courtyard
- Natural Ventilation (0.7%) – Cross ventilation, East-West orientation
- Fan-forced ventilation cooling (0.2%)
- Passive solar direct gain: High mass (0.3%) – Indigenous materials plastering
- Dehumidification (25.6%) – Cross ventilation coupled with stack effect
- Cooling and Dehumidification (71.2%) – Selection of natural materials for construction

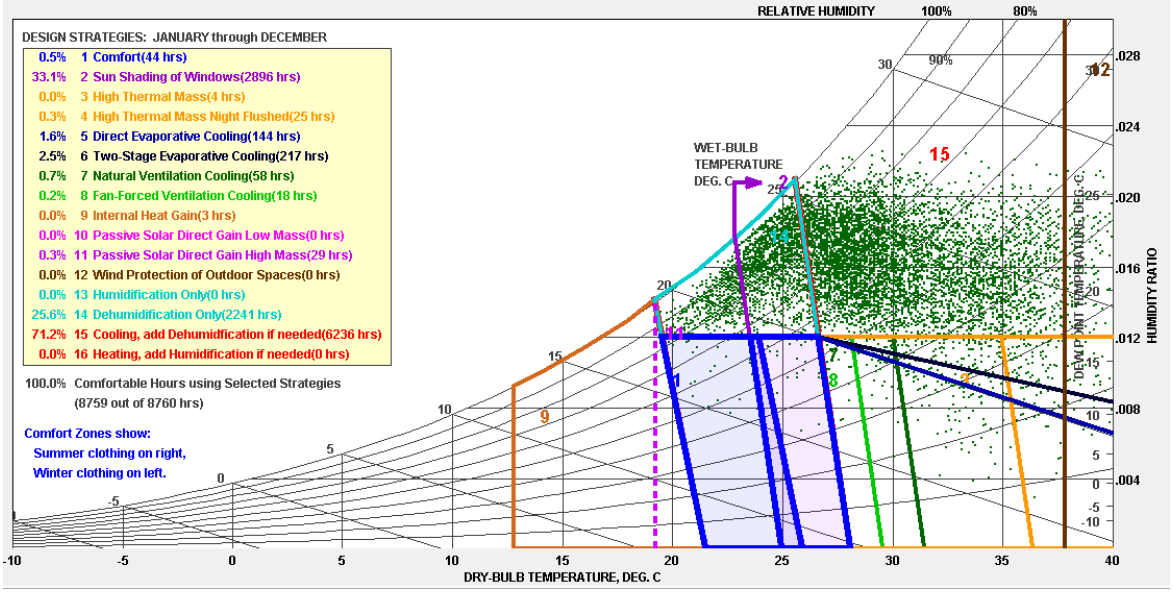


Figure 14. Psychometric Chart indicating Design Strategies for Karaikudi

By the combination of the above techniques, one can infer that the climate responsive architecture features, use of indigenous & local materials for construction, and use of local labour and craftsmen, with a clear understanding of the geographical & climatic conditions, has made Chettinadu houses and epitome in providing natural comfort, lessening the dependency on artificial ventilation.

RESULTS AND DISCUSSION

In short, traditional building materials play a vital role in contemporary architecture, primarily in family and in public buildings to a lesser extent. The extent to which they are used can be explained by the demands of people for materials of top quality. Chettinadu traditional materials show an intensive understanding and reaction to native settings and climate. Chettinad's traditional hoses are suitable for the climate with their different types of local materials and create an efficient environment for human life. There is no doubt that the current generation can draw from a traditional house a lot of good knowledgeable solutions to create a good sustainable architecture for Chettinadu.

CONCLUSION

Chettinadu houses prove clearly that architectural aspects play a major role in creating a safe and comfortable living environment. In specific nature, the suitable utilization of materials, spatial organization and construction methods fetch a required comfortable ambience in the residence. Customary buildings have a lot of concealed principles like the thermal design and they are appropriate even today. It is most of the hour to conserve energy and assure thermal comfort.

The bequest values associated with the traditional principles in construction techniques and the materials is important for the future generation to achieve sustainable strategies in the buildings.

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Design of Shading Devices to Achieve Visual Comfort and Reduce Energy Consumption: A Literature Review

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Abstract: Buildings are responsible for consuming a large amount of our limited and depleting natural resources. To tackle this, various technological advancements within the building scenario have been introduced. It is now the responsibility of the architects to study, refine and include these technologies into our buildings. Shading devices and dynamic shading devices, in particular, have made great strides in reducing energy consumption and could potentially improve indoor daylight environment through proper design. The type of effect these shading systems have on energy and lighting is limited to particular latitude and local conditions. Hence, it becomes necessary to study the best strategy in tandem with the site's unique local conditions and latitude. Studies have indicated that WWR, orientation and type of shading systems, used in different combinations provides very different results. The challenge is to find the best performing systems by running various combinations of simulations. Shading systems reduce the air temperature inside buildings, resulting is reduced cooling energy. However, different types of shading systems – vertical/horizontal, louvers, dynamic combination of fixed systems and set points – along with other parameters can result in very different cooling energy demand. Hence, there is a need to cross compare the results to find the best scenario. While it is necessary to reduce cooling demand, it also necessary to increase daylight indoors for better visual comfort. Tropical climates have always tended to favour reduction of heat gain over daylight environment. Recent technological advancement has made it possible to increase percentage of time available for good daylight environment indoors while reducing heat gain. These include dynamic shading systems, glazing systems, lighting control systems and simulation software. To find the optimization between energy consumption and daylight is difficult but it is considered best to keep a standard lighting quality that is to be met and then choose which shading system provides the least energy demand. Shading systems can be categorized into fixed and dynamic, with the dynamic system providing better performance in most conditions. Dynamic systems can be composed of set points (eg – illuminance, radiation, daylight prevention, glare etc) or by varying material, length, and angle of the shades. To further bring down energy consumption, solar energy can also be considered to offset lighting demand.

Keywords: Shading System; Dynamic Shading Systems; Energy Consumption; Daylight; Visual Comfort; Cooling Energy Demand; Lighting Energy Demand

INTRODUCTION

Increase in global energy consumption has resulted in devastating consequences around the world. The rise in carbon dioxide and climate change are pressing issues facing the society. Buildings are responsible for consuming large amounts of energy, making it necessary for architects to step in to study and implement innovative solutions. In tropical climates, an important element taken into consideration to reduce heat gain inside buildings is the sun shades. When omitting sun shades from the buildings in this region, 40% of the load may be directly associated with heat gains (Mohammad et al, 2017). With the advancement of science and technology along with simulation tools, it is now possible to restructure the way we think about our buildings. Automation and intelligent framework in buildings could perhaps bring about a radical change in the way we tackle architectural design. The world is striving towards a more sustainable and healthier future with scientists all around the world trying to find alternative sources of energy. However, until then or perhaps even after, energy efficient building designs are going to pave the way towards that future.

This paper shall first focus on the evolution of climate conscious building design and how this has shaped new technologies to be integrated with the buildings. This includes analyzing various studies to restore comfort in buildings and its need to do so, the evolution of glazing technology, lighting control system and dynamic shading systems. The paper shall also briefly look into India's role in promoting energy conservation policies and to what extent is shading considered an important element. Before designing a shading system, there are elements that have to be optimized first to find the best performing system. Hence, studies that include locational adjustments, orientation and WWR shall be analyzed in terms of energy efficiency and daylighting environment. In order to better understand daylight performance in a building, the different parameters that could be included will be looked into. The various technologies to be included in the design such as lighting control technology and glazing typologies will be cross-compared in terms of performance. The literature study will try to establish how designing sun shades to their optimal performance can reduce indoor air temperature,

resulting in lower cooling energy demand. While shading systems can reduce cooling demand, they may also decrease daylight inside a building which may result in higher artificial lighting demand. Hence, the strategies certain studies have taken to an optimization have been discussed. The paper also extensively analyses different shading systems and its overall performance in terms of energy consumption and lighting environment. The different simulation software used to extract this information has also been included in this paper.

RESEARCH AND TECHNOLOGY FOR CLIMATE CONSCIOUS BUILDING DESIGN

The road towards energy conservation and refining techniques in the construction of buildings based on climatic parameters has started to take the center stage. The 1960s has seen a boom in the study and evaluation of climatic conditions and indoor thermal comfort. One of the most prominent was the Olgyay's bio-climatic chart in 1963 which provided climatic information and rudimentary design interventions (Al-Azri et al, 2013). In very quick succession, a more in-depth study led to Fanger proposing PMV model in 1972 to predict the subjective evaluation of thermal conditions and proposed the Heat Balance Model in 1972 to analyze the thermal physiology (Toe and Kubota, 2013). Givoni's bioclimatic chart in 1992 brought in design suggestions to restore comfort in indoor spaces (Al-Azri et al, 2013) and Humphrey's Adaptive Model in 1998 gave a renewed understanding on how occupants will adjust their surrounding or their behavior to restore comfort (Toe and Kubota, 2013). Through all this study it was predominantly believed that in designing of tropical buildings, 'eliminating solar heat gain is the overriding factor' (Hopkinson et al, 1966). This belief has led to buildings being designed with very little visual comfort and total energy considerations. However, certain typology of buildings also require good visual conditions for productivity – classrooms, for example, require good lighting conditions for completion of tasks and learning.

Technology has come a long way since these studies and there is a need to re-evaluate the way we design buildings in tropical climates. The rise in energy-efficient technology can be first traced to the energy crisis in the 1970s in the USA, where there was a major push to find energy efficient glazing for the skyscrapers built in 1920s-1930s which were consuming too much energy (Jones, 2013). The new glazing technologies included double/triple glazing unit in the 1940s and 1950s, coated glazing in 1960s, low-e glazing in 1980s, electrochromatic glass in the 1990s and thermochromatic glass in the 2000s (Jones, 2013). At the same time, lighting control technology has made a transformation in the 2000s to be more energy efficient. Example include occupancy sensors, daylight sensor, dimming technology, time-scheduling, on/off automatic switch etc (Liu et al, 2013). A major development since the 1990s but more recently coming into prominence are the dynamic shading systems (Jones, 2013).

With fixed shading systems, shading can significantly reduce daylight inside the building. Also, due to their static position, despite solar radiation being low (or direct sunlight absent at certain times of the day), it effectively blocks sky view. Building envelope design becomes a significant factor in such buildings where it becomes necessary not only to reduce cooling demand but also to provide visual comfort. Hence, dynamic shading that automatically maneuvers itself to an optimal position could provide multiple benefits – ultimately providing better comfort conditions while reducing energy consumption. For example – in the western façade, if sun shade is absent in the morning – it could increase daylight, reduce artificial lighting energy and reduce cooling demand (heat gain from electrical lights). If the sunshade is opened up in the late afternoon where direct solar radiation falls on the façade – it could prevent large heat gain inside the building. In the past few years shading has been increasingly looked at as an important element to reduce total energy in buildings due to increased technological improvements

INDIA AND ENERGY CONSERVATION

Since the 1973 world oil crisis, the Indian government has been actively promoting energy conservation policies (Vasudevan et al., 2011) However, it was not until 2001 with the passing of Energy Conservation Act in 2011 and with it the constitution of Bureau of Energy Efficiency that things started aggressively picking up (Vasudevan et al., 2011). Since buildings play a major role in energy consumption BEE introduced Energy Conservation Building Code in 2007 where a minimum standard of performance of set and could be 40% more efficient that non-compliant building (Vasudevan et al., 2011). Despite these efforts both energy use and co2 has increased by 2.2% per year and 2.7% per year from 1990-2008 due to India's increased economic growth and increasing quality of life (Mathur, 2011). Carbon dioxide emissions from India are 3% of the cumulative global emissions and India's energy need is predicted to increase 3 times in the next fifteen years (Mathur, 2011).

However, India has not fully adopted dynamic shading devices as a real option to tackle heat gain inside buildings while at the same time providing visual comfort to spaces that are most affected by it.

Very little study has been done in the Indian context on the performance of dynamic shading devices; even the Energy Conservation Building Code (ECBC) does not mention it. Building envelope design, especially sun-shade design can significantly reduce energy demand (cooling demand being a major contributor). A dynamic system will additionally increase daylight availability resulting in a further decrease in energy. There is a need to optimize such a shading device to get the best possible results keeping into mind multiple criteria - Daylight, glare, cooling demand, and total energy consumption. Comparing various shading system and combining the best scenario based on season and time can give an insight into how much energy can be saved while maintaining comfort conditions. If a similar methodology is followed in every city to design a dynamic shading device it could ultimately lead to the reduction of India's part in co2 emissions – bringing us closer to achieving Goal 13 (climate change) of SDG.

LITERATURE REVIEW

Latitude and Shading Performance

Many studies have recently been conducted in the past 5 years to find the optimum shading system control; however, such studies are limited to the geographical conditions the studies have been conducted in. For example, simulations to access the performance of shading system in difference latitudes (Malaga – 376.7213 N, Milan – 45.4662 N and London – 51.504 N) resulted in very different energy savings and indoor visual environment with better performance found in Malaya where there are less heating demand and more availability of daylight (Hernandez et al, 2017). A similar study was conducted with 8 cities in China (latitude range from 47.4 – 20 N) and USA (latitude range from 42.4-21.3 N) where it was found that there is a relationship between optimal SHGC and latitude (Lai et al, 2017). It was also found that minimum GSC increases with decreasing latitude, low lying latitudes should have larger PDR for energy savings and shading devices do not always perform well in higher latitudes.

This sets the case that each city must have been individually studied for designing a shading device. Since different latitudes have a significantly different performance for the same shading device, it becomes vital to design based on local conditions. Since sun-path is different for even a degree change in latitude, it must be expected that optimal design of sun-shades will vary. However, both studies do not consider different climatic conditions and height above sea level.

ORIENTATION AND SHADING PERFORMANCE

Orientation is an important factor to take into consideration as it can play a significant role in the choice of shading devices, energy demand and visual environment (Atzeri et al, 2013; Kim et al, 2015; Manzan and Padovan, 2015; Chvatal and Mazer, 2011; Tzempelikos and Shen and 2013; Nielson et al 2011). In Rome, it was seen that East and West orientation have larger cooling loads for every shading device studied, glazing type and size (Atzeri et al, 2013). These orientations can be considered critical and perhaps more variations in dynamic shading devices are needed to find the best solution. Without shading, another major problem was discovered – occupants would face 30% of their working time with glare discomfort in South and North orientation. However, the use of dynamic Venetian blinds in these orientations can reduce the hours of glare discomfort to zero. It is interesting to note that the use of dynamic shading in this study has increased glare discomfort in the East and West orientation. Neilson et al, 2011 found that the difference between choosing the best and worst shading system in Denmark based on orientation was between 12%-15% in each orientation. Kim et al, 2015 found that fixed shading devices that are designed based on sun path for each orientation resulted in a 50% reduction in solar insolation on the window in Incheon, South Korea. To arrive at this conclusion a virtual grid was created over the window to analyze solar radiation falling on top of it. This data was segregated based on the max grid (grid receiving the highest solar radiation), min grid (gird receiving the lowest solar radiation) and average grid (average of all the grids). With the addition of shading, South-East orientation had the highest average grid reduction and also the highest min grid reduction. The North-East orientation, on the other hand, had the highest max grid reduction. Manzan and Padovan (2015) found that each orientation has a shading system that suits best. Shading devices in different orientations have a different effect on both the cooling load and Uniform Daylight Index. In their case, for south-west façade using a particular kind of fixed shading resulted in 23.3% reduction in energy and higher UDI performance in Trieste, Italy. Chvvatal and Mazer, 2011,

in Sao Carlos, studied the effect of various fixed shading devices in different orientation by evaluating the total energy consumption, lighting levels, and lighting consumption. It was found that the impact of shading devices is lowest on total energy consumption in the South-East while the North-East orientation saw a large reduction in total energy consumption with the addition of horizontal shading. At the same time, the North-East had a low impact on lighting levels. In the West, lighting levels had a higher impact (increase in lighting levels) with the addition of horizontal shading. With the addition of horizontal and mixed shading, the north had the lowest impact on the lighting levels. An interesting result showed that there was no need for shading in the South and South-East orientations. In Philadelphia, using various factors, Tsempelikos and Shen, 2013 found there is a working plane illuminance of more than 2000 lux for a large part of the area for cases with 40% WWR and 10% shading transmittance for south and north facades using solar radiation and direct sunlight prevention set points.

Orientation can play a significant role in both energy consumption and lighting. Hence, the right shading device must be selected for the best performance. Design of sun shading device must be based on parameters that take into consideration orientation for more effective results.

WWR AND SHADING PERFORMANCE

WWR has a significant impact on the performance of the shading devices, hence, there is a need to optimize it before optimizing the shading device. For example, in Philadelphia, dynamic system with direct sunlight prevention set point and the same with the addition of solar heat gain set point resulted in visual discomfort in higher WWR (Tzempelikos and Shen, 2013). It also found that a dynamic system with solar radiation set point is independent of WWR.

However, WWR becomes a significant factor for a dynamic system with illuminance set point. Another research found that WWR, orientation, and choice of shading device have a strong relation with cooling demand in Denmark (Nielson et al, 2011). For example, for the windows in the northern direction, no and fixed shading performed best at 1.5m height and the dynamic system performed best at 2.0m height. The choice of type of shading device becomes dependent on WWR. For example, a dynamic system performed best in the West with window height at 1.5 but recorded the best performance at 2.0m in the North. A common misconception is that a dynamic system would always outperform better than fixed but this seems to have put that in question. Tzempelikos and Athienitis (2007) found a critical WWR whereupon increase in WWR does not affect DAR. Their study which was conducted in Montreal discovered that the critical WWR in the south façade was 30%.

A critical WWR was also found against annual lighting consumption and found that between 45%-50% a critical WWR is reached, beyond which there are not much savings in electrical lighting consumption.Shading design will be incomplete without optimizing the WWR. Critical WWR can be found for each orientation and be used as the base whereupon the shading system can be optimized. WWR and shading design must be worked on simultaneously with each orientation.

LIGHTING CONTROL STRATEGIES

The choice of lighting control strategy plays a crucial role in artificial lighting demand. Tzempelikos and Athieniti (2007) found that 20% of cooling energy consumption is reduced if lighting control with automatic on/off used instead of lights being continuously on in Montreal. Atzeri et al (2013) discovered that using artificial lighting with dimming technology can reduce the lighting energy consumption from 30% to 60% when compared to the on/off system in Rome.

Whereas, Hernandez et al, 2017 found that dimming lighting system with occupancy sensors performed best when compared to manual off/on, the occupancy sensor and dimming lighting system. These automatic systems in all the studies are based on a certain illuminance set-point.

If the daylight illuminance is below this value, the automatic on/off lighting system will turn on and if daylight illuminance is more than this value it would turn off. In a dimming control system, the lights will dim (conserving energy) to maintain the illuminance set-point at all times.

Automatic system outperforms the manual lighting systems and lighting being continuously on. Since artificial lighting with dimming technology reduces the lighting energy significantly, this could be considered the best choice to bring down both total energy demand (cooling + lighting)

EVALUATING GLAZING TYPES

The glazing type used must also be optimized for better fenestration performance. Low-e glazing performed better in places with high heating demand while solar and reflective glasses performed better in places with high cooling demand in Malaya (Hernandez et al, 2017). Tzempelikos and Shen, 2013 studied the impact various glazing systems had on heating/cooling energy in Philadelphia. They simulated the building using double clear glazing, double clear glazing with low-e coating, double clear glazing with spectrally selective low-e coating and lower transmittance. The results showed that spectrally selective low-r coating with lower transmittance reduced heating and cooling load.

While many studies have been conducted to reveal that the best glazing type is dependent on the location in question, it needs to be explored if different shading systems perform better with different glazing systems. For overall better performance, it would become necessary to choose the right glazing system before or along with designing the sun-shades.

VISUAL COMFORT PARAMETERS

The recent developments and boom in automated control technologies, visual comfort has become a focal point of study in tropical buildings which predominantly has been following strategies to cut off heat gain resulting in smaller windows and bigger shading systems. The various visual comfort parameters studied in this field of research are Daylight Autonomy (Hernandez et al., 2017; Mandalaki et al, 2014 and Tzempelikos and Shen, 2013), Useful Daylight Index (Hernandez et al, 2017, Kim et al, 2015, Manzan and Padovan, 2015; Mandalaki et al, 2014), Daylight Factor (Kim et al, 2015; Nielson et al, 2011 and Stazi et al, 2014), Daylight Availability Ratio (Tzempelikos and Athienitis, 2007), Daylight Glare Index (Atzeri et al, 2013 and Manadalaki et al, 2014), Unified Glare Index (Atzeri et al, 2013) and Daylight Glare Probability (Hien and Istiadji, 2013).

EFFECT OF SHADING ON INDOOR TEMPERATURE REDUCTION

The relation between the addition of shading device and its relation to indoor temperature reduction cannot be accessed in air-conditioned buildings. Hence to make this assessment the air-conditioned buildings were simulated to act as naturally ventilated and buildings to make the following discoveries. Al-Tamimi and Fadzi (2011) found that egg crate shading in Penang, Malaysia can provide a max temperature reduction of 5.1 and 1.4 degree Celsius in unventilated and ventilated rooms. However, the average annual temperature reduction was about 1.3 and 0.4 degree Celsius. The egg crates in unventilated rooms would increase comfort hours significantly. The egg crates kept the temperature below 28.6 degree Celsius which resulted in a 117% improvement in comfort hours. A research in Singapore by Hien and Istiadj (2013) found a temperature reduction of 0.5-1 degree Celsius can be possible with the addition of shading. Vertical, horizontal and louver type shading resulted in 0.98, 0.61-0.88- and 0.08-0.26-degree Celsius temperature reduction. The presence of plants on the shading devices can cause 0.003-degree Celsius temperature reduction. In Asansol, West Bengal a temperature reduction of 1.5 degree Celsius was achieved using a dynamic shading system which was modeled on time schedule based on sun-path and solar radiation data at each time step (Samanta et al, 2014). Simulations for ten typical summer days in Ningbo, China showed that after shading there is an indoor temperature reduction of 1-2.5 degree Celsius (Yao, 2014). Annual simulations show that 5-degree Celsius temperature reduction can be achieved at certain times in the summer. In winter, solar shades can reduce heat loss, resulting in slightly higher temperatures.

Shading systems effectively reduce the indoor temperature in non-air-conditioned spaces and the extent of reduction is dependent on several factors including the type of shading system, orientation, and location. In air-conditioned spaces, the result of reduced heat gain will result in a reduction of cooling demand. If the reduction is significant, it may not even require air-conditioning in certain times if the temperature is below the cooling set-point.

EFFECT OF SHADING ON COOLING LOADS

In air-conditioned buildings, the addition of shading devices is essential to reduce cooling loads (Atzeri et al, 2013). In Malaya, Spain, reduced thermal demand was found in all shading cases when compared to no shading scenario. Horizontal louvers reduced energy demand by 60%. Vertical louver angled at 60 degrees resulted in 68% reduction, a - 60-degree louver angle resulted in 64% reduction, a 30-degree louver angle resulted in 51% and a - 30-degree louver angle resulted in 42% reduction (Hernandez et al, 2017). In Bangkok, three different

fixed shading systems where analyzed and realized that energy reduction range was between 8%-20% based on the type of system used (Mohhamed et al, 2017). The largest reduction was observed in SHELL tower which was installed with spiral-shaped shading. In Incheon, a 35.1% reduction in cooling load was achieved by introducing shading system designed according to the sun path diagram between the months April to September (Kim et al, 2015). April had the highest cooling load reduction of 66%. The cooling load was plotted against average daily temperature to find the regression equation to predict the cooling load. Tzempeliko and Athienitis (2007) found that by using the critical WWR, automatic on/off system and dynamic roller shade with illuminance set point, 50% reduction in cooling energy can be achieved. Tzempelikos and Shen (2013) simulated for shading devices with different parameters for set-points and compared them to the total energy consumption. Roller shades that are closed all the time, resulted in 134.1 Kwh/m2/year energy consumption while the same roller shades being open all the time resulted in 116.9 Kwh/m2/year energy consumption. The total energy demand when shading control with solar radiation set point was used was 115 Kwh/m2/year, shading control with illuminance set point resulted in 5% higher consumption that solar radiation control, shading control with direct sunlight prevention set point had a low total energy consumption and solar control with direct sunlight prevention with solar heat gain set point resulted in 3.6 Kwh/m2/year reduction. In Ningbo, China, the energy savings by the addition of dynamic shading, was equivalent to reducing the wall insulation to half of the energy standards with the combination of low-e windows (Yao, 2014).

The amount of reduction in cooling energy has a huge variation based on the type of shading systems studied by researchers along with the location, orientation, WWR, glazing type etc. This means that every city must be specifically studied to tackle local issues. However, this data must be used along with the visual environment created to select the best performing system.

COOLING ENERGY VS. ARTIFICIAL LIGHTING ENERGY

The most difficult aspect of optimizing shading system in terms of cooling energy and lighting energy is that a reverse proportionality exists between artificial lighting and cooling demand (Nielson et al, 2011). When it comes to visual comfort there again comes a need to optimize. In a dynamic system in Philadelphia, based on its set points, can result in very different cooling energy and artificial lighting energy consumption (Tzempelikos and Shen, 2013). Dynamic shading control with direct sun prevention set point achieved the lowest lighting energy while dynamic shading with direct sunlight prevention and solar heat gain setpoint achieved the lowest cooling energy.

Since a reverse proportionality exists between artificial lighting energy and cooling demand there is a need to optimize the shading system. However, the method of choosing the right shading system is haphazard and not based on solid logic. Moreover, it would become very difficult to find the ideal optimization point between them. Also, in the effort to reduce total energy consumption, preference would be given to choosing an optimization point which reduces as much cooling energy. This would impact natural lighting inside building and reliance on artificial lighting would increase. Hence, the optimization must consider the base level of lighting quality that must be achieved.

OPTIMIZATION BASED ON COOLING ENERGY AND LIGHTING

Hernandez et al (2017) studied the effect of different louver angles on cooling demand and lighting energy. A vertical louver angled at 60 degrees was able to reduce the cooling demand by 68% but had a DA value of just 7.5%. Hence, vertical louver angled at 30 degrees was reasoned as the optimized choice where a 50% cooling energy was achieved and high UDI_100-2000 of 69% was achieved. A study in Chania, Crete, also revealed a similar issue where canopy louvers did best in terms of daylight performance but fared poorly in energy consumption (Mandalaki et al, 2014). Hence the Brise-Soleil system was reasoned as the best choice in terms of energy needs and visual comfort. In a few cases, such as Ningbo in China, recorded a very minimal effect on lighting quality even as cooling load decreased when solar radiation set-point was used (Yao, 2014).

Instead of optimizing the shading device based on cooling and artificial energy demand, it would be more beneficial to use indoor lighting quality. However, no methodology to support the claim of best performing system is mentioned. Hence, it is important to lay out the logic used to support how one system performs better based on the two parameters.

OPTIMIZING SHADING SYSTEMS

It is to be noted, that research in shading devices has deviated into two paths. Despite notable advancements in dynamic shading the technology has not yet fully penetrated the market at a global stage. Research in dynamic systems can be found as early as 2007 in a research paper by Tzempelikos and Athienitis (2007) in Montreal (Canada), however, researchers such as Hernandez et al (2017) in Malaya (Spain) are still basing their study to find the optimum length or angle of fixed systems. However, countries whose research on sun shades had predominantly been about the fixed system have started to explore this option.

The latter's study of fixed shading system was the base for creating an optimized shading technology. Fixed shading system with different types, length and angles were first explored to find the most optimized position. Al-Tamimi and Fadzil (2011) studied multiple shading system options and found that the egg crate system was the best performing system as it avoids solar radiation in various angles in Malaysia. Horizontal and vertical shading device angles were explored in each orientation to investigate the impact on energy consumption and lighting (Chvatal and mazer, 2011). A similar category of shading but changing the length or depth of the shading devices resulted in changes in the overall performance.

Stazi et al (2014) simulated louver systems of varying materials, length of the slat and vertical distance between slats. The study found that longer slats resulted in deeper daylight penetration and that wooden louvers performed better. In the course of their research, they discovered that by changing the aluminum shading angle from 45 degrees to 60 degrees in winter and 20-degree summer they can reduce the heating and cooling load by 2kWh/m2 year. Extending this forward, each length/angle of a shading device performs well at different times. Hence, a dynamic shading system with time-scheduling was introduced. This is where the length and angle of the shading device may change based on each time step. In a research conducted in Dubai, a dynamic system (drop awning) was constructed based on 10 operational steps of varying length and angle. The length and angle were recorded at each hourly step (Lee et al, 2016). The best step at each hour then became the control strategy for the shades for certain set-points. A Programmable Logic Controller (PLC) was designed based on window shading percentage of the time schedule (Samanta et al, 2014). This was done by modeling a dynamic shading system based on fixed shading time step.

Dynamic systems, however, can be controlled even in real time basis. Tzempelikos and Athienitis (2007) have worked with roller shades that adjust itself based on daylighting or illuminance set point to be maintained indoors. There are now many options to programme the dynamic shading devices based on the set-points of various parameters. Tzempelikos and Shen (2013) explored different dynamic shading devices such as shading control with solar radiation set-point, illuminance set-point, direct sunlight prevention set-point, and direct sunlight prevention and solar heat gain set-point. It was found that different shading devices performed differently based on WWR and orientation. The different set-points also resulted in very different visual conditions, artificial lighting energy, and cooling energy.

With visual comfort becoming a prominent aspect of shading in addition to reducing cooling demand, set-points dedicated to lighting needs have also come into the picture. Xiong and Tzempelikos (2016) explored three control strategies – Glare based control, vertical plane illuminance-based control (Ev<2500 lux) and work plane illuminance-based control (Ewp<2000 lux). While they explore visual comfort conditions and lighting energy they did not study cooling energy demand – which could have given a broader understanding of its performance.

The optimization of shading system seems to work on a comparative basis, which is done by selecting which particular shading system performs better than the others at a given time, date, month, latitude, WWR etc. A dynamic shading system's logic based on real-time seems to be controlled in two ways – sun movement or set-points. Shading based on sun movement has the advantage of adjusting itself based on hourly account throughout the year. Set-points, on the other hand, has the advantage of being more pro-active in changing its position based on timely conditions. There is a need to compare both these shading systems to see which one is more advantageous.

PV INTEGRATED SHADING SYSTEMS

Most shading devices while reducing cooling demand may increase electrical lighting demand. To tackle this offset, PV panels are used as sunshades for fixed shading systems (Mandalaki et al, 2014). In Chania, Crete, it was found that PV integrated shading systems supports the electricity needs during the hours 500lux daylight light is not met. While the surrounding shade is most efficient if the PV panels are used to heat or cool interiors

spaces. However, further research is still necessary to evaluate how dynamic shading responds with PV integration.

SOFTWARE

Almost all the research papers in this particular topic of study have used software to simulate and predict outcomes of how a shading system performs at any given time of the year. The most popular software used for the study are EnergyPlus (Atzer et al, 2013; Lee et al, 2016; Kim et al, 2015; Tzempelikos and Shen, 2013; Yao, 2014; Stazi et al.,2014; Chvatal and Mazer, 2011) and TRNSYS (Hernandez et al., 2017; Tzempelikos and Athienitis, 2007; Lai et al, 2017 and Samanta et al, 2014). A relatively new software called IES-VE has started to be used to simulate for a wide variety of parameters including temperature, cooling load, lighting load, illuminance, UDI, Glare probability etc. (Mohammed et al., 2017 and Al-Tamimi and Fazal, 2011) Both software can simulate for both energy demand and lighting parameters. However, some papers used separate software to simulate for visual conditions with more accuracy such as DAYSIM (Hernandez et al, 2017; Manzan and Pandovan, 2015 and Mandalaki, 2014) and Radiance (Mohammed et al, 2017)

CONCLUSION

Innovative solutions for energy conservation have become the need of the hour, especially at this juncture in human history. Shading systems have a high potential to conserve energy if properly designed and thus require increased effort to optimize it to suit local conditions. Addition of shading devices has a substantial effect on heat gain inside buildings in tropical climates. This results in a decrease in indoor air temperature, bringing down the cooling load. However, the typology of shading devices has a large effect on how much the cooling load can be reduced. The difficulty comes when certain typology of buildings require excellent visual conditions to be productive. The addition of shading devices may deprive these spaces of natural light and ideal visual environment. Hence, there is a need to design shading devices that allow as much natural light as possible while reducing heat gain. A good visual environment must be a parameter to judge the effectiveness of a shading system. Shading system may cut of sky view, resulting in reduced daylight and even glare. Hence, to judge good visual environment - Daylight Autonomy, Uniform Daylight Index, Glare Index, and Daylight Glare Probability – needs to be studied. Different shading systems result in a different visual environment. However, the best results cannot be obtained by simply optimizing the shading device. If a building is to be designed from the initial stage it becomes equally important to optimize WWR, select the best lighting control strategy and design based on each orientation unique challenges. As latitudes changes, so do the shading design – hence different solutions arise for every degree change in latitude. As cooling load increases, lighting energy decreases and vice-versa. Which means an inverse proportionality exists between the two variables. Hence, lighting quality must be seen in comparison with cooling load. There is a need to evaluate the best performing system based on certain criteria in both parameters. Dynamic shading systems have predominantly outperformed fixed systems in terms of cooling load reduction. However, the type of control strategy used for the dynamic system that gives the best output needs to be investigated. There are two types of control strategy within the dynamic system. One is to maneuver the shades based on sun path (using either fins or louvers) and the other is to control shades using set points (solar radiation/illuminance/glare). The current codes available must be updated to include dynamic shading as an important building component, especially when a large number of research papers have verified their effectiveness.

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Bulletproof Green building for comfort of soldiers in Siachen

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Abstract: The building is designed with "Y" like shape structure to ensure maximum heating from sun, which can provide better heating than only south facing walls to warm the interior of the tent like temporary pre-cast, portable structure which is designed for extreme conditions in places like Siachen where temperature can drop upto -60 C. The structure is designed to obtain the required heat energy from passive solar heating as well as heat released from the body (respiration) and body heat. The design tries to reduce all possible ways of heat loss. The design also checks that the insulation technique does not hinder the fresh air flow into the structure and this ventilation system which mimics the termite mound offers very less loss of heat by conduction and convention. The heat in the night time is maintained by greenhouse effect provided by the polycarbonate walls and a layer of greenhouses gases like carbon-dioxide, water-vapour and methane sandwiched in between the polycarbonate walls. These gases are obtained in natural process like respiration of humans and anaerobic decomposition of bio-waste by bacteria. The building design would prove to be a low-cost, green building and which doesn't harm the surroundings nearby during its construction. The design provides warmth to its occupants without using any external energy and efficient than only south facing walls/windows which are used for heating the interiors.

Keywords: Passive solar heating, body heat, termite mound.

INTRODUCTION

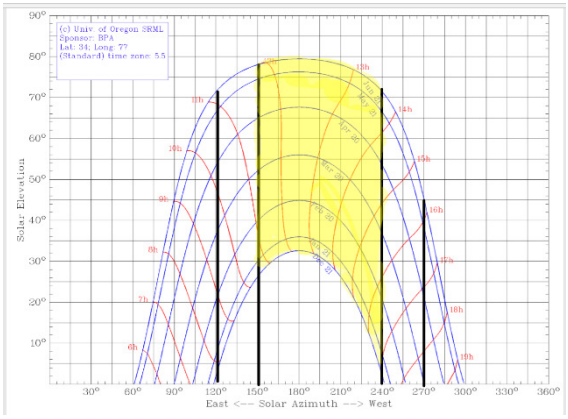
The temperature in Siachen, the highest battlefield, can drop to -60 C and providing warm conditions inside the temporary building build for the soldiers is very difficult task as the place, Siachen (35.4 N, 77.1 E) , which is 12000 feet above sea level is isolated and away from general power supply. As well as carrying huge batteries in the tough terrain and extreme weather conditions is a difficult task. So the better method would be to use the solar energy as well the heat released during respiration which accounts to about 360,000 joule per hour and providing best insulating techniques to minimize heat loss. The idea of TERMITE MOUND is used to provide fresh air supply as well as to remove carbon-dioxide (expired air) without much effecting the insulation techniques. The heat in the night is maintained by the presence of greenhouse material provided as the walls as well the greenhouse gases in between the walls.

Method of construction

The building is designed to be a pre-cast, portable, easy and quick construction type. So it can easily be installed within hours near the camps wherever necessary and shifted whenever required. The building is completely a self-sustainable which doesn't require external power supply for heating its interior, but mainly rely on naturally available heating sources and tough insulation. The building is also designed in such a way that whenever required, the angle of the walls as well the tilt of the walls can be changed according with the help man power and no external source of energy required. This ensures the perpendicular rays of sun, maximum intensity as well as maximum heating during extreme weather conditions.

The graph.1 shown below helps us to understand that orientation of walls according to solar angle specification is necessary for maximum intensity of solar rays reaching the interiors. The building is designed according to the graph which heating of interiors mainly depends on latitude of place and the season of the year and hence prove to efficient than only south facing walls. The main design of the building is the wings of the building are at an angle to each other on the basis of analysis of the graph.1.

Considering the day of winter solstice the azimuthal angle for the morning is around 120 degree and in the evening is around 240 degree and maximum heating at 180 degree. So the design includes the walls present at these angles to provide maximum heating during all the times of the day. During other days the considering maximum heating hours between 9 hours to 15hours the orientation of the according to solar azimuthal angle is considered and the design would well suit for it too.



Graph 1. The variation of solar azimuthal angle and tilt angle in Siachen (34 N, 77 E)
(Source: http://solardat.uoregon.edu)

The building is provided with internal central column which supports the entire structure as well as act like a chimney to drain out the exhaled air as well as methane produced during decomposition of biowaste by bacterial. It drains these greenhouse gases to the gap in between the layers of 6mm polycarbonate sheets. This way of draining out the air doesn't much affect the insulation system.

The inflow of fresh air is provided by the inlets at bottom part of the panels so that only fresh air is allowed and escape of heat is reduced. The walls not facing the sun is covered with naturally available snow, so that heat loss by radiation is prevented and the snow is a good insulator as well.

Idea and technology

The temperature is maintained by the body heat and passive heating by sun.

Just a south facing house would not able to provide enough heating in a place like Siachen where the azimuthal angle varies greatly about 120 degrees in the winter as well as number of hours of exposure to sun is less. So placing the southern walls at 120, 150, 240, 270 degrees with south-north line would be a better idea where energy is mainly dependent on passive solar heating. So when the polycarbonate walls are placed at these respective angles and given a tilt according to the solar elevation angle we can maximize heating in all parts of

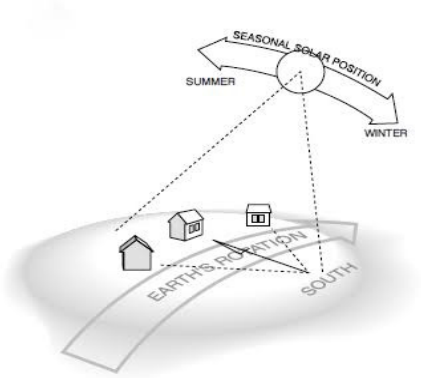


Figure 1. The image depicts why south facing walls/windows are used to heat the interiors in northern hemisphere.

the day as well as the year, ensuring the rays on the walls are almost perpendicular to maximize the intensity.

The central column not only acts like a chimney for ventilation but also provide strength to the structure by acting like a spine of human, absorbing the shock forces acting on the building. Thus supports the entire structure by acting like a physical pendulum. The material used for the construction of central column is pre-casted hollow rod of high thermal mass which can absorb heat from exhaled air as well, releasing in during cooler nights. So a concrete hollow pre-cast rod can be used.

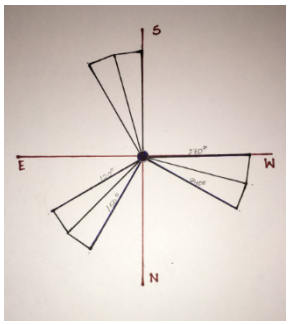


Figure 2. The image depicts the top view of the structure, where the polycarbonate walls are oriented to maximize intense solar rays from entering the interiors.
Source: Author, 2018

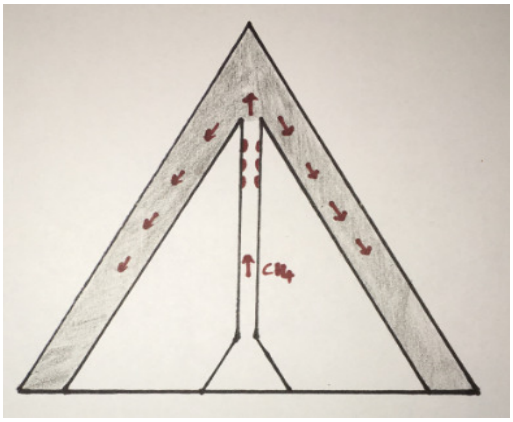


Figure 3. The image shows the movement of CO2, CH4, H2O (vapour) from central column to the space in between the polycarbonate walls. The design mimics the termite mound ventilation.
Source: Author, 2018.

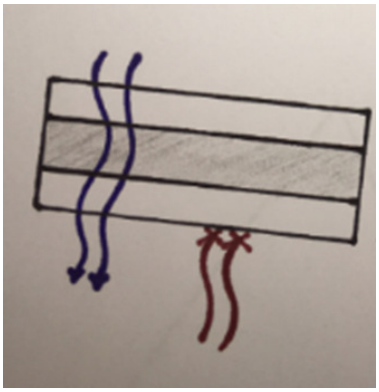


Figure 4.6mm thick polycarbonate layer with 8mm air gap in between which collects the greenhouse gases.
(Source: Author, 2018)

The material used for the flooring should again be a material of high thermal mass, absorbing heat from body energy as well the solar energy and releasing it when the temperature inside the room drops.

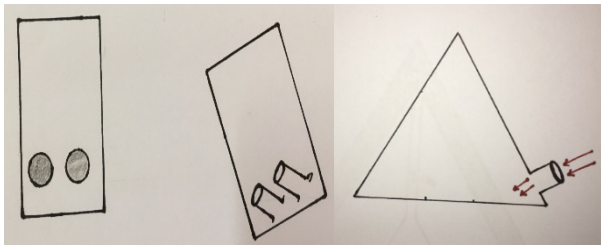
The material used for construction is POLYCARBONATE- polycarbonate is chosen because it a material used in greenhouses, transparent allowing solar rays to pass through it with transmission of around 96 percent. The polycarbonate has high heat retention capacity than glass and provides higher average temperature than glass. It has better insulation properties and mechanical strength than glass. Siachen soldiers have another problem of extreme exposure to UV rays and polycarbonate being a UV resistant material would provide protection against UV rays as well.

The layers between the 6mm thick polycarbonate is sandwiched with a layer of 8mm thick carbon-dioxide, water-vapour and methane in between. These gases being greenhouse gases don't allow heat radiations from

inside to escape outside as well absorb and re-emit energy in thermal infrared range which can help in heating during the night. This layer of gases in between the polycarbonate panels also act as a insulating layer. The carbon-dioxide and water-vapour are collected which is a result of exhaled air of occupants inside the building and methane is formed as a result of gas formed as a result of anaerobic bacterial decomposition of biowaste.

In the act of providing better insulation the building is entirely covered leaving practically no air spaces in between to reduce the heat loss by convention and conduction. So the natural convention flow of fresh air and exhaled air becomes difficult.

Keeping insulation in mind a design mimicking the termite mound is used where the inflow of fresh air which is dense than exhaled air because it is cooler is accomplished by air inlets provided at the base of the walls and the exhaled air is simultaneously removed by central column which works on Bernoulli's principle. The exhaled air being less dense as it hooter than fresh air, rises up heating the entire room and collects in the top part of central column. As the wind blows over the opening of central column the, region of low pressure is created. Hence the collected exhaled gases from the central, collected gases flow naturally outside. Thus a natural convention is maintained without much disturbing the insulation.



(a) (b)

Figure 5. the view of the panels of the walls having air inlet for fresh air flow at the bottom of the panels, to ensure only flow of fresh air minimising the flow of heat outside. *(Sources: Author, 2018)*

The walls not facing the sun directly is covered with ice so that heat loss by conduction (ice is an insulator) and radiation (ice reflects 85 percent of light) is minimized.

Improvements

The laminated polycarbonate sheets are bulletproof up to level 3 providing safety only to a limited extent. So, the polymer sheets which are highly bulletproof with level-8 impact resistance are available in the market which has high solar energy transmittance, UV protection as well as better thermal insulation. These bulletproof material can be used in construction of walls the building providing safety as well as required comfort, warmth for the occupants inside it.

CONCLUSION

A simple igloo provides the interior temperature of around -7 C to 16 C when the outside surrounding temperature in -45 C. So the building we have designed is expected to provide a better interior warm temperature as,

Hence heat loss by

- Conduction – is prevented by providing good insulation as the walls made of polycarbonate sheets sandwiched with greenhouse gases in between. The greenhouse gases in between the polycarbonate sheets provide insulation as well.
- These layers of polycarbonate sheet and greenhouse gases allow short wavelength solar radiations from outside to pass into the building but prevent the longer wavelength thermal radiations radiated from inside of the house to pass to the outside surroundings. Hence heat (due to body heat and the heat due to passive solar heating) is maintained inside the building. The layer of the greenhouse gases carbon-dioxide, methane and water-vapour absorbs and re-emits radiations in thermal infrared range. Hence they trap the heat within the building and help to keep the building warm even during the night time when passive solar heating is not possible.

- Convention- is minimized by avoiding conventional ventilation system like windows or ventilators. But the fresh flow of air is well maintained by using a ventilation system mimicking the termite mound, this design also ensures minimum heat loss by convention.
- Radiation- is minimized by covering the walls which is not under the influence of sun with ice which is a good reflector and naturally available in the construction site.

The walls of the buildings are oriented according to the requirements of the place Siachen, so as to ensure maximum heating by solar energy. This design ensures to provide better heating than only south facing transparent walls as the walls the building designed are oriented in such a way so as to provide maximum intensity of solar energy reaching inside of the building during the entire year and any particular day without using any extra mechanical or electrical energy. The polycarbonate panels with high mechanical strength also provide protection against UV rays as well because **the** place Siachen has high exposure to UV rays.

Thus the building design ensures low cost, pre-cast, highly efficient green portable structure, which provides warmth and comfort to the occupants inside it without using external energy source but by making complete utilization of heat from naturally available sources like solar energy and body heat and heat released from respiration which accounts to about 360000 per person per hour.

The building with these properties is of importance to army in places of extreme weather conditions like Siachen because those places are away from power supply, and storage of energy by conventional methods is a difficult task.

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Need for Energy efficient techniques- High rise residential buildings in Hot & Humid climatic conditions

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Abstract: We are aware that one of the biggest consumers of energy is many countries is the Building sector and the sector counts to around to 30 % of the primary energy demands. The role of high-rise residential buildings in the overall carbon foot print of the metropolitan cities is going to be higher in the forthcoming years. Towering Apartment buildings, which are also called as "Vertical cities", are the solutions to congesting urban sprawl. And thereby the answer for the arising Housing needs of the city. The paper aims to establish the need for energy efficient techniques in towering apartment structures. The various parameters in designing of such structures in warm and humid climatic conditions have been studied and analyzed to provide a comprehensive design solution to enhance their energy performance. The major focus would be to formulate integrated passive cooling techniques to reduce the cooling Load in apartment buildings.

Keywords: energy efficiency, high rise residential buildings, hot & humid climatic conditions

INTRODUCTION

The paper is divided into three parts for the easy comprehension of the research. The first part deals with the context of the study. Establishing the need and necessity for energy efficient techniques, particularly in High-rise Apartment buildings of Hot and humid climatic conditions is the first part of the research paper. The second part aims to provide with comprehensive design solutions that primarily aim to reduce the cooling load in the High rise residential buildings.

I. PART 1: CONTEXT OF THE STUDY

State of Tamil Nadu, India, has predominantly tropical climatic conditions with slight seasonal variations. Temperature and Humidity remains relatively in the higher side throughout the year. The average temperature range in the plains is 20° to 38°. It also has a shoreline that extends more than 1000 km. Owing to this unique geographical juxtaposition, the climatic conditions provides with challenges in the Building sector.

Building sector mounts up to 30 % of the overall energy consumption of the country. In the overall Building sector energy consumption, more than 60 % is by the Residential buildings in the country. The breakup of the

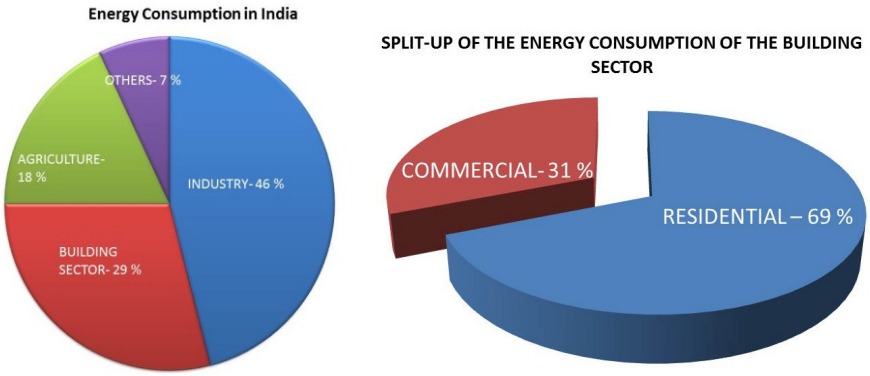

Figure 1. Details of the Energy Consumption in India.
(Source: Journal, By FarheenBano, MohammaedArif Kamal, Architecture Research 2016)

energy consumption is been given in the Figure: 01.

Tamil Nadu ranks seventh in the list of most heavily populated state in India with a population density of about 555 people per km2, which proves to be unquestionably higher than that, of the Indian average of 382 people per km2 (Census of India, 2011). Tamil Nadu can be considered to be the most upcoming urbanized state with a population of 35 million spread over 13,755 square km, which amounts to only 11.61 percent of the total state area. These data significantly suggests that the state is in growing demand for the housing of the urbanized population. This has been adding to the electrical load of the state. Below is the brief look into the Consumer and sales mix of the Electrical load consumption in the financial year 2016 through Figure .02. This clearly

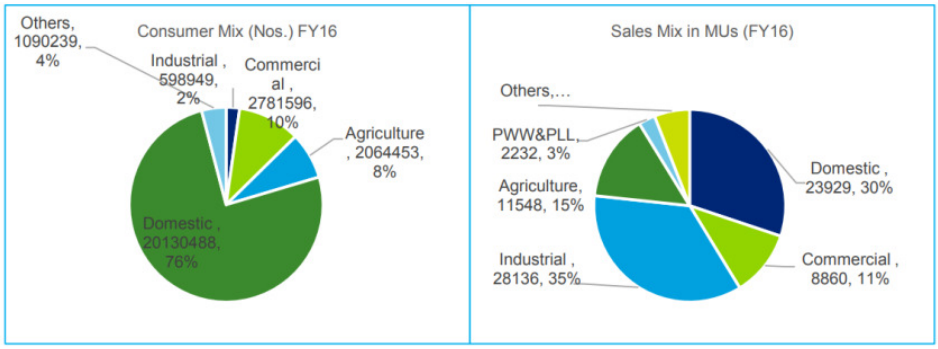

Figure 2. Consumer and Sales Mix (FY 16) of State of Tamil Nadu
(Source: Document on Power for all: TamilNadu, a joint initiative by Government of India with Government of TamilNadu., Year-2017)

suggests the domestic users are the major consumers of Electrical load of the state.

The increasing opportunities in the urban area have increased the HH (House Holds), which are taken in to account of the growing energy demand of the state. The below table supports that the energy demand of the Urban HH will be around 2.5 times higher than the rural HH by FY19.

Table 1. Per HH per Day Consumption (kWh)
(Source Document on Power for all: TamilNadu, a joint initiative by Government of India with Government of TamilNadu, 2017)

Particulars	Fin Year 16	Fin Year 17	Fin Year 18	Fin Year 19
Urban HH	4.54	4.72	4.91	5.10
Rural HH	1.97	2.05	2.13	2.22

Need for High –rise Apartment buildings

By and large, a skyscraper structure is a building which is taller than the reach of available fire-fighting equipment. To be precise, this varies between 75 feet (23 meters) and 100 feet (30 meters). According to various sources, High rise buildings are about 7 to 10 stories which depend on the slab- to slab distance between floors.

In her book, The Skyscraper and the City: The Woolworth Building and the Making of Modern New York, Author Gail Fenske, elaborated the journey of the high rise buildings with the evolution of city scape. She discusses about the increasing population which is largely urban, has created an increasing demand for skyscrapers.

Tall buildings can accommodate more people in the same pocket of land in comparison to the low-rise building on the same pocket of land. High rise buildings also becomes the need for the hour since, they provide with the opportunity to create more “Green- Lung” pockets of the city like Parks, plazas, play grounds and other community spaces. It also reduces the commuter distance for the community who used to travel long hours to reach their destinations, thereby leading to energy conservation as well.

Need for Energy efficient Techniques in High Rise apartment Buildings

Having to consider that the High rise apartment Buildings would be the solutions for the housing issues of the urban areas, the focus is again on the establishment of decrease of energy consumption in towering apartment

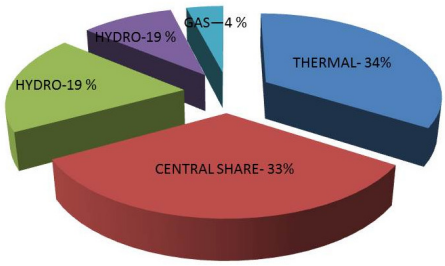

Figure 3. Installed Generating Capacity in TN – State, Private and National Share
(Source: TNEB (www.tneb.org) as on 6.2.2016
Source: Chapter 3 Overview of TN's Electricity sector, A Road map to TamilNadu Electricity Demand – supply by 2050: By Shankar Sharma)

buildings, in particular to the warm humid climatic conditions. The cooling load in the hot humid climate conditions is higher in comparison to the other climatic conditions. The electrical consumption of such buildings will be adding stress to the already higher projected participation of the urban electrical demands in the overall supply of the load.

Figure 03, clearly indicates that the most part of the energy produced for the overall demand of the state is produced from Thermal power stations, which is based on the non-renewable sources of energy. In order to manage the energy balance, the approach of "Energy efficiency" is the most appropriate in the given context. This paves way to the focus of the research paper, comprehensive design solutions to decrease the cooling load of the High rise residential buildings.

II. PART 2: COMPREHENSIVE DESIGN PARAMETERS TO ACHIEVE LESS ENERGY CONSUMPTION IN TALL RESIDENTIAL BUILDINGS

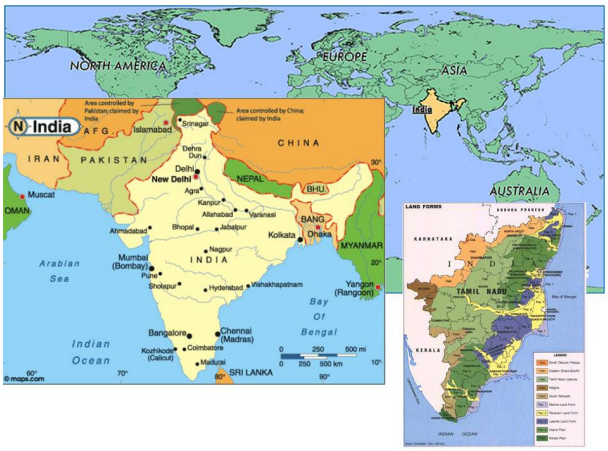

Figure 4. Location of State of Tamil Nadu, India
(Source: World Atlas)

The climatic conditions of the state, particularly the city of Chennai, capital of the state, undergo hot and high humid climatic conditions. The temperature is on the higher side for most of the year, and the humidity in the city is relative to the sea conditions of Bay of Bengal, the shoreline of which is abutting the city, as already discussed. Below is the table that shows the temperature chart of the city for the past century. The overall climate change of the world is reflected in the city's temperature.

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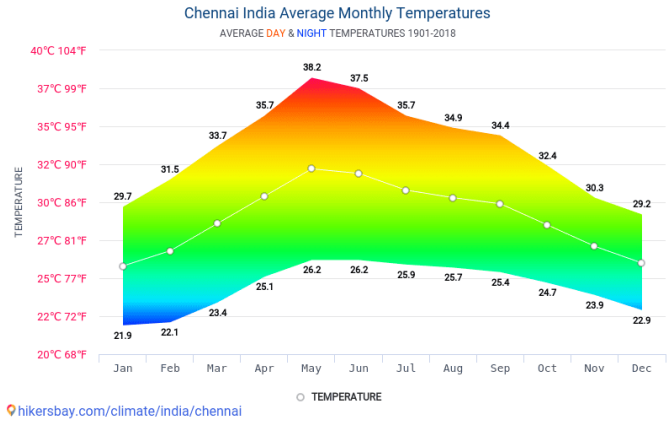

Figure 5. Chennai –India Average Monthly temperatures
(Source: Tables of monthly and yearly climate statistics for Chennai, gathered from Meteorological Department. http://hikersbay.com/climate-conditions/india/chennai/climate-conditions-in-chennai)

discussed. Below is the table that shows the temperature chart of the city for the past century. The overall climate change of the world is reflected in the city's temperature.

Basic principles in energy efficient building design

It is obvious from the discussion that reduction of energy consumption in buildings is essential. It is now significant to focus on the primary strategies that can achieve the same in residential buildings for hot & humid climatic conditions. A wide composition of review involving various sources were endeavored to derive certain parameters for designing energy efficient structure. Below are certain aspects that have to be processed to reduce the energy consumption in buildings, particularly in Hot & humid climatic conditions.

Planning parameters: *The various parameters of planning aspects can be enlisted as Analysis of site, Form of the structure, Orientation of the buildings, Landscaping in and around the buildings. Figure shows the interaction of the room comfort with the aspects of site planning.*

Building envelope

The parameters like External wall, Thermal insulation, Building material, roofing systems, windows constitute

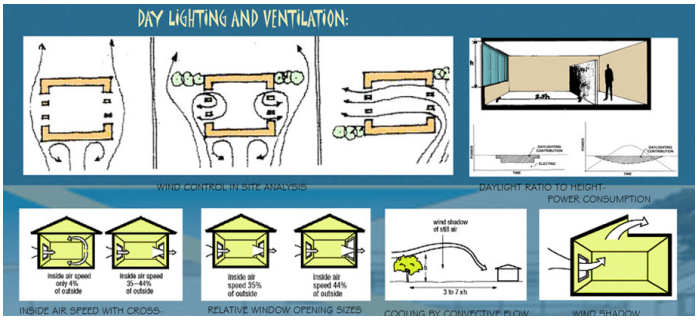

Figure 5. Heat Gain
(Source: Author, 2010)

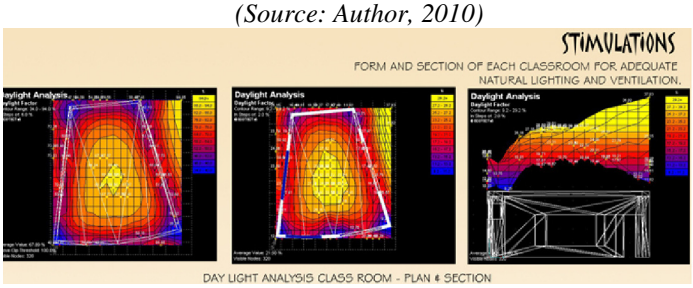

Figure 6. Daylight Analysis, through case study with computational analysis
(Source: Author, 2010)

the major role in the heat gains of the Building envelope. The aspect of windows varies with size, orientation, shading device, Natural ventilation and radiation through day lighting.

PRIMARY STRATEGIES FOR UNDERSTANDING THE COOLING LOAD STRATEGIES

There are various parameters to combat the cooling load in high rise buildings. But towards this there are two major aspects to be aimed in designing energy efficient buildings. Namely,

1. Maximizing day lighting strategies to minimize lighting load.

2. Maximizing passive cooling techniques to minimize the cooling loads in the buildings.

But, during the process of minimizing the lighting loads in the building, the designer has to make sure that heat gains should not be maximized, but then will be increasing the radiation gain in the buildings. The following parameters are the major design parameters that can be implemented to reduce heat gains,

- Building Envelope
- Orientation
- Ratio between surface area and volume of the structure
- Form of the structure
- Various components of the structure
  - Wall
  - Roof
  - Fenestrations

The following figure 7 portrays the Heat gain through various parameters which are the major sources of Heat Gain.

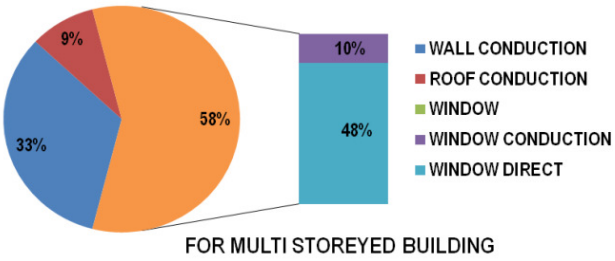

Figure 7. Heat Gain
(Source: FarheenBano et al.)

SOFTWARE TOOLS THAT CAN BE USED IN SIMULATION

When we look into various methods of achieving energy efficiency in building, the most modern practices include computation analysis. There are lots of software tools that can be used for computational analysis of the buildings. There are two types of usage for Software tools: 1. Simulation engine, 2. Modeler Application (Interface). The applications of the software are varied in nature, but the computational analysis of the software is very different for various coding that is being followed. The design solutions are based on the dynamic interactions in a building. The various changes in these systems have to be taken into account while calculating and feeding in the various parameters. After the systematic analysis of the various parameters, the process of the approach that is followed in the computational analysis is discussed in the Figure 11. The user will be feeding in the Modeler, the input files of the design. The modeler software solves the files to provide with solutions that are processed as output files. There is two ways the process the files after this, 1. The file is processed through Modeler software again for changes, 2. Otherwise the output data is processed to visualization tool to general user friendly files that can be processed further.

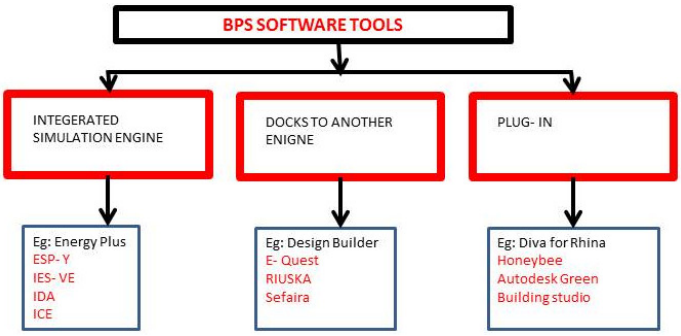

Figure 8. Types of BPS software tools
(Source: Author, 2018)

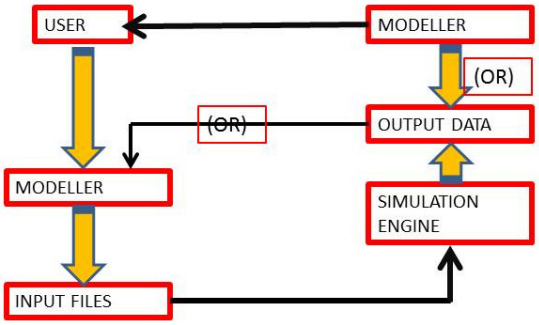

Figure 9. Process for the Computational Analysis
Source: Author, 2018

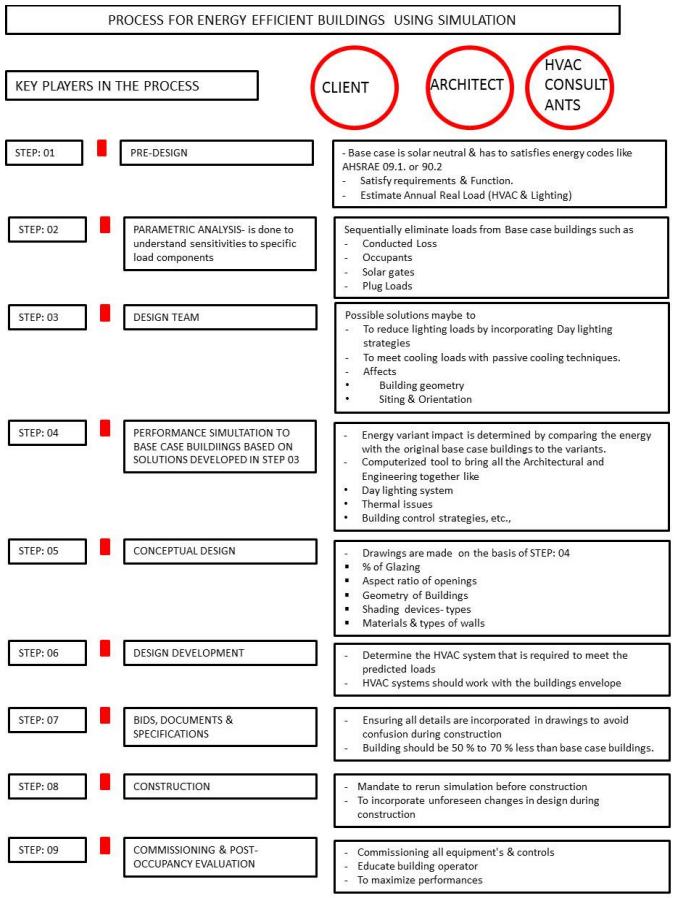

Figure 10. Process of creating energy efficient buildings using simulation
(Source: Author, 2018)

PROCESS FOR CREATING ENERGY EFFICIENT BUILDINGS USING SIMULATION

Simulation is the most unearthed tool for creating energy efficient buildings. The most widely used process for creating energy efficient buildings using simulation is the process in which the owner gives the brief to the architect or the design team, who in turn provides with the design solutions which are then processed by the HVAC team. But at present, this process will not be leading to energy efficient buildings. Figure 10 projects the step by step process of creation of low energy buildings through simulation and computational assistance.

CONCLUSION

Figure 06 discusses the framework of the application of techniques to achieve less energy consumption in the high rise apartment structure. The process that comprises of four major steps along with the other components of

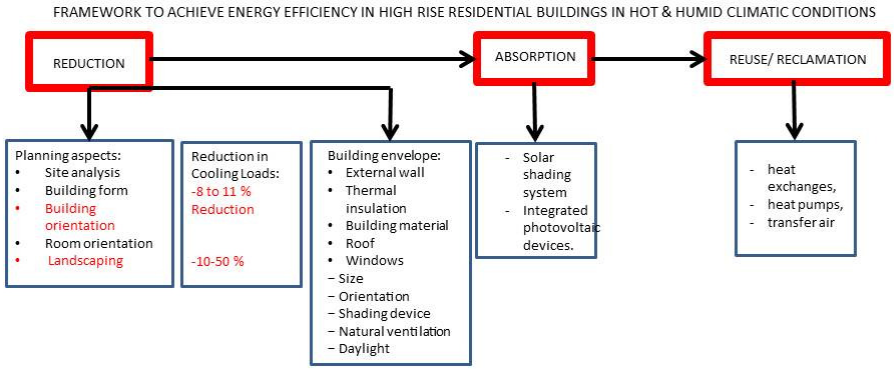

Figure 11. Framework to achieve Energy efficient in High rise Residential Buildings
(Source: Author, 2018)

design process is being presented in the figure.

The rise of our expectation in lifestyle in everyday comforts and population growth that is being created in Nations will prompt higher energy utilization and environmental impact. Developing countries need to understand that the energy consumption in buildings plays important role in the overall global warming. With hot and humid climatic conditions, Energy consumption in buildings in increased by cooling load. Specific considerations are to be given to tending to cooling load through effective energy efficient systems.

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Investigations on Thermal Comfort Conditions in Public Building with Reference to Air Movement

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Abstract: Thermal Comfort is the state of mind which reveals satisfaction of the thermal environment is assessed by subjective evaluation. Rise in the temperatures, lower ventilation rate in office work space will introduce adverse impacts on working efficiency and health of the occupants. The satisfactory thermal-comfort states in work space provide positive impact on the wellbeing of occupant. The main factors making impact on the thermal comfort are namely environmental and personal. In first (i.e. Environmental factors), it includes air and radiant temperature, air velocity and also relative humidity. The later (i.e. Personal) include metabolic heat and clothing insulation. The flow of air is an important factor affecting thermal-comfort in a work space. A case study of public building at Latur Maharashtra was done with TESTO 480 professional multifunctional instrument. Analysis of data revealed the importance of air movement for thermal comfort in office building. Present study confirms the relevance of air movement at higher indoor temperature and low humidity.

Keywords: Thermal comfort, air movement, ventilation, relative humidity.

INTRODUCTION

Thermal comfort is an important factor in an office building where occupant has to perform their routine work would affect on their performance, efficiency. Rising temperature and also less ventilation rate have an adverse effect on working performance and health of occupants. (Mendell and Heath, 2005; Wargocki and Wyon, 2007; Bakó-Biró et al., 2012). The thermal comfort is defined as "that condition of mind, which expresses satisfaction with the thermal environment" (ISO Standard 7730). The continued environmental stress can drain occupant's physical and mental resources which ultimately affects their performance. The environmental factors relative humidity, air temperature, air velocity and mean radiant temperature and two personal factors physical activity and clothing levels affects the human thermal comfort (ANSI/ASHRAE Standard 55-2004). Thermal comfort in steady state and isothermal condition, the body heat balance can be described by using four environmental and two personal variables. (ANSI/ASHRAE Standard 55).Other numerous minor parameters which also influence thermal comfort, which can be achieved through different combinations of environmental and personal variables (Fanger,1972). There is no necessity of air flow for thermal comfort when air temperature is in acceptable limits. Air flow over surface of occupant's body allows dissipation of body heat continuously.

As ambient temperature increases, natural air velocity will not be adequate and must require artificially improved by use of mechanical means. Occupants in working space using fan when temperature is on higher side are more comfort than those without fan. In hot-dry climatic region an important environmental variable for thermal comfort is air velocity which is achieved with use of fans. (MadhaviIndragantiet.al.,2012). Extensive research in the field of thermal comfort is done in western and few countries in Asia and Africa. Till now tendency to use the standards as described in ASHRAE – Standard 55-2005. Before introduction of 2016 revised version of National Building Code (NBC) in March 2017, earlier first-hand field work was carried out by few Indian researcher (Sharma and Ali, 1986, Indraganti, 2010a) and underlined the necessity of thermal comfort standards for Indian context. Thermal comfort mathematical equations derived by Centre for Advanced Research in Building Science and Energy (CARSE) at CEPT University is incorporated in the National Building Code 2016 version, named as 'India Model for Adaptive Comfort' (IMAC) for the Indian specific standard.

Area of study

Latur District Council Office building is located in Latur city of Maharashtra state, India was selected as an object for this study. This building is a low-rise structure, and was constructed in 1990. It is a three storied building and has built-up area 1497.72 m2per floor. The building form is rectangular in plan, rooms are arranged facing to single corridor along the length of building. Longer sides are faced to east and west side. All

selected office rooms are having windows on single wall either east facing or west facing. Total ten office rooms were selected, three on ground floor, three on second floor and four on third floor.

Table 1. Office rooms descriptions (Source: Author, 2018)

Room number	Floor	Orientation	Floor area in m^2	Number of occupants
GF-01	Ground	East	89.19	11
GF-02	Ground	East	119.54	12
GF-03	Ground	West	100.40	09
FF-04	First	East	90.68	09
FF-05	First	East	89.40	09
FF-06	First	West	91.04	11
SF-07	Second	East	118.26	10
SF-08	Second	East	58.85	06
SF-09	Second	East	119.54	13
SF-10	Second	West	58.85	07

Under the Köppen climate classification, Latur has a (Bsh) subtropical steppe climate (Koppen-Geiger climate classification, 2006). As per National Building Code classification climate of study region is identified as hot-dry.



Figure 1. Latur District Council Office Building, Latur, Maharashtra, India, (A) Geographical Location, (B) East Side view, (C) West Side View, (D) Internal View of Office Room
(Source: (A) www.google.com/maps, 2018; (B) To (D) Author, 2018)

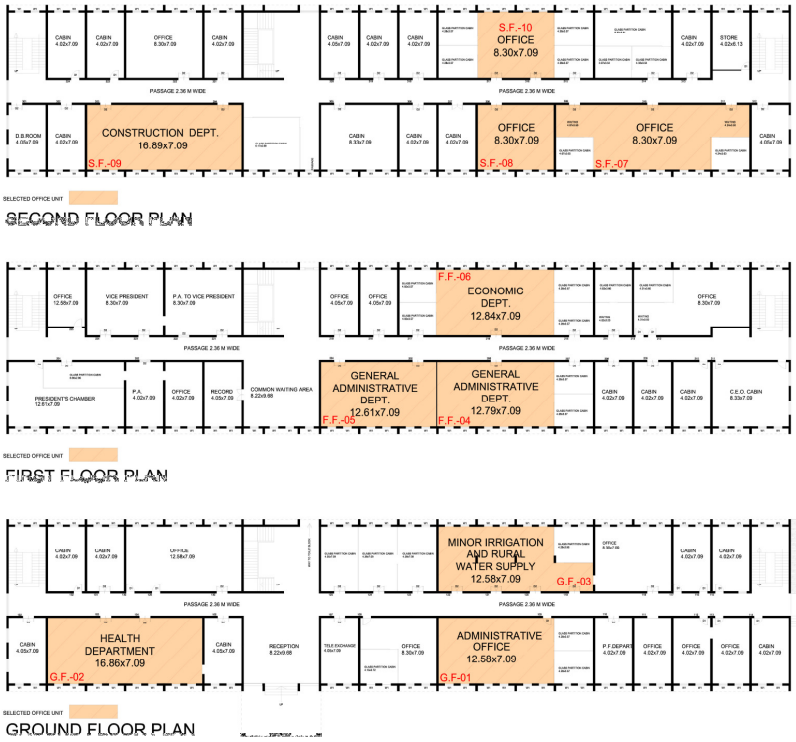

Figure 2: Floor Plans of Building Latur District Council Office Building, Latur, Maharashtra, India
(Drawing Source: Author, 2018)

METHODOLOGY

Environmental parameters relative humidity air velocity and temperature were measured by TESTO 480 professional multifunctional digital instrument in selected office rooms. Measurements were carried out at 1.10 meters height from the floor level, as per required standards (ISO 7730, 2005; ASHRAE 55, 2010).

Sampling was done in six sets as mentioned in Table 2. First single set of reading was taken before occupying office by staff when fan was off. Last single set reading was taken after vacating office by staff, when fan was off. The field study was conducted on 17th May 2018 from 09.00 to 19.00 hours. Object building geographical location, exterior photos of facades are shown in Figure 1. The floor plan of building, office room location, room orientation and geometrical shape are shown in Figures 2.

Before starting sampling, meeting of participants was conducted before one day and aim of study was explained. Officially permission was obtained from the head of the office. The participants were asked to carry out routine office work and were asked to response the questionnaire at the end of the sampling (ASHRAE 55-2010).

Table 2. Sampling plan (Source: Author, 2018).

Set Number	Fan ON/OFF	Time	Remark
1	OFF	09.00-10.30	Before occupying office by staff.
2	ON/OFF	11.00-12.30	After settling office staff, routine office activity in progress before lunch hours.
3	ON/OFF	12.30-14.00	Intermediate sampling when routine office activity in progress.
4	ON/OFF	15.00-16.30	Settling office staff after lunch hours.
5	ON/OFF	16.30-18.00	After settling office staff, routine office activity in progress after lunch hours.
6	OFF	18.00-19.00	After leaving of office by staff.

Table 3.TESTO 480 (Source: www.testo.com, 2018)		
Environmental Parameter	**Measuring range**	**Accuracy**
Relative Humidity	0 to 100 %	0.10 %
Temperature	-100 to +400 °C	0.01 °C
Air Velocity	0.10- 15.00 m/s	0.01 m/s

Field studies conducted in Hong Kong which having sub-tropical climate shows that 80 % occupants satisfied when air velocity was 1.00-1.50 m/s in summer season. Air velocity 1.50 m/s resulted in recording 33.50 °C as a comfort temperature (Cheng & Ng, 2006). For low humidity level air velocity is not much significance on evaporation, but it plays important role in hot- dry climate affecting the convection rate. When air velocity increased maximum occupants feel comfortable. For light and sedentary activity level average indoor air velocity should be less than 0.25 m/s in cool season and 0.15 m/s in winter (ISO-7730).

In present study lowest, indoor temperature 31.70 °C was observed at time slot 9.00 to 10.30; highest humidity 43.00 % was observed at zero air velocity. It is observed that increase in velocity by 0.50 m/s when switching on fan increases temperature by 1.00 °C for all time slots.

Maximum humidity decreases by 13.00 % when air velocity was observed 0.40 m/s at time slot 11.00 to 12.30. Increase in humidity was observed at time slot 18.00 to 19.00 when fan was off and office was unoccupied.

RESULT AND DISCUSSION

The using ceiling fans and opening windows for air movement are a good for thermal comfort behavioral adaptation. Researcher has shown that the building occupants use ceiling fans and opening windows for air movement for higher temperature. Studies carried out in India and Iran reveal decrease in comfort temperature 32-40 °C at air velocity >0.25 m/s (Nicol, 1974; Sharma and Ali,1986). The use of ceiling fans for improvement of indoor thermal comfort in buildings is accepted in tropical and subtropical climatic zones. The fans use quite simple technology, inexpensive, individually operable and effective method to increase air movement with less energy consumption (Aynsley 2005).

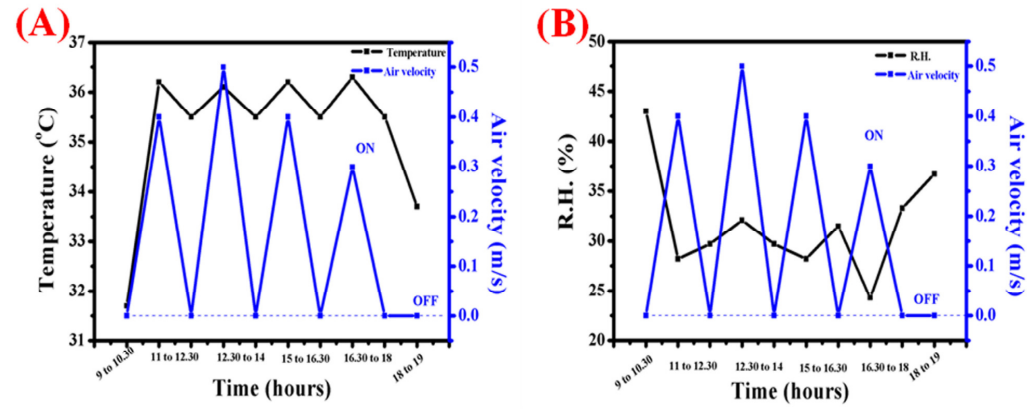

Figure 3. (A) Temperature Vs Air Velocity, (B) Humidity Vs Air Velocity

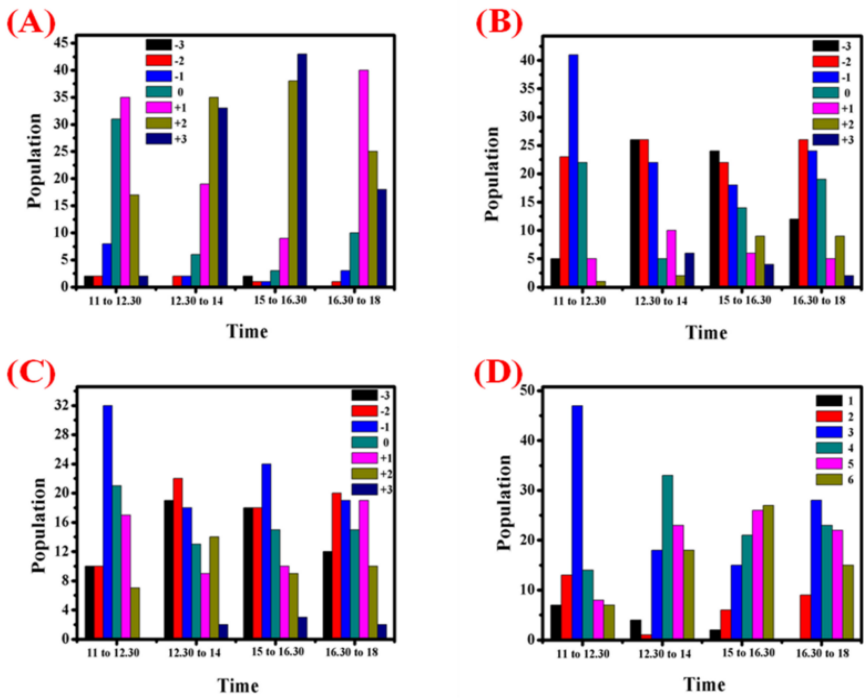

Figure 4. Subjective Analysis (A) Thermal Sensation Vote; (B) Humidity Sensation Vote; (C) Air Movement Vote; (D) Thermal Preference Vote
(Source: Author, 2018)

Thermal Sensation Vote (TSV) neutral was observed at time slot 11.00 to 12.30, which was 31.96 %. Cold TSV was observed at time slot 11.00 to 12.30, which was 2.06 %. Hot sensation was observed at time slot 15.00 to 16.30, which was 44.33 %. Humidity Sensation Vote (HSV) very dry was observed at time slot 12.30 to 14.00 which was 26.80 %. Neutral was observed at time slot 11.00 to 12.30 with 22.68 %. Acceptable Air Movement Sensation (AMS) was observed at time slot 11.00 to 12.30 with 23.71 %. While very still was observed at time slot 15.00 to 16.30 with 15.46 %. Overall Thermal Preference Vote (TPV) of 27.84 % was very uncomfortable at time slot 15.00 to 16.30 while very comfortable with 7.22 % at time slot 11.00 to 12.30 was observed. Air velocity of 0.4 m/s satisfies 23.71% of the occupants thermally comfortable at time slot 11.00 to 12.30. While having air velocity 0.00 m/s at time slot 15.00 to 16.30 27.84 % occupants voted uncomfortable.

CONCLUSION

Over all comfort satisfaction is achieved by use of fans when higher temperatures with low humidity. The India Model for Adaptive Comfort (IMAC) model suggests 19.60 to 28.50 °C for naturally ventilated building as a neutral temperature. This study revels occupants are also comfortable in temperature more above this. With the good air ventilation system either naturally or mechanical the comfort levels can be improved. The preference to air movement varied with increase in temperature, at same time humidity had a less effect.

Acknowledgement

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Identifying the impact of Impervious Surface Cover of Sellur Neighbourhood region on the Pandhalkudi channel & River Vaigai within the urban settings Madurai city

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Abstract: In the context of investigating the impact of a Sellur Neighbourhood region within Madurai's Urban sprawl on Pandhalkudi urban drainage channel (sub channel) and on River Vaigai (main channel), a study was conducted to identify changes in terms of the physio-chemical variations. Sellur Neighbourhood with the highest population of density 60,621 person /sq.km carrying drainage from 10 wards and with the Open space of 10.92%, influence the Pandhakudi Channel. The impact recorded was found to be higher than other channels. Water samples were collected during pre and post monsoon of 2017 at the confluence of Pandhalkudi channel and on the upstream and downstream of the confluence point. The Impervious Surface Cover (ISC) in this urban stretch records 89.09 %.Physical variables, namely temperature, colour, odour and taste and chemical variables, namely pH, CL, Nitrates, TDS, TH and COD were performed. Pandhalkudi channel from North has TH of 440 mg/L and TDS of 1107 mg/L, exhibiting anomalous concentrations against the permissible standards prescribed by BIS. Opulapadithurai causeway recorded greater variation in TDS levels between the upstream and downstream side as 785.4 mg/L and 469.4 mg /L respectively. The study identifies the impact on River Vaigai exhibiting 1) Variance in the physiochemical values in the Upstream, confluence point and downstream of the confluence points, 2) Variations in the Immediate Causeways next to the confluence point.

Keywords: Urban Land use; Impervious Surface Cover; Physical and Chemical parameters

INTRODUCTION

The main focus of this paper is to investigate and understand the impact of a Sellur Neighborhood region within Madurai's Urban sprawl on Pandhalkudi urban drainage channel (sub channel) and on River Vaigai (main river channel) within the Madurai urban limits in terms of its physical and geometrical dimensions. Currently Madurai is the second largest urban center in the state of the Tamil Nadu is situated on the latitude 9 o 55' North and 78o 7' East having an average altitude of 130 m above the mean sea level. The city is situated on a multi-basined drainage pattern region with River Vaigai bisecting the city. The historical core city of Madurai belongs to 9th Century A.D was in southern banks of River Vaigai. Rivers are an important feature in urban landscape and its corridor is known for its natural, cultural and recreational values (Baschak& Brown, 1994). In the present context most of the Urban River systems are often heavily degraded and is common to all urban areas in the world. (Morley & Karr, 2002).These urban channels acts as a drainage channels disposing the urban waste waters and carries urban sewage generated from the city. In the monsoon periods these channels carry flash floods from the urban watershed. Allan (1995), Karr J R, (1999), Steele M K, Heffernan, (2014) notes that 60% of the rivers in the world are affected deeply by various human activities. The Term Urban Sprawl can be defined as the haphazard development on to the green belts and on the open lands, resulting in the multiplication of Impervious Surface Cover (Bourne L, 2001). This developmental process has a profound impact on the health of rivers (Zandbergen, 1998), ecosystems of rivers (Yuan et al, 2006 and water quality of rivers (Allan, 1995; Ren et al, 2003). The sewage discharge influences the quality of the river and changes its physical and chemical properties(Field & Pitt, 1990; Klein, 1979).

The River and the City

The River Vaigai originates from Varusha Nadu Hills on the Western Ghats and ends in Ramanathapuram coastal area. The total distance covered is around 232 Km. Madurai is the only city with the population of 15 lakhs on the River Vaigai banks. Theni, Manamadurai, Paramakudi, and Ramanathapuram are other cities with the population less than eight lakhs in the region. Geographically the River Vaigai (non perennial in nature)

divides the city into northern and southern portion; the former is more elevated than the latter. There are numerous low lying depressions collecting water from monsoon season called Kanmoi on either side of the river. These kanmoi's are connected to the River Vaigai through channels. In the Last three decades, urban land expansion had created an enormous stress on its urban ecosystems. The post-independence era after 1947, witnessed the city experiencing significant changes in its spatial degree and migration of people from rural area. The population of the city increased from 8.9 lakhs (1981) with the Municipal area of 52.2 sq.km to a population of 15.35 lakhs (2011) with the municipal area of 147.9 sq.km. There was a subsequent development on the infrastructure and transportation network. The Study area consists of the urban stretch of Sellur Channel also called as Pandhalkudi channel for 2.4 km from SellurKanmai to River Vaigai (Fig 04).

Importance of the study

Numerous tanks were constructed to capture the flow in Vaigai and supply water to the river. Even though no major dam was constructed across river to store and utilize, all river flows were diverted and stored in tanks. This method of harnessing water through tanks in all the rivers, rather than by storing water in a single dam and conveying it by canals for a long distance is different management point of view. All these indicate the channels excavated to feed the tanks were wider enough to absorb flash floods of Vaigai River. This made the region strong in terms of its water storage capacity. Sudden or gradual change in its land use had a strong impact on its character. One small change /disturbances in the network can trigger a huge impact in the system. Complete change from agricultural use that contained water channels for drainage and surplus purposes to urban land use with impervious layers with roads, buildings paved area and concrete lined channels had done a considerable damage to this Sellur Channel. The impact of Urbanization on this channel and subsequently on the River Vaigai needs to be explored. Therefore it is important to study this river and give special attention to the physical condition of the water course as it is in complex web of the tank system (refer Fig 4).

Need for a Theory

Urban development induces changes in the physical form (both horizontally and vertically), flow regulation in the river through land use in the catchment areas (Gregory, 1987). Gregory et al., 1992 conducted a study in England that identified the river channel change due to Urbanization between the periods 1930 to 1991. The channel capacity and the width increased up to 2 to 2.5 times at the downstream of urbanization increased to 2 times between the periods 1866 to 1991. Hammer, 1972, identified that degrees of channel enlargement vary according to the types of Urbanization and the Impervious Surface Cover. Arnold and Gibbons, 1996, found out relationship between the ISC and the runoff water with reference to forested catchment. Increase in ISC to 10-20% increases runoff twofold, 35-50% increases runoff threefold and 75- 100% increases runoff fivefold. The runoff contains contaminants like heavy metals, nutrients, and rubber residues from roads, litter, oils, sewage, garbage and debris from the urban area (Chin et al., 2013).

Land use changes the rivers and Lake Environment (Gao et al., 2003). Land use/ground cover near the stream edges (500 m from the river edge) is another important factor to be considered in the Urban development process as it creates ISC on the stream edges affecting the river channel (Thibault, 1997). Chemical changes in streams are governed by the type and extent of Urbanization (commercial, residential and Industrial), presence of wastewater treatment plant, sewer systems (Paul, Meyer, 2001). These metals are discharged from the industries and automobile workshops and collected on the roads and paved areas and carried by the runoff water. Thus ISC, Land use changes and the type of Urbanization influences the stream water quality.

METHOD

Composite samples were taken at 6 different locations on the upstream and downstream side of the causeways (less than 100 m aerial distance) and the confluence of the channels entering into the River Vaigai. The readings were taken on pre and post-monsoon period June 2016 and Jan 2017 respectively. The water samples were analyzed for the following physiochemical parameters viz., temperature, color, taste, odor, pH, Total Dissolved Solids (TDS), Total Hardness (TH), Chloride, Nitrate, and Chemical Oxidation Demand (COD). The obtained samples were analyzed in the laboratory according to the standard procedures of APHA standards, 2005 and standards prescribed by the Bureau of Indian Standards. The impacts of urbanization and ISC on the river channel were analyzed supplementing its water quality degradation.

FINDINGS AND DISCUSSIONS

Sellur and Urbanization

Table 1 discusses the rate of Urbanization in the northern portion of the city. The population of the study area in the year 2002 was 11,892. It increased to 2,55,218 in the year 2018 at the rate of 17.84% each year. The total area including the 10 administrative wards consists of 4.21 sq.km with the population density of 60,621 persons/ sq.km. There has been a considerable reduction in the green cover area from 0.44 sq. km to 0.13 sq.km with the ISC increasing to 89.08. The total length of the Pandhalkudi channel is 2.26 km with the average width of 9m. The entire channel was lined with concrete on all sides in the year 2009 under government schemes. Residential Land use dominates the entire urban stretch on either side of the Urban Channel. Nearly 80% of the land use consists of ISC greater than 40% (Fig 2). Vegetative cover greater than 5 M diameter is seldom present in the stretch (Fig 1&3). Thus the riparian landscape is too poor in the stretch.

Table 1. Details of Northern drain channels from Urban Catchments

S.No	Channel Name	Length (km)	Average Width (m)	Concrete Lining	Number of wards	Total Area (sq.km)	Population	Population Density (population per sq.km)	Open space(sq.km)	% of open space	% of Impervious Surface Cover (ISC)
	Northern Side										
1	Thathaneri	4.6	4	yes	6	6.42	1,29,993	20,248	1.45	22.58	77.42
2	Pandhalkudi	2.26	9	yes	10	4.21	2,55,218	60,621	0.46	10.92	89.08
3	Vandiyur	3.2	6	no	4	9.43	76,416	08,124	2.76	29.26	70.73

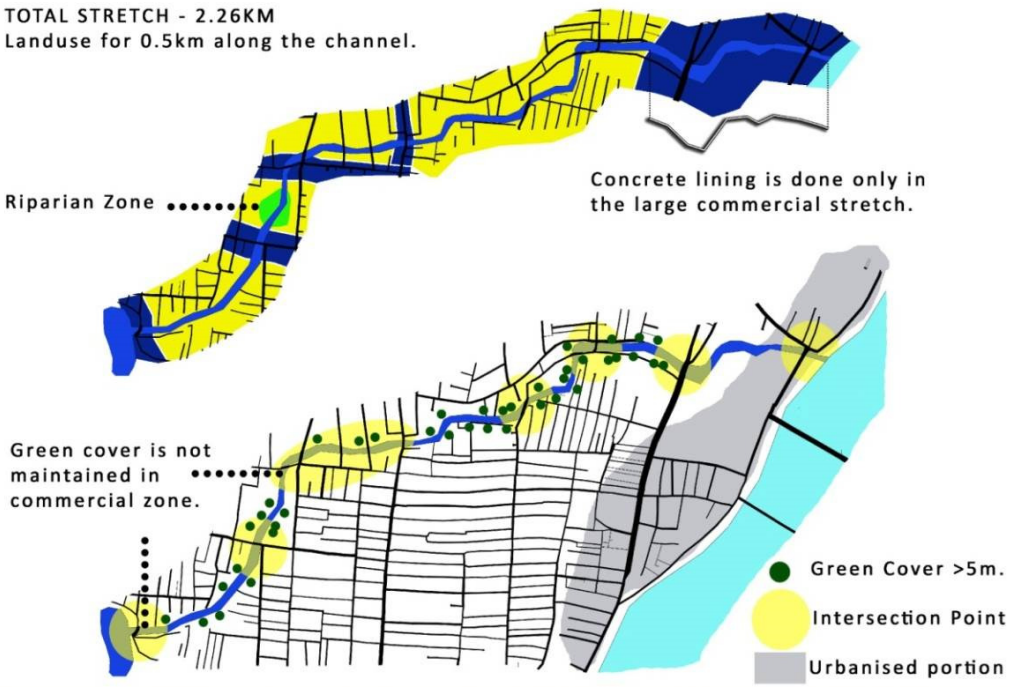

Figure 1. Land Use along the channel

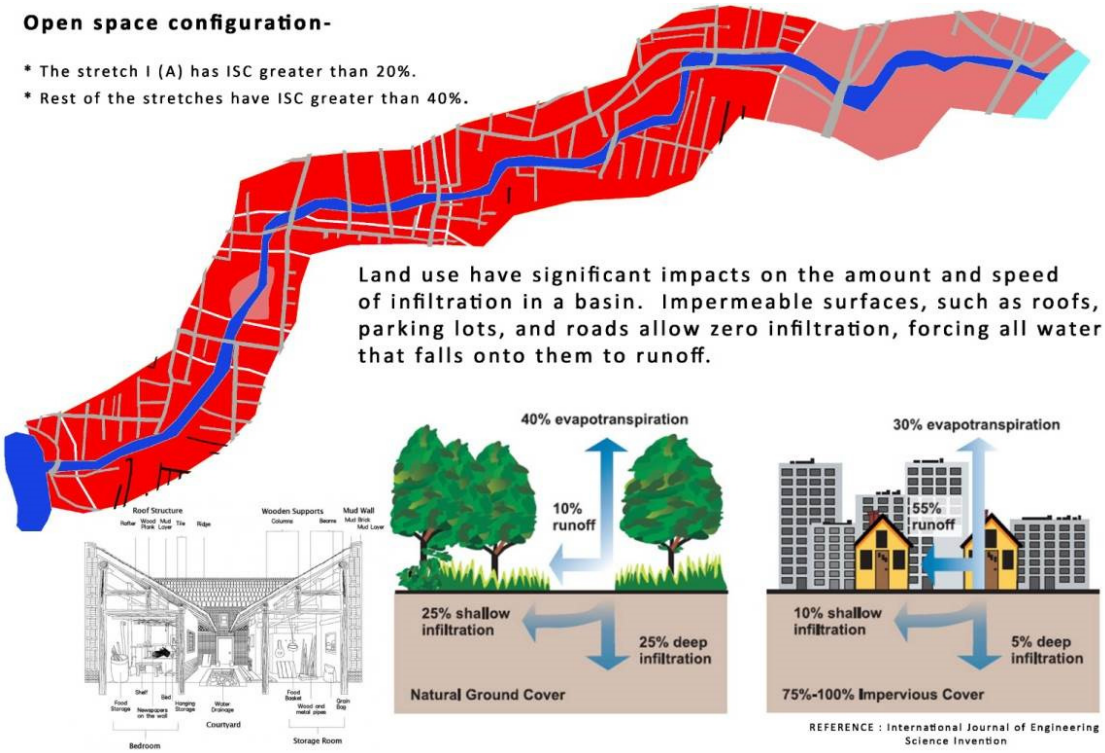

Figure 2.ISC greater than 40 % and greater than 20 %

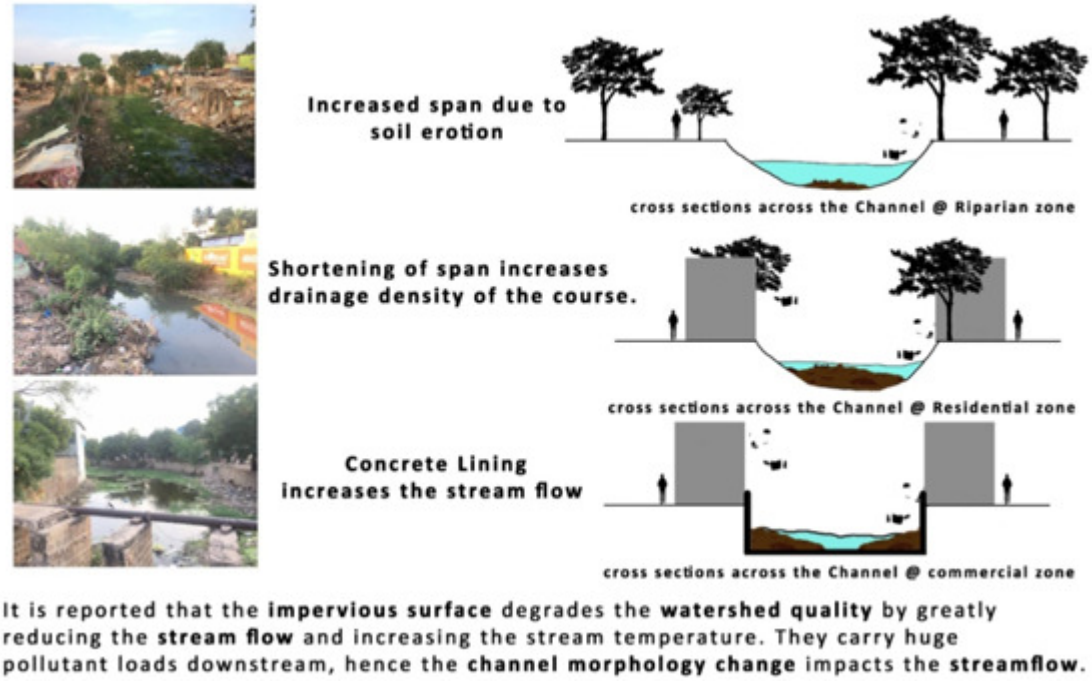

Figure 3. Section of Pandhalkudi Channel

The Physio- Chemical variations

Table 02 exhibits the different values taken at the sample sites. The Odour and taste exceed the permissible limits in Kal causeway (Fig 5c) is non-objectionable (NOB) and non-agreeable (NAG). Total Hardness and Total Dissolved Solids in the pre and post monsoon time on the upstream and downstream were 236 mg/ L and 204 mg/L and 421 mg/L and 364.3 mg/L respectively. Opulapadithurai causeway (Fig 5d) is present next to the confluence of Pandhalkudi channel on the north. The temperature and the color are within the limits while the taste and the odor exceed the limits. The TDS reading at Opulapadithurai causeway is 785.4 mg/L on the

upstream side (S4) and 469.4 mg/L on the downstream side (S5) in the pre-monsoon period. The main sources for TDS are, Septic system, Landfills, soil nature, Hazardous waste fills, Dissolved minerals, iron, manganese, and organic livestock waste. (Indian standards IS 10500:1991). COD was higher in the Opulapadithurai causeway in both the seasons. The pre-monsoon and post-monsoon readings at the upstream of Opulapadithurai causeway the COD value reached 404 mg/L and 310 mg/L respectively. The downstream side of the causeway recorded 96 mg/L & 62 mg/L respectively exceeding the Permissible limits. This causeway also functions as check dam blocking the discharge from Pandhalkudi channel. Thus the variation is high on the upstream and downstream side. Pandhalkudi Channel (S3) from the northern urban basin, showed a drastic difference in the total hardness and TDS readings. Pandhalkudi channel reads as 440mg /L in the pre-monsoon season.

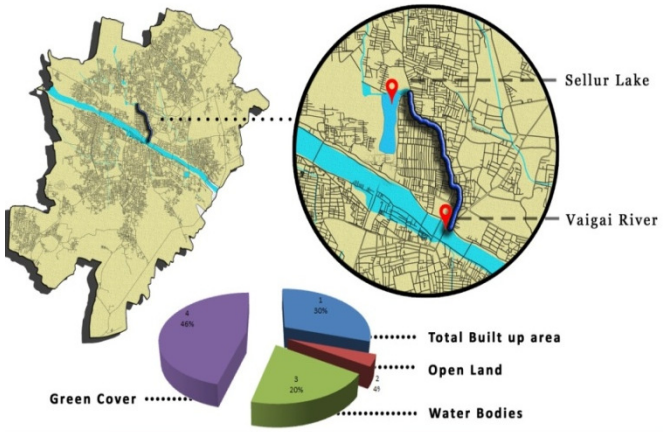

Figure 4. Regional Map of Madurai with Pandahlkudi channel



Figure 5. Visuals of the Channel and Causeway: (a) Sewage lines into channel; (b) Pandhalkudi; (c) Kal Causeway and (d) Opulapadithurai Causeway

Table 2. Physio Chemical values

Parameters (BIS Value)	Periods	UP's KAL Causeway S1	DN's KAL Causeway S2	Pandhakudi Channel S3	UP's Opulapaditurai S4	DN's Opulapaditurai S5
Temp	PRE	32	32	34	34	35

	POST	28	29	29	30	29
colour	PRE	NIL	NIL	NIL	NIL	NIL
	POST	NIL	NIL	NIL	NIL	NIL
Taste	PRE	NAG	AG	NAG	NAG	NAG
	POST	NAG	AG	NAG	NAG	AG
Odor	PRE	OB	OB	OB	OB	OB
	POST	NOB	NOB	OB	OB	OB
pH ≤8.5	PRE	7.9	7.87	8.9	8.3	8.03
	POST	7.9	7.95	8.4	8.2	7.95
CL ≤250	PRE	128.0	107	322	228	136
	POST	97.3	85	265	178	110
TH ≤300	PRE	236	204	440	280	224
	POST	188	161	362	218	182
NITR ≤45	PRE	13.7	28.1	21.7	18.2	15.3
	POST	10.2	22.0	17.2	16.0	14.0
TDS ≤500	PRE	421	364.3	1107	785.4	469.4
	POST	400	291.2	912	610.0	382.0
COD ≤10	PRE	16	8.0	308	404	96
	POST	12	6.0	220	310	62

The TDS level is extremely higher in Pandhalkudi is 1107 mg/L and 912 mg/L during pre and post-monsoon periods.

CONCLUSION

The concrete lining blocks the infiltration of the water in the ground and the channel act as conduits carrying all the sediments into the river. During the pre-monsoon (summer) season the sewage dominates the flow, and in the post-monsoon (winter) season, the increased freshwater dilutes the sewage flow. Pandhalkudi Channel from the north records the Maximum Levels in terms of Total Hardness as 440 mg/l and TDS of 1107 Mg/L. The COD reads as 308 mg/L in pre monsoon season. The variations of physicochemical values within the urban stretch are indicating the release of untreated sewage water from residences and small industries present in the urban basin. The water reaches the upstream side of Opulapadithurai traveling around 500 m, and the TDS values decrease to 785 mg/L indicates a fluctuating mechanism of the river. The TDS variation between upstream and downstream in Opulapadithurai causeway is greater than 300 mg/L and at Kal causeway is less than 100 mg/L (refer Fig 5a &5b). The variations at Opulapadithurai causeway aremaximum because it is the first physical barrier after Pandhalkudi Channel. The causeways differentiate the natural flow characters of the river. Considering the runoff from the urban catchment, untreated sewage from the north through the channel, the concrete lining of the channels and the ISC, it can be said that within the urban limits, the Pandhalkudi Channel influences the River Vaigai and the values exceeds beyond the permissible limits changing the water quality drastically. The research further recommends to include the impact of ISC in the urban planning context to protect the urban natural Environment.

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Implementation of Six Sigma on Interior Finishes in Construction

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Abstract: A country's development is measured according to the growth of the construction sector as it provides investment openings across many other industries involved. The major challenges faced by construction sector nowadays are delay in project completion, cost increase and complying with required standards and specifications. By nature, it produces a large quantity of waste and consumes more resources, which makes control of projects very difficult. While the key factor is to meet high quality standards, in the absence of robust quality management system, fail to meet the norms. Hence it is essential to strategize the methods for improving quality of construction and one such technique is using concept of Six Sigma. In construction industry six sigma principles aims at reducing variation and invalidate the root causes of defect if applied with efficient methodology. This research describes how six sigma and its principles can be implemented in construction sector. A study was conducted in Asta AVM, a high rise residential building for interior finishing work. Six sigma principles are executed and current sigma level of the activity has been derived. DMAIC methodology, one of the predominant methods of six sigma has been applied in this study by examining the errors, finding the source of the errors and suggests recommendations to enhance the overall quality. The results will suggest changes that are necessary in current work strategy that can help to improvise the quality and enhances user satisfaction which is an important factor.

Keywords: Quality Management; Six Sigma; Process improvement; Statistical method; Cost saving.

INTRODUCTION

Quality Management is achieving and sustaining a high quality output complying with requisites and achieving user fulfilment. In this highly competitive world market it is important to achieve quality output and excellent performance and these factors drives many organizations to implement the new principles for quality management. One of the most important principles is Six Sigma. It is a set of analytical tools and techniques using statistical methodology for process improvement. It focuses on improving the quality of a process and its output by identifying and eliminating the causes of defects and minimizes variation. Six Sigma techniques are effectively applied to analyse and identify the wastages which will result in substantial savings in cost. The aim of this research is to implement six sigma concepts on interior finishing work of a high rise residential building to minimize errors and thereby to improve quality of work.

The Key objectives are, to understand the principles and methodology of six sigma concept especially DMAIC which means Define, Measure, Analyse, Improve and Control, to intensify the quality of an ongoing activity that is, interior finishing work of an ongoing housing project and to comply certain pre-requisites and achieve high-quality output by implementing Six Sigma concepts.

The scope of this research includes Six Sigma basic theory, concepts and working structure will be studied in detail with various associated tools. Further Sigma level for interior finishing work of an ongoing project will be calculated and Six Sigma principles will be applied for the same to improve quality. Then DMAIC methodology namely Define, Measure, Analyse, Improve, Control will be adopted to establish norms to enhance the quality of the on-going process.

The methodology adopted are literature study - Study about basic principles of six sigma and study different journals to obtain a methodology to carry out the research, Documentation - Select a building to carryout case study and collect required data to obtain the sigma level for the internal finishes, Analysis – Examine current Sigma level (data analysis) and Proposal - Implement DMAIC principles for quality improvement.

LITERATURE STUDY

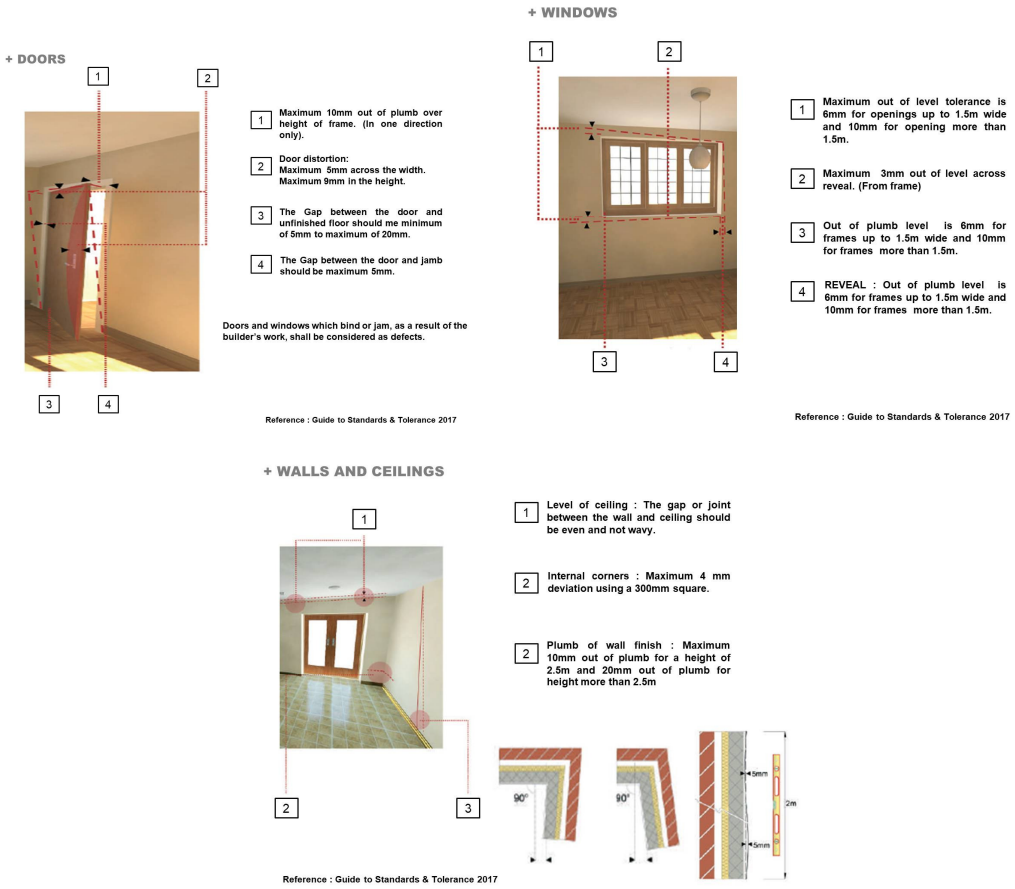
Standards and Tolerances

The components used to construct buildings are usually mobilized by hand in a site. The conditions may not be ideal and thus the materials are assembled with certain 'imperfections'. It may seem easy to design on paper but it is impossible to give a precise dimension, mix or placement. It may be troublesome to check whether a variation from perfection is just the character of a selected style of construction or if it constitutes to errors. Thus it is a must to specify certain acceptable variations or tolerances that are not to be considered as errors. Tolerances and standards should be specified in contract documents and should be understood by architects, engineers, contractors and site supervisors. Given below are certain tolerances which are acceptable.

CASE STUDY

Why is Six Sigma applied for interior finishes?

A successful contractor is judged based on his ongoing and completed projects. His buildings are evaluated on the basis of quality, workmanship and standards. It is evident that end users are mostly not satisfied with interior finishing work. It is also easily exposed to naked eye unlike mechanical, electrical and plumbing works which are predominately concealed.



Since it involves extensive labour works, there are possibility of errors and defects. Thus more care should be taken while working on interior finishing. An example of how six-sigma methods is applied for improving the calibre of interior finishes for a high rise housing project is described in this research. The assessment for architectural works includes walls, ceilings, doors and windows. The following aspects are inspected. In case of walls and ceilings they are:

1. Finishing

2. 2. Alignment and evenness
3. 3. Cracks and Damages
4. 4. Hollowness and Jointing
5. In case of doors and windows they are:
6. 1. Joints & Gaps
7. 2. Alignment & Evenness
8. 3. Materials & Damages
9. 4. Functionality
10. 5. Accessories Defects.
11. Building selection
12. About Project:
13. Name of project: ASTA AVM
14. Architects: Nataraj &Venkat associates.
15. Structural Design: Alex Jacob, United Consultants
16. Project Management Consultants: Amace Projects Pvt. Ltd.

Asta AVM offers well-designed flats with single, double and triple bedrooms and well-crafted duplex and penthouses are also offered.

They provide residences spread across 5 blocks over an area of 6.5 acres with high quality specifications ensuring a comfortable living space.

DOCUMENTATION

Asta AVM, high-rise housing building comprising of twelve (12) flats in a floor with three bedroom flats and two bedroom flats. The study was done for 6 flats out of 12 and one floor was considered due to similarity. The assessment was done for doors, windows, walls and ceiling.

The one within acceptable tolerance is indicated with '0' else it is indicated as '1'. NA indicates those which are Not Applicable. The total number of errors, total number of opportunities for errors in each assessment sheet is calculated to derive its yield and sigma level of the on-going process. Among the interior finishes like doors, windows, tiling and plastering, walls and ceilings contribute to major segment of work which is very challenging. Thus a complete analysis of walls and ceilings are shown below.

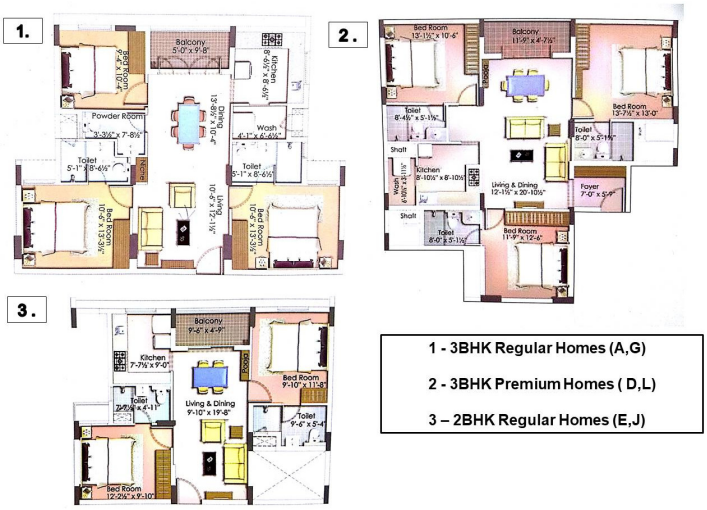


Figure 1. Asta AVM plans *(Source: Internet Search)*

Walls

ACTIVITIES/ LOCATION	LIVING DINING				KITCHEN UTILITY				BR 1				BR 2				BR3			
➢ FINISHING	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. Rough or patchy surface.	1	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0
2. Consistent colour tone.	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
➢ ALIGNMENT & EVENESS	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. Walls meet at right angles.	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
2. Evenness of surface	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	1	0	0	0	0
3. Verticality of walls.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
➢ CRACKS & DAMAGES	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. No visible damage or defects	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
➢ JOINTING	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. Straightness of corners & joints.	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Flat A

ACTIVITIES/ LOCATION	LIVING DINING	KITCHEN UTILITY	BR 1	BR 2	T 1	T 2
➢ FINISHING						
1. No rough or patchy surface.	1	1	1	1	0	0
2. Consistent colour tone.	0	0	0	0	0	0
➢ ALIGNMENT & EVENESS						
1. Evenness of surface	1	1	0	0	0	0
➢ CRACKS & DAMAGES						
1. No visible damage or defects	0	0	1	1	0	0
➢ ROUGHNESS						
1. No rough surface	0	0	0	0	0	0

Flat E

Ceilings

ACTIVITIES/ LOCATION	LIVING DINING	KITCHEN UTILITY	BR 1	BR 2	BR3
➢ FINISHING					
1. No rough or patchy surface.	0	1	1	0	0
2. Consistent colour tone.	0	0	0	0	0
➢ ALIGNMENT & EVENESS					
1. Evenness of surface	0	0	0	0	0
➢ CRACKS & DAMAGES					
1. No visible damage or defects	0	0	1	1	0
➢ ROUGHNESS					
1. No rough surface	0	0	0	0	0

Flat A

ACTIVITIES/ LOCATION	LIVING DINING				KITCHEN UTILITY				BR 1				BR 2			
➢ FINISHING	w1	w2	w3	w4	w1	w2	w3	w4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. No rough or patchy surface.	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
2. Consistent colour tone.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
➢ ALIGNMENT & EVENESS	w1	w2	w3	w4	w1	w2	w3	w4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. Walls meet at right angles.	0	0	0	0	0	0	1	1	0	0	0	0	1	1	1	1
2. Evenness of surface	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0
3. Verticality of walls.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
➢ CRACKS & DAMAGES	w1	w2	w3	w4	w1	w2	w3	w4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. No visible damage or defects	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
➢ JOINTING	w1	w2	w3	w4	w1	w2	w3	w4	w 1	w 2	w 3	w 4	w 1	w 2	w 3	w 4
1. Straightness of corners & joints.	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0

Flat E

ANALYSIS

S.NO	FLAT NO.	DEFECTS		OPPORTUNITIES
		WALLS	CEILINGS	
1.	A	33	4	180
2.	D	28	6	180
3.	E	26	8	142
4.	G	28	4	180
5.	J	26	8	142
6.	L	43	5	180
	TOTAL	219		1004

YIELD PERCENTAGE

$$\text{YIELD \%} = \frac{NO.OF\ TICK}{NO.OF\ OPPORTUNITIES} \times 100$$

= [(1004 – 219) / 1004] X 100

= [785 / 1004] X 100

= 78.18%

FROM THE TABLE SIGMA LEVEL
= 2.28

$$1.\ DPMO = \frac{NO.OF\ DEFECTS}{(NO.OF\ OPPORTUNITIES) X\ (NO.OF\ UNITS)} \times 1{,}000{,}000$$

= [219/ 1004 (6)] X 1,000,000

= 27265.94
= 3.4

SIGMA	DPMO *	YIELD
1.0	691,462	30.8538%
2.0	308,538	69.1462%
3.0	66,807	93.3193%
4.0	6,210	99.3790%
5.0	233	99.9767%
6.0	3.4	99.9997%

* DPMO = Defects per million opportunities

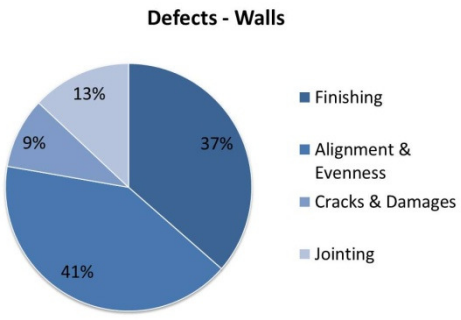
PROPOSAL

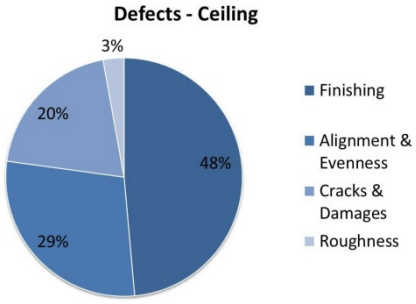
Implementation of DMAIC for walls & ceilings

DMAIC – Define Stage

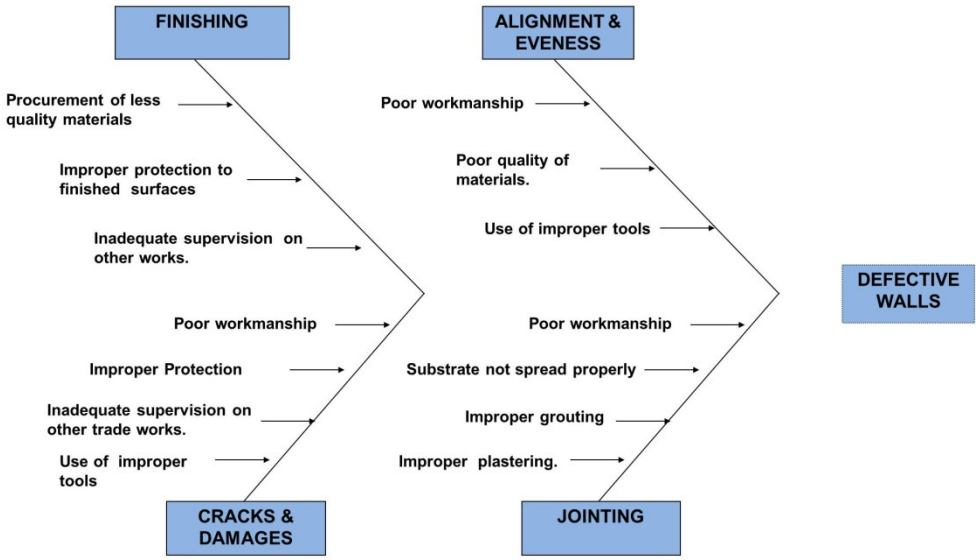
SUPPLIER	INPUT	PROCESS	OUTPUT	CUSTOMER
1. BUILDER	1. Cement 2. water 3. Blocks for brick work. 4. Measuring tape 5. Nylon string 6. Plumb bob 7. Straight edge 8. Architectural plan. 9. Measurements of openings.	1. Marking is done with the help of straight edge and right angle to be checked. 2. Surface preparation is done by removing the unwanted materials. 3. Wetting of surface. 4. Diagonal check is done. 5. First layer of brick work or block work is layed. 6. Room dimensions are achieved. 7. Openings are marked. 8. Wall construction is done up to sill level. 9. Marking of doors and windows are made. 10. Window sill is 3inch thick. 11. Brick work is done up to lintel level. 12. Check for plumb. 13. Construction of sunshade. 14. Completion of block work above lintel.	FINISHED INTERNAL WALLS & CEILINGS	APARTMENT OWNERS

DMAIC - Measure Stage





DMAIC - Analyse Stage



DMAIC - Improve Stage

S.NO	DEFECTS	RECOMMENDATIONS
1.	FINISHING	• Proper surface preparation. • Use proper tools. • Ensure even level using spirit level. • Proper protection.
2.	ALIGNMENT & EVENESS	• Check for plumb level • Diagonal check should be done. • Block work should be layed properly
3.	CRACKS & DAMAGES	• Proper tools should be used. • Adequate supervision on work required. • Adequate bearing required.
4.	JOINTING	• Substrate should be spread properly. • Plastering should be done properly. • Mud applied should not be too thick or too quickly.
5.	ROUGHNESS	• Sanding must be done properly. • Adequate supervision is required. • Plastering should be done effectively.

DMAIC - Control Stage

Control phase is the final stage of DMAIC method. It is a guide to monitor the process, check the stability of the improvement and ensure that it is sustained. Following is a checklist which is used to follow up the process, inspect the outcome, and check for defects and to work on rectification process.

Checklist for walls & ceilings:

Walls: 1. Check for missing mortar. 2. Are the bricks flaking or cracking? 3. Check for loose, missing or rotten siding, deteriorated paint, if it should be rectified. 4. Check if the windows and doors work. 5. Are the walls straight vertically and horizontally? 6. Check for cracked or loose plaster. 7. Check for stains, physical damage or previous repair evidence. 8. Check for any drywall seams or nails showing? Ceilings: 1. Check for cracks in the plaster or loose, sagging plaster. 2. Check for stains, mechanical damage. 3. Check for seams or nails showing?

DMAIC framework is an improvement cycle and this continues till the results are achieved. By implementing the suggestions provided in improve stage; one can achieve considerable improvement in sigma level. All contractors should focus on achieving the sixth sigma thus resulting in high-quality output at reduced cost and within time.

CONCLUSION

To achieve superior quality in housing industry and improve the performance, various new philosophies in construction are studied in recent years. But due to varied processes related to construction, their quality, complexity and lack of specific metrics, this issue remains questionable and demands more study. In this research paper, interior finishes of a high rise housing building have been examined and sigma level of the ongoing process has been derived. This research manifests the importance of DMAIC methodology and how it can help to elevate quality, quantity and at the same time will have positive impact on technical and financial success of project considerably. These inferences and recommendations can be implemented in any other construction firms. In order to implement six sigma techniques, the design or construction firms must analyse their needs, construct a plan of action according to their respective organizational needs, scope and goals. This needs a top down approach with commitment and involvement.

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Roof pond: Suitable cooling Strategy for energy efficiency in Hot and Dry Climate.

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Abstract: Roof is the expose part of the building which receives maximum solar radiation and it is very important to design it in climatically suitable way to protect building from weather. Evaporation, radiation and conduction are the different processes happened in Roof pond system which thermally protect the building. The comparative study has been done in the between different types of roof pond, including exposed and enclosed with or without sprays, damp gunny sacks and ventilated roof pond. This paper analyse literature on passive cooling techniques which is generally used in hot and dry climate to reduce the load on mechanical cooling of buildings using strategy of roof pond. The main aims of this research are the study of various roof pond arrangements and their action with their effectiveness and explore effects of performance of roof ponds and energy saving through Roof pond in Hot and Dry Climate in India. This study provides the current status of roof pond to reduce load on active system i.e. cooling load which is majorly through roof in Hot and Dry climate without losing human comfort.

Keywords: Roof Pond, passive techniques of cooling, Energy Efficiency, Hot and Dry Climate.

INTRODUCTION

The study analysis states the overall constructed area to increment by about 5 times from 2100 crores sq. Feet (2005) to approximately 10400 crores square feet by 2030. Building energy utilization is mounting annually at 8 %,which accounts for over 30% of electrical energy utilization within the country (Mangotra).

According to the International Energy Agency (IEA), building construction and building sector are responsible for 36% of the world's total energy consumption. For any building, thermal performance becomes one of the key factors in determining the overall level of comfort inside it. (IEA, 2017) Envelope places important role in energy consumption of the building.

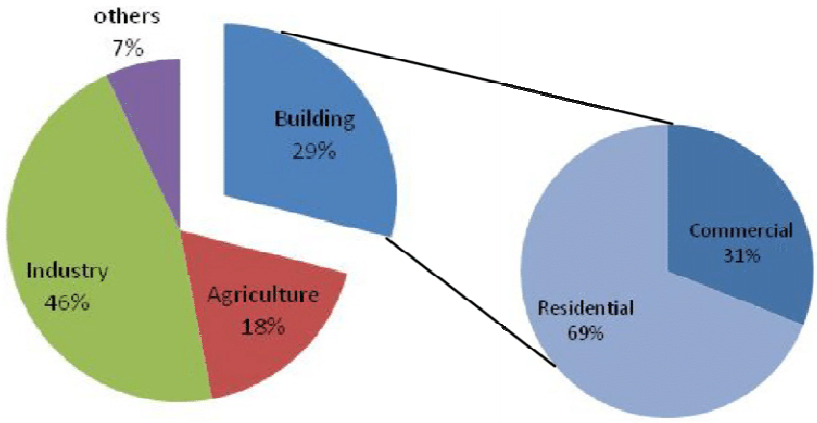

Figure 1. Examining the Role of Building Envelope for Buildings in India Source: (Mangotra)

In hot and dry climate, the buildings receive solar radiations throughout the year and to achieve thermal comfort indoors mechanisms are needed for cutting down the heat gain by the surfaces of the building. Roofs are in maximum contact with sun, thus affect the ambient temperature to a great extent. An intelligent choice of material selection for roofing can help in reducing the energy consumption of our built environment. Building orientation is not affect anything in roof pond systems, the provision of both heating and cooling system.

BASIC ROOF POND SYSTEM

Water ponds are constructed over flat roofs to avoid excess heating by the sun; the pond is covered or shaded. The water cools the building by conduction. This decreases both indoor air temperature and radiant temperatures with an increase in humidity. This is only applied on water insulated roofs and is recommended for regions with mostly hot climate in other to prevent heat loss in winter.

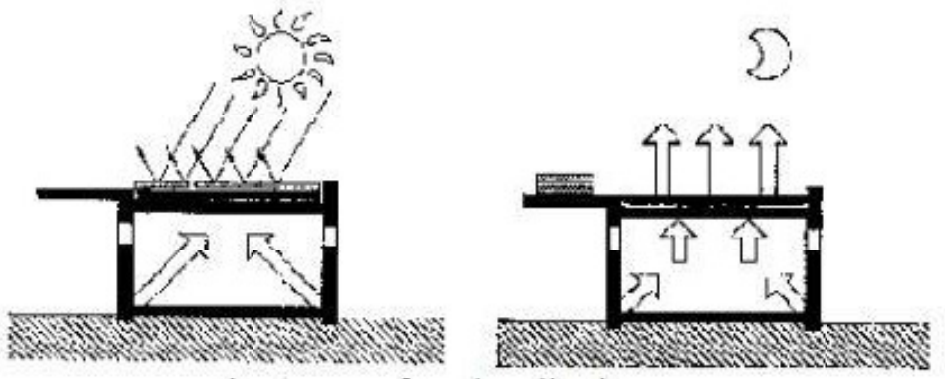

Figure 2. Working of roof pond Source: (MuktarInusa, Asst. Prof. Dr. HalilZaferAlibaba, 2017)

Roof pond is a strategy for cooling as well as heating .These roof ponds are erected by enfolding water in transparent plastic sacks. These roof ponds are made up of metallic or fiberglass containers by covering by plastic cover. Moveable insulation panels are kept between the skins with polyurethane foam

ANALYSIS OF ROOF POND TYPES AND THEIR CHARACTERISTICS

1. Uncovered pond with sprays

The uncovered pond operates during both daytime and night time. The recommended dewdrop range is 0.5-1 mm, 1 to 1.5 volume/hour should be the flow rate to spraying water and nosegay height should be minimum 0.5 m. when the difference between water temperature and ambient WBT is 3-4oC above then the spraying stops to avoid warming the pond. The spraying is done at night time to decrease the water temperature and conserve electrical energy through passive means.

Uncovered ponds with sprays are often desirable due to their minimalism. A disadvantage of the assembly is the external dust like leaves; bird waste is in direct contact with the water so the maintenance is the issue in this uncovered system of water pond.

2. Exposed pond without sprays

The uncovered roof pond without spray is the same type as above but the only difference is spraying of water is done in this type with the recommended water of depth 30 cm. As the roof is directly expose to the sun, the water gets heated because of solar radiation so, the evaporation rate is very high in this type of roof pond so the continuous water temperature fluctuates. The humidity level increase in this type with is required for Climate like Hot and Dry. The heat captivated is inversely proportion to the lowermost reflectance (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011).

3. Covered with sprays

Covered with sprays type of roof pond is covered during daytime because the water gets heated and evaporate during day and the spraying of water is done at night time. As the water is covered the depth of the roof pond is in the range of 30-50cm. This depth is adequate to cooling the roof. The cooling effect at night will rise with conductance of the backing roof (A.Spanaki, 2007).

4. Covered without sprays

The system of covered roof pond with spray the insulation is recommended and it provides cooling result at all times with insignificant temperature variations. The opaque insulating cover is recommended because opaque material cover the water from solar radiation and it reduces the evaporation rate of the water. The emissivity of

the cover, the solar absorptance for opaque covers does not affect performance even the gap between water and the opaque insulating cover doesn't affect performance. In this type of roof pond system, the water requirement reduces and the effectiveness is increasing because of insulating opaque cover on it.

5. Skytherm

In the Skytherm system is the preferable roof is metal roof instead of concrete roof which contains gunny bags having depth of 100-250 mm. Transformation of heat is the main function of roof pond which should be done in between the water pond and the metal deck and the top should make waterproof with the help of thin plastic sheet (Spanaki, 2007). The underside of the deck is painted with the colour because it's a galvanized material. The Water, concrete and insulating material should be in rising order in summer season in Hot and Dry climate and should be descending proportion in winter.

6. Energy roof

In Energy roof system a thin, clear plastic film is used as thermal protection drifts on the water which is contained within parapet. The roof basin is supported on a metal ceiling and filled with ap-proximately 400mm of water. For summer cooling, in the distributing tube water is driven out at night, above the insulation water allows it to flows in a thin layer and long wave radiation at night help to cool the water. At the higher edge of the plastic film, water spray promotes evaporative cooling (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011).

7. Cool roof

In cool roof type of roof pond the water dispersed at night time with the help of moving insulation. The difference between the water temperature and the ambient wet bulb temperature should maintain between 1 to 2˚K.on this case water temperature is maintain less than the wet bulb temperature. The insula¬tion boards should be of resistant to water material, such us polystyrene (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011).

8. Walkable pond

Walkable pond system consist of insulation is within the pond. During the summer, the insulation above the pond, is filled with water to height of around 3cm. With gaps permitting thermos phonic circulation, the insulation boards divide the water into two layers above and below. (A.Spanaki, 2007) The system is applicable in desert regions (A.Spanaki, 2007).

9. Wet gunny bags

The rearmost invented variant of roof pond consists of mesh with floatable materials like polystyrene strips are attached underneath and gunny bags placed on it. (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011) The insulation inhibits heat indulgence at night and a spraying system becomes essential. For metal-decked roofs the optimal water depth is 20 cm and for concrete roof is about 5 cm. The system is stress-free to erect and control (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011).

10. Ventilated Roof Pond

Ventilated roof pond is the one of the maintenance free roof pond systems in which the insulated roof which is light in weight and properly insulated is covered on water with the large opening kept between the water pond and shade. This system has easy operation and evaporation rate is also high compare to covered roof pond system. This type of roof has null maintenance except closing the opening in winter season (Artemisia Spanaki, RheocharisTsoutsos, DionysiaKolokotsa, 2011). This type of roof can also be also suitable for sloping roof. The air gap can be easily obtained in this type of roof.

Roof Pond for Hot and Dry Climate

There are two distinct Roof Pond Systems, one is heating mode and another is Cooling mode. In Hot and dry climate the outdoor temperature is very high almost eight months in a year. So cooling is the main strategy for designing.

For Climate like Hot and Dry different Cooling strategy can be applicable, one of them is Roof Pond or Cool Roof. The Study states that it is the strategy which is applicable for both cooling and heating need in Hot and Dry climate. Even it works differently for Daytime and night time.

- Configuration A: roof pond with indirect evaporative cooling function, shaded and with a ventilated space between the cover to enhance evaporative processes and the roof pond ; the cover provides a small overhang and has measures 1.0×1.0m;
- Configuration B: as in (A), but with water-tight reservoir, covered by the same metallic material as the reservoir's.
- Configuration C: roof pond, exposed and unshaded;
- Configuration D: selective solar exposure of the pond in winter, with venetian blinds (with a tilt angle of 45°) used during daytime and fully closed at night; the pond is permanently covered by a glass surface to prevent convective heat losses and the reservoir is painted black and filled to the top (with water depth 10cm) (Leandro Fernandes, Eduardo Krüger, 2017).

Table 1. Analysis of different configuration of roof pond. Source: (Leandro Fernandes, Eduardo Krüger, 2017)

Variable	Configuration a *29 Oct*		Configuration b *2 May*		Configuration c *20 Jan*		Configuration d *11 Sept*	
	T_{out}	TC	T_{out}	TC	T_{out}	TC	T_{out}	TC
T_{max}	32,0	22,3	25,2	22,4	29,4	31,6	27,4	40,1
T_{min}	14,6	15,4	13,2	15,7	17,1	14,4	14,5	24,1
T_{swing}	17,4	6,9	12,0	6,7	12,3	17,2	12,9	16,0
T_{avg}	22,2	18,8	18,8	19,0	22,1	20,9	19,3	30,9

Where, 'Tout' –Ambient temperatures, 'TC': Measured indoor temperatures in the test cell

As per the Ambient temperatures (Tout) behaved quite differently in the four monitoring rounds, with seasonal effects. Daily temperature swings varied among the four days with the highest fluctuation occurring in the shoulder season. In general, daily swings were high (>10K), which reflects local climate. Measured indoor temperatures in the test cell (TC) showed varied behaviour. The first two configurations, which tested the evaporative and function of the roof pond and the thermal mass of the water body without evaporation, but under a shading cover, had quite similar fluctuations.

DISCUSSION AND CONCLUSION

Based on the study made, it is apparent that the use of air conditioning in the buildings can be reduced tremendously to the minimum. We can now build houses that are environmentally responsible and are most comfortable to occupy with very little energy demand. The heat load of the buildings is reduced by the use of Roof Pond technique.

The depth of water in the roof pond is an important parameter discussed in studies. In study states that if we increase the depth of water the evaporation rate changes therefore it automatically reduce the demand of mechanical cooling even the humidity increases in the atmosphere which is one the important parameters in Hot and Dry climate per unit volume especially in Hot and Dry climate. Low depths of water ponds extract more heat from the ceiling, which should be avoided in the heating season. For open roof ponds which are not covered the depth of water should be more than in the enclosed roof ponds. For non-shaded roof ponds, where the water is expose to the atmosphere and spraying system is not available. The depth of the water pond should be at least 30 cm. Thus, for the uncovered roof pond to be more effective, an increase in water depth would create more stability and store more heat in the pond. According to literature, high water deepness for uncovered roof ponds and low water depths for covered ponds. (Krüger, E., L. Fernandes, and S. Lange., 2016). According to literature, should be reached not only with increased water depth but also with an additional insulation layer. Water depth is thus an important consideration and should even affect the thermal performance, along with the adequate dimensioning of the opening area. Roof pond has a low initial cost with very less maintenance. The roof design and efficiency of roof becomes more powerful if the building load will reduce with the help of

combination of other passive strategy like roof pond for Hot and Dry. Less research on information of the life cycle costs of roof ponds. Analyses recommended testing such factors in future studies.

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Amalgamation of Behavior, Culture & Environmental Sustainability in designing an "Eco-campus"

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Abstract: Eco-campus is a campus that integrates Behavior, Culture and Environmental Sustainability. In the present generation interacting with each other is as important as interacting with the nature. An educational campus intending to call itself sustainable with respect to energy efficiency and resources should also cater to the emotional quotient of the people by providing a free, creative, high caliber and active environment since the living and working environment affects the human health and productivity. The role of an architect is to create a campus in consideration with all the aspects of behavior, culture & environmental sustainability. The paper revolves around a thesis project where a residential educational campus has to be designed in jodhpur- place where the climate is hot and semi-arid, with very less rainfall. Designing a residential campus in such a challenging site requires research on various aspects like climate, vernacular techniques of construction, environmental sustainability, cultural background and social life, behavior of students in campus open spaces. The methodology is based on design research where literature was gathered on various aspects like sustainability both environmental and social activities, the techniques involved in converting a campus to Eco-campus, that enhance the social & behavioral aspects in creating a lively campus, case studies with relevance to campus design, sustainability and active user participation like, IIM Bangalore, IIM Ahmadabad, IIM Kanpur, PETRONAS university were identified and studied, Research on students behavior on campus open spaces were conducted by Naturalistic observation and behavioural mapping, vernacular architecture of Jodhpur was studied and favorable incorporable traditional construction techniques were identified. By incorporating the analysis and findings an effort was made to create a design that is an embodiment for co-existence of environment & human relations.

Keywords: Eco-campus, Sustainability, Behavior, Culture, Traditional Architecture

INTRODUCTION

As a challenge & a response, cause & effect, the modes of education & their physical forms have reflected the impulses of our society. The Current prospects & problems in campus design are mostly based on structure & content. People spend their lives searching for the solution where architecture accommodates changes in educational concepts. Often architects are involved in solving these issues. However no one is bothered about how the design solutions are being used? What are the open spaces that are being created by these design solutions? How the users behave in these open spaces? What are the factors that make a user comfortable in a space? What are the factors that make him ignore an open space? What are the activities? Often all these questions go unnoticed in case of a campus design. A detailed research has to be done in finding out the behavioral aspects of users in open spaces in a campus design, which can create a different outlook in utilization of open space in a healthier & positive way.

The paper is an attempt to provide a positive influence of all perspectives of behavior, culture & sustainability in a thesis project where a residential educational campus has to be designed in jodhpur- place where the climate is hot and semi-arid, with very less rainfall. There are various perspectives where the word Eco or simply Ecology is being conceived, 2 such notions are Campus Ecology by James.H.Banning (1978) and Sustainable Architecture as Ecology by Anirban Adhya and Philip D. Plowright (2015), even though their perspective or scale of the structure are different the main intended concept revolves around human interaction with environment. In this particular context an attempt has been made to influence user- user transactions in a particular space, the design is more about enhancing the emotional quotient of the users by providing active interaction space. Over the past decades many attempts had been made to define design as a course of action and problem solving techniques by optimization (Simon.H, 1996 & Schon.D, 1987), and research as a systematic enquiry Synder.J (1984), amalgamation of design and research can create a offspring which could result in a unique way of visualizing campus design. Literature on campus design by suggests various ways in which the

morphology of campus can be iterated based on time span, physical area, precision of program & characteristics of design(Dober, 2000), implementation of technology in futuristic designs (Pearce, 2001) or the experience provided for an individual in the campus in Indian context (Kanvinde, 1969). Mostly architects are inspired to draw their concepts mostly from their experience and feelings, and case studies based on concepts like fortress in brick, inspiration from Fatehpur Sikhri & Madurai, representative modular and crescent moon , designed by great architects Louis-I-Kahn, B.V.doshi, Achyut Kanvinde and Foster +partners respectively are chosen to understand their take on campus design. Theoretical approaches involving person/environment interactions help in sensible predictions between user-environment transactions by Baker (1968), Clark & Trow (1966), Holland (1973), Stern's (1970), Moos (1976) & Pervin's (1968), the application of any one theory can predict the behavior in a particular setting, incorporation of design and behavior with sensible sustainable techniques of construction will evoke ecology.

RESEARCH METHODOLOGY

Mixed method approach was employed in this paper as the Research methodology, Creswell 2009; one of the approaches involves Case studies & Combined strategies- A Multiple Case studies, an empirical study that investigates the real-life context. (Groat & Wang, 2013). Behavioural aspects were investigated using methods like naturalistic observation & behavioural mapping, the results applied in the design of user oriented open spaces, Inferences from the Case studies were applied in the conceptual zoning, sustainability became part of the design program.

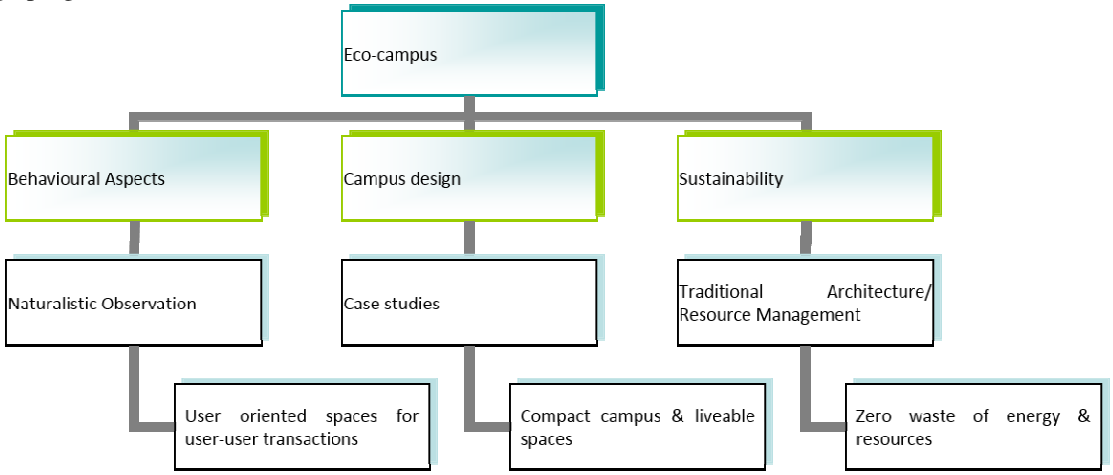


Figure 1. Research Methodology applied in the project,
(Source: Swetha 2018)

DESIGN INTERVENTION

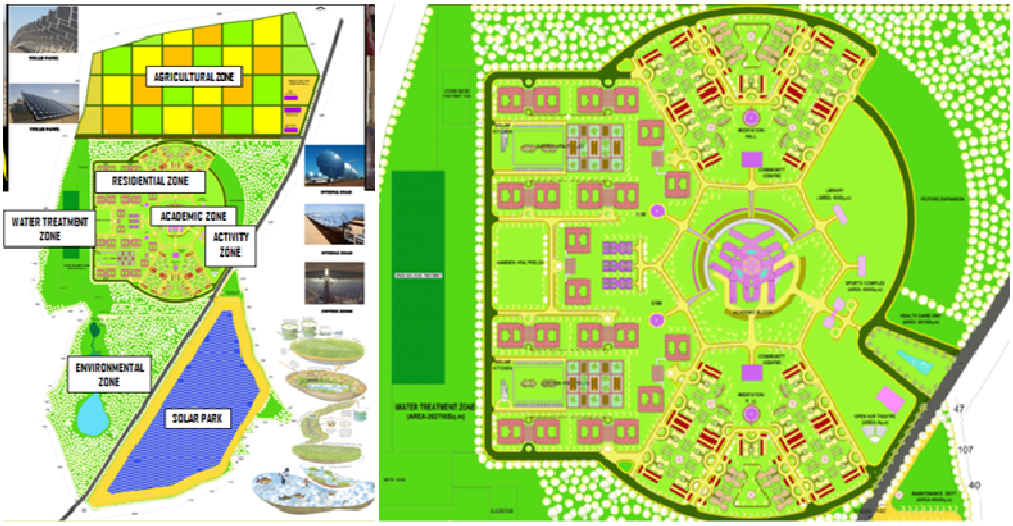


Figure 2. Site zoning and site plan of the project- IIT Jodhpur, *(Source: Swetha 2013)*

The main concept of the zoning was to segregate zones as per activities, the academic and residential were the located in the core of the site the distance of traversing was kept minimal, the inference from the case studies pointed out towards a compact planning, minimum footprint was maintained, certain spaces left for future expansion, the main activity zone and administration zone faced the national highway, academic zone accessible from residential as well as administration, the heavy motorized vehicles restricted to the outer core, and the interiors accessed by lighter vehicles, energy generated from the solar farm, water treated in the treatment zone and then passed on to the environmental zone. The open spaces which were part of the buildings were studied carefully and theories of behavioural psychology applied to these spaces, detailed out, most of the designs were flexible, and easily maintained by the users themselves.

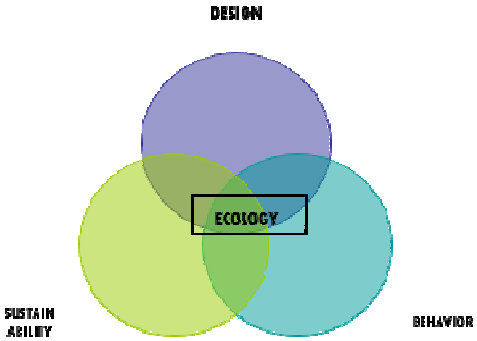
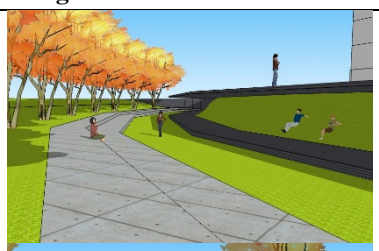
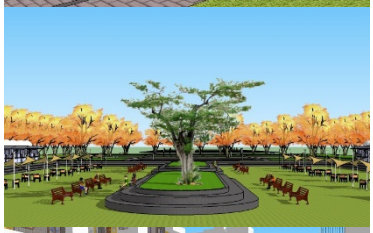


Figure 3. Conceptual Diagram depicting the elements of ecology
(Source: Swetha 2018)

Table 1. Conceptual views showing various user-oriented spaces at different levels

S.No	Design-View	Detail
1		**Landscape area in front of the Academic Block**- Interaction space can be utilized for group discussion or gatherings, or even as a resting place, the projection from above level is used to shade the spaces below. The contours are designed to break the monotonous nature of the site and create interest in its usage. Shaded spaces enhance the interaction in the arid climate.
2		**Playfields**- The playfields are provided with level differences which can be altered as seating, also as storage spaces. This flexibility allows more number of users to watch, play and rest. The accessibility from the food courts and hostel increases frequency of usage.
3		**Food courts**- zoned in between the hostels allows large number of users to access frequently, the length of traversing is minimized, the central part of the food court is provided with seating of various types, a person can sit alone in a group or facing others. Due to Flexibility and availability of the seating the place becomes active
4		**Landscaped area in between housing blocks**- The resting places and common gathering spaces are placed in between the housing blocks for easy access. The places are shaded during the evening orientation of the blocks and in between spaces are organized in order to achieve this. The seating can also be used as gathering space also.

CONCLUSION

First of all the papers opts a different approach in understanding the behavior psychology of person-environment relationship, the behavioral theories formulated in the 20th century were applied in observing the user in the 21st century campus environment mostly on active open spaces, and the results were observed and then the design was formulated. Secondly the case studies of leading architect designed campus were analyzed carefully and understood how a simple concept can lead to a complex iteration and how even in the initial design stage the architect thought about the user and designed this was purely based on his massive knowledge and experience in campus design. Thirdly how the concept of sustainability was applied technically and the vernacular/traditional culture in its own was more than sustainable, application of the cultural features lead to an amalgamation of a unique feature which was contemporary and supported all the aspects of ecology. The word "Eco-Campus" was achieved by integrating good design outcomes, behavioral study of users and sustainable/ traditional cultural aspects. Further research on the topic can help in providing proper guidelines for futuristic campus design.

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Silicon-based Waste as a Sustainable Architectural Alternative for Building Facades

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Abstract: The materials used for building envelopes are mostly used for functional and aesthetic purposes, rather than for sustainability and comfort. Silicon-based waste from electronics and appliances and those from silicon wafer manufacturing can be reused and recycled for this purpose, thus reducing waste generation. These recycled panels have the potential and scope to aid in 'passive heating and cooling techniques'. They might make a good alternative for skins, facades, cladding, roofs and other building envelopes. Thus, further research on the subject is required, which can contribute significantly towards sustainability and energy saving.

Keywords: Silicon semiconductors, Silicon wafers, Silicon e-waste, Silicon facade cladding panel

INTRODUCTION

Cladding of building facades has been a finishing touch of an architect in a building. It is the application of one material over another to provide a skin or layer which serves several purposes like weather resistance, a degree of thermal insulation, and to improve the appearance of buildings. A wide range of materials are used for cladding like metal, wood, vinyl, brick. They are also made of composite materials like cement, aluminium, recycled polystyrene, wood, wheat/rice straw fibres etc. Cladding materials are preferably risk-free from fire, water and wind. Over all these requirements, the most important and alarming need is sustainability.

Sustainability in buildings is efficient use of resources by considering the environmental impacts that are created on sourcing the materials, their construction processes and their after effects. The projects must not just be seen for their benefits but also their impact on the community and environment. The concept of sustainability is growing into great importance that a sustainable alternative is searched for for every single thing today and hence the emergence of several new sustainable materials every day. This leaves us in the world of vast opportunities to explore various ways of using the materials that we declare its end, as the first resource for a new product.

The fastest growing waste stream in the industrialized world is the electronics industry. The electronics industry being the world's largest and fastest growing manufacturing industry with rapid growth combined with rapid product obsolescence has resulted in enormous amount of discarded electronics leading to a disastrous proportion of growing quantity of electronic waste. Electronic Waste, also known as e-waste is described as the old, end-of-life (EOL) electronic appliances such as TVs, laptops, computers, DVD players, freezers and refrigerators, MP3 players, mobile phones, etc which have been disposed of by their original users.

Recycling and salvaging some or most parts of these will greatly reduce the impacts they have on the environment, especially their hazards. Similarly, manufacturing processes have their own set of wastes that can be very much recycled or reformed into new materials. The vision is to salvage silicon-based wastes from both electronics and other silicon-based manufacturing processes, for reusing and application in the building construction industry, due to the inherent properties and composition of silicon that has enormous scope in the field.

The aim of the study is to establish the idea and thought that silicon wastes generated in the manufacturing processes of silicon wafers can possibly be cast into panels for use as cladding, skins or any other form, as a building material and this can be a sustainable addition/factor to the building design.

Limitations

The use of silicon-based panels produced from the manufacturing process of silicon wafers should theoretically work as a sustainable building material. However, it is limited to the manufacturing process, the thickness, size,

its dimensions, its components, grade of silicon used, and amount of impurities, quality of manufacturing and climatic conditions in which it is used upon. It is also limited to how the material is used i.e. as an insulator, as cladding, as a skin and so on. The efficiency of this concept can only be proved upon further experiments and research.

RESEARCH

Semiconductors

A semiconductor material has an electrical conductivity value falling between that of a metal and an insulator. By deliberate and controlled introduction of impurities known as doping, into the semiconductor's crystal structure their conducting properties are altered in desired useful ways. They can also be modified to form highly efficient semiconductors. This property of it has enormous scope for development and use in the building and construction industry, in terms of both sustainability and aesthetics. Silicon is the most common semiconductor used in various appliances in various fields.

Silicon Semiconductors

Silicon semiconductor properties can aid sustainability because it's both an insulator and a conductor and it dissipates heat very quickly. Insulators absorb heat over long periods while taking longer to expel it. Metals transmit a lot of heat. Thus, there is a need for a 'buffer' material between both i.e. semiconductors. Silicon is highly valuable and abundant - 8th abundant material, with various uses and applications. Pure silicon is a perfect insulator, while silicon form used in electronics and appliances, is a semiconductor, having both conduction and insulation properties. Both pure silicon, and silicon semiconductor has scope for various types of applications in building, towards sustainable design and development. Wastes generated from the manufacturing of solar panels are also very valuable as they are mostly pure silicon-based wastes.

Solar panels are made of silicon wafers, either monocrystalline or polycrystalline. The manufacturing process of silicon wafers for solar panels results in large quantities of silicon-based waste generated. This silicon waste is recyclable and meltable. This silicon-based waste has a few percentage of impurities and is mostly powder form and thus it cannot be re-used for the solar panel manufacturing process. However, unlike solar panels which require almost 100% pure silicon, these solar based wastes can be made into panels or cast into any forms or shapes required. They can also be used for any form of building envelope (non-load bearing).

Silicon Waste

Every day about 250,000 Si wafers are produced globally to make chips for various electronic products. One of the leading companies in this electronic industry, IBM estimates that 3.3% of these silicon wafers are scrapped before they reach the market. This contributes majorly to the wafer scrap of about 3 million per year. These wasted wafers have the potential of producing solar panels capable of generating 13.5MW of energy.

The production of highly pure semiconductors is increasing every year. During the silicon wafer production process, about 60% which is approximately 2400 tons of silicon is scrapped with the wastewater disposal from cutting and polishing of the wafers. The most important point to be noted is that the recycling these semiconductors to highly pure silicon is very costly. These potential wafers open up an opportunity to be made use of and hence reduce the numbers on the amount of waste produced.

Properties of Silicon

Silicon is less expensive than other intrinsic semiconductor materials as it is the principal component of common sand. Silicon is has several important properties like they are easier to process, it has the ability to handle high power levels, it has less reverse bias leakage and it is more stable at high temperatures.

Single crystal silicon is processed into wafers ranging from 150 to 450 mm in diameter. Wafers as thin as 1mm in thickness are circular slice of single crystal semiconductor material cut from the ingot of single crystal semiconductor.

Thermo physical Properties of Silicon Wafer

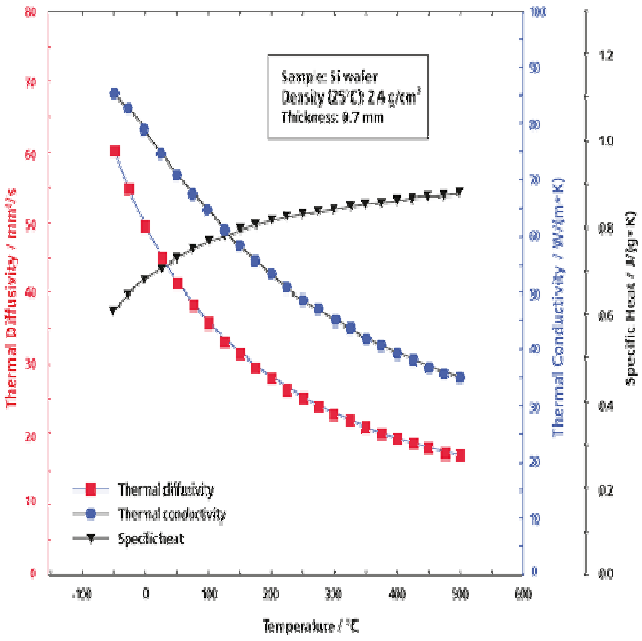

Figure 1.LFA and DSC measurement of a silicon wafer between -100°C and 500°C.
(Source: www.netzsch-thermal-analysis.com*, 2012)*

APPLICATIONS

In summer, these silicon panels have the ability to absorb heat and they can thus act as very good heat absorbers. They theoretically have the ability to dissipate heat rapidly and due to their conductivity property, can conduct the heat equally to all parts of the connected panels, even if they are in the shaded region. During winter, they can act to be very good insulators. This is because they are semiconductors by nature. Thus, they have enormous potential to be a very sustainable building material because of their ability to help in both passive heating and

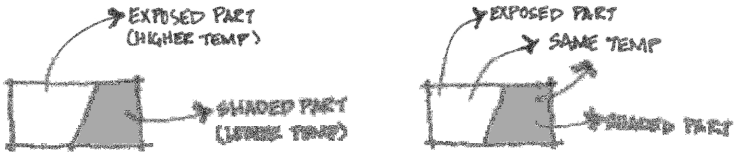

Figure 2. Ordinary Cladded Wall (left) vs Silicon Panel Cladded Wall (right).
(Source: Author, 2018)

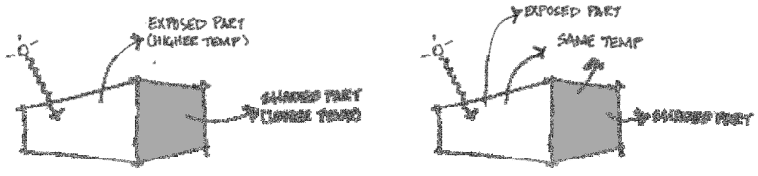

Figure 3. 2 Sides of Building Facades Cladded - Ordinary Cladded Facades (left) vs Silicon Panel Cladded Facades(right). *(Source: Author, 2018)*

cooling techniques.

The silicon chips from electronic wastes can also be recycled and used for this process. Also useful, will be old solar panels that can be recycled to aid the process furthermore. The recycled silicon panels is cast into required forms and are mounted onto a load bearing frame, as a shell or secondary skin to the building, or cladded onto the wall surface, as a cladding material. They also have scope to be used for roofing and other non-load bearing building envelopes.

HAZARDS

The hazards of manufacturing such silicon-based panels might arise and need to be checked when manufacturing the process is finalized. Also, exposure to sun, rain and other environmental factors and its long-term effect on these panels also need to be monitored and experimented upon. The environmental hazards of the manufacturing, installation and other processes involved in construction also need to be tabulated.

CONCLUSION

Silicon, as a semi-conductor material has enormous scope for being manufactured into a very much sustainable building element. The use of Silicon panels, generated from silicon wastes from silicon wafer manufacturing, recycling of silicon chips used in electronics and appliances, and recycling of old solar panels, can potentially aid in achieving passive heating and cooling, thus resulting in sustainable buildings. The manufacturing, efficiency and performance of these silicon panels need to be experimented and further researched upon. The hazards of such should also be determined. This can potentially reduce the electronic wastes and also reduce the energy load on the buildings. They can potentially replace other materials, as a more sustainable alternative in building construction. Further research and proof of this, has to be done imminently.

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Energy Efficient Strategies and Facility Management in Healthcare Buildings

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Abstract: Hospitals are responsible for a large amount of energy demand due to their continuous operations and other supporting function than a commercial building. Obtaining high quality of indoor climate and thermal comfort for the patients are required for the improvement of their health. The methodology includes reviewing of the most typical energy consumption facilities and the main design parameters to applying energy efficiency techniques in hospitals. Simple energy conservation techniques and passive architectural strategies according to the user and efficient facility management in hospitals can save up to forty per cent of energy consumption. The aim of the paper is to explore the areas of energy savings and study the passive design techniques for energy efficiency in the hospitals to achieve the best thermal comfort.

Keywords: Indoor Climate, Energy Conservation, Passive Architecture, Energy Efficiency, Thermal Comfort

INTRODUCTION

Hospitals are the most complex, diverse, and energy-intensive facilities compare to other institutional buildings. The healthcare and energy consumption are the two critical points to be considered in hospitals. Hospitals must be operational throughout the day and night in all days of week and it is important to maintain services during power outages, natural disasters, and emergencies. The lifesaving equipment must continue functioning uninterrupted all the time. Along with the uninterrupted facilities care should be taken for thermal comfort level of indoor which is very essential to help patients to recover fast. The thermal comfort can be achieved through natural and artificial method. The natural methods are considered as energy efficient which includes use of good day lighting, efficient ventilation, and landscape for visual comfort as well as regulate air quality, insulation of building. Incorporating these energy efficient features in the hospital makes the patients recover fast

Environmentally conscious practices in hospitals would ensure the health of building occupants and also reduce the pollution from the building.

Hospitals need to provide their patients and staff a variety of indoor environments because of diverse comfort. The personal factors, both physical and emotional satisfaction and environmental factors directly affect the thermal comfort.

In India there is a demand for healthcare facilities and it is necessary to study the energy consumption in the building. A hospital building must ensure effective planning to ensure energy efficiency in the heating, ventilation and air conditioning (HVAC) system, use natural light as far as possible without compromising on illumination, efficient waste disposal systems and use of renewable energy. All equipment must be procured only after ascertaining that they consume minimal energy and retrofitting existing equipment must also be considered in this regard.The major energy consumption in hospital go for lighting (30%-40%), HVAC (30%-65%), water pumping 10%-12% and other facilities like diagnosis and treatment equipment's (5%-15%).

The Need for Energy Efficient Hospitals

The hospital building can play a very significant role by incorporating energy efficiency, renewable energy and sustainable green design features to achieve sustainable environment and energy structure. The careful design along with patient safety, system redundancy, equipment reliability makes a hospital sustainable over a long run. The buildings should be attractive along with efficient structural supports and proper usage of spaces with longer useful life. The hospitals give a prime opportunity to the architects to balance aesthetics, services, structure and energy efficiency along with user comfort which leads to sustainable design.

The technologies and the design methodologies related to each other for reducing energy consumption, maintenance of medical equipment, advanced building material and technical systems for lighting, heating and

ventilation. Use of advanced equipment's and technology, proper ducting system and layout planning will help to reduce mechanical load, cost and efficient functioning of the building.

ENERGY EFFICIENT PLANNING FOR HOSPITALS

Hospitals are the complex buildings because of its functionality and end users with varied healthcare demands. There are different department where need of medically controlled environment and infection control. The energy consumption depending upon user perspective and functionality of various departments. the operation theatres, intensive care units, emergency units, clinical laboratory, radio therapy department requires more customised energy consumption through mechanical devices to maintain specific temperature, humid and air temperature throughout the period of use. The architects and planners must consider while designing health care facilities are comfort of patient and other users, innovative design and energy efficiency. The zoning of various departments and placement of facilities plays very important role in efficient functioning of hospitals. In patient centric design, placement of vertical and horizontal circulation planning is very important which helps end users in proper way-finding, security, privacy and reduction in the use of lifts etc.

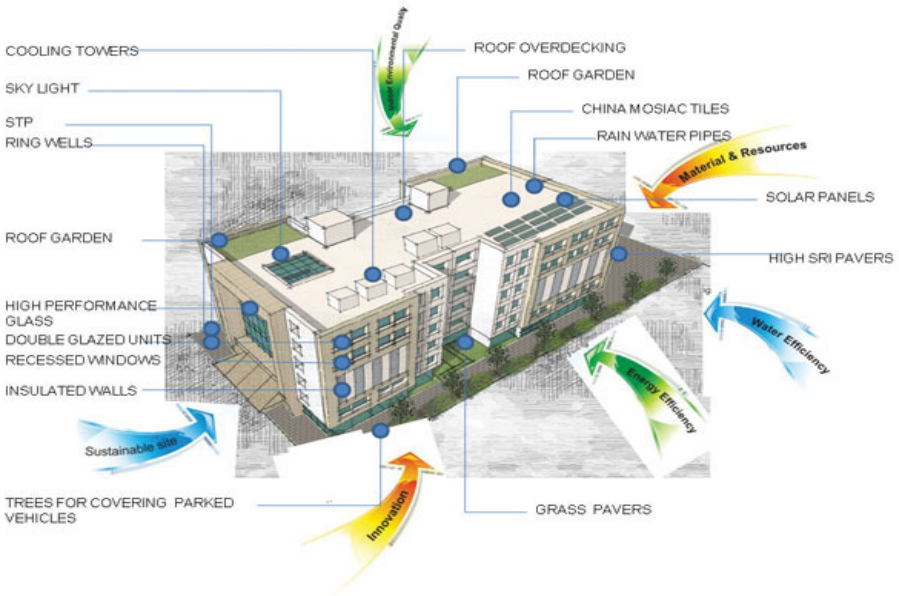


Figure 1.LEED Platinum rated Kohinoor Hospital at Mumbai
(Source -https://www.nbmcw.com/)

Hospital design conceptualizes around many design parameters which includes privacy and dignity of patients, pleasing environment, accessible services, adaptable accommodation, multi-functional spaces, material preference, lighting and space conditioning types and methods adopted, spaces and their ambience and size. The physical and social environment in a hospital depends on well-integrated and coordinated design. The energy efficient codes of ECBC, BEE, Teri-Griha, LEED etc. have formulated design guidelines and parameters for the hospital buildings.

The first consideration in choosing the site of a hospital is convenience for the patients. In view of the increasing importance of the outpatient service given by the hospital, convenience of access to patients is absolutely essential, and should take priority over other factors in the selection of the site. The most important consideration while choosing the site is for convenience for the patients and also it should be large enough to enable the hospital to expand and develop in the future. The proper access to the patients is very essential and prime importance should be given to internal circulation routes on the site for the successful planning of hospitals

The medical service departments, particularly the radio-diagnostic service and the laboratories, should be planned to allow substantial growth according to the demand and preferably these department should be placed in ground and basement floor for the easy servicing. Outpatient department, laboratories, emergency section, diagnosis sections are can be placed in ground and first floor where floating population is more and use of lifts are very minimal.Segregated entrances as per various user will lead to efficient functioning of departments,

proper monitoring, security and privacy. The various departments of hospitals can be zoned separately as per energy consumption and functions.

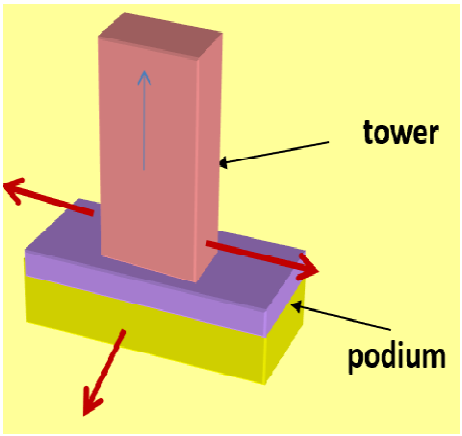


Figure 2. Tower Podium Hospital
(Source -Author)

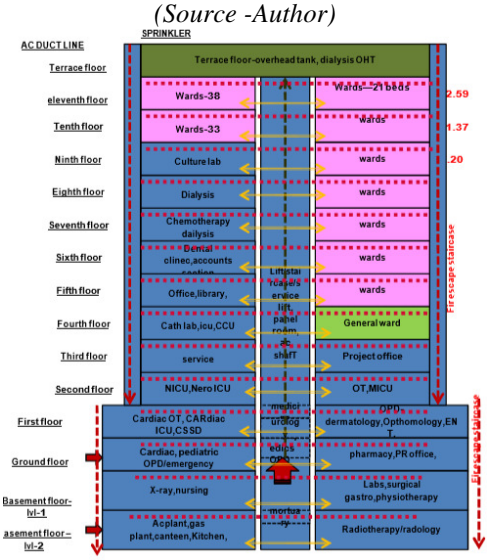


Figure 3. Typical hospital section showing vertical stacking
(Source -Author)

The tower and podium concept in hospital design will give the provision to both horizontal and vertical expansion. The common facilities like diagnosis, imaging, lab services can be in podium block whereas wards can be in upper tower block. The expansion can be done vertically but simultaneously it may change the stacking program by replacing or changing the space layout. Vertical stacking of spaces reduces the building footprint and allows more natural light into the building which reduces operational cost, waste and demolition cost. The core with vertical transportation, services give the main department to expose to outer walls to get maximum light and ventilation. The reduction in lengths of ducting system, cables and pipelines will reduce installation costs, maintenance costs. If outpatient department which works from morning to evening can be placed separately where energy supply can be disconnected in non-functioning hours. The lifts can be planned to stop in alternate floors which reduces operational cost and energy consumption.

CLIMATIC CONSIDERATION IN DESIGN

Consideration of climate is very important criteria in country like India wherein there is diverse climate from north to south and east to west. In certain climates, buildings have to be heated in winter or cooled in summer; and, in some areas, buildings may need both heating and cooling, at different times of the year. The more spread out the hospital, the larger is the surface available for heat loss or heat gain and the more expensive is the maintenance by artificial means of the desired internal conditions. The expense of cooling by air- conditioning is

very great, far exceeding that of heating in most climates. Therefore, wherever air- conditioning is deemed to be necessary, the building should be designed in as compact a manner as possible. The building always be placed north south direction the major consideration of placement of departments to be as per solar radiation. The departments like outpatient department, wards, administration areas where required natural light and ventilation can be placed in north and east side where as the areas like operation theatre, intensive care units, labs, radiotherapy requires controlled ventilation and light with less openings can be placed in south and west side. In warm humid cross ventilation is very important simultaneously need to take care of spread of airborne infection. The south and west façade have to be treated properly to reduce the HVAC load.

The volume of the hospital should be kept down by the use of low ceiling and by restricting the size of rooms to the absolute minimum. It is of vital importance that the decision should be taken at an early stage as to whether cooling by air- conditioning is required, as the whole design of the building will be affected by this decision. In hot climates, air- conditioning will always be needed for operating theatres and, very often, for recovery wards, labour rooms, X- ray rooms, and other special areas.

The buildings should be light and open and planned so that even the slightest breeze can pass right through the buildings at low level to cool the occupants. It is impossible to plan highly concentrated hospitals for use in hot, humid climates without recourse to air- conditioning. In hot, dry climates, the nights are cool, and the object of the building design is to protect the occupants from the fierce heat during the day. Buildings in these climates are therefore massive, with heavy walls and small windows. The heavy walls absorb the daytime heat and dissipate it at night. The small windows keep the amount of radiation entering the building to a minimum. In developing the master plan, attention must be given to the relation of building to each other with regard to sunlight and shade.

In hot climates, the buildings can be planned to shade each other to some extent. In temperate climates, where the winters are not very long or very severe, it will not be necessary to give great weight to the problem of heating in relation to the general plan of the hospital, which can be designed primarily with other considerations in mind. But in climates of extreme cold and long winters, where the cost of heating is heavy, some thought should be given to making sure that the general plan results in a reasonably compact building. In warm climates more, cross ventilation is required for the comfort. In cold climates, the ventilation of hospitals during the winter presents difficulties, as sufficient ventilation is apt to cause undue cooling by the introduction of cold air from the outside. Certain areas like operation theatres and any other areas where open wounds are exposed to air must be provided with artificial ventilation. These areas must be ventilated with high level of air hygiene. It is important that patients lying in bed should not be exposed to too large an area of sky in direct view through the windows. Control of glare from windows requires great care in design, and various special arrangements have been proposed for this purpose. It is therefore important for the architect to consider the design of the windows in the light of criteria that are now known to be good for hospital purposes.

FACILITY MANAGEMENT SERVICES

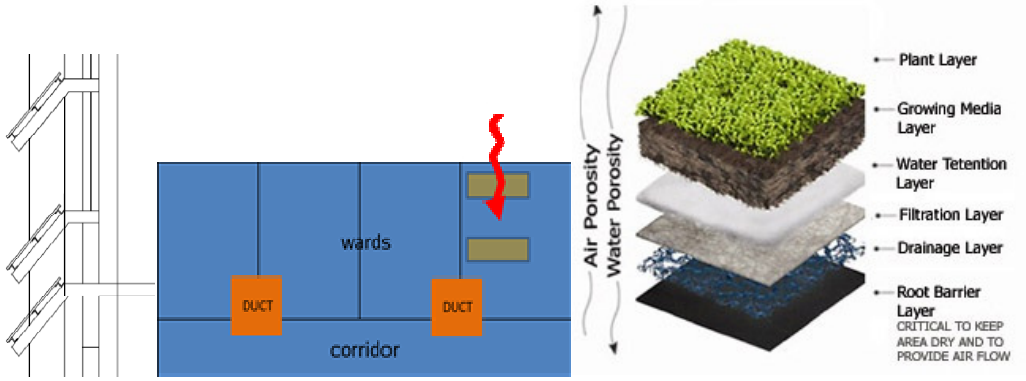
Vertical transportation should be placed in the centre to get equidistance from functional areas. The clustered elevators and staircase shall have advantage of efficient vertical transportation with minimal walking distance. The maximum walking distance to elevators should not exceed 60 m.

More than a third of the cost of hospital building goes into the mechanical engineering services – heating and ventilating, electricity, lifts, and communications. The services are very important factors in the hospital design and service engineer needed in early stage of designing to estimate approximate demand of water, electricity and HVAC load. Their advice can be taken into consideration while selecting the site and master plan level.

The engineers must also collaborate with and advise the architect on the space that will be needed in the building to house the mechanical services. The mechanical services must be planned so that easy access can be obtained to all equipment for repairs and maintenance without disruption of the daily function of the hospital. Implementing a turn-key pre-treatment plant will reduce the amount of waste water from the boiler, creating a significant reduction in energy consumption as well as lower operational costs. Further energy savings can be achieved through the optimisation of cooling towers. Within the cooling towers, fans and recirculation pumps that cool the water can be swapped out with alternatives that are more energy efficient, allowing water to be recirculated at a desired rate rather than a constant rate.

CONSTRUCTION DETAILS

Lack of proper insulation in the roofs and walls etc. can lead to patient discomfort through solar heat conduction, also leads to more energy consumption. To improve the quality of patient care through energy efficient techniques with proper insulation of building is very important in hospitals. Flooring materials like, rubber, vinyl flooring re good for seamless finish which is easy to maintain from dust.The granite and marble flooring used for aesthetics and easy maintenance but have to take care of slippering.



(a) (b) (c)

Figure 4. (a) Windows with large overhangs to protect from solar radiation and glare; (b) Inpatient ward configuration to get larger window surface; (c)Green Roof

Wall treatment is very necessary to give the thermal insulation which is very important to reduce mechanical load in the building. The south and west side of the walls are to be treated to minimize the solar radiation entering in to the building. The treatment can be done through double wall, insulating layer, cladding or by providing projects or fins on the wall surface.

The openings or windows should be large enough to allow sufficient natural light. Same time it has to be treated for glare with appropriate techniques. The windows can be treated with antiglare glass or reflective glass which allow light and minimize the solar radiation entering in to the building. High Performance glass, optimal Window to wall ratio, and recessed and shaded windows will create comfort ambience inside the building by minimizing solar radiation and enhancing the outer view. Artificial lighting constitutes 20% of the overall energy load which helps in 50% saving. Natural lights in patient areas reduce the consumption of electricity. The large windows and open sky light keep the area cool and ventilated. Cross ventilation has a greater potential to manipulate the pressure gradient developed around buildings.

Green roof increases the thickness of the slab by providing insulation for the below rooms from solar radiation and keep the indoor environment cool. It helps to lower the urban air temperature and also the cooling loads on a building by 50%-90%. Green roof enhances the air quality as well as give protection from ultraviolet rays and mechanical impact. These sustainable features also provide visual comfort for the user by allowing them to look in to greenery.

USE OF RENEWABLE ENERGY IN HOSPITALS

Renewable energy referrers to energy generated from natural resources solar radiation, wind, biomass, etc. The implementation of renewable energy depends on the support of government policies, market condition and availability of natural resources. Use of renewable energy help to reduce the artificial o energy consumption. The initial cost of implementing renewable energy will be more but in terms of long term benefit it is considered to be negligible. This can reduce the adverse effect on environment due to power plant emissions in the hospitals.

Solar energy-To harvest solar energy the building should be planned to get maximum solar energy to meet the requirement of the hospital. The surfaces can be designed to install the photovoltaic cells to generate more

solar energy for the lighting and heating purpose. The photovoltaic cells can be mounted on the roof, shading, and ground or integrated in the hospital building. The solar panels should not be get shaded by other panels, trees or buildings which reduces the efficiency of panels. Proper placement of panels in the building makes solar power reliable and more economical.



Figure 5. Building -Integrated Photovoltaic Cell

Wind—wind energy can be used to produce electricity using wind turbans in the building. Small scale turbines can give opportunities to use renewable energy. The various issues like vibration, tall buildings and vegetation around the building should be considered while planning to harness wind energy. Turbines should be located far from buildings to ensure noise control and safety.

Smart Technologies

Hospitals use lots of advanced technologies to ensure patient safety, from electronic health care management systems to wearable health monitors. The Smart technologies can help in addressing the long operating hours and high equipment loads. Smart sensor techniques are very useful in efficient use of the services like HVAC, lighting, plumbing and sanitation. This also helps to regulate the comfort level of the user especially patients and reduce the energy consumption. Smart technologies are become very user friendly and patients can be independently managed themselves without others help in managing with minimal staff. The water conservation can be implemented through using sanitary fittings with sensor technology which reduce the water wastage.

CONCLUSION

Hospitals are enormously complex buildings with many unique requirements. Energy efficiency presents both a challenge and an opportunity for healthcare facilities. Regulatory requirements, infection control, the intensity of energy and water use, 24/7 uninterrupted operation set healthcare facilities apart from other building typology. Energy efficiency in healthcare requires different strategies than those that are effective for other industries. Energy efficiency parameters should be treated as must and important criteria in designing the hospital building which help in sustainability and reducing the cost of expansion, long term maintenance, operations and services. The thoughtful planning of energy efficiency hospital will lead to long term benefit to the society.

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Historicity Sustainability and Urban Identity: Case Study on the Urban regeneration for Madurai

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Abstract: Cities have always been a place of attraction, allure people with its assets. Availability of easy and quick workforces baits the entrepreneurs, making the place more magnetic. This rapid urbanization may leave the cities, rundown of its resource in the future. To meet the upcoming Global demands, new territorial concepts arise, leaving out uncertain and unpredictable urban grown in cities ironically. Trans-national policies add to it. Local Development authorities are facing enormous pressure due to such transformations led by new economies. Thus the concepts of conventional urban morphology are changing. In such a scenario, Urban Informatics led by SMART technologies, help authorities to understand the way city behaves, better, through ICT. However, Environmental, Socio-cultural and economic values of the indigenous social groups need to be closely addressed on REGENERATION strategies for an integrated development. Meticulous and tailor-made urban studies can be conducted to address those issues. Thus, highlights on sustainability of local communities in SMART city proposals can be ensured in Heritage sites.

Keywords: SMART city, Heritage cities, local community, Urban Informatics, Urban identity

INTRODUCTION

Indian Urbanism has always been largely traditional since ages. The urban morphology is basically a Kinship based and extended society. Thus the urban form and pattern is an evidence of its strong negotiation of its social construct and relationship. Here the religious ideologies play a very prominent role in the arrangement of the socio spatial framework of these cities. Hence the local social order forms the backbone of the city structure. This paper focuses on regeneration of traditional towns under the needs of Global climatic change and the needs for reinstating the identity for a sustainable future.

Historical value of Madurai

Madurai is more a large town of Strong Historic ideals, Culture and Heritage. Having been experienced under a variety of great cross cultural influences under various rulers, the city has transformed and has thrived on several unnatural conditions. The Vaigai River forms the lifeline of the city's Cultural and water resources apart from few natural ponds and water bodies that keeps the city alive. It has a very well connected intra city water management system. Architecture of the city is largely functional with appropriate aesthetics and styles symbolizing the past and their influence. Large and small mixed use buildings are closely arranged in the long-established context in a concentric square around the Meenakshi Amman Temple precinct forming the historic core. Built form density, Street pattern and the scale and intentional distribution of open spaces reflect the care for humanizing aspects of the city's built fabric. The pattern and size of land parcels and their deliberate locations in the central core prove the continuous social negotiations prevailing in the city. A city that was developed based on strong religious principles and social condition has expanded itself way beyond its historical core today.

Economic structure of the city

Heritage tourism is the backbone of the city's economy. Automotive, Textile, Rubber, Granite are primary industrial types. Other sectors include large and heavy industrial, agriculture and small scale industries. In this scenario, Global trends and governmental policies demand for a new perspective towards the city growth and sustainability. While on the other hand the rising population due to rapid urbanization is resulting in increasing road traffic, congestion and unavailability of parking areas, new housing demands, social and physical infrastructure and services etc. The city away from the historical fabric is largely centered on industrial and new

institutional areas that come up along the periphery. Uncontrolled real estate scenario heightened up by the unexpected governmental decisions on urban expansion policies influenced by global trends adds to the new decentralized governance and constantly expanding suburban development.

The city under transformation

A city is a creation of various courses of action from different groups of people at different time intervals. It can also be viewed as a result of collection of activities and decisions by its administration. Traditional cities are very unique in the way they work. Art, Architecture, choice of materials and many inherited practices of our ancestors are the reasons for its diverse nature. This is a city that is known more for its own set of distinctive values, historical significance, events and firmness in maintaining its identity through many of its phases of change ever since its evolution. It can be understood as an artifact of collective memories. So designing places uncommon, in this conformist city is a big challenge. And thus, understanding this city as a process by its people will help the city administration to make holistic decision. Also, in the milieu of Culture and practice, these cities show dichotomies between the past and the present, for becoming modern yet stay conventional. Thus the historical canvas of the city fabric today stays colorful with variety and intermingled and juxtaposed architecture and urban forms.

Thus this city of duality between the Grassroots and decision makers has evolved itself to a city over these ages which are very evident in the historic registry revealing ground reality. Apart from being a religiously branded, the city is also known for its 24x7 work culture. Women Safety, child friendly environment and natural surveillance is a great asset of the city. Apart from being well connected with in, the city is gifted with inter and intra city Road, Rail and air connectivity and systems. Because the city is supported with substantial state of art institutional and health sectors, the nearby villages benefit. The city in its current growth pattern follows nonnative trends of urban expansion fueling the new investments. Boom economies like IT and ITEs and new commercial trends already had left the city's development scattered around peripheral areas. Change of Landuse from agricultural to other purposes supported by the ill effects of Climate change has further added to the change. This unpredictable out of control scattered developments slowly eats up the already available limited resources. For the city to sustain in future a careful and meaningful approach of planning is necessary. As a result the per-capita role of the communities and people comes into picture to retain and wisely use the resources available for a better sustainable future.

Global Sustainability goals and the role of citizen

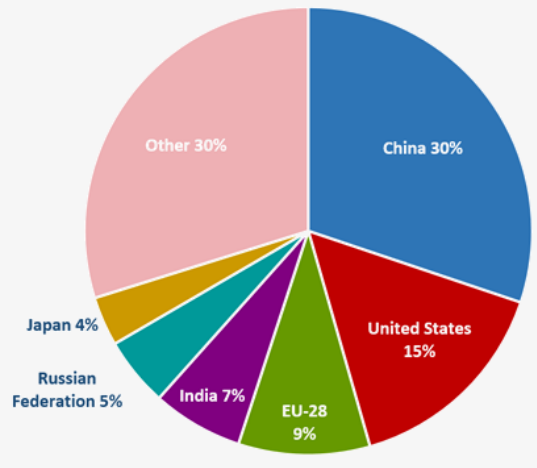

Figure 1. 2014 Global Co2 Emissions from fossil fuel combustion and some industrial processes

India as a country is facing many challenges on achieving sustainability. Due to overgrowing motorized vehicular use in India, Carbon emission today happens to be the major issue, as most of these traditional economies were based primarily on the carbon supported production technologies. Alternative energy systems are in need. It is apparent that there is a huge task left for these traditional cities to focus towards the upcoming Global Climatic changes and related issues. At local level, clean and fresh air, Healthy natural environment and

ration of potable water are the biggest of the challenges for the city government. Controls on preserving and maintaining natural assets and energy will ensure fool proof sustainability. Ensuring the access for participation and effective efforts to involve its citizens in governmental policies will ensure awareness and full act towards the accomplishment of Sustainable initiatives. The UN global sustainability goals points out 12 major areas for all its member countries. The chart below shows the global emission of Co2 from member countries and their role globally.

BEING SMART AND CULTURAL HERITAGE

Today the government initiatives are primarily centered on the digitalizing of available city data using the Data informatics. For the city to be more socially sustainable, the information has to reach the masses to ensure equity with an equal participatory approach towards an integrated development. On one hand the smart technologies help in promoting the local heritage through smart cultural heritage initiatives using digital technologies linking the institutions and communities in many smart global cities. To share the ideas through cultural artifacts these systems help to a large extent. This has the possibility to enlarge Social innovation ideas and practices for upcoming generations.

DIGITAL LIFE AND THE CITY

Traditional cities are known for its work, family and social life balance. It should be closely monitored at all degrees of the city governance by the city authority. In today's scenario the above mentioned aspects remain lopsided in most of the urban areas. On one hand, Smart phones and technology has reduced physical mobility between closed social groups to a large extent, but has invited colossal digital connections and associations across nations. Block chain economies replace traditional transactions. This has invited infinite new foreign ventures and new economic perspectives with in a very short span of time. Clustering of business among world networks in a global value chain is the trend. This will avoid the vendor lock-in situations and will invite free market policies for a global good. Paradoxically, the introduction of Global value chains is replacing local micro economy in few areas. For this, the supply chain management of the systems has to be completely monitored and maintained by the local government.

CONCLUSION

Even though, India is getting smarter through the usage of ICT and open knowledge systems, it is still old-fashioned on heritage and culture. There is silent and constant repulse of sharing private data over the unfamiliar global connected network of communities. Without a guaranteed participation of the grassroots and unreachable sections in for Governmental initiatives urban regeneration policies goes vague: Hence revitalizing a traditional city which is embedded with traditional customs and practice goes unfair. Unauthentic database becomes a threat for unreachable communities. In a city of inequality and social bias based on the conventional community structure and old social order, the real sustainability as discussed in the UN for world nations becomes unfulfilled. To achieve a practical solution, open and transparent platforms and systems are needed to unwind the governmental expectations over the stakeholders and vice versa to prove the democracy.

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Tangible Parameters for Affordable Low Cost Housing in India

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Abstract: Shelter is one of the basic needs of every human being. In any civilised society, every citizen should be provided with a reasonably decent and liveable shelter or housing/dwelling unit. India is facing an acute housing shortage to the tune of 18.7million. 98% of this is comprised by families of the weaker and low income groups, whose actual income makes it impossible for them to own even the cheapest available housing unit, given the souring housing market. The paper discusses about the problem of Affordable housing that are happening all over the world . Shelter has many references, which includes cost, choice, community and conservation aspects of a house without which the housing cannot be complete. Government is taking lot of effort in uplifting affordable housing economically through various schemes, missions and policies. If all the parameters are carefully put to practice, the goal to provide houses by 2022, which appears utopian at the moment, may definitely become feasible. Without the cost factor, the goal of achieving affordability in housing cannot be attained. Among many parameters related to affordability, an architect can certainly aim at reducing the cost through various aspects of his design, including layout, clustering, materials, technology and component design. Thus the paper discusses about the various aspects of designing &planning. Also the paper deals with information regarding various building materials and technology which play a primary role in arriving at an affordable cost for the house by giving more importance to performance demands than appearance.

Keywords: affordable housing, housing shortage, tangible parameters

INTRODUCTION

The shortage of housing in urban areas is alarming. In present scenario people from low or irregular income are likely to find it difficult to buy their own house. There is rapid increase in housing prices and rents in urban areas have pushed the dreams of having ownership of houses beyond the reach of growing number of LIG and EWS. So there is a need for appropriate and affordable shelter, which embodies the values of the users, and forms an integral component of the fabric of neighbourhood life as well as the entire social background. Thus the cost of houses includes taxes, insurance and utility costs, choice, community and conservation aspects of a house.

What is affordable housing - need of uniformity

"Affordability Housing" refers to any housing that meets some form of affordability criterion, which could be income level of the family, size of the dwelling unit or affordability in terms of EMI size or ratio of house price to annual income".

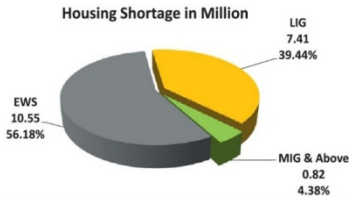


Figure 1. Housing Shortage in India
(Source- Report of the Technical Urban Group (TG-12) on Urban Housing Shortage 2012-17)

Need of the project

The growing population in India has led to many problems such as land shortage, housing shortage, and congested transport system which is increasing overall nuisance. India, like most major emerging economies in other countries, has been experiencing increasing urbanization. As per the census of India in 2001, population

living in rural areas is about 72%, and 28% in urban areas. But in 2011, it had changed to 69% rural population and 31% urban population. In fact, as per census 2011, for the first time since India's independence, the absolute increase in population was more in urban areas than in rural areas. India's urban population is growing at an average 2.1% every year since 2015. It is likely to reach 60 crore by 2031 (up from 37.7 crore today). But the growth in housing has been unable to keep pace with the growing population.

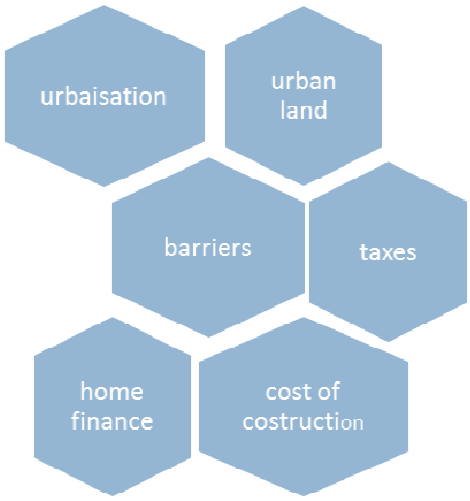


Figure 2. Barriers in development of Affordable Housing

The cost of housing comprises several factors, each of which is responsible for the high costs of housing today. Only the cost of land and materials is not the root cause of the higher cost of houses. If all the factors are properly dealt with, it will not be impossible for 'housing for all' to become a reality by 2022, as mandated by the present Government.

Affordable Housing in India is based on income categories, income levels, size of dwelling unit and affordability of an individual. According to the Confederation of Real Estate Developers' Associations of India (CREDAI) , affordable housing has been defined in broader way . Affordable housing is usually provided to three sections of society: The economically weaker section, the lower income group and the middle income group.

- The Economically Weaker Section - upto 30.00 sq of carpet area
- The Lower Income Group Section – upto 60.00 sqm of carpet area
- The Middle Income Group- I& II – 120.00-150.00 sqm of carpet area

Thus a house is defined as an all-weather single unit or a unit in a multi-storeyed super structure with adequate basic civic services and infrastructure services like toilet, water, electricity, etc. India is facing an acute housing shortage to the tune of 18.7 million. 98 % of this is comprised by families of the weaker and low income groups, whose actual incomes make it impossible for them to own even the cheapest available housing unit, given the soaring housing market.

UNDERSTANDING THE FACTORS OF LOW COST AFFORDABLE HOUSING

Some of the factors which are considered vital in present scenario for affordability are discussed here.

Cost Reduction

Without the cost factor, the goal of achieving affordability in housing cannot be attained. Among many parameters related to this issue, an architect can certainly aim at reducing the cost through various aspects of his design:

- Including layout, clustering, materials, technology and component design.
- Hence, it is necessary to devise a technology and invent materials, which can substitute the conventional and reduce the cost by giving more importance to performance demands than appearance.

- Optimization of space and materials through design innovation could also give tangible results in improving space and cost efficiency.
- Design of wall, roof and window components can be constructed by using waste and eco- friendly materials with industrialized building system as one of the significant parameters of cost reduction, while saving energy to achieve sustainability.

Site Selection

An affordable housing project should be situated such that workplace and other facilities are within reasonable distances. Public transport should connect the housing areas effectively so that the users will get benefit of it. Housing should not be developed far away from prime workplace centre as the users will have to pay heavy cost for public transport. Location should be such that it will take lesser time to commute to workplace and save fuel. Reduction of cost begins with the selection of the site. For housing to be affordable, careful site selection is essential. The following criteria may be considered for selecting a proper site.

- The site should be under the category of 'residential' as per the local master plan (otherwise a lot of energy, money and time is lost in initiating the development and construction process, leading to unnecessary cost overruns)
- Not be within an eco-sensitive zone
- Not be a low lying area, which is likely to be affected by floods
- Not have a regular geometric shape (It is always better to have a larger frontage, which faces the approach road. This frontage should be free of encroachment.
- Be well connected with transportation hubs, such as railway station, bus terminus, airport, as well as educational institutions and hospitals.
- Be close to basic physical infrastructure including potable water, electricity, sewage and drainage disposal points.
- Have soil with good bearing capacity.
- Be located away from restrictive archaeological areas and the airport funnel zone
- Not be in the vicinity of any polluting and hazardous industry (Even air polluting industries located at a distance, which fall in the windward direction, may make a housing scheme non-liveable and unpopular)
- Be free from obstructions, such as HT lines, water channels, underground gas pipe lines and abadies or slums

The Layout Plan

The layout plan of any residential area plays a decisive role in checking the overall cost of the housing plot or the built unit. As a matter of fact, an efficient layout plan can reduce the cost of the housing unit by as much as 10–15 per cent. Therefore, it becomes a challenge for the architect as well as the town planner, who are required to improvise, strategize and focus more on creativity while preparing the layout plan of the residential area. It is pertinent to mention here that the infrastructural pattern of the project is greatly dependent on the layout plan and determines its cost and efficiency. The following guidelines may be of help in this regard:

- Care should be taken to retain the natural topography and contours (Unnecessary levelling of a site leads to extra cost, and in most cases disturbs the site drainage).
- Effort should be made to conserve the site's existing flora and fauna.
- The saleable area should be maximized by following the basic principles of geometry.
- Economising on road areas and lengths.
- Avoiding wasteful odd- shaped open spaces.
- Even though, it is a common practice to arrange housing units around open spaces for better social cohesion amongst the residents, this results in a marginal increase in the length of service pipes. This causes costs to go up. Therefore, the planner should try and come up with a balanced approach.
- There should be provision for all the basic social infrastructures, like schools, hospitals and community centres, within the residential areas. This will save people the effort and trouble of commuting long distances and spending on transport and fuel.
- Properties that are large should ideally face trunk and arterial roads.

- The sources of water supply should be located at the highest points, while the sewage and drainage disposal points should be located at lower levels. This results in better efficiency in terms of energy and savings in terms of running costs of these services.
- Decentralisation of physical and social infrastructural facilities helps in initial as well as perpetual costs.
- The housing plots should be rectangular in shape with their shorter side facing the road. The most functional and economical ratio of width to length is considered to be 1:2.
- Floor Area Ratio or FAR norms should be upgraded on the basis of the status of infrastructural services.

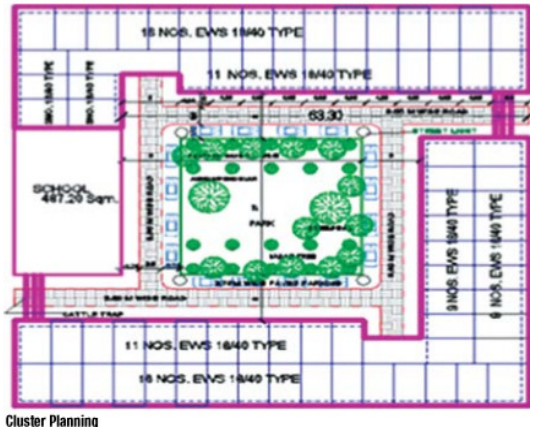


Figure 3. Layout of Housing Units
(Source- Paper by Prof. Subodh Shankar, in Architecture - Time Space & People)

The Housing Unit Design

The housing unit is the end product of a housing project, and is the actual place where people live. This 'dwelling' ought to be not just safe and comfortable but also healthy and capable of meeting or fulfilling the basic needs of human inhabitation. At the same time, the EMIs should be affordable so that the owner of the house does not have to shoulder much burden.

Therefore, it is extremely important for an architect to follow all the basic principles of design within the affordability limits of the various income groups. Size of dwelling units plays very important role in affordable housing because at the same time housing should be durable and stand once built will stand for next 30 – 40 years. Some of the more significant principles are listed as follows:

- Reducing the length of the wall as much as possible. The ratio of the perimeter to the plinth should be low.
- Going for a simplistic design with lesser offsets.
- Optimise on the number of doors and sizes of windows.
- The wet yet core areas, such as toilets and kitchen should be clubbed together.
- Reducing or eliminating altogether the circulation areas.
- Constructing common walls between two housing units.
- Optimising room sizes and heights.
- Creating multipurpose spaces.
- Using vertical spaces for storage purpose.
- Optimising the height of floor.
- Encouraging semi-finished type of construction and core housing system.
- This ensures that the house owners do not end up redoing the finishing items, such as flooring and internal wall plastering.
- Ensuring that there is no wastage of scarce building materials.

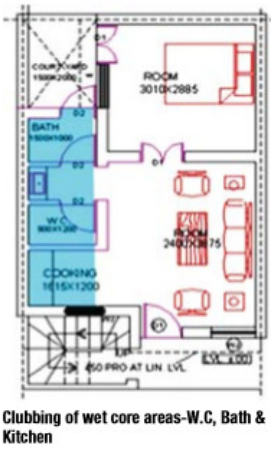


Figure 4. Layout of Individual Units
(Source- Paper by Prof. Subodh Shankar, in Architecture - Time Space & People)

User Responsive Design

After assuring the affordability aspect of the dwelling unit which include providing optimum space, optimized volume, modest basic amenities with effective cost specifications. The humane aspect i.e. user satisfaction should also be researched upon. From the point of view of the users well being physically and psychologically healthy environment is the priority for better response of different user group .This would include:

- Adequate space for different activities with appropriate location and adjacencies.
- Excellent condition of light and ventilation. Conducive private open space for family
- Incremental Housing Flexibility to adapt to activity needs in different phases of a day. This humane aspect is seen neglected and dealt very shallowly while understanding affordable housing.

Building Materials and Technology

In addition to the design and planning aspects as discussed earlier, building materials and technology also play a primary role in arriving at an affordable cost for the house. It is a known fact that building materials are largely responsible for the menace of global warming. Therefore, the building materials and technology should be selected on the basis of their present cost, as well as from the point of view of environmental sustainability and life cycle costs. The following points may be kept in mind while deciding on these aspects:

- Use materials available locally as far as possible.
- Select the materials on the basis of their life cycle costs rather than the present cost.
- Opt for the 41/2" staggered brick walling system instead of solid 9"brick walls.
- Choose Rat Trap bond walling systems.

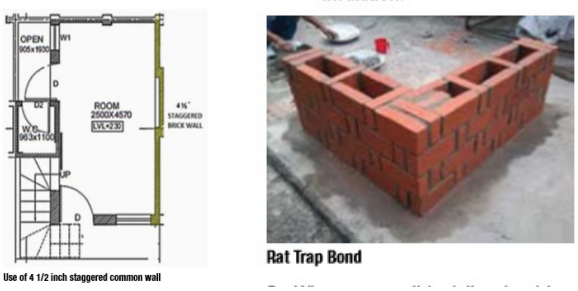
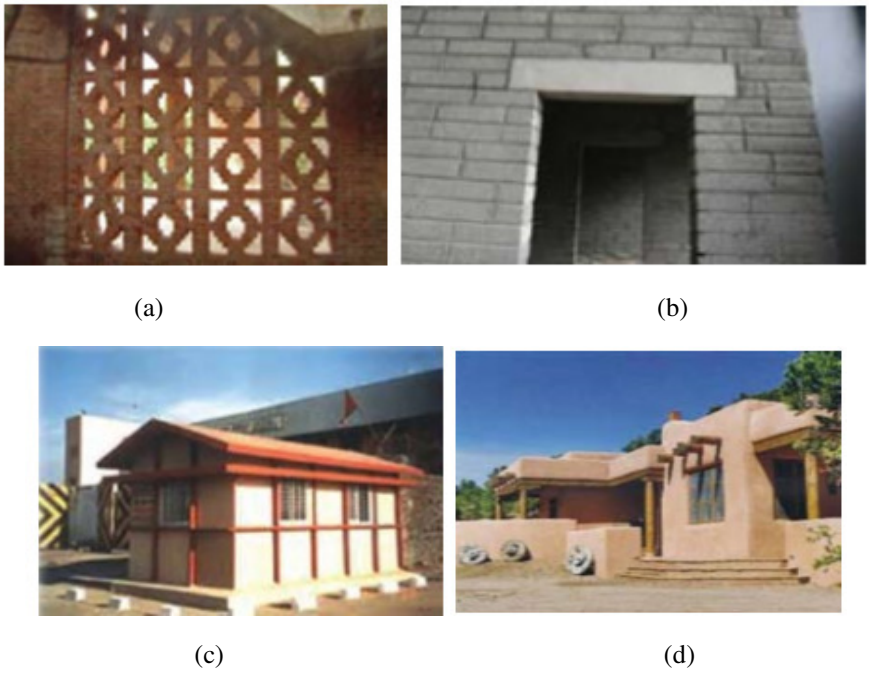


Figure 5. Left: Layout of Individual House; Right: Rat Trap Bond *(Source- Official website of Building Materials and Technology Promotion Council (BMPTC)*

The benefits of the system are as follows:

i) It helps reduce material consumption by 25 to 30 per cent.
ii) Low material consumption leads to a significant reduction in cost.
iii) It provides better thermal insulation.



(a) (b)

(c) (d)

Figure 6.(a) Jalli; (b) Precast Lintel; (c) use of Ferro cement; (d) use of clay
(Source- Official website of Building Materials and Technology Promotion Council (BMPTC))

- Wherever possible, Jalies should be used in place of windows.

The benefits are as follows:

i) They reduce costs.
ii) They enhance building aesthetics.
iii)

- Easy-to-handle prefabricated components should be used as far as possible.

The benefits are as follows:

i) This helps the standardization process.
ii) These maintain the quality of construction.
iii) These reduce the construction time.

- Encourage the use of Ferro cement.

The benefits are as follows:

i) It is light –weight.
ii) It is cost efficient.
iii) It is energy efficient.
iv) It is a green material.

- Make use of Adobe (clay) construction extensively.

The benefits are as follows:

i) It is cheap.

ii) It is eco-friendly.
- Avoid complex construction systems.
- Avoid high-rise structures. They unnecessarily increase the pro- rata cost of construction.

Finance

Housing projects require a lot of finance. Finance is not easy to arrange and can be rather expensive. Therefore, a proper financing mechanism is the backbone of any affordable housing. Without developing adequate financing mechanisms or making available special financial packages to both the developers as well as to the house purchasers, housing projects cannot aim to succeed. To curb the cost of finances, the period of construction should be reduced to the bare minimum, with the help of modern technology. The latest scientific monitoring tools should be introduced in all housing projects. There should be more flexible EMIs with lower initial installments and longer repayment periods. For people working in the informal sector, loan repayment should be facilitated on a daily basis instead of monthly installments.

Miscellaneous Costs

i) In India, the process of sanctioning building plans is a tedious and time consuming one, which puts unnecessary burden on the allottees. Therefore, there is a need to simplify this process immediately. As far as possible, pre-sanctioned building plans should be made available to the allottees at the time of giving the possession of the property.
ii) The cost of publicity of a housing project, which is ultimately borne by the house purchasers, must be kept reasonably low by the developers. Also, the costs of application forms and luxuriously printed brochures put unnecessary burden on the prospective buyers. These should also be made reasonable.
iii) In the governmental system, the administrative charges also add to the soaring housing costs—almost about 10–15 %. This should be brought down to 4–5% only by way of efficient working and reducing the typical bureaucratic approach to planning and execution.
iv) In case of private builders and developers, the profit margins are a cause of worry. But it is not known, who in this globalised open economy system, can control them or advise them to help achieve the goal of providing a shelter over every head by 2022.

CONCLUSION

Undoubtedly, shelter is one of the basic needs of every human being. In any civilised society, each and every citizen should be provided with a reasonably decent and livable shelter or housing/dwelling unit. The government of the day has to work relentlessly to achieve this goal. It is good that the present government has bound itself with a mandate of achieving this goal. If all the parameters are carefully put to practice, this goal, which appears utopian at the moment, may definitely become feasible. It would be ideal if all of us, that is, architects, town planners and engineers, could bind ourselves with the mandate of the government and ensure that each and every citizen of India has a shelter over his head by 2022.

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Design by Passive Systems: Passive Design Techniques for Enhancement of Energy Performance of the Building by Measuring the Impact of Building Envelope

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Abstract: The paper presents the use of passive techniques in architectural design to evaluate the performance of building envelope solutions, the different materials, the elements and the techniques bearing a new perspective in to the building façade that provides an environment which improves the thermal comfort inside a building. The work also presents a conceptual design strategy to calculate the building performance index using design software to facilitate effectively the challenges to bring about the changes in environment through passive technology .Further the study also emphasizes on the strategies to help in sustaining natural resources, reduce greenhouse gas effect & bringing awareness among communities to achieve an energy efficiency by making passive buildings.

Keywords: Thermal comfort, Building Envelope, Building Performance, Whole Building Energy Simulation, Shading devices, Energy efficient building

INTRODUCTION

Human development has its foundations in the manner in which energy is produced, consumed and managed. Energy serves as a significant indicator of economic development of all nations, wherein, in an effort to meet their demands, the energy sector has witnessed a rapid growth in many sectors of a country's economy - infrastructure, power, agriculture, transport, housing, construction. Buildings account for nearly 40% of energy consumed worldwide as per some reports and hence, this sector plays a key role in effective energy and climate policies. In the Southeast Asian regions, new construction of residential and commercial activities account for almost 5 % annually, compared to 2 % in other comparable countries. The International Energy Outlook 2018, EIA, reports India to be the fourth largest energy consumer in the world, soon to become the third largest. Further, it projects that among all nations, the fastest growth in building's energy consumption will occur in India, through 2040.

Of the total energy produces in India, 29% of it is used by the buildings, out of which 9% is commercial and 20% by residential [2]. It is pertinent to note that commercial buildings are on the top when it comes to energy consumption after agriculture and industry, are the third largest consumers of energy. Presently, close to around 660 million sqm. of spaces are used for commercial activities and by the year 2030, it is forecasted that it will rise to about 1,800 million sqm. and more than 70% of the commercial floor space built will be air-conditioned. Alarmingly, the EIA also projects that of the total energy consumed in India under commercial sector, Electricity proportion will rise from around 60% in 2015 to 65% in 2040.

Regulating the growth in demand for energy through energy efficiency in buildings contributes to sustainable development and in this context, the possibility of energy saving of 40 % to 60 % through alternate strategies and cost effective designs are still unexplored considering the available technologies of traditional and vernacular architecture. Passive design strategies are also amongst the many possibilities to save the buildings from consuming more power and to make them more energy efficient. Passive design is an integral part of today's architecture which is by now, widely explored and used in the current market practices.

Passive design is a design that uses natural elements, materials and climate and adopts different design strategies to take advantage to maintain or provide a comfortable temperature in the building. A passive house building is a fine example of voluntary standards for energy efficiency, to heat or cool the structure without the use of mechanical equipment and devices. Passive means are considered in place of mechanical systems that require sophisticated heating and refrigeration systems. The considerations that include right from the inception of a

building design are the design of building envelope : the form , the orientation, the selection of materials , the placements of openings , the insulation of enclosures, the installation of skylight are the few elements focused to eliminate the use of mechanical systems and to maintain a desirable indoor temperature in the building.

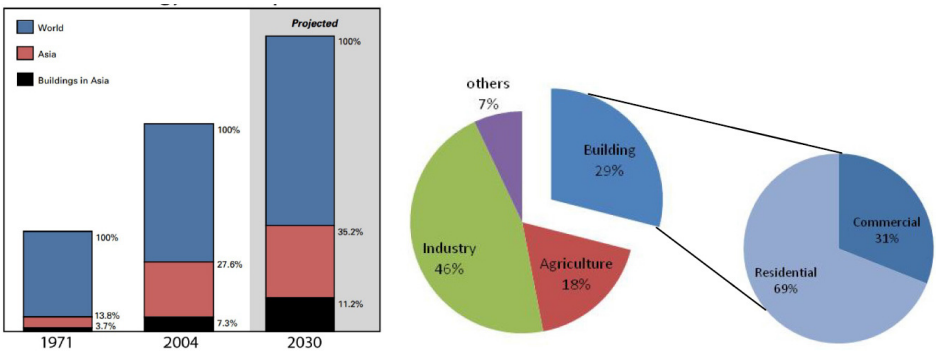

Figure 1. Left: Total Final Energy Consumption *(Source: Asia/World Energy Outlook 2006,IEEJ)*; Right: Breakdown of energy consumption pattern in India*(Source Central Electricity Authority's 'Year End Review 2012-13)*

PRINCIPLES OF PASSIVE DESIGN

Passive Design is essentially about maintaining thermal comfort by understanding local climate (micro-climate) and taking advantage of natural energy. As an approach towards environmental design, Passive Design employs several strategies that can be integrated into the buildings in various climatic conditions around the world such as building orientation and form, daylighting, shading devices, ventilation, , insulation, thermal mass. Technological interventions can also be considered to enhance these techniques and strategies (passive / active) enabling intelligent controls or simply relying on green prospects of Biophilic design to improve well-being in the built environment. This section will illustrate components of built environment that help us adopt passive designing techniques to achieve human comfort.

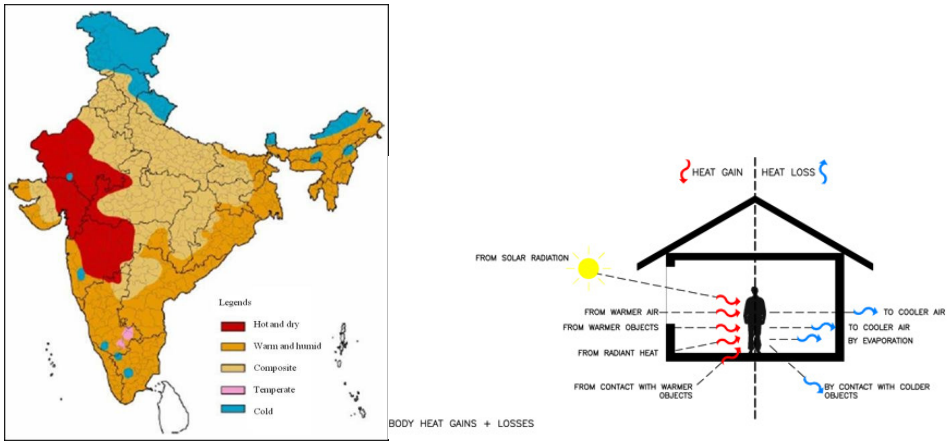

Figure 2. Left: Climate Zones of India *(Source:ECBC 2007)*; Right: Thermal Comfort through heat gain/loss *(Source: https://gruenecodesign.com.au/thermal-comfort)*

Design for climate

India being a vast country has different climatic zones which are classified into five principal zones, viz., Warm and Humid, Temperate, Composite, Cold and Hot and Dry climates. As the building energy consumption is climate dependent. The difference in these climate zones requires different principles in building envelope designs to achieve the desired thermal comfort for buildings. The ASHRAE Standard 55(2013), defines Thermal Comfort as “that condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation.” When designing a habitat meant to be occupied by people, this Thermal comfort must be an important priority. The comfort range of still air, for the Indian climate, corresponds to 22 ºC-40 ºC dry

bulb temperature with a relative humidity of 35%– 65%. Apart from these, various other climatic aspects such as radiation, vapor pressure and wind speed affect human comfort.

Orientation

An appropriate orientation of the building assists in improving thermal comfort and environmental benefits. Orientation can refer to an individual room or more significantly, the building facade. The term 'building orientation' is essentially the positioning and orientation of the building with reference to that of Sun, to gain maximize solar heat gain when needed in cold climate and to minimize solar heat gain in a hot climate. The Sun path diagram is used to track the position of Sun at a desired point of time and space, through which an optimum orientation can be arrived at. On ascertaining the ideal orientation, the heat invading into the building can then be put on check by identifying type and extent of shading, glazing, roofs, and walls. Window- Wall Ratios (WWR) can be calculated to counter the effects of inappropriate orientation.

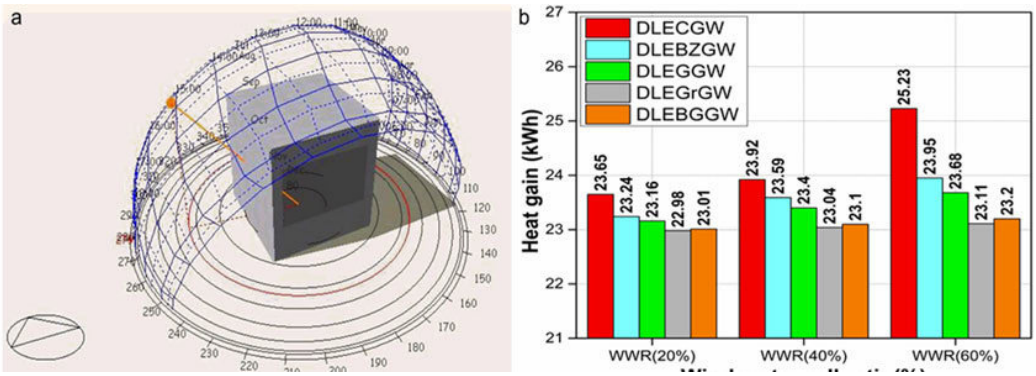

Figure 3. Left: Sun path diagram of Hyderabad on peak summer day; Right: Heat gain in buildings of Hyderabad climatic conditions
(Source:Kiran Kumar G., (2017). Investigation of Various Low Emissivity Glass Materials for Green Energy Building Construction in Indian Climatic Zones)

Thermal mass

Thermal mass properties of various building forms and construction types help in reducing energy consumption and increasing comfort. Bricks, Concrete and few other types of dense material having high thermal mass, is used in passive design, sometimes with external insulation, to absorb, store and release heat as case required during diurnal fluctuations.

Insulation

Building envelope effectiveness can be augmented through insulation by reducing loss of heat and heat gain across floors, roof and walls. The property of Insulation materials is to resist flow of heat, (the greater the R-value, the higher the insulation). The R-value differs according to material properties, thickness, and density. Insulation products vary in terms of tone and texture, surface finish, core ingredients and importantly, functionality. Materials for insulation need to be specified not just based on standard tested values but also depending on the decisions of environmental protection, durability, compatibility, installation conditions, and human health and safety.

BUILDING ENVELOPE

This paper mainly focuses on the 'building envelopes ' which play key role to accomplish the passive design strategy and curtail the unnecessary heat that comes into the building, increasing the performance of the building. The building envelope provisions are dependent on climate, thermal comfort and the architectural form varying according to the location of the place. The building envelope can mean to represent a physical enclosure that separates the interior and the exterior spaces in a building without compromising on the aesthetics and the architectural principles that are incorporated in the building design. It consists primarily of three elements: the roof, the walls and the fenestrations. The heat generated from the activities of the occupants as well as the equipment within the building affects the rates of thermal gains in comparison to external thermal loading (from

Sun and outdoor climate). The volume of the building and massing also significantly impacts the performance of building envelope.

Energy Conservation Building Code (ECBC) of India makes elaborate recommendations and prescriptive norms for the performance of a commercial building and its several components on energy usage for specific climate zones. Apart from essential building services demanded by commercial buildings such as HVAC, illumination, electrical power and motors etc, ECBC effectively addresses to a broad scope of building envelope parameters.

Roof

The SHG through the roof depends upon the climate zone the building falls into as laid out by the National Building Code of India. The orientation , the shape of the building , the insulation , reflective surface of the roof , courtyard design are the design parameters applicable to the roof design to achieve maximum U - value and minimum R value to the design[5] . It is recommended to provide strong insulation, appropriate material and optimum of thermal conductivity to ward off the higher incidence of solar radiation through the roof. Cool roofs have other benefits apart from curtailing the unwanted heat into the building, as they can minimize costs incurred on their maintenance and maintain the strength and durability of the roof. They also help in reducing the urban heat islands effect which in turn helps in prevention of global warming.

Walls

Major part of the building envelope is comprised of Walls which are exposed to great amounts of direct solar radiation. There are many proven methods to cut down on the heat flow through the exposed walls such as increase thermal mass by increasing the cross-sectional area, cavity wall, using insulating material or even a simpler solution like applying reflective paint coatings in distemper on exposed side of the walls can essentially increases the resistance to heat flow. Another effective strategy is to install wall-shading devices that reduce solar gain.

Fenestrations and Glazing

Fenestrations, glazing, windows and openings are crucial constituents of a passive building since heat loss or gain occurs mostly through windows even in a well-insulated building. A good building envelope design would help in trapping winter heat and excluding summer heat into the building. The air movement is also allowed optimum for better ventilation purposes. In order to promote heat gain in the interior of a building, Glass can be used taking advantage of its characteristic behavior that of allowing solar radiation to pass through its transparency but obstruct deep penetrating radiation. Incident solar radiation can be reduced by preventing its transmission using Double/triple glazing by layers of air gap in between. Heat gain through reflective glazing is gaining popularity in contemporary scenario as they facilitate unobstructed more particularly in situations where external shading cannot be considered. Thus the window openings or glazed surfaces substantiate a significant part of cooling load in a building.

Shading through overhangs and side-fins

A very effective way of curbing rising indoor temperatures is through external shading devices which have the ability to cut down excessive solar incidence, thus presenting the most energy efficient behavior for the building. Their advantages also rely on their means to cleverly disguise into the overall building aesthetics by integrating some façade elements based on the location of the shading element and inclination angles in the form of overhangs or inset windows [6]. Based on the operational demands, the fixed overhangs or side-fins can be made adjustable to provide benefit in both summer and winter scenarios.

WHOLE BUILDING ENERGY SIMULATION

Sustainable design and energy-efficient design in the recent times has gained mainstream interest among professionals, as a result of which, whole building energy simulation programs are increasingly employed in design phase to determine cost-effective design strategies that save energy. Currently these Whole Building Energy Simulations are an intelligent way of assessing the effect of energy efficiency initiatives undertaken for a building. Predicting the annual energy performance for a given building can be achieved through the whole building energy simulation processes which rely on the building orientation and form, its facade characteristics

and design, the building materials being used, indoor environmental conditions, weather data , HVAC and lighting system , occupant activities and schedules,. These computer-simulated programs model the detailed building models, simulating various spatial conditions, ventilation, thermal loads, and other energy intensive processes occurring inside the building to calculate energy performance. Using certain features of the simulation program, individual components such as walls, roofs, building forms, openings, glazing can be independently studied. The simulation program can be strategically employed to envisage the energy performance of the building design thus modelled by changing the set parameters.

Case-Study: Care Hospital, Gachibowli, Hyderabad-Annual Building Utility Performance Report

The aim of the current study is to compare the heating and cooling loads of a commercial building and further validate the efficacies of installing shading devices on its different facades. The study also aims to demonstrate the advantages of installing Photo Voltaic modules by utilizing the incident surface areas of those shading devices for a significant cost savings in the annual air-conditioning energy demand by the building[7]. The Building Energy Modeling was performed using the software EnergyPlus Version 8.7. The built form was being modeled in Rhinoceros Software.

Care Hospital is located at Gachibowli, Hyderabad, and Telangana, India. Latitude and longitude of the site is 17o27'N and 78o28'E. Elevation is 545m from sea level. Hyderabad city has a Tropical hot and dry climate with annual mean temperature is 26.6oC and monthly mean temperatures are 21-33oC.

CARE Hospitals Group set up this 250-bed hospital in Hi-tech City, the fast-growing IT hub of Hyderabad and went operational in 2016, offering special medical care in the Cardiac Sciences, Neurology and Renal Sciences, Oncology and Organ Transplants.



Figure 4. Care Hospital, Gachibowli, Hyderabad, Telangana

Climatic Data Summary:

As per IND_Hyderabad.431280_ISHRAE data, Site that Care Hospital is located is at Hyderabad Telangana IND for which Latitude {N 17° 27'} & Longitude {E 78° 28'} where Time Zone is GMT +5.5 Hours. The elevation of the building above sea level is 545meters and Standard Pressure at elevation is 94947Pa. Weather File Design Conditions were obtained from Climate Design Data 2009 ASHRAE Handbook.

Building Data Summary:

The total building area is 13740.89 m2 and net conditioned building area is 13740.89 m2.

Analysis of Model

Refer to Tables 1 through 6 for summary of analysis

Table 1. Climatic data of building

Heating Design Temperature 99.6% (C)	13.9°
Heating Design Temperature 99% (C)	15.2°
Cooling Design Temperature 0.4% (C)	40.2°
Cooling Design Temperature 1% (C)	39.1°
Cooling Design Temperature 2% (C)	38°

Maximum Dry Bulb Temperature (C)	41.2°
Maximum Dry Bulb Occurs on	May-23
Minimum Dry Bulb Temperature (C)	11.7°
Minimum Dry Bulb Occurs on	Dec-22
Maximum Dew Point Temperature (C)	24.6°
Maximum Dew Point Occurs on	Jun-15
Minimum Dew Point Temperature (C)	0.0°
Minimum Dew Point Occurs on	Feb-19
ASHRAE Handbook 2009 Cooling Degree-Days	6136
Weather File Cooling Degree-Days (base 10°C)	6103
ASHRAE Handbook 2009 Heating Degree-Days	0
Weather File Heating Degree-Days (base 18°C)	0
Köppen Classification	BWh
Köppen Description	Subtropical hot desert (lat. 15-25°N)
Köppen Recommendation	Unbearably hot dry periods in summer
ASHRAE Climate Zone	1B
ASHRAE Description	Very Hot-Dry

Table 2. Window-Wall ratio data of building

Area	**Total**	**North(315^0 to 45^0)**	**East($45^0$to 135^0)**	**South(135^0 to 225^0)**	**West(225^0 to 315^0)**
Gross Wall Area [m^2]	4858.6	1703.28	726.06	1703.28	726.06
Above Gross Wall Area [m^2]	4858.6	1703.28	726.06	1703.28	726.06
Window Opening Area [m^2]	2429.3	851.64	363.03	851.64	363.03
Gross Window-Wall Ratio	50	50	50	50	50
Above Gross Window-Wall	50	50	50	50	50

Table 3. Source Energy Conversion Factors Values

Site to Source Energy Conversion	**Site=>Source Conversion Factor**
Electricity	3.167
Natural Gas	1.084
District Cooling	1.056
District Heating	3.613

Table 4. Energy Savings Values before Installation

Site and Source Energy	**Total Energy [kWh]**	**Energy Per Total Building Area [kWh/m2]**
Total Site Energy	3748678.13	272.81
Net Site Energy	3748678.13	272.81
Total Source Energy	5351942.11	389.49
Net Source Energy	5351942.11	389.49

Table 5. Energy Savings Values after Installation

Site and Source Energy	**Total Energy [kWh]**	**Energy Per Total Building Area [kWh/m2]**
Total Site Energy	3308325.07	240.77
Net Site Energy	3308325.07	240.77
Total Source Energy	4888090.72	355.73
Net Source Energy	4888090.72	355.73

Table 6. Annual Load Calculations

Types of Loads	**Before Installation**	**AfterInstallation**
Cooling load	3.0885e+6kWh	2.6478e+6kWh
Heating load	1791.995 kWh	2188.707 kWh

Total Thermal load	3.0903e+6kWh	2.65e+6kWh
Total solar gain	1.2426e+6 kWh	460644 kWh
Infiltration energy	67457 kWh	67457 kWh
Mechanical Ventilation Energy	556975 kWh	550338 kWh
Operative temperature	25.146 C	24.76 C
Mean radiant temperature	26.567 C	25.835 C

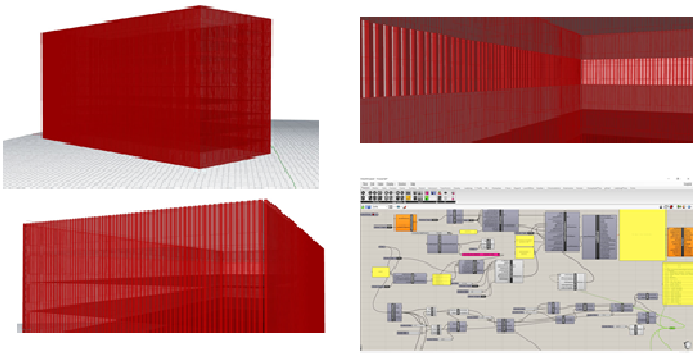

Figure 5. Screen captures from Rhino 5.0 model of the proposed Building envelope and parametric operations in Grasshopper

The Total Solar Radiation Analysis of the building will be as follows

The total solar radiation of all sides is 6.8245e+6 kWh/m2 in which Terrace is 3.4604e+6 kWh/m2,South is 1.4544e+6 kWh/m2, West is 0.6919e+6 kWh/m2, North is 0.6314 kWh/m2and East is 0.6827e+6 kWh/m2. The Annual AC energy produced by PV Modules is: 7792.74 kWh/year in which: South panels is 4018.3 kWh/year, West panels is 1922 kWh/year, North panels is 893.34 kWh/year and East panels is 959.11 kWh/year. The Total Energy Savings of building is 440700 kWh/year which is worth of INR.35.88 lakhs. (@Rs 8/- per unit).

CONCLUSION

Until recent few decades ago, nations across have shown great insensitivity towards environmental concerns and only in the recent times has the society by and large, showing will towards minimizing the carbon footprint by reducing the use of energy sources. Such irresponsible actions caused much irreversible environmental consequences owing to greenhouse emissions. In contemporary times, many of the passive design technologies have stood to offer major benefits, directly and indirectly, by providing comfort to occupants as well as contributing to great savings in energy. Mechanical ventilation for thermal comfort especially in tropical climates becomes necessary, causing rise in the building's life cycle costs [7].

This present study attempted to demonstrate the advantages of sun-screen systems by way of integrating vertical side-fins integrated with PV modules to fully glazed commercial buildings in hot and dry climatic zone such as Hyderabad. In regards to the overall efficacies of external shading devices (vertical fins) on the four sides, the before-after scenario results showed that they reduce the solar gain by 62.9% demonstrating to be the most effective for thermal comfort needs. Also, the reduction in Operative Air Temperature proportionately brought down the energy demand for Mechanical Air Ventilation.

Further, the annual Cooling Load conditions in the building reduced by 14.2% contributing to the significant saving in energy. Thus, there is an immense potential for saving energy by optimizing the building envelope design, incorporating well-conceived external shading devices integrated with PV modules, for commercial buildings in India.

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Sustainable Cities for the Future

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Abstract: "Cities are here to stay." With the ongoing trends of rapid urbanization, the United Nations predicts 68% of the world population will be living in cities by 2050. Our cities are crumbling under the pressure to provide a prosperous life for its inhabitants. It needs to be able to meet the needs of the current and future generations, without compromising on the natural environment. The future is dependent on the choices we make today in context to building design, waste-management, energy systems and transportation. We need to integrate these systems to work in harmony and cater to one another. "Think globally, act locally" needs to be the motto to drive sustainable initiatives into the future. Sustainable design is when eco-friendly practices and building technology go hand in hand. It seeks to minimize the impact of construction and change on the ecological system. The urban environment needs to be improved because cities are becoming polluted, noisy, dirty, ugly and gloomy. The quality of city life is declining. The demand for a better life is loud and clear. This paper proposes strategies and measures under broad based themes to improve city sustainability, health, environment, ecology, and economy and resource efficiency.

Keywords: Sustainable development, green spaces, transportation, waste management, policies

INTRODUCTION

Cities are the most advanced works of art of human civilization (Mumford, 1970). The Latin word for cities is 'civitas', 'civilization' and 'citizenship' is derived from the same word. Cities and society have evolved together. Cities are the centers of money and power. They inspire, they provoke. Be it the philosophy of 'democracy' or Jane Jacobs fight for inclusiveness in cities, cities can evoke political, social and economic changes.

In December 2015, The Paris Agreement reached at COP21 of the United Nations Framework Convention on Climate Change (UNFCCC) explicitly mentioned cities for the first time, recognizing the enormous impact these urban sprawls have on the future, socially and physically.

The importance of urban sustainability is now receiving widespread recognition as the prerequisite for a progressive sustainable future. However, in the concept of urban sustainability lies a double paradox. While it might seem simple to make well-resourced, orderly towns and cities in high-income countries, these have their challenges embedded in policy making, consumption patterns, lifestyle and vested interests and will require immense effort, financial and political will. But poor countries represent the ultimate challenge of widespread poverty, resource and service deficits and chronic traffic congestion are a few of the many issues resulting in poor living conditions. (Mike Jenks, Nicola Dempsey) Hence, sustainability is a global approach that needs to be addressed at the local context to best fit every city's unique situations.

THE SCENE OF CONCERN

The cities of the past two centuries have largely been shaped by the principles of modernization and development. We see their manifestation in the form of large-scale urbanization, industrialization, and focus on the rights of individual freedom. Urbanization has led to unchecked economic and population growth opening the dialogue for future developments. (Dominique Hes, Chrisna Du Plessis)

Cities will be inhabited by two-third of the world's population by 2030. Nearly 80% of global urban population is expected to be residing in cities of emerging economies. India too, has a very high migration population from rural areas moving to cities in search of opportunities.

Urban economies have created significant opportunities subsequently, exerting pressure on the limited infrastructure and resources. Cities are 'unnatural' settings that need to feed off a host environment for basic

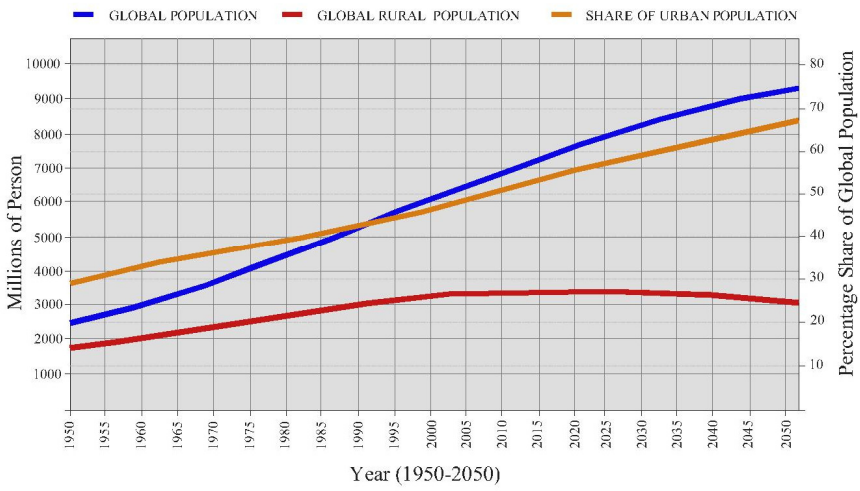

Figure 1. Population trends and projections, 1950-2050, World Economic and Social Survey 2013

supplies like food, water and material. The supplies come from neighboring fertile areas. When cities fail, their hinterlands also become wastelands. (Girardet)

In 1974, the Cocoyoc Declaration was presented to the general assembly of the United Nations by a group of scientists and policy makers, where they raised concerns on environmental degradation and rising pressure on resources. The report called for the need of developing new models of development based on alternative consumption patterns and technologies that would make it possible to meet the basic human needs for all world people. Even today the message of these early thinkers is relevant and even more urgent.

Development has rarely been considerate to the impacts it has on the environment or society. The damage is hence witnessed in large-scale financial crises to changes in global climate. The longer unsustainable development is in practice, the more extreme its consequences shall be.

Over-crowding, pollution, lack of sanitation, rise in crime rates are few piercing issues at hand. Indian cities are being crippled by congestion, pollution, informal settlements, poverty and sewerage and sanitation problems.

Cities account for 60–80% of energy consumption. More than 70% of worldwide carbon dioxide emissions are accountable for by cities that occupy only less than 2% of the earth's total lands surface.

Across the globe, social and environmental concerns are real. Cities face many challenges beyond climate change, failing transportation infrastructure, inadequate housing facilities, lack of clean drinking water, need for food, congestion and un-planned rapidly growing urban sprawls beyond the city's municipal boundary line.

SUSTAINABILITY IS THE KEY TO SUCCESSFUL GROWTH OF A CITY

Sustainable development can be defined in many ways. The definition from Our Common Future, also known as the Brundtland Report is most commonly quoted:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED, 1987)

Sustainability at its core is the ability to balance demand (consumption) and availability (resources) with concern to environment, social and economic limitations.

A high quality of life can be achieved on the foundation of urban sustainability. Sustainable cities ensure a good quality of life for its citizens by providing an environmentally friendly, socially integrated and economically balanced place to live and grow in.

Environmental sustainability can be attained through implementing effective solutions like-

- Basic standards of living – Every citizen is entitled to adequate shelter, safe drinking water, sufficient food, right to education and basic healthcare.
- Built environment – Buildings need to respond to the local climatic conditions and make use of passive and active design techniques to reduce energy consumption.
- Clean environment and waste management – A culture of recycling and reuse needs to be inculcated.
- Green Spaces – Urban green, absorbs rainfall, prevents floods, reduces noise, purifies air, reduces stress and adds to beautification of the city. Green-roofs add to the green pockets in the city. Urban farming, contributes to the food supply chain.
- Energy Efficiency – Alternative sources of energy, like solar electricity and wind power to be used. The dependency on cars for communication needs to be marginalized. Use of bi-cycles and mass public transportation to be encouraged.
- Commitment to the cause – Local governments to work with the community to implement and practice sustainable initiatives.

Many cities around the world have taken up the mandate of sustainability and are implementing innovative ideas to efficiently mitigate the cons of urbanization. National governments recognize urban areas as important nodes of growth both in terms of economy and socio-cultural centres. They are placing themselves on the path to sustainable growth by encouraging the use of public transport, providing adequate infrastructure, using alternate energy and efficient technology.

PRECEDENT STUDY

According to Arcadis, London is the most sustainable city of 2018, followed by Stockholm and Edinburgh. By 2019, London will be the first National Park City. Presently 47% of the city is parks and water bodies. This campaign will push for half of the city area to be parks and water bodies, by 2050.

Though this year's Arcadis list is dominated by European cities, cities across the globe have been consciously doing their bit towards adapting sustainable practices. Social and economic reforms are the key to sustainability efforts at Johannesburg, South Africa. Along with World Bank the city is working on urban regeneration, mixed used-projects and green space development. Mysore, India uses an intelligent transport system, where buses use best routes and times, passengers get real time information, and uninterrupted, reliable public transport is available for all. Ho Chi Minh City is a mega city in Vietnam. It is only 2 meters above seas level, forcing the government to take on an integrated strategy focusing on urban improvements, flood-risk management, and institutional reforms. (World Bank Group)

Copenhagen is a pioneer in sustainable transformations. By 2025, it aims to be the world's first carbon-neutral capital. Since 2010, green roofs have been made mandatory in Copenhagen. The city is built for biking and Copenhageners use their bike to get around for all occasions. Electric buses will replace the presently used fuel buses in 2019. Open green spaces have been integrated into the city such that 96% of its habitants can reach an open space in as little as 5 mins. The tap water in Denmark undergoes strict regulations to be of potable quality.

Singapore, Seoul and Hong Kong have been making significant efforts to adapt sustainable practices. Singapore has developed a Sustainable Development Blueprint, leading to 2030. It intends to improve its energy efficiency by 35%, buildings to be certified green buildings and houses to be at walking distances from train stations.

Governance and integrated master planning has shaped Singapore's sustainable growth. The government collaborates with the public sector and its citizens to bridge the gaps in its vision. The CBD integrates leisure activities and tourist destinations to keep the area active through all times. Lush greenery and recreational spaces integrated into residential projects, provides for better living conditions.

Public-transport and electronic rapid pricing for car's keeps a check on the number of car being used in the city. They city also encourages innovative packaging designs to keep packing waste low.

The Indian state of Andhra Pradesh has collaborated with the state of Singapore to develop a master plan for the new its new capital, Amravati.

RECOMMENDED THEMES FOR SUSTAINABLE DEVELOPMENT

There are a multiple methods of a Sustainable Development which can be from the bottom up rather than a top down method. Transportation, building efficiency, energy consumption, urban farming, waste management, water management, public spaces and parks, heritage conservation, all need to be addressed to collaborate an overall sustainable life cycle of resources and consumption. The way forward to achieve this balanced production and consumption relation is discussed below under the listed 5 themes.

- Structuring of Industries and land renewal
- Sustainable Urban planning methods and processes
- Unambiguous standards
- Integrated approach with large scale recycling
- Integration and co-ordination of all departments

Structuring of Industries and land renewal

The character and features of a city result from large-scale land use planning decisions. There is a new demand for urban housing due to the restructuring of urban economies away from the manufacturing and service sectors which is driving up the housing costs. Hence, there is a need to ameliorate the land-use planning pattern. Land reforms will also ease escalating land prices. It is more economical to move industries to the fringe areas of cities with the demand and cost of land at the core of the city rising. Economical transportation costs allows for the industrial areas to move out of the heart of the city but, location of transportation nodes and auxiliary services are still important factors affecting the choice of industrial zones.

Even at the fringe of the city the environmental impact these industries have, can be irreversible if not checked. With tighter national environmental standards being implemented industries need to monitor the emissions and waste they put out into the environment. Waste needs to be segregated into reusable or compostable or recyclable categories and disposed accordingly. Hazardous waste should be segregated from recyclable waste.

Sustainable Urban planning methods and processes

Integration of Mass-transit networks and urban amenities has balanced the sustainable growth of cities. A mass-transit system which is efficient and attractive has effectively taken private vehicles like cars off the urban roads which have resulted in less emissions and congestions. It helps reduce a city's toxic emissions and greenhouse gases by lessening single-automobile usage. Increased use of transits is a more traditional way forward. The challenge to local communities is to go beyond mass - transit in their planning and development by reducing dependency on these nodes while promoting pedestrianisation and use of bi-cycle especially at the neighbourhood level. Cities like London, Melbourne and Copenhagen are growing a culture for bicycle-users by integrating dedicated bicycle lanes into the transportation network of the city.

The green and open areas in the cities act as the lung spaces which makes it more attractive and comfortable places to live and work. The urban forests and parks serve as a filter to decontaminate dust particles caused by vehicles, industrial development, and other pollutants. They also absorb carbon dioxide, helping in purifying the air. The best of the green spaces has an element of surprise and are smaller pockets in the city that can be easily accessed by people. (Johnce Walker) In Brooklyn, the 2,000 Gallon Project diverted storm water that would overflow by planting trees and vegetation using dumpsters. The permanent solution is no doubt but planting trees. Cities like Washington, D.C and others have committed to a 40% canopy cover goal.

The most sustainable cities have recognized these benefits and included efforts to enhance mass transit and green space in their development programmes. Copenhagen's port- Ocean Quay has immensely contributed to the turnaround in urban sustainability of the city. An area of 9,900 square-meters of green roofs has been developed in the three port buildings.

These roofs grow live vegetation and as a result, the plants on the roof control noise pollution and harvest rain water. Here the green spaces and the mass transit system has been integrated.

Unambiguous standards

Design interventions cannot be implemented individually. The involvement and responsibility of the public helps in the smooth functioning of a dynamic urban setting, its economy and society which does not depend only on the vision and policies from the government. The citizens of the city need to be aware of the goals and strategies put forth by the policy makers and have to implement these so that there is a smooth functioning and implementation of the sustainable planning methods. To achieve the same result, the goals and visions need to be advertised so that the citizens and the community are aware of the same. Cities like Qingdao, China adopt goals, publicize their progress towards achieving them, and hold responsible parties accountable for their performance by excellent environmental control and management and stringent monitoring of digital information and hence achieve high standards of sustainability. Qingdao's consistent performance in wastewater treatment is due to the enforcement from Shandong province officials, who put forth waste-reduction goals for each of the one thousand highest polluters of the region and made sure they achieved it. Hence, individuals, communities and organizations need to join hands to realize and achieve sustainable development goals.

Integrated approach with large scale recycling

The best performing cities need to work on ways of reducing the volume and increase the efficiency of resource consumption. No waste should remain as 'waste'. It needs to find its way back into the life-cycle of being a commodity for use. Integrated waste and recyclable management would need customized solutions to seamlessly manage complete hazardous and hazardous waste streams. Appropriate collection methods would need to be put in place for waste collection, followed by sorting and re-cycling of waste. Continuous analysis and assessment of the process is needed to sustain quality of waste management. And most importantly the recycled product needs to be accepted and saleable product in the market. Though green commodities are gaining popularity, recycled products are still to enjoy the same kind of patronage.

Integration and co-ordination of all departments

Sustainable planning and development of a city should be a combined effort and planning by all departments concerned so that it is a wholesome approach and not an individual intervention. This gives scope for an overall development. For example a successful mass-transit project typically should include experts from the urban planners, construction specialists and also the environmentalists who will give a better perspective to the implementation and a successful operation of the project.

CONCLUSION

Could an urbanized world be ecologically sustainable?
A city responds to the raw materials it consumes and also the manufactured goods it produces with which it releases a lot of wastes and pollution. One of the appropriate ways should be the three R's- Reduce, Re-use and Recycle. The ideal way to deal with scarce resources is judicious consumption. The wastes should be reduced and the discarded should be recycled. Efficient public transport systems like the mass transit systems are another method to achieve sustainable development.



Figure 2. Left: Three pillars of Sustainability; Right: The attributes for an Ideal City

The development has to be in such a manner that we minimize the depletion of natural resources and maintain and sustain without causing further damage to the environment. It should build strong infrastructure, with an inclusive sustainable industrialization and foster growth.

Ultimately to achieve this ideal sustainable city the dimensions of social, economic and environment need to be in synergy. The big ideas of sustainability are in place, the challenge now is to bridge the gap between theory and practice.

Acknowledgement

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Architectural Geometry: Sacred, Fractal and Parametrics

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Abstract: Architecture is a term which with itself brings a thousand of words, activities, methods and phenomenon into the picture. The more you know it, the more you want to know it. Since centuries, architecture has kept ascending with time. From the ancient megalithic temples to modern contemporary buildings, Geometry has been an indispensable aspect in the field of architecture. Intentionally or unintentionally, architects, engineers and construction experts use geometry for the purpose of design, and execution of the projects. The architectural composition of a building is a result of play of geometrical shapes and their order. Harmony and beauty are ideas central to philosophy of architecture. If a building invokes positive feelings within us, it has done its task. And in this, geometry plays a great part. Every element with its different shape and proportion delivers a different aura, a different psychology. This study aims to reveal the evolution and transition of three different aspects of geometry: sacred, fractal and parametric designs with the evolution and transition of architectural designs and their construction methods. The study tries to explain and brief out the successive trend in the use and applications of these three facets: sacred, fractal and parametrics in architectural design, form and space organization and their construction and presentation methods through understanding the elements of these three and their applications in architecture.

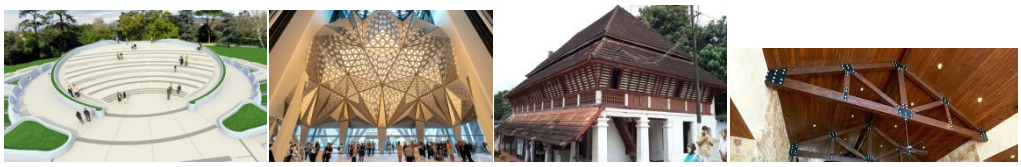
Keywords: Geometry, sacred, fractal, parametric

INTRODUCTION

Geometry is a formative idea in architecture. Since the emergence of history of architecture, geometry has been in use as a design tool. In architecture, geometry comes into use in two varied ways; one is to design and to apply the design and another is to present the design in form of presentation drawings. The latter one is in the form of perspective drawings, orthographic projections and for this the basic geometries, Euclidean, descriptive and projective geometries are used. Geometry is understood to be a constitutive part of architecture, indispensable to it, but not dependent on it. It helps us in figuring out the proportions and parameters for developing the spaces and form of a building. Through history of geometry and that of architecture there were developed some rules and standards based on geometry which formed very basic concepts for architectural composition. Generating the architectural form and space based on the geometrical rules and abstracting them within basic geometrical elements make the resulted from more understandable and recognizable.

Roles of geometry in architecture

Geometrical elements directly affect space formation and form of the building as in either conceptual and constructional meaning or it can be said that, those elements have added aesthetic, symbolic and conceptual richness to architectural design.



(a) (b) (c) (d)

Figure 1. (a) Semi Circular or arched shape of the Amphitheatre *(Source: firenzefiera.it)*; (b) The interior of Morpheus Hotel lobby *(Source: cyprusmail.com)*; (c) Pitched roof of a house in Kerala *(Source: only1degree.org)*; (d) Triangular shape of the truss supporting the roof *(Source: buildwithbmc.com)*

History of use of geometry in architecture

Men in ancient time built to accommodate his spatial needs. Royal men used buildings as a royalty. Their abodes possessed a natural geometry along with ornamental highlights.

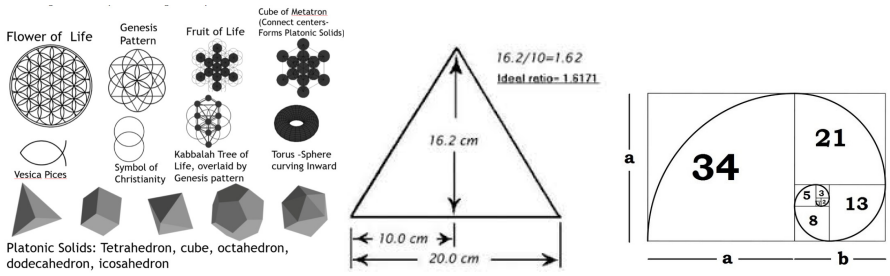
The Egyptians' Understanding of Geometry can truly be visualized in the Great pyramids of Egypt. Pyramids reflect their attempt to model their human world on "cosmic order" to indicate their stability. Geometry there was strongly related to astronomy and religion. The whole architecture of that timeline was based on "occult geometry system", which was a system of measurements, dimensions and proportion, which were considered as divine and sacred by religious leaders. In the Greek Period the tapering of columns and demonstration of proportion and visual effects of building according to the dimension of columns of different order was the main concept of building design. The geometrical and technical achievements of Gothic Period were in brief, differentiating between non-bearing walls and the bearing columns, usage of the pointed arch and vault-supporting ribs, large use of glass and tracery in various forms and shapes and development of flying buttresses.

Symmetric, inclusive geometric designs and repeating fractal-like design structures that are detailed in VaastuShastra can exemplarily be visualized in ancient Indian temples, the construction of which marks many centuries back. The planning layout, the placement of the spaces, the shapes of the entrances, 'Garbhagrihas', and the 'Mandapas' are all evolved with the help of geometrical rules and elements.

Different types of geometries are used for different purposes in architecture, may it be the evolution of the form or the presentation of the design of the structure. Sacred Geometry, Fractal Geometry and Parametric Design are three different aspects of geometry in architecture and have been the basis of design of a huge number of architectural beauties.

SACRED GEOMETRY

Sacred geometry constitutes certain geometric shapes and certain geometric proportions that have some sacred and symbolic meanings. The utilization of sacred geometry by man goes back many centuries. It has contributed to the architectural concepts in design of spires, minarets, pyramids, temples, churches, cathedrals etc. This study explains how different cultures translate their beliefs into physical structures through the utilization of sacred geometry. The patterns and rules of proportions in this geometry have been derived from the ancient Vedas and are majorly inspired by cosmologies and creation of universe. Since the very beginning of architectural history, sacred geometry has been in use. From ancient Greece and Egypt to Pompeii, a perpetual use of certain shapes, ratios and patterns that stand for a deeper religious and mathematical way, to connect to God, in ancient cultures. Sacred Geometry can be commonly visualized and recognised in several types of religious structures from temples, churches and mosques. It is expressed in the form of relief, tiles, art, design and architecture. The origin of sacred geometry is to build and design within a certain framework, which can include specific orientations, proportions and harmonic repetitions, often reflected in the natural world. Architecture and design hold the potential to enhance our spirits, upgrade our health and inspire us and revive our lives. Our perspective changes when we design by relating the spaces to the natural world and becomes in harmony with the rhythms, patterns and seasons of the earth.



(a) (b) (c)

Figure 2. (a) Vesica Pisces, its derivatives and platonic solids *(Source: www.soulsofdistortion.nl/SODA_chapter4.html)*; (b) Triangle according to Golden Ratio *(Source:malinc.se)*; (c) Fibonacci Spiral *(Source: sacredgeome--tryarchitecture.com)*

Elements of Sacred Geometry

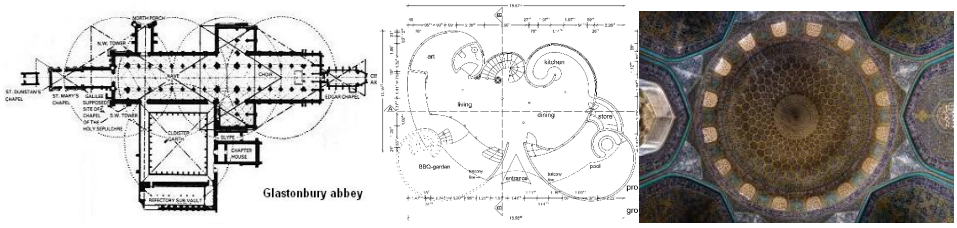
Sacred Geometry involves symbols, patterns, geometrical proportions, shapes that have been derived from nature or have some sacred meaning. It provides us with the geometric factors upon which the design of buildings is made, from both architectural and structural point of view. The proportions derived from the sacred geometry have been used in the design of number of gothic cathedrals.

These symbols, patterns, proportions, shapes can be said as the elements of scared geometry and some of them are listed below:

- Golden Ratio
- Fibonacci spiral
- Vesica Pisces and its derivatives
- Platonic solids

Applications of sacred geometric concepts in architecture

The use of sacred geometrical patterns, shapes and ratios are conveyed in the form of tiles, relief, art, design and architecture. The continuation of Vesica Pisces results in geometric matrix called 'ad Triangulum' which has been the basis of planning of many cathedrals in Europe.

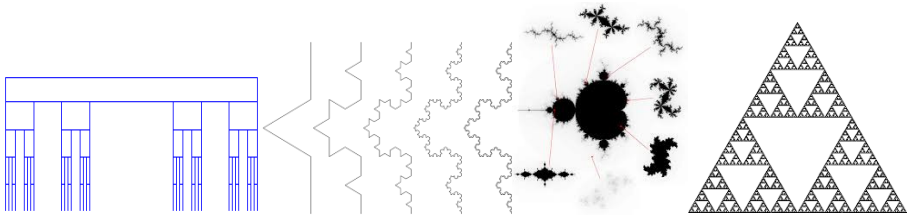


(a) (b) (c)

Figure 3. (a) Plan of Glastonbury abbey, based on Sacred patterns *(Source:* http://www.ancient-wisdom.com*)*; (b) Floor plan based onFibonacci Spiral *(Source: sacredgeometry-architecture.com)*; (c) Sacred patterns on ceilingof dome in lotfollah mosque *(Source: atlantapcc.org)*

FRACTAL GEOMETRY

Fractal geometry can be defined as the study of mathematical shapes that present a continual repetition of never ending, self-similar, sinuous details when observed more closely." Self-similarity can be described as repetition of elements that change in scale, but a similar shape is retained. It is a rare example that allows the architect or designer to present a complex understanding of nature.



(a) (b) (c) (d)

Figure 4. (a) Cantor's Comb *(Source:* mathcurve.com*)*; (b) Koch's curve*(Source:blog.zacharyabel.com)*; (c) Julia sets*(Source:paulborke.net);* (d)Sierpinski's Triangle*(Source: mathworld.wolfram.com)*

Fractals are patterns, made up of smaller-scales copied of them, possessing self-similarity across decreasing and increasing scales. In several practical applications, time and space related analysis is needed to characterize and determine the hidden order in complex patterns; fractal geometry is a suitable means for finding out about such

complexity over many scales for natural phenomena. The most important thing in aesthetics is the order in irregular pattern as it holds the concept of dynamic force, which exhibits a natural phenomenon and not a technical or mechanical process. Fractal geometry has played a powerful part in architectural design.

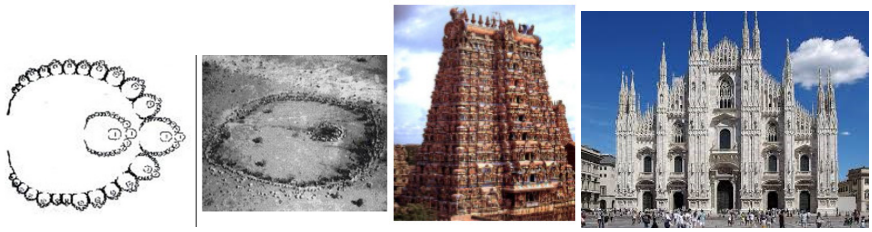
Elements of Fractal geometry

There are four basic elements of fractal geometry:

- Cantor's Comb
- Koch's curve
- Sierpinski's Triangle
- Julia sets

Applications of Fractals in architecture

In ancient architecture, the use of fractal patterns can be seen in the Maya settlements. Fractal characteristics can be recognised in few of the ancient African human settlements. An application of fractals in Europe marks the starting of 12th century. The floor of agani cathedral is decorated by serpienski gasket form of fractal patterned as a group of mosaics. The formation of spaces in a building design is a resultant of fractals as to keep the whole site in harmony, the spaces are kept similar in shape and their sizes are altered. Almost every ancient temple in southern or northern India, exhibit fractal characteristics in the 'shikharas' and the cascading floors.



(a) (b) (c)

Figure 5.(a) Fractal characteristics in ancient African settlement Ba-lla*(Source: JinuKtchley ,fractals in architecture, 2003)*; (b) Cascading floors of a South Indian Temple *(Source:archaeology-online.net)*; (c) Fractal concepts used in European Cathedral *(Source:touropia.com)*

PARAMETRIC DESIGNS

Parametric designs are the designs driven by parameters. A process based on algorithmic thinking that allows the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response is parametric design. They can start with a ordinary design-drawing or a model. The dimensions of the design are then made variable by turning them into parameters. When parameters are changed, other designs emerge, which are similar to the starting design but can vary to a larger extent and be instantly adapted according to the need. It is a design standard in which the complex geometries of the buildings and structures are changed and varied based on the relationship between its elements. Parametric design is basically generating geometry from a set of initial parameters and the design resulting from the relationship they constitute. It is about obtaining a hierarchy of mathematical and geometric relations by the utilization of algorithms and variables, that make you reach a certain design, but to find out the whole range of designs possible, that the variability of the initial parameters may allow. Parametric designs can be said as designing by going beyond geometry. With the new innovations in the design techniques, the construction of such designs has been made easier. The construction of freeform buildings, the freeform skin is based on the basic concept of parametrics.

One of the descriptive characters of parametricism is that it suggests that all elements of the design become parametrically variable and mutually adaptive. It can be said as a self-referential system, in which all the elements are interconnected and if there is a change caused in one particle due to some outside influence, alteration occurs in other.

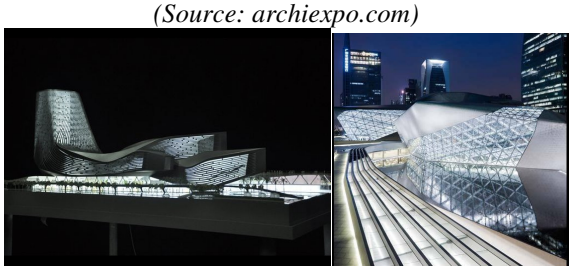
IN THE MODERN ERA

It is evident that with the time, architecture has kept varying and has grown in the terms of usage of materials, the advancement of construction techniques, and usage of computational and technological methods. Every architectural style has been witnessed by a period. Some of the styles were in practice for a limited period of time, but some of them were continued to be in practice. From Neolithic, Sumerian, classical; the most ancient styles of architecture to the post modernism, neo modernism and parametricism which are in practice from years to the present time, architecture has kept ascending. The timeline for any of these three facets; sacred, fractal and parametrics cannot be strictly defined because designs with these concepts have kept emerging with time. It could be said that the evolution of geometrical concepts has been from sacred to fractal and parametric designs. But even sacred geometrical concepts have been in practice till now, but its usage has evolved with respect to the current time.

Faisal mosque situated in Islamabad, Pakistan on the margalla hills. The mosque doesn't have a dome and is shaped like a Bedouin tent. It is surrounded by four 79m tall minarets which are an essential feature of mosque architecture.

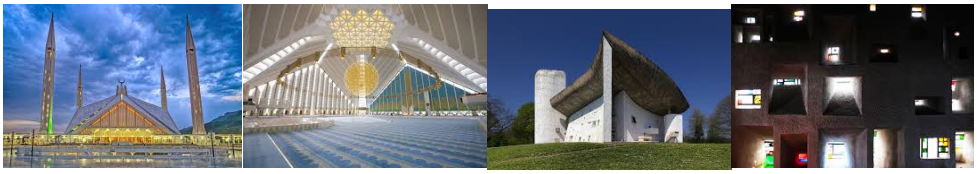


Figure 6. Roof of the Robert and arlenekogod courtyard, Smithsonian American art museum *(Source: archiexpo.com)*



(a) (b)

Figure 7. (a) Kaohsiung Port and Cruise service Center by ReiserUmemoto; (b) Gunagzhou Opera by ZahaHadid architects, China
(Source: www.huffingtonpost.com)

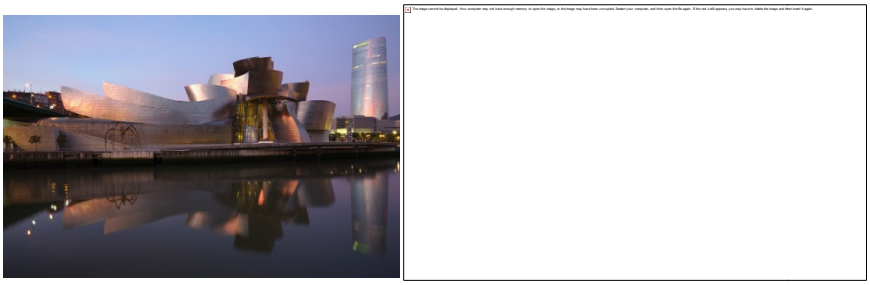


(a) (b) (c) (d)

Figure 8. (a) Faisal Mosque Islambad, Pakistan*(Source: Ali Mir Getty Images)*; (b) Interior of Faisal Mosque; (c) Chaptel Notre Dame de haut; (d) Interior of the Chapel *(Source: inexhibit.com)*

Chapel Notre dame de Haut is built in 1955 and is designed by the well-known Franco-Swiss architect Le Corbusier. It is considered to be one of his finest examples. It is a Roman Catholic chapel in Ron champ. This chapel has been described as the first post-modern building by some people and others call it as the first building of the movement Expressionist architecture. The openings were scattered randomly all around the wall, slanting towards their centres, letting in the light at different angles, which added to the sacred nature of the building.

Although the shapes and patterns used were not arbitrary, and as stated by Le Corbusier, they were derived from golden section.



(a) (b)

Figure 9. (a) Guggenheim Museum designed by Frank O. Gehry *(Source: enwikipedia.org)*; (b) Trans terminal at Tokyo, designed by Ushida Findlay partnership *(JinuKtchley, fractals in architecture, 2003)*

CONCLUSION

Although, parametricism is at boom in the modern era, sacred and fractal concepts are prevailing too. Moreover, fractal concepts in parametric models and use of sacred geometric patterns in form of relief, ceiling, etc. in the modern era buildings are noticeable. Beautiful architectural designs incorporating these mixed uses of concepts are appreciable and noteworthy.

Thus, the study states it true that an architectural style or an architectural geometry does not vanish away, it might be overshadowed, but one could always find its presence when looked upon carefully. So, these three facets of architectural geometry: sacred, fractal and parametric have been presented in different phases of time but their presence and their utilisation does not limit to a single phase, they have been continued to be in practice till date with due respect to present timeline and the other trending architectural styles.

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An Approach towards Sustainable Slum Upgradation: A case of Ranchi city

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Abstract: Slums are considered as a deprived settlement with growing population density, health and safety hazards, and the weaker economic conditions (Habitat, 2003). As per census, 2011 India has 1.3crores urban slum households which are estimated to be increased 65 million than that of 52 million in 2001.In smaller Indian cities, the population share lives in slums is around 62%. The projected population and urbanization trends show that in next two decades share of urban households would grow from 28% to around 50%. This is a clear indication of fact that the slum population might grow exponentially in urban India, if the situation is not taken care of. So, GOI is determent to remedy the situation by initiating different flagship programmes. This paper, critically analyze the initiative of GOI through an evaluation of policies in slums of Ranchi. As a matter of fact local action within the context of national policies is important for sustainable development with all three aspects of social, economic and environmental for slums up gradation. In Ranchi, there are total 17 slums with total population of around 77602 distributed in 55 wards. The paper also suggests recommendations that would help in enabling different stakeholders to play optimal role in partnership designed to make effective sustainable slum up gradation and to contribute towards the development of slum free cities.

Keywords: Slum up gradation, Sustainable Development, "In-Situ" Slum Redevelopment

INTRODUCTION

Growth of slums is directly proportional to Urbanization. These are the byproducts of infrastructural deficiencies in urban areas. Slums play a vital role in defining livability level and quality of environment in any city. On one hand urbanization is an irreversible process and on the other hand it is a necessity for progressive nations due to its direct relation to the wealth generation and contribution to regional economy. Rapid growth of population is catalyzing urbanization. It is estimated that three-quarter population of entire world will be living in cities by 2050. Out of these developing nations' share is the biggest. Presently, approx. 850 million people live in informal urban settlement around the world. But in developing countries the share will go up to 1.5 billion by 2025. The availability and growth of slums are result of not only population growth but also of the lack of access to various opportunities for dwellers.

Slums face several issues. Lack of transportation facilities, rapid population growth, poor health of people and weaker safety measures are few to name. The developing states of India are more prone to this due to increasing gap between demand of services and supply of infrastructure. In 2011 India has total 1.3 crores urban slum households which are increase 65 million than that of 52 million in 2001. In smaller Indian cities, the population share lives in slums is around 62%. The projected population and urbanization trends show that in next two decades share of urban households would grow from 28% to around 50%. This is a clear indication of fact that the slum population might grow exponentially in urban India, if the situation is not taken care of.

Alike other Indian states, Jharkhand too has similar issues related to slums. After the formation of new state of Jharkhand in 2000 the urbanization rate and growth of slums had increased rapidly. The studies and reports show that in 2001, only 11 urban centers with slums were there in Jharkhand. But in 2011, the number became 31. The population living in slums of Jharkhand faced 23.7% growth as a component of total population growth in urban areas with 32% increase.

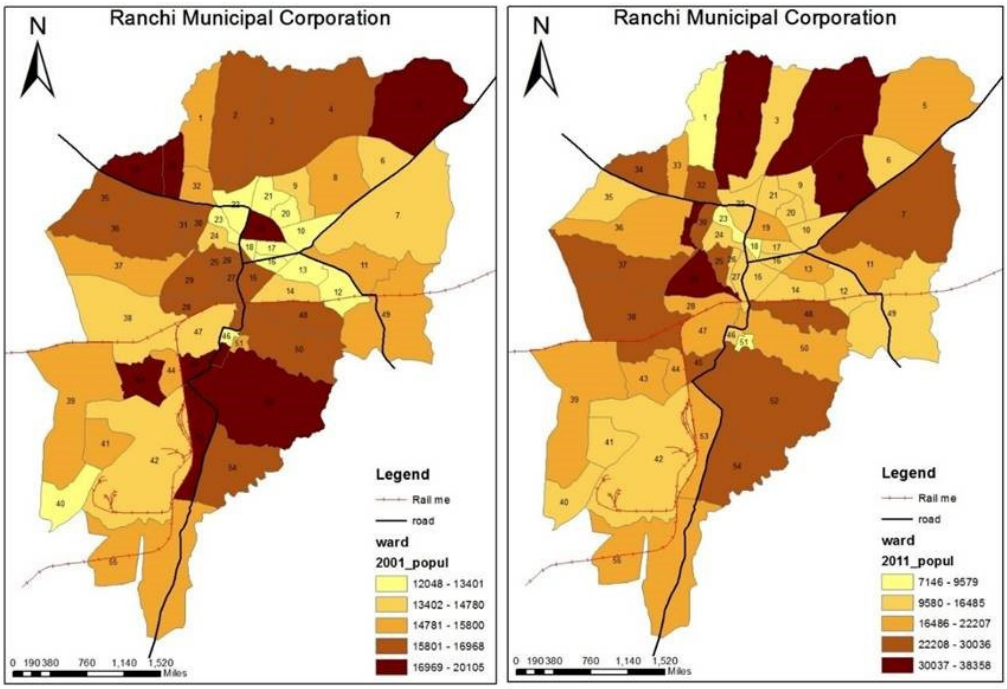
GOI is determent to remedy the situation by initiating different flagship programs. In same line, GOI launched several slums up gradation program time to time. In June 2015, Indian government had launched a mission called "Housing for All by 2022" under PMAY - Housing for All (Urban) to fulfill the dwelling requirement for urban poor.

This paper, critically analyze the initiative of GOI through an evaluation of policies in slums of Ranchi. As a matter of fact local action within the context of national policies is important for sustainable development with all three aspects of social, economic and environmental for slums up gradation. The paper also suggests recommendations that would help in enabling different stakeholders to play optimal role in partnership designed to make effective sustainable slum up gradation and to contribute towards the development of slum free cities.

Case of Slums in Ranchi

The 21st century Jharkhand sustained urbanization and population growth simultaneously. The major reason behind migration to urban areas in Jharkhand is the economic capability of large cities and their contribution to employment opportunities through better means of livelihood. Alike other Indian states, in Jharkhand too, migration played a vital in urban growth. The urban centers in Jharkhand like Ranchi, an industrial town has become the attracting points for the employment seekers. Sometimes strategically planned urbanization becomes a failed attempt due to an excessive demand for basic amenities leading to deterioration of the physical environment. Therefore, slums have emerged as an integral part of uncontrolled urbanization, which are nothing but the result of failure of governments' socio-economic policies and program. Hence, quality of life suffers due to regular in-migration and broadening gap between demand and supply of basic services and other infrastructures in urban areas. In Ranchi, there are total 17 slums with total population of around 77602 distributed in 55 wards.

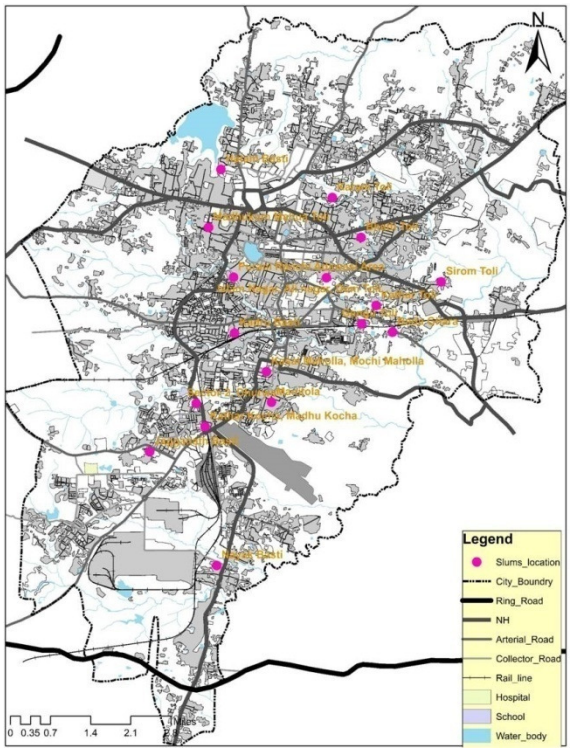
Map1 shows the ward-wise population density and their respective growth during the last decade whereas Map2 shows the ward-wise location of the slums in Ranchi.



Map 1. Ward wise population density of Ranchi city over 2001 to 2011
(Source: Census 2001-11)

JnNURM and other organization have done survey on the slum of Ranchi city. There are many studies which have been done on the feasibility of affordable housing for urban poor by various planning consultants in other states of the country. But there is lack of affordable housing project to the urban poor of Ranchi city. There are many slums up gradation schemes launched by center as well as state running successfully in the other states and many examples all over the world. Recent center scheme is PMAY for affordable housing to the urban poor. So, there is a need to examine how this scheme serves the purpose of sustainable slum up gradation to the urban poor in case of Ranchi city. This paper serves the efficiency of In-situ slum Re-development in Private Partnership in the provision of affordable housing for the urban poor along with the satisfaction level of the end user.

Figure1 shows the physical condition of the Dibdhi slums in Ranchi. The inner walk way is transforming as drainage. The surrounding is unhygienic due to lack of sewerage and solid waste management. Most of the houses are kachcha house.



Map 2. Location of Slums
(Source: Ranchi Master Plan 2037*)*



Figure 3. Physical infrastructure of Dibdhi slum in Ranchi city
(Source: Author, 2018)

THE POLICIES AND THEIR IMPLICATIONS

As stated, urbanization is not actually a problem unless it produces slum like situations in its regions. The actual problem lies in obsolete organizational structures, governing tools, inadequate legal framework related to such policies, short-sight of the decision makers and operational failures. Various times it has been observed that government leaves up gradation of slums and quality of life on foreign aid agencies' responsibilities. This volunteer approach is not well adopted. One of the reasons is rapid expansion of these slums, which means that society has no effective control over it.

Environment and physical improvement of urban slums considered as basic need from the fifth-year plan of India. In line there are many initiatives were taken by GOI for betterment of the lives of slum dwellers by giving access to physical amenities, community infrastructure and affordable housing with main focus on area rejuvenation. While having a number of schemes for slum up gradation programme with National Slum Development Programme1996 to BSUP2006 became failure due to lack of government official interest.

Recently launched PMAY-Housing for all (Urban) has unique vision to provide house to each household by 2022. One of the major components of the scheme is to take help of in-situ slum re-development. Through that government has formulated a strategic framework to give incentives to private developers for using land as a resource. This policy also comprises of a small slum up gradation dimension to involve beneficiary-led individual construction of dwelling unit.

For low risk slums, government proposed an in-situ re-development tool without considering the tenure status. The plan is to execute this policy under public-private-partnership model. Under this state government or local bodies would provide addition FSI in slum areas for re-development. This is would result in vertical growth of the sprawl within the city limits. After, vertical re-development, the balance area may be used for commercial resale by private developers. This would negate the loss incurred during the construction of dwelling units for slum dwellers by private developers and would create a win-win situation for all. Wherever this model is not possible to execute, government will share the financial implications up to 60-75%.

Various policies may attain higher efficiencies if the participation would increase of slum dwellers. By involving slum dwellers at different stages, the entire re-development and up gradation process may become more sustainable. These stages are policy formations, design, implementation, operation and management.

Table 1. Analysis of Government initiatives (Source: Compiled from various sources)

Government Initiatives	**Inferences**
NSDP (1996-2002)	Provision of community infrastructure and social amenities without uprooting existing houses avoids disturbing livelihoods saves social cost.
BSUP (2006-2012)	Provision of housing near place of occupation, utilities and active participation of slum dweller, using maximum government subsidies by them makes it cost-effective.
In-Situ Slum Redevelopment (Housing for All) (2015-Present)	Provision of quality construction for housing by giving benefits to private sector to win future bids on the basis of quality work of ongoing project. It also ensures the identity of right beneficiaries and would not disrupt livelihoods of slum dweller for long term.

ECOSYSTEM FOR SUSTAINABILITY

Ecosystem model has strategic management which is capable of better understanding how multi-sided stakeholders involve (Eisenmann, 2006). This model has potential to combine not only stakeholders but also consider different factors like environment, social and economy with their exact position in the system on the basis of their contribution. It can give therapy to poor economic growth and crucial role in sustainable development and poverty alleviation. It can help in efficient use of natural resources and is achieved by balance between socio-economic developments of increasing population with growing demands of energy and food security. It can solve problem of socio-economic and ecological challenges, what today's human facing.

In ecosystem, each factor has importance. The use of new technology in building construction and materials reduces the building cost (Mahadik, 2015). Controlled drainage system and water conservation save water for future demand (Oosterban, 2006). The use of bio gas is good for environment and cost saving and raw material is available in form of Indian household feed materials, make self-dependent for cooking gas and ministry also provide subsidy on this. In data given by Ministry of New and Renewal Energy (Biogas Technology Development Division) about 47.5 lakhs biogas plant installed in the country by 2014. As per MNRE, country

receives about 5,000 trillion kWh/year, which is much greater than the annual energy requirement. This radiation can be utilized for solar system which makes building energy efficient. Solar Street light can be used for security and night activity.

Above discussion have its positive impact on health, recreation, community, skills, environment and other services are help to make efficient use of resources which will lead economic growth, safety and security against social crimes. Initially, Slum dweller participation in economic services depends on government will, which include facilitation of training and placements; loans and technical support for self-employment and establishment of cottage industries.

Poverty divides societies and discouraging poor people participation in social and civic activities and could be influenced by socio-economic status (Baum & Potter, 2000). Socio-economic status could be gained by education and income. It is very important to make slum dweller an integral part of society. It gives a feeling of well-being. Over 62% of urban population lives in slum of these cities but have remained under-privileged. There is no doubt that regular revenue generation is required for ULB progressive growth and this will achieve by the module given in fig.-2. The problem in slum up gradation projects, most of the benefit directly goes to developer without involving the poor tenants in these benefits. Excluding of slum dweller from these benefits violating the ecosystem of city run. Researchers establish that ecosystem model is the best model for long growth and continues earning. The new technology used for physical, social and economic services. Land and tenure security play crucial role for slum up gradation environment. It gives feeling of ownership which will lead extra care of surroundings.

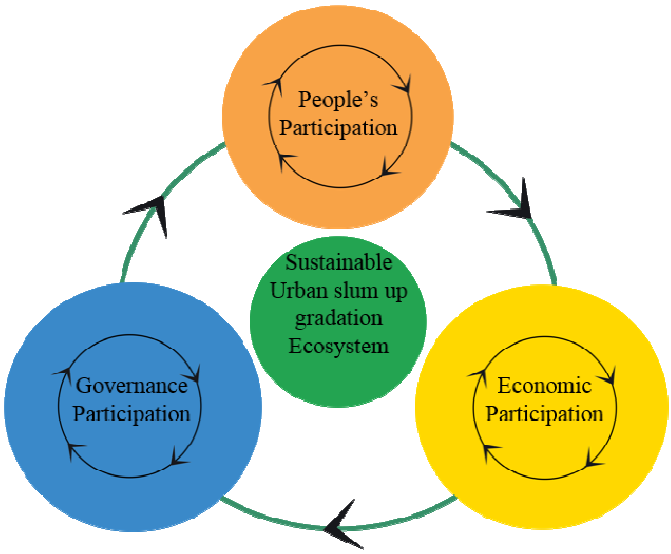


Figure 4. Ecosystem approach model

RECOMMENDATION AND CONCLUSION

In this Paper, with the help of discussion over ecosystem in sustainable slum up gradation and In-Situ Slum Redevelopment produced an enhance module of In-Situ Slum Redevelopment. The aim of this model is to justify the implication of a typical ecosystem in sustainable slum up gradation for In-Situ Slum Redevelopment. And also differentiate between various stakeholders to make an effective network system with explain the interdependencies among them. The figure 3 clearly positions the different stakeholders on the basis of their contribution.

Sustainable slum up gradation is the outcomes of efficient use of resources and it depends on the efficiency of module. This suggested model may have potential to cope the pressure of social, economy and environment in slum up gradation. To make energy efficient it is very important to use renewal energy and is cost effective as discussed above.

In case of Ranchi, utilizing digital India mission to make strong MIS system for slum dweller and categorized them on the basis of their education and skills. The combination of demand and supply bring them into this system. To win the bid, the developer must contribute to earn passive income of slum dwellers by promoting cottage industry like, organic farming on the site or market for handicraft. Initially, the project need investment from stakeholder and time to time inspection till the system is not able to generate revenue. Furthermore, slum dwellers of the suggested ecosystems are able to take decision and make it more stable by understating the role and position of their own potential as well as others.

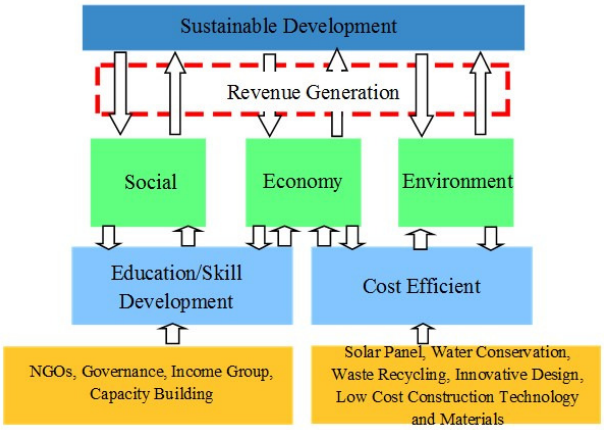


Figure 5. Recommendation for in-situ slum up gradation
(Source: Author, 2018)

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A Holistic Approach for a More Meaningful Reduction in Carbon Impacts of Buildings

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Abstract: The recent UN IPCC report on climate change gives us a narrow window of 12 years to limit temperature rise to 1.5°C and thus limit climate change catastrophe. According to the environmental advocacy organization Zero Code, the world is set to add 230 billion m² of buildings by 2060, roughly accumulating area equivalent to the City of New York to our planet approximately every 34 days. In this context, measures in buildings that reduce operational energy and carbon over the next 30-50 years, while meaningful, will only provide partial benefit when considering UN's 12-year narrow window. A more immediate impact comes from reduction of embodied carbon in buildings resulting from extraction, manufacturing and transportation of building materials and products coupled with the construction process. This paper outlines a qualitative step-by-step methodology for holistic carbon reduction in buildings that balances the short-term priority of embodied carbon with the long-term priority of operational carbon. The proposed methodology is supported by tools, resources and uses a case for illustration. Design strategies for embodied carbon reduction include reusing existing buildings where possible, choosing low-impact materials and structural systems for new construction, reducing material waste in design, and employing salvaged materials. Lifecycle Analysis (LCA) is proposed as a medium for assessing the collective impact of these strategies. Design strategies for operational carbon reduction include climate-driven passive architectural considerations, energy efficiency measures and a combination of onsite and offsite renewable energy. Whole building energy simulation is proposed as a medium for assessing the collective impact of these strategies.

Keywords: Embodied Energy, Operational Energy, Carbon Reduction

INTRODUCTION

Buildings lead global CO2 emissions, with 28% coming from building operations and 11% coming from embodied carbon (Architecture 2030, 2018). Two issues are rapidly converging to draw the attention of the architecture and construction industry to carbon emissions from buildings: Time value of carbon and the magnitude of new construction slated to happen in the near future.

Time Value of Carbon

As recently as October 2018, climate scientists at the UN Intergovernmental Panel on Climate Change (IPCC), in their report, said that there is only about a dozen years available to mankind to control the rise in temperature due to global warming to a maximum of 1.5°C. They posit that a rise of even half a degree above this threshold would put hundreds of millions of people in serious risk of extreme conditions such as floods, extreme heat, drought or even poverty (Watts, 2018). This sense of urgency necessitates the exploration by the building design industry of potential savings in carbon emissions offered by different strategies and the timeframe of those savings (Strain, 2016). The implication of this 'time value of carbon' notion is that while carbon emission reductions are valuable as a whole, reductions in the nearer term (embodied) are more valuable than reductions in the longer term (operations).

Magnitude of New Construction in the Near Future

The research of the environmental advocacy organizations 'ZERO Code' and 'Architecture 2030' find that by the year 2060, two out of three people will live in cities. To support this urban growth, 230 billion m² of building space worldwide is expected to be added by 2060, effectively doubling the global building stock through the addition of one 'New York City' every 34 days (ZERO Code, 2018). This staggering growth needs to be shaped by environmental concerns, carbon-related and beyond, before the building sector emissions are locked-in for the foreseeable future.

In the methodology section of this paper, we will more deeply explore where the carbon impacts of buildings come from and suggest a step-by-step approach for prioritizing action by the building design and construction industry.

METHODOLOGY AND RESULTS

Carbon emissions from buildings come from several different phases in their lifecycle:

- Embodied Carbon: These emissions are based on the energy used during the phases of resource extraction, manufacturing, transportation, construction, demolition, and disposal of building materials and products.
- Operational Carbon: These emissions come from burning fossil fuels to operate buildings once they are occupied upon construction completion.

Experts have proposed that embodied carbon and operational carbon together form lifecycle carbon emissions of a building (Yang, 2016). This distinction helps with understanding the different contributors to CO2 emissions from buildings and nudges us to avoid neglecting embodied carbon's role.

Design decisions, especially those taken early in the design process, have the largest impact on a building's lifecycle carbon. For this reason, the authors recommend an integrative process that relies on an analytical approach to define baseline conditions, set targets for improvements, and implement strategies for achieving those improvement thresholds. Even though quantification of emissions is possible during later stages of a project, changes to the original intent can prove burdensome and less effective.

Embodied Carbon

Based on the authors' own professional experience (Nicolow & Koti, 2018) and literature review (Strain, 2016) (Architecture 2030, 2018) for this paper, a qualitative step-by-step approach for reduction in embodied carbon would entail:

- Use or repurpose existing buildings
- When new construction is unavoidable:
    - Design for durability
    - Optimize architectural and structural systems for material efficiency
    - Understand your region and source local materials (to reduce transportation emissions)
    - Specify materials with lower energy footprint, and give preference to those manufactured with renewable energy or those that use low-emissions transportation
    - Specify salvaged materials
    - Set carbon reduction targets appropriate to your project and achieve them

Specifically, with respect to the last bullet point above, whole-building lifecycle analysis (LCA) can help establish a baseline design on top of which appropriate strategies can be applied to achieve embodied energy and carbon reduction targets. Or,whole-building LCA can help compare several design options for the most optimal option from an embodied emissions standpoint.

For example, under the US version of LEED v4 BD+C New Construction certification system's Materials & Resources category, the 'whole-building life-cycle assessment' option under the 'Building life-cycle impact reduction' credit rewards 10% reduction from a baseline building in a minimum of three of the following categories (USGBC, 2018):

- Global warming potential (GHGs), in kg CO2e;
- Depletion of stratospheric ozone, in kg CFC-11;
- Formation of tropospheric ozone, in kg NOx, kg O3 eq, or kg ethene;
- Acidification of land and sources of water, in moles H+ or kg SO2;
- Eutrophication, in kg nitrogen or kg phosphate;
- Non-renewable energy sources' depletion, in MJ.

International Living Future Institute's (ILFI) Zero Carbon Certification for buildings, among other requirements, requires an analysis of primary materials of the foundation, structure, and enclosure for a similar 10% reduction in embodied carbon emissions of the project, compared to a baseline scenario, while also

conforming with a not-to-exceed absolute emissions (ILFI, 2018). This certification has identified the following carbon calculators:

- Athena Impact Estimator
- Environment Agency's Carbon Calculator for Construction Activities
- eTool
- One Click LCA
- Tally
- Other approved comparable calculators

The free Excellence in Design for Greater Efficiencies (EDGE) software, developed by International Finance Corporation (IFC) in collaboration with Architecture 2030, claims to provide some India-specific (among a total of 144 countries) analysis capabilities in the areas of energy, water, and embodied energy in materials (EDGE, 2018). The India-specific analysis capability in EDGE appears to draw upon on a comprehensive construction materials database of embodied energy and global warming potential developed by IFC in partnership with European Union.

EDGE offers to take things step further, in India and other countries, by offering a certification to help with recognition and marketability of buildings. There are several India-specific case studies that display predicted operational energy, operational water and embodied energy savings. One such case study reviewed by the authors claims a 70% reduction in embodied energy of materials through the use of autoclaved aerated concrete blocks for internal and external walls, ceramic tile flooring and UPVC window frames.

A New Zealand study used LCA to compare global warming potential and embodied energy of four different hypothetical design options of an office building sited in the Campus premises of University of Canterbury. The four alternatives primarily differed in their use of Concrete, Steel, Timber and Timber Plus for structural materials. The Timber Plus option used wood to the maximum possible extent. Among other things the study found that the Steel building had the highest values for embodied energy and global warming potential, followed by the remaining three. However, when the full life cycle (including operational energy) was considered, the total primary energy used by the Timber building was found to be more than that of the Concrete building (John et al., 2008)

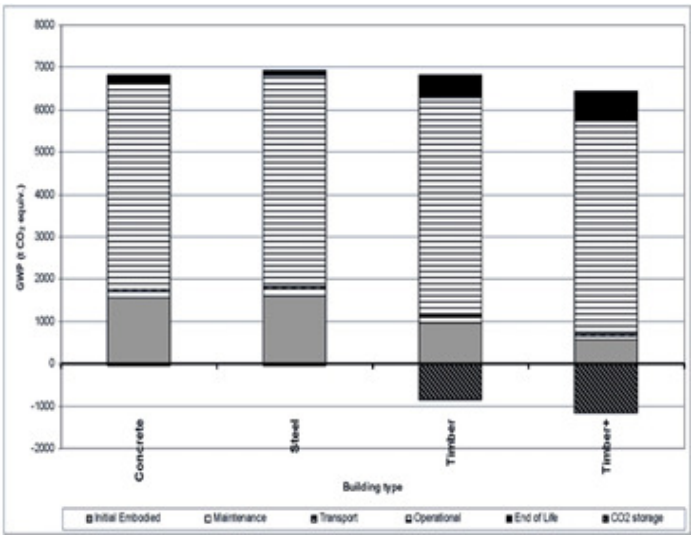

Figure 1.GWP (Tonnes of co2 equivalent) comparison from the New Zealand study
(Source: John et al., 2008)

The outcome of LCA is typically sensitive to the context of a project and the rigor of the information collection and assumptions made. The above example is for illustration purposes only and is not meant to be generalized.

Operational Carbon

While operational carbon gets greater attention in the design and construction industry, only projects that come with an owner or an energy code mandate tend to conduct whole building energy analysis to reduce operational energy and thus carbon.

ZERO Code, which aims to promote zero-net-carbon buildings on a larger scale, recommends two simple steps for immediately achieving such an end goal:

1. Design an energy efficient building compliant with the energy efficiency standard ASHRAE 90.1-2016 or equivalent at a minimum through:
   - Efficient building envelope or daylighting
   - Passive heating or cooling and ventilation
   - Efficient controls or systems or equipment
2. Address the remaining energy needs of the building with on-site or off-site renewable energy or a combination of the two.

ZERO Code fully recognizes the space constraints resulting from rapid urbanization and recommends credible pathways for off-site renewable energy where on-site renewable by itself may not be sufficient for achieving zero-net-carbon in operation.

The recently released ASHRAE Standard 209 for energy simulation-aided design proposes 'modeling cycles' aligned with various building design and operation phases, informing the choice of tools, processes, and analyst qualifications:

- Modelling Cycle1 – Simple Box Modeling
- Modelling Cycle 2 – Conceptual Design Modelling
- Modelling Cycle 3 – Load Reduction Modelling
- Modelling Cycle 4 – HVAC System Selection Modelling
- Modelling Cycle 5 – Design Refinement
- Modelling Cycle 6 – Design Integration and Optimization
- Modelling Cycle 7 – Energy Simulation-Aided Value Engineering
- Modelling Cycle 8 – As-Designed Energy Performance
- Modelling Cycle 9 – Change Orders
- Modelling Cycle 10 – As-Built Energy Performance
- Modelling Cycle 11 – Post Occupancy Energy Performance Comparison

The Bullitt Center building (Figure 2) in Seattle, WA, USA, often referred to as the greenest commercial building in the world, is a 50,000 ft² commercial building that began operating in April, 2013. It has achieved the Living Building Challenge certification after, among other things, demonstrating net positive energy performance (producing more energy onsite than it consumes on an annual basis) over a 12-month performance period.



Figure 2. Bullitt center (Lehoux, 2013)
Source: Creative commons license

Still a rarity for a majority of the buildings built today, Bullitt Center's design team employed an integrative process, whole building energy analysis, and measures similar to those recommended by ZERO Code to achieve such a high performance. Figure 3 below illustrates all the strategies employed by the design team to drive up the performance of a minimally code compliant baseline to one that met the frugal solar budget from a rooftop photovoltaic system.

The Kendeda Building for Innovative Sustainable Design, under construction at Georgia Institute of Technology in Atlanta, GA, USA, is expected to be occupied in mid-2019. It is a 37,000 ft² higher education building that has gone through a rigorous design process like the Bullitt Center. The design team, including one of the authors of this paper, employed energy analysis to assess measures down to the detail of what coffee type to serve and how the building's operating hour's impact energy performance.

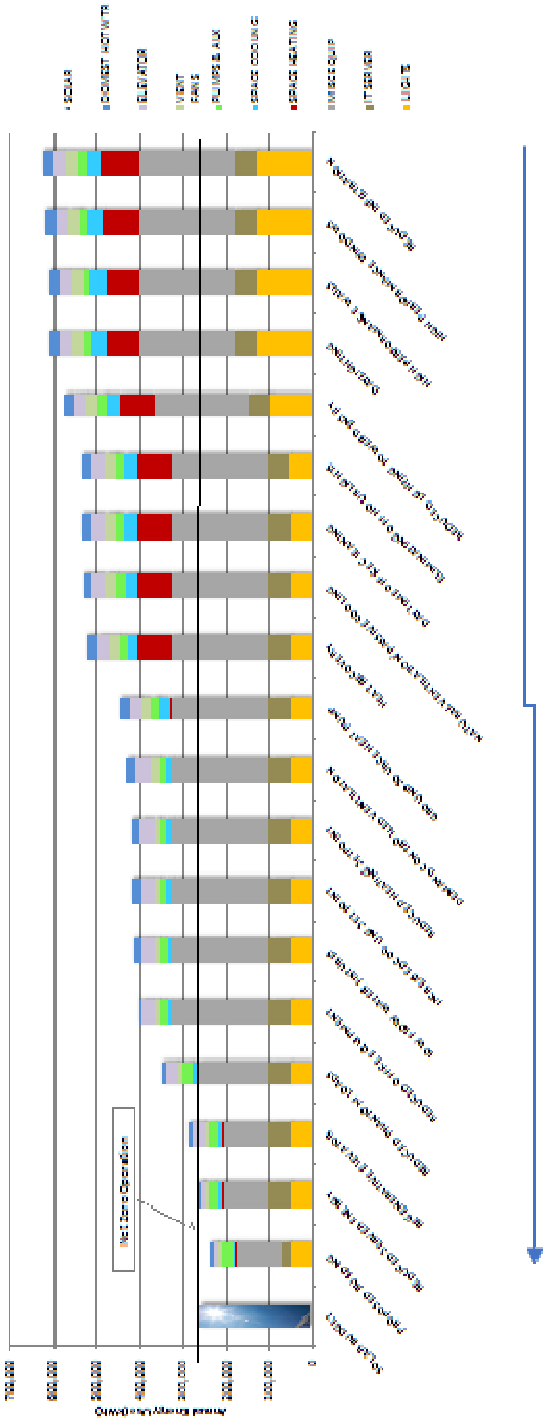

Figure 3. Bullitt Center, from right to left: energy efficiency measures employed during design that helped improve a code minimum building to match solar budget of the site leading to a net zero operation. *(Source:PAEEngineers and Miller Hull Partnership)*

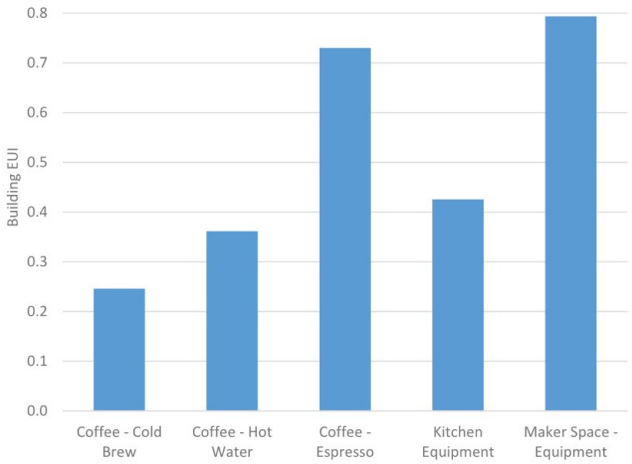

Figure 4. Kendeda building: Coffee options' contribution to predicted energy use intensity (EUI) of 32 kbtu/ft2/year

DISCUSSION

There is an urgent need for the building design as well as construction industry worldwide to act and tackle both the embodied and operational aspects of lifecycle carbon emissions from buildings, through design phase optimization. Owners can do their part by setting the right expectations during design phases and operating buildings responsibly.

Yang found that even where use of timber structure in building construction in the US initially appeared to be a silver bullet from an embodied carbon standpoint, whether the wood was sourced from replenished harvest areas and what happened to the wood at the end of life of the building (incinerated, recycled, reused, sent to landfill) varied its impact considerably. She concluded that wood is 'a' solution, not 'the' solution.

While the EDGE database and software might be more recent resources for India-specific situations, a 2001 study by scientists from Indian Institute of Science found that the soil-cement blocks and lime-pozzolana mortar were good lower energy content substitutes to burnt clay bricks and cement/cement-pozzolana mortars respectively. They have other useful recommendations such as using stabilized mud blocks as filler blocks in reinforced concrete and building with load bearing masonry where feasible in lieu of reinforced concrete structure (Reddy & Jagadish, 2003).

For operational carbon, the sources of energy play a vital role in impacting the emissions of a building and inform the conversion factors applied to a building's energy performance to arrive at the equivalent CO2 emissions.

In 2008, Harvey Bryan of Arizona University proposed a metric called Carbon Use Intensity (CUI) for operational carbon emissions of buildings, with units of lbs-CO2/ft2-year. CUI was derived after applying CO2 equivalent conversion factors to various fuel types contributing to the EUI (kBtu/ft2/year) of a building (Bryan, 2008).

Underscoring the need for a holistic approach, the Royal Institute of Chartered Surveyors (RICS), UK, recently issued a statement with requirements for and guidance on reliably assessing 'whole life' carbon emissions for buildings using a consistent methodology and assumptions (RICS, 2017). Modules broken down by lifecycle stages include:

[A1-A3] Product stage
[A4 and A5] Construction process stage
[B1] Use
[B2] Maintenance
[B3 and B4] Repair and replacement
[B5] Refurbishment
[B6] Operational energy use
[B7] Operational water use

[C1] Deconstruction and demolition process
[C2] Transport
[C3] Waste processing for reuse, recovery or recycling
[C4] Disposal
[D] Benefits and loads beyond system boundary

In the interim, where a simplified approach is warranted, building on Yang's and Bryan's work, one may use traditional tools for LCA for embodied carbon and CUI for operation carbon as follows:

Simplified Building Lifecycle CO2emissionsin lbs for design stages = (Embodied CO2in lbs.)+ (n x ft2 x Operational CUI)

where 'n' is the expected lifespan of the building in years (assuming construction and disposal related emissions are included in the embodied category).

Further refinement to the above equation can help improve how time value of carbon is accounted for, giving different and adjustable weightings to embody and operation carbon.

CONCLUSION

Time is ticking in the race to limit temperature rise due to global warming that is directly connected to carbon emissions, and at the same time, there is a significant risk from the building industry due to potential doubling of the building stock in the next forty years. This creates an urgent need to address the building industry's role holistically in terms of reduction in embodied carbon as well as operational carbon. Although operational carbon's impact will be felt over the lifespan of a building, the impact of embodied carbon appears to have a higher weighting in terms of time value. Therefore, a project-specific holistic approach is suggested to bring about a meaningful reduction in carbon impacts of buildings that includes a step-by-step approach to tackling embodied carbon using whole-building LCA, ILFI's Zero Carbon Certification, or EDGE certification, as well as reduction in operational carbon using prescriptions of ZERO Code or ASHRAE Standard 209. Comprehensive methods, such as the one by RICS above, are being developed in various parts of the world independently or in a consolidated manner for an integrated approach to reduce carbon emissions at all stages of procurement, construction, operation, and disposal. Until such comprehensive tools become a norm, the authors are proposing that a simple combination of embodied and operational carbon, arrived at with the help of existing tools and resources, be used to determine the combined carbon impact of any building, and reduction of the same.

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Towards a higher quality of built environment in the perspective of change in the urban context

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Abstract: Traditional Architecture is always unique in identity and possesses ideas in specific to the regional context. Here, the study carried is on traditional core settlement of Kanchipuram which is analyzed using random sampling method. Selected households are surveyed to reveal the design elements in built environment and its change. The paper discusses a number of social conceptual aspects that includes concept of social capital, reversing decline are applied to the present situation of Kanchipuram. It further discusses the reasons for changes which have occurred. Towards paving a way for a better quality of built environment, the paper suggests methods and processes. The design component method was suggested with social conception for the physical design. It is a micro solution providing a huge employment opportunity.

Keywords: re-construction, social capital, heritage, design component, built environment

INTRODUCTION

As an attempt to define high quality of built environment, it is the quality of the built environment to fit aptly to its context. With reference to urban inner city areas and heritage conservation the context refers to the social dimensions. The social dimensions are the individuals, families and cultural groups utilizing the built environment. The traditional urban fabric undergoes a lot of change with the pressure caused by modernism. It undergoes a physical change which in turn influences its very context.

Considering the change in the urban context there are three kinds of impacts on the building. They are

- Buildings in the inner city which are still intact
- Buildings which have undergone partial changes
- Buildings which have undergone complete changes

Thou change in inevitable, the changes caused by modernism is impacting authentic and unique built environment and associated life style.

Therefore the high quality of the built environment refers to the response to its context. It is authentic in terms of the social activities it holds, the building materials, the design and detailing. It is a natural response to the need and behaviour of the people.

The paper attempts to assess the changes caused in Kanchipuram. The paper also proposes methods, processes to bring back the higher quality in the built environment. It further suggests the role of architects and planners in bringing about the high quality.

The context of vernacular contains economic aspects embedded within the social dimensions. Hence the paper does not mention economic aspects of household separately.

The solutions suggested in the paper represent two aspects

- Conservation of existing vernacular structures
- Physical design for certain social pre-conditions for future development

The social pre-conditions considered form the basic concept behind the physical design methods suggested in the paper.

It is important to refer to the concept of social capital. A thick social capital refers to the region or community is pre requisite to good change. This social capital includes a set of social norms of conduct, knowledge, mutual obligation, expectations and trust (Andrea Colantanio and Tim Dixon, 2011).This pre-condition which is present

in the inner city enable them to carry out a number of tasks internally. Heritage conservation could also be one among those tasks.

Professionals can play a role of withstanding the external pressure of modernisation. The can also bride between the social capital and bureaucratic aspects of heritage conservation. Hence the paper refers to a social concept which is far in depth than participation and empowerment of people to carry out certain tasks.

The paper also discusses the reversing decline of the traditional zones of Kanchipuram. The paper suggests that the reversing the decline can start from the physical domain. The quality of physical domain increases with the conservation initiatives. The initiatives focus on the 'work of art' and 'wellbeing' broadly. Consequently all the other facets are also impacted positively. There is a betterment in the social front, the embedded economic front, environmental sensitization and aspects if image and identity also.

The study was carried out in Kanchipuram one of the seven important pilgrimage centres of India. Kanchipuram holds a number of prominent temples which are spiritually and historically important. The city has some functions or the other in 80% of the days in aa year. This indicates that Kanchipuram has a very thick social capital. The feasibility of implementation of conservation has a ripe potential when the importance of heritage conservation is realised by the people.

METHODS

The survey was conducted in the traditional core of Kanchipuram. The aim of the survey was to assess the scenario of change in the traditional fabric of the city. The scenario of change from vernacular to modern was termed as re-construction. The study area comprises of the PeriyaKanchi, the central processional route and ChinnaKanchi.A sample size of 103 household units were surveyed in PeriyaKanchi and a sample size of 82 household units were surveyed in ChinnaKanchi.

The forthcoming results and discussion section presents a few important relevant results. It presents more on the perceived reasoning on the scenario if change. It also discusses on the processes of design and implementation of conservation projects.

RESULTS AND DISCUSSION

The assessment revealed that 46% of the buildings in PeriyaKanchi and 82% of buildings in chinnakanchi are still intact and are vernacular. There has been changes in the settlement structure and at the level of the buildings.

The key reasons of change are

- The need for parking space for two wheelers and four wheelers
- The need for modern amenities such as air conditioner
- Need for washrooms in close vicinity to usable spaces
- Need for a compartmentalized space planning.

To a certain extend building of a number of storey and renting them was also a reason for change. The pressure from private groups involved in real estate promotion was already resisted to a certain extend by the people. However it also forms a reason for change.

The results also suggested that the fervor of socializing with the neighbors and within the society has not decreased. A large percentage of 67% of the households were owners and not rentals. These two reasons provide an opportunity which is very conducive for heritage conservation.

The thick social capital of Kanchipuram as mentioned earlier is conducive for heritage conservation. In the survey it was also observed that a need for privacy within the houses increased which has led to or which is a resultant of compartmentalized planning of houses with more private spaces. The heavy metal grills in the house fronts for the purpose of security has engulfed the 'thinnai' which were effective socializing spaces.

Towards implementing conservation measures, the role of architects, designers and planners are discussed henceforth. Certain concepts for design for the conservation measures were evolved with social aspects as the focus. The concepts holds good for the following built environments.

- Vernacular houses which has undergone partial changes
- Buildings that have changed completely
- Buildings of non-core areas and sub urban areas
- Streetscapes

The concept considers the following aspects

- Social interaction which is the key to family and social structures
- Required privacy to the right degree
- To avoid social alienation

The changes to the mentioned built environments can be brought about by not disturbing the whole fabric. It could involve a process were the designed components can be made as prototypes and induced into suitable locations in the buildings. This requires a careful understanding of the buildings structure, material strength and spatial usage aspects. The prototypes thus made could be replicated, scales and customized to buildings of different types.

The figures 1a, 1b & 1c represent certain examples of designed components as per the social concepts mentioned above.



(a)



(b)



(c)

Figure 1. (a) Design component – A seating space on looking a courtyard in the interiors; (b) Design component – Front part of the house with a thinnai, car parking children play area and an on looking balcony in the first floor; (c) Design component – A seating space abutting the main entrance to the house in the interiors

Incorporating such designed components in the buildings would pave a way for a higher quality of built environment in the scenario of change in the context of declining or non-declining urban areas.

CONCLUSION

Instead of viewing heritage as a product and tourists as consumers. The research paper manipulates the arts, crafts, traditional construction techniques incorporated into the design components as the products put forth by sensitive architects, traditional masons, labours, and craft persons. The local people could be the consumers for such products i.e design components.

The design components would also involve crafts and detailing hence forth employing a large number of people including architects and planners. Customization of the pre designed design components into a building also involves sensitive designing and applications.

Hence this method would be a micro solution towards the betterment of the built environment. There could be further research on financial sustainability and economic considerations of this solution.

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Sustainable Construction

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Abstract: The term sustainability is often misunderstood predominantly to be a synonym of 'green' or close to terms such as 'environment friendly' or 'eco-friendly', while it appears to have an immense implication that includes sustainable communities and sustainable businesses. Sustainability broadly encompasses economic, environmental and social strands. Without sustaining the economics and socio-cultural layers of the society, environmental sustainability is highly difficult to achieve, especially in developing countries. Here we shall revisit the central issues that shape up the agenda of sustainable construction.

Keywords: Sustainable development, sustainable construction, market, government.

SUSTAINABLE DEVELOPMENT

In 1950's and 1960's i.e. during the post world war period, development strategies were majorly focused on less developed countries or developing countries. Here, the development was primarily concerned with economic growth and its distribution over a period of time. This period took major strategically reference from Rostow's model of stages of economic growth. This 5 stage model (figure 1), focuses on assisting the developing nations in the course of aid and skill transfer to develop the manufacturing and industrial sector.

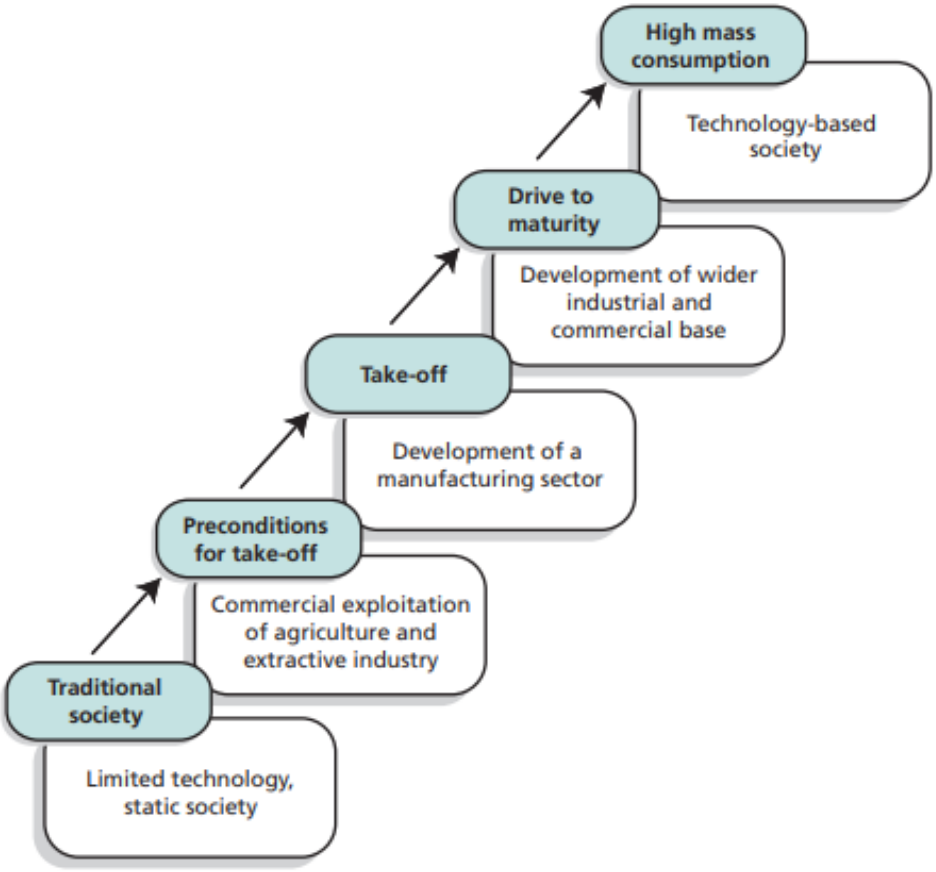


Figure 1. Rostow's model of phases of economic growth
(Source- Adapted from Elliot (1999:11); Construction Economics by Danny Myers)

Rostow's model of phases of economic growth

In 1970's environmental concerns began as world started looking at world's poor and their surroundings. Concerns regarding the deficit of hygienic environ started to seize the lime light. Now, issues related to development and environment seemed interdependent. In 1987, after the Brundtland Report by world commission, the idea of sustainable development as integrated development including equity and justice as contributing factors have been popularized. There are 3 declared interpretations of sustainable development, they are:

Three important interpretations of sustainable development		
Development that meets the needs of the present without compromising the ability of the future generations to meets theie own needs.-(WCED 1987)	Development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural built and social systems. -(ICLEI 1996)	Development that eradicates poverty, reduces inequality and makes growth inclusive, and production and consumption more sustainable, while combating climate changes and respecting a range of other planetary boundaries - (UN 2012).

Sustainable development improves the non-monetary factors such as environment, community, which in turn contributes to the improvement of general quality of life. It encompasses three strands and they are economic development, environmental development, and social development ((figure 2). The synergy between these three strands gives us positive sustainable outcomes.

Three strands of sustainability

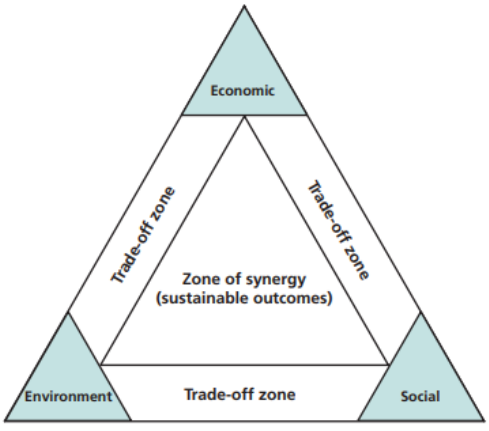


Figure 2. Three strands of sustainability
Source- Construction Economics by Danny Myers

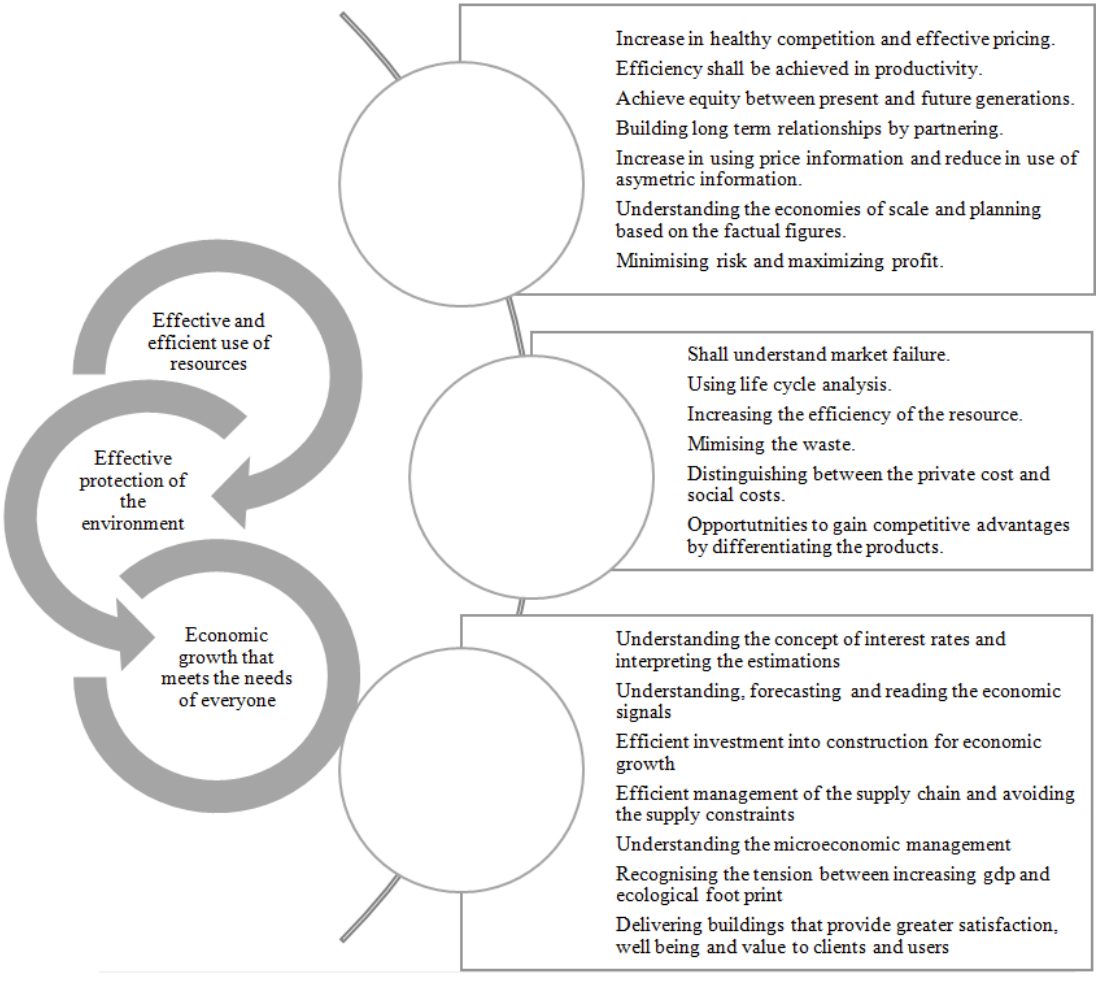
SUSTAINABLE CONSTRUCTION

Generally, construction industry is referred to as the engine of the economic growth of the country. This industry is not just important for economic growth, but is also the key to quality of life as its end products include the built environment that is the reflection of the life of people and the region. With reference to the mass balance model, it has been observed that the consumption of raw materials is very high in construction industry than any other industrial sectors. It provides huge employment and involves application of major technological solutions efficiently. Different countries define sustainable construction in their own way. Focus areas of the sustainable agenda differ from country to country based on its population, economic growth, development goals, social concerns etc…

Sustainability is a major challenge for developing countries as problems in these regions concerns with huge population that are poor, marginalized and who often live below poverty line living in slums without provision of basic facilities. Hence co working on two major concepts of 'green agenda' that deals with sustainability and 'brown agenda' that deals with development is a key challenge to the developing countries. Brown or Green single point schematic access shall not effect on the outcome of green growth. Thus, construction sectors in developing countries need to face a greater challenge as their role does not end by responding to the developmental needs such as adequate housing, infrastructure and needs of growing urbanization. It needs to react in a responsible manner both socially and economically. Du Plessis expresses Sustainable construction in developing countries as an all-inclusive process that aims to reestablish and maintain harmony between the built and natural environments and create settlements that sustain human dignity and encourage equal economic status.

	Brown	Green
Key concern	Human well-being	Eco-systemic well-being
Time frame	Immediate	Delayed
Scale	Local	Think global, act local
Concerned about	Low-income groups	Future generations
View of nature	Manipulate and use	Protect and work with
Environmental services	Provide more	Use less

Source- McGranahan and Satterthwaite (2000)



Later, the factor of climate change became an important addition to issues that has to be addressed. This led to great emphasis on concept of energy efficiency, new technological and design practices along with international targets for reduction of carbon emissions. In order to achieve the new goal, lot of complex approaches have been made that increase the complexity rather than ascertaining straight simple solutions. Simple Key ideas stand to be the reduction in consumption of resources and energy in the building industry, minimize the amount of contamination of the environs, and also revere diverse contributors of the construction process. The last factor marks as a major problematic area as the client and the contractors are often indifferent to each other's concerns

and needs. The relationship between the two parties determines the course of the project. They should together create higher standard of living and respect for all the people involved in the development from the on-site workers to the neighborhood populace at the end. There is a requirement of cost-effective way to produce and run the buildings and the infrastructure based on the concept that, with less inputs they should be able to yield more. Use of resources and technologies that are effortlessly replenished above their existence contribute positively to their environment.

Factors contributing to sustainable construction majorly revolve around three key parts, i.e,

- Effective and efficient resource usage
- Effective means of environmental protection
- Economic growth that meets everyone's needs

Role of markets

Most of the market forces are ruled by private players who are minimally governed by the rules laid by the government. This ideally leaves the question of resource allocation to the actions and choices of private individuals and companies, as they look for to make the most of their earnings as well as contentment. But this approach seems to be inefficient as the long term outlook is missing in the stakeholders owing to short term profits that create an imbalance in the economic chain in the future.

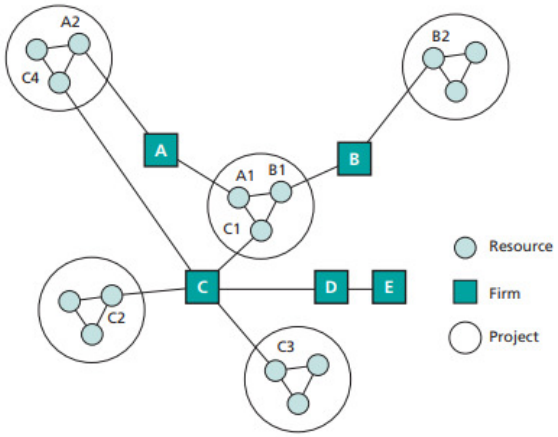


Figure 3. Role of markets
(Source- Dubois and Gadde (2002:625)- Construction Economics by Danny Myers)

Specialized literature on economics and construction suggest this to be a concept of loose and tight coupling, where construction industry is always termed as loosely coupled system. In this system very, few variables are perceived to be common in the production process as the units involved in the process most often functions independent of each other. For instance, there is huge disparity amid the manufacturing of the building materials and their application of these materials in the processes on-site. Hence, this gap requires closure and also longs a shift from conventional project-based approaches to cohesive approaches and on-site installation of the project components according to new trend (figure 3). The loosely coupled situations build primarily on imperfect information. In construction project chain, loose coupling can occur in various relationships, i.e. among individuals, at organizational level, among the sub-contractors, various consultants, most importantly between developers and users. In most cases working relationships relay upon the working that happen based on the judgment and decisions made on the conditions on site. Hence, it is very important to have trust in each other's decisions and judgments.

Another major challenge is the mind-set that fragments the responsibility of sustainable construction. There is a circle of blame (figure 4) that forms when investors, developers, clients and construction firms blame each other as to not adopting the sustainable strategy. Players who opt to relate the strategy of product delineation will be the first to break out of the circle.

The role of governments

Different countries across the globe adopt diverse strategies for sustainable construction. Strategies of developed countries address major targets and governments of these countries have potential to be a pro active influence on the issue of sustainability. Whereas the governments of developing and underdeveloped countries shall have less intervention and less interest in the issue of sustainability as the major targets regarding development of country take the lime light. Governments can make policy and make mandates but in highly populated countries monitoring its implementation is the key challenge. In such circumstances, they choose to take achievable targets which can be called as 'low hanging fruits' in other terms but still challenge remains in extending and continuing the road map.

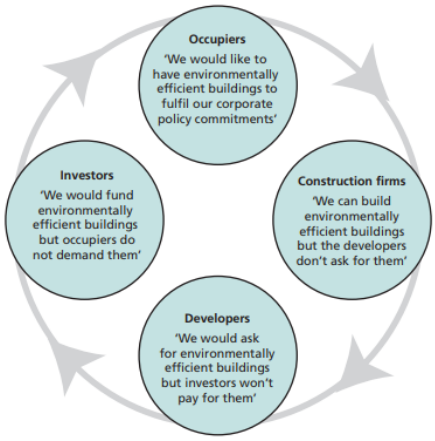


Figure 4. The circle blame
(Source- Adapted from Cadman (2000))

If we examine the role of governments, we notice the following from various sustainable initiatives taken and strategies reported that:

- Government can play a role of regulator regarding aspects of building planning regulations.
- Government can be a policy maker for issues that affect various industries for example energy efficiency, climate change, waste management etc.
- It can play role of major client in case of developing countries where there is requirement for public infrastructure facilities.

Focus on its role of client can bring major changes to the development and progress in implementing sustainable agenda. Adopting building information modeling technique on public sector can cause a drastic change in the way system progresses and achieve sustainability agenda. The building industry is characterized as having a As a result of this, construction process becomes complex. Building Information Modeling (BIM) can be visualized as one of the important tools that can bring construction team together collaboratively for an efficient work. Adapting BIM helps to put forward the probability for a real radical change in the way in which activities related to construction are accomplished across the entire supply chain. Thus, construction industry needs to follow this path extensively.

CONCLUSION

Construction industry requires a cultural shift, is something that is being spoken from numerous years but has not been implemented effectively. To achieve major sustainable goals, it is important to make the whole construction industry sustainable. Major drivers of the changes could be research, collaboration, Training, and working as team. Apart from the major drivers there could be four strategies for greening the industry for a sustainable future. They are:

Defensive option	Offensive option	Eco-efficiency option	Sustainability option
• Here regulations shall be made mandatory and output ahsll be changed to comply the regualtions. • The costs that firms incur in case of non complaince of code shall be very high.	• Strategies shall be made by firms to gain a competitive advantage by differentiating its products from those of its competitors.	• It is about designing win-win solutions by reducing environmental impacts and costs. it depends on idea of achieving value for money on a holistic and long term objective.	• This is the most difficult option as it seeks to achieve triple bottomline benefits- adressing economic viability, environmental soundness and social responsibility.

All the options are quite impactful subjected to its implementation. In case of developing countries, it is suggested to adopt each strategy in various stages as in no stage complete result can be achieved subjected to varied conditions. To start with, defensive option can play a major role as it can bring majority of the players out of the beyond compliance culture when implemented rigidly. Then it will be a mix of the offensive option and eco-efficiency option as players themselves shall start adopting one of the two as the regulations become strict and they need to make profits with in the mandate that call for innovation and research that shall help adopting the offensive option to make difference to products and some would go the eco-efficiency way to land in win situation. The sustainability way is difficult to achieve as emphasis shall shift on to environmental soundness and social benefits which do not yield great profits for business sector. But step by step we can pave way for this option as that is the need of the hour for developing countries.

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Assessing the Significance of Indoor Landscape in Built Environment of Warm Humid Climate, Chennai

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Abstract: In recent times, we must amidst that number of pressing environmental issues. Our existence progress through this worsened environment in an unethical way as a community should get started to take note of these declining issues of the habitable environment which may question our existence itself in future. Various countries and organizations have started to move towards improved environmental living conditions, practices and measures that are sustainable solutions for the current trend of deteriorating environmental quality. There are many strategies that try to resolve the growing environmental deterioration and one such influential Criteria's landscaping Indoor and outdoor urban built environment to enhance livability of built environment in Urban Environment. This paper intends to explore the Landscape applications of Residential Environment and impact caused by of landscape elements in studied case Example of Arihant Towers Chennai.

Keywords: sustainable Indoor landscape, urban built environment, Warm humid Climate with Vegetation and its impact, Chennai Arihant Towers Apartment Assessment.

INTRODUCTION

In recent years, growth in human population has transformed most of our rural sector into urban locality. This transformation has led to deforestation and destroyed agricultural sector. Deforestation and its associated aftermaths, has altered global climatic conditions resulting in uneven rainfall, drought, flood, depletion of ozone layer, water and air pollution [1-3].

As described demerits has affected the ecological cycle eventually leading to extinction of many species [4-7]. Recent study by Nyuk et.al clearly explains the significance of urban plantation on the thermal comfort of independent houses and on the surrounding environment. In this study, it is proved that the roof top gardening helps in improving the thermal comfort of individual buildings and surrounding environments [8-11]. Hence now at the whole we are in force to improve our living standards by considering ecological cycle. We need to develop city without compromising ecological needs.

Hence, we are in force to develop green buildings. Green buildings contribute major role in generation of oxygen as well as maintenance of temperature. On the other hand they also contribute major role in solid waste management and waste water recycle leading to sustainable living environment. Here in this paper we are going to analyze how green buildings play vital role in maintaining the temperature of building.

Residence BResidence A



Figure 1. Showing the elevation of Arihant Tower Residential complex with Study A & B Residences.

In this study it has been analyzed that how vegetation contribute an important role in controlling the surface temperature of the place, apart from governing aesthetical quality as well as air and noise pollution in the urban areas. Moreover it has been studied that how vegetation acts as a layer of insulation surrounding the wall and preventing the indoor spaces from various climatic conditions. The data obtained has been further taken to large

scale analysis and calculated that how entire apartment of Arihant towers can contribute in altering the microclimate of the place.



Figure 2. Showing the two different residences with Landscape and without landscape.

METHODOLOGY

To analyze the thermal quality of vegetation in the indoor spaces of warm humid climatic condition of Chennai, the surface temperature reading of two residence, one with green cover and another without green cover in the multi-storey building has been measured during the month April (peak summer) and during the month of December (comfortable winter) with the help of Infrared thermometer having instrumental error of ±0.10°C (negligible).The readings has been further taken to analyze the insulation capacity of vegetation in different Chennai climatic condition. The data obtained has been taken to analyze, how a single apartment filled with green jungle can contribute in upholding the temperature of a place in urban scenario.

STUDY AREA DESCRIPTION

The apartment is located between the busy surroundings that is opposite to central bus–terminal, Chennai. Hence entire apartment was experiencing heavy noise as well as air pollution. In this scenario the exception was Residence B, which was surrounded by flourishing green environment in the balcony, living room and bedroom (see Figure 3 and 4). Which acted as buffer zone preventing the residence from heavy pollution and at the same time it included a sustainable living condition with the existence of waste water management as well as solid waste management system.



Figure 3. Views of landscape in the semi open spaces

Different types of plants were grown such as Edible plants. E.g.: Potato's, Xeriscape Plantation, Flowering plants and Creepers. Different methods of plantation was followed such as

Growing potted plants in the lobby space as well as in balcony.

Plantation in the bamboos

Window was covered with hanging planter box

Plantation on the PVC pipes etc.

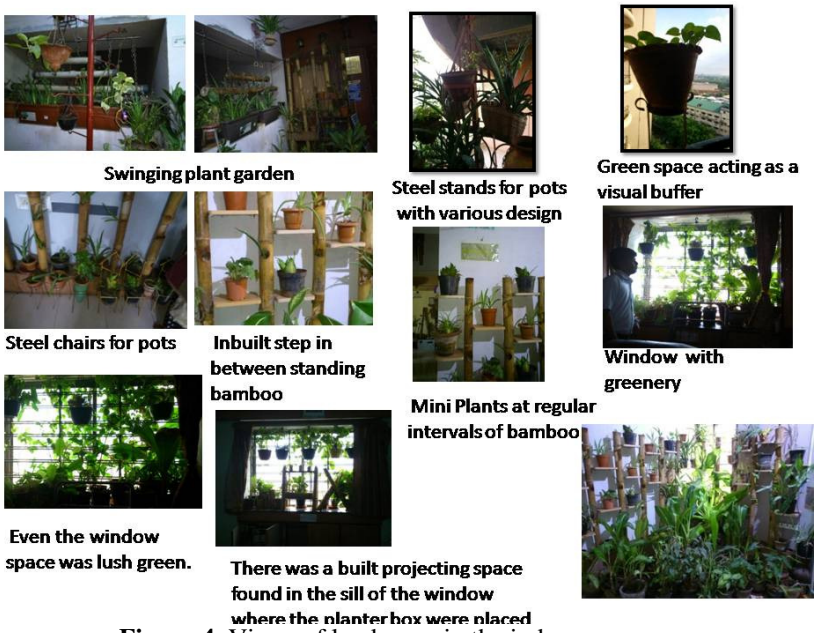

Figure 4. Views of landscape in the indoor spaces

Different type of soil condition was kept for different plants. The most commonly used soil ratio was 25% of red soil +25% of river soil + 25% of native soil of plants+ 25% of organic soil. Many plants in the bamboos and PVC pipes grew on choir that is without soil. Choir provided adequate nutrients to plants and it also supported the plants to grow well without soil by providing adequate nutrition as well as manure and by retaining moisture for longer time period. Irrigation of water was done through the spray gun. The recycled water from the kitchen and bathrooms was used for irrigation. No fresh water was used for irrigation .By this we can findthatwaste water management was done carefully in water demanding city like Chennai.

Limitation

The study is done to understand the surface temperature of landscaped building as well as building without landscape. Here the functioning of waste water recycling plant, natural lighting as well as solid waste management system has been barred. The study quantifies only temperature differences on both Indoor built environment alone.

RESULTS AND DISCUSSION

Thermal comfort for the month April'14

The temperature profiles of residence A (normal residence) and B (green house) corresponding to the month of are April'14 are compared, as shown in Table 1 and 2.The mean temperature of residence A and B calculated from Table 1 is found to be 27.5±0.10□C and 35±0.25□C respectively.

The diurnal temperature of residence A and B calculated from Table 1 is found to be 10±0.10□C and 3±0.25□C. Mean and diurnal temperature values deduced from Table 1 clearly indicates that residence B offers superior human comfort during the month of April'14 when compared to residence A. In case of residence B, the plants act as a natural air conditioning system and maintain the diurnal temperature range well below ≈3□C.

On contrast if we look into residence A, the absence of plantation significantly reduces/disturbs the thermal comfort; the same can be understood from the relatively broader diurnal temperature range ≈10□C.

Comparatively larger diurnal temperature range in residence A indicates that plantation acts as a heat exchanger convoy for maintaining the thermal comfort in residence B.Hence, plantation acts as a natural insulation for residence B and consequently controls the human comfort when compared to residence A. This can be inferred from the insulation capacity values mentioned in the Table 1. Presence of plantation increases and to certain extent maintains the insulation capacity of residence B, whereas the absence of plantation decreases the insulation capacity of residence the resulting in relatively poor thermal comfort (see Table 1).

Table 1. Temperature profiles corresponding to the month of April'14 are compared for residence A and B
Source: Author, 2014.

Alteration of temperature by entire Arihant tower in the urban scenario

Average Mean Insulation capacity of vegetation from morning 6am till evening 6pm is 21.47□C for a single residence. Arihant towers consist of 204 residences approximately in 17 floors in 12 wings. If every residence is filled with green jungle then total insulation capacity of vegetation will be 43.78% of the total ground area of Arihant towers during summer season.

Vegetation in the indoor as well as semi-open space a can contribute in alteration of temperature of a place up to the extent of approximately 43.78%, preventing from warm humid climate. There may occur further variation in temperature change based on variation of floors and building materials used in the residence.

Table 1. Temperature profiles corresponding to the month of April'14 are compared for residence A and B				
Temperature During the Month of April'14				
Time	Residence A (in degree Celsius)	Residence B (in degree Celsius)	Temperature Difference A-B (in degree Celsius)	Insulation Capacity of residence B (%)
6:00	29	26	3	10.34
7:00	31	26	5	16.13
8:00	33	27	6	18.18
9:00	35	27	8	22.85
10:00	37	28	9	24.32
11:00	38	28	10	26.31
12:00	39	29	10	25.64
13:00	38	29	9	23.68
14:00	38	29	9	23.68
15:00	37	28	9	24.32
16:00	36	27	9	25
17:00	34	27	7	20.59
18:00	33	27	6	18.18
Mean	35±0.25	27.5±0.10		21.47

Thermal comfort for the month Dec'14

Table 2. Temperature profiles corresponding to the month of December'14 are compared for residence A and B				
Temperature During the Month of Dec'14				
Time	**Residence A (in degree Celsius)**	**Residence B (in degree Celsius)**	**Temperature Difference A-B (in degree Celsius)**	**Insulation Capacity (%)**
6:00	22	24	-2	-9.09
7:00	22	24	-2	-9.09
8:00	23	25	-2	-8.69
9:00	24	25	-1	-4.16
10:00	25	25	0	N.A
11:00	26	26	0	N.A
12:00	27	26	1	3.70
13:00	27	26	1	3.70

14:00	26	25	1	3.84
15:00	25	25	0	N.A
16:00	25	24	1	4.0
17:00	24	24	0	N.A
18:00	23	24	-1	-4.34
Mean	**24.5±0.25**	**24.8±0.10**		

Table 2 shows the temperature profiles of residence A (normal residence) and B (green house) corresponding to the month of Dec'14. The mean temperature of residence A and B calculated from Table 2is found to be 24.5±0.25□C and 24.8±0.10□C respectively. The mean temperature of residence A and residence is almost equal. The diurnal temperature of residence A and B calculated from Table 2 is found to be 4±0.10□C and 2±0.25□C. Diurnal temperature values deduced from Table 1 clearly indicates that residence B offers superior human comfort during the month of Dec'14 when compared to residence A.

CONCLUSION

This paper discusses the influence of plants on temperature in indoor environment of warm humid climatic condition, Chennai. The residence with plantation results in better indoor comfort during Apr'14 and Dec'14. As stated by the ASHRE standard 55 for NVB's. During Apr'14, the residence containingplantation (residence B) resulted in superior insulation capacity than the residence without plantation. In the case of residence B, the plantation acts as natural air conditioning system and maintains indoor Environmental comfort under considerable condition. During Dec'14, the same residence with plantation acts as a natural dehumidifier and maintains human comfort. From the data obtained, it has been found that if entire apartment is covered with green vegetation, then it can modify the temperature of place up to 43.78% during summer.

So we conclude from our study that, plantation in buildings adds a significant value to human comfort than residence without plantation. Specifically in growing rate of population and vehicular accesses in urban sectors which creates pollution will be reduced by means of vegetation in indoor built environment also reduces temperature considerably. Therefore, Plantations acts asinsulation layer against human discomfort irrespective of warm humid climatic condition of Chennai can also be incorporated in various new developments of residential towers to reduce extreme heat during summer.

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Daylight Glare and its Share in impeding classroom performance: A Descriptive analysis with reference to selected schools in Tiruchirappalli.

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Abstract: The prime objective of the study is to examine the role of daylight glare in determining the performance of the students in the classroom of selected primary and middle schools in Tiruchirappalli. This study attempts to identify certain classroom activities that are deterred by the daylight glare experienced by the students in classrooms. This study analyses different type of discomfort glare probability that cause visual fatigue and to study the identified tasks performed in specific daylight conditions. The study results indicate the prospect that daylight glare is a definite element in causing discomfort among the students while performing various classroom tasks. Thereby, this study suggests that daylight glare causing discomfort in the classroom can be addressed by design articulation and selecting appropriate physical attributes of the classroom.

Keyword: Daylight glare, discomfort glare probability, disability glare probability, visual fatigue

INTRODUCTION

"Daylight is essential in daily life for sustainable living and eases the occupants in buildings. Nevertheless, light is crucial for our vision. The objects are seen around us when light bounces off them and enter our eyes thereby, 85% of our learning happens through this sense modality. Consequently, daylight is the source of life and sustained learning for humankind takes place right from our childhood to final stage in life. Most of our systematic learning during childhood happens in a structured environment called classrooms in schools at many levels. However, the learning depends on various aspects in the built environment and one definite critical and sustainable element is the daylight. But sometimes, the amount (greater than about 10,000cd/m2) of light can impede our vision and cause a state called glare. Depending upon the nature of discomfort it produces, the glare is divided into two: i) Discomfort Glare – it refers to the discomfort without decrease in vision. ii) Disability Glare- it refers to discomfort with certain amount of loss in vision. This study attempts to examine the share of daylight glare in obstructing the activity, function and the visual performance of the students in selected classrooms so that insights can be inferred for future sustainable design of classroom. Feasibly, it examined a set of four variables which are the common elements of learning activity in a typical classroom. They are as follows: i) daylight glare and its impact on classroom comprehension. ii) daylight glare and its impact on Color recognition ability, iii) daylight glare and its impact on sensory learning and iv) daylight glare and its impact on developing skills.

Research questions

- Does the daylight glare impede the comprehending ability of the students in the classroom?
- Does the daylight glare affect Color recognition ability among of the students in the classroom?
- Does daylight glare cause visual fatigue which in turn affects the sensory learning of the students in the classroom?
- Does daylight glare impede the developing skills of the students in the classroom?

Objective

- To examine the share of daylight glare in impeding comprehension among students in classroom.
- To prove the role of daylight glare in impeding the Color recognition ability among the students in the classroom.
- To demonstrate the role of daylight share in the sensory learning through visual fatigue of the students in the classroom.

- To examine the impact of daylight glare in impeding the developing skills of the students in the classroom.

LITERATURE REVIEW

Glare is a condition where there will be persistent discomfort accompanied by loss of vision or without the loss of vision. CIE [Commission Internationale de L'Eclairage, 1995] has contributed to daylight studies in different conditions and made several inferences pertaining to glare and its properties. R. Hopkinson (1972) has studied the light intensity and the change in brightness shall affect the vision to certain levels. Since daylight is natural it has certain qualities that support life, productivity and energy savings too. (Reinhart,2002). Adequate use of daylight allows one to save not only on electricity consumption and reinforce sustainability in practice, but it instigates people to perform better, when exposed to daylight. (Boyce,2003) on the contrary, inadequate daylight shall affect the performance of the occupants at physical level, perceptual level and conceptual levels. If there is daylight deficiency, it could disturb the mood, fertility and the normal rhythm of the occupants. Glare depends on the following: i) light source, ii) angle, iii) line of sight, and adaptation of the observer

The lists shown below are some of the discomfort – glare indices:

- Daylight Glare Index (DGI) [Chauvel, J., Collins, B., 1982. Hopkinson, R.G 1972]
- CIE Glare Index (CGI) [Einhorn, H.D., 1969 , Einhorn, H.D., 1979]
- Unified Glare Rating (UGR) [CIE (1992)]
- Predicted Glare Sensation Vote (PGSV) [Tokura, M., Iwata, T. 1996, Tokura, M., Iwata, T. 1993]
- Daylight Glare Probability (DGP) [Wienold, J., 2003]

Glare can be classified into several different types including 1) Disability, 2) Discomfort, 3) Scotomatic (photo stress), 4) Dazzling and 5) Dysphotopsia. This study will focus only on the disability glare and discomfort glare.

A decrease in visual performance may be caused due to surface reflections or bright luminance sources creating increased forward scatter of light within the eye. as a consequence of light exposure which does not necessarily impair object visibility.

Scope and limitation

- The study is focused on the descriptive analysis of glare with reference to: i) discomfort glare and ii) disability glare in affecting the visual performance of the students in classroom environment.
- The study sample is from a small target group of students studying primary class to high school in Trichy District.

Research hypothesis

H1: Daylight glare is strongly associated in impeding the comprehending ability of the students in the classroom

H2: Daylight glare is strongly associated in impeding the Color recognition ability among the students in the classroom.

H3: Daylight glare is strongly associated in impeding the sensory learning through visual fatigue of the students in the classroom.

H4: Daylight glare is strongly associated in impeding the developing skills of the students in the classroom.

METHODOLOGY

In order to understand how daylight glare is affecting the learning activities of the students in the classroom both boys and girls studying in primary and high school level students in Trichy district were selected with a total of 125 students were observed and Table 1 Shows the sample distribution at two different schools (see Figure 1& 2) in Trichy district. Semi-structured interviews of the participants (includes both genders) were conducted to formulate effective survey questionnaires (see Appendix-I) focusing the following i) Daylight glare and its impact on the comprehending ability of the students in the classroom, ii) Daylight glare and its impact on Color recognition ability among of the students in the classroom: iii) Daylight glare and its impact on Color recognition ability among of the students in the classroom. iv) Daylight glare and visual fatigue affecting the

sensory learning of the students in the classroom. Consequently, survey was conducted among students of both genders. For each variable (learning activity) two questions were constructed on a 5-point scale and the scores are analysed. The results of the survey suggested useful data about the share of daylight glare in affecting the various learning activities among the students of selected levels.

From our study data, it is demonstrated that Daylight glare has significant share in impeding students' performance in the classroom.

Table 1. School wise Distribution of respondents for the survey

	School # 1	**School # 2**	**Total no. of students**
No.of boys	31	42	73
No.of Girls	22	30	52

Table 2. Daylight Glare Probability (DGP) [Wienold, J., 2003]

Glare rating	DGP value
Imperceptible	0.33
Perceptible	0.38
Disturbing	0.42
Intolerable	0.53

Table 3. The Value of Discomfort Glare Probability (DGP) for different activities in classroom @ School # 1

Activity affected by Daylight Glare	**DGP value**	**% in classroom**
Comprehension in classroom	0.45	45
Color recognition ability	0.54	24
Sensory learning	0.39	18
Developing skills	0.39	13

Table 4. The Value of Discomfort Glare Probability (DGP) for different activities in classroom @ School # 2

Activity affected by Daylight Glare	**DGP value**	**% in classroom**
Comprehension in classroom	0.45	52
Color recognition ability	0.54	28
Sensory learning	0.39	12
Developing skills	0.39	8



Figure 1. The view of the classroom in School # 1 @ Trichy



Figure 2. The view of the classroom in school # 2 @ Trichy

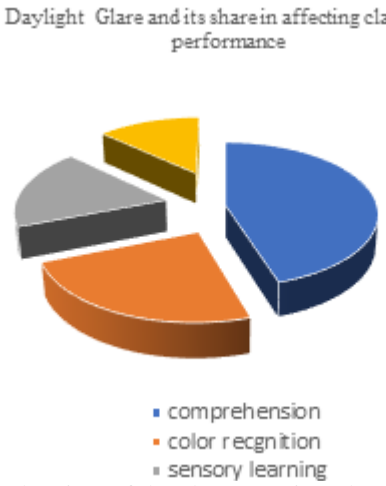

Figure 3. The view of the classroom in School # 1 @ Trichy

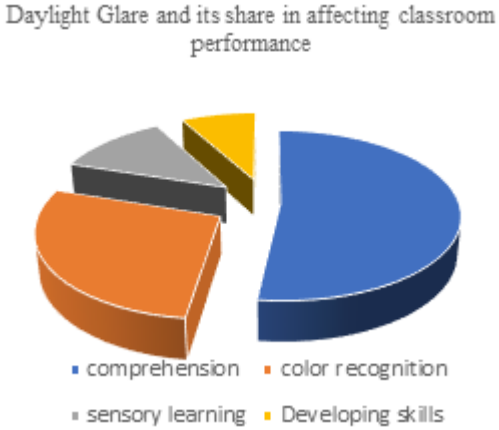

Figure 4. The view of the classroom in school # 2 @ Trichy

RESULTS

The data is analysed with the scores obtained and results are shown descriptively in Figure 3 & 4, through pie diagram. From the results of the daylight glare studied in selected school classrooms it is evident that the daylight Glare has a significant share of 45% impact in impeding the comprehension of the students in the lessons at classroom of the school # 1 (see Figure: 1). Likewise, it has a significant share of 52% impact in impeding the comprehension of the students in the lessons at classroom of the school # 2. (see Figure: 2). Whereas the Color recognition activities of the students in the classrooms were affected by Daylight glare at 28% and 24% in the school #1 &# 2 respectively. Consequently, the other learning activities like sensory learning and developing skills are affected by daylight glare is less significant though they are within the perceptible value of discomfort. Thus, the Hypothesis H1 & H2 are strongly supported by the study results proving that the existing Daylight glare in the classroom has significant share in impeding a range of learning

activity among students in classroom of selected schools. Hence, it is manifested that appropriate design for daylight conditions will definitely support and promote energy saving & sustainable living environment.

FUTURE DIRECTION OF STUDY

Daylight Glare and its impact on certain learning activities can be studied in different contexts by adding various architectural features encompassing wide range of activity with diverse age group and specific climatic conditions so as to get more insight on sustainable environment.

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Design Considerations for Energy Efficient Residential Buildings in Warm-Humid Climatic Regions in India

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Abstract: 'Sustainability', has become a well desired objective for any kind of development on global platform. Certain aspects such as climate responsive, eco-friendly, energy efficiency, etc., have become integral parameters in achieving sustainability. Implicating sustainable aspects in commercial, industrial establishments and large scale projects is vitalized from past few decades. Energy efficient approaches and implications in India are in vogue but not in the required potencies. Recent studies inferred that India would be having additional 20 billion meter square of new building floor area by 2030; and projections predicted 85% - 90% of new constructions will be for residential purposes. Also, global research confers 'per capita final energy use' in urban areas is likely to get doubled by 2050, compared to 2005. India, being a developing nation with rapidly urbanizing communities, is likely to consume energy in an exponential rate. This triggers the necessity for intensifying energy efficient applications in built environment, especially in residential sector. This paper concentrates on understanding general design considerations for built environment pertaining to warm-humid climatic regions as this is one of the predominant climatic zones in India and also study various energy efficiency related codes and practices in India. This paper discusses various adoptable design applications inferred from success case examples as a result of research and development activities executed by renowned agencies in India. This paper tries to infer and propose certain 'general design considerations to achieve energy efficiency in residential buildings within warm-humid climatic regions in India'.

Keywords: sustainable, energy efficient, residential, warm-humid, design considerations

INTRODUCTION

Sustainable development is a comprehensive phenomenon resonating across the global platform in all the possible applications in contemporary world. As development is inevitable, the driving fuel for any development is 'energy'. Exploitation of energy recourses in exponential rate results in adverse impacts and such ill-impacts are being experienced across the globe as a result of conventional climate change. Statistical studies conferring the rise in global energy consumption and also the increment of rate of occurrence of disasters related to climate. The established interrelation between energy and climate is a potential tool in streamlining energy efficiency related issues.

Global Scenario

The annual track of global energy consumption marked an exponential annual increase in energy consumption since 2010 and raised 1.9% in 2017. International Energy Agency (IEA) has been working with Brazil, China, India, Indonesia, Mexico and South Africa under Efficiency in Emerging Economies (EEEE) Program since 2014 predicted that by 2040, more than 40% energy consumption will be rise by these countries within which 40% of CO2 emissions and 36% of energy consumption by building construction sector. The major share for energy consumption is going for space cooling in the building compared with the space heating and water heating thus the rising demand (See Figure 1a). By 2040 the energy consumption levels would increase by 19% higher than present day due to the usage of air conditioning. This triggers the requirement of emphasis ought to be given to achieve energy efficiency in space cooling while policy making (See Figure 1b).



Figure 1. Global Energy Consumption Trends, *Source: Agency, 2018*

Energy efficiency is the potential fuel in driving towards sustainability. Objectives being social & environmental benefits, assuring energy security and mitigating the probable adverse impacts of global conventional climate change. The Efficient World Scenario (EWS) expects 60%n more building space and double the Gross Domestic Products (GDP) demand by 2040 (Agency, Energy Efficiency: Buildings, 2018).

The objective of 'energy efficiency in building' shall be achieved by proper design approach so as to reduce the energy, which is required for heating and cooling. Workability depends on strategic application of the scientific tools like solar protections, orientation and shape of building, passive solar systems, insulation, air-sealed construction, streamlined ventilation, etc. (SAINT-GOBIN, 2018)

The advantages thus achieved could be improvised comfort factor in indoor spaces, cut down the electricity bills, improvised ambient air quality, mitigation of moisture related issues and reducing greenhouse gas emissions to assure the wellbeing of the society (Solutions, 2016).

Indian Scenario

It is expected that by 2050, India would experience an incremental change in energy consumption in the building sector as well CO2 emissions by 700% when compared to 2005 levels, as per Centre for Climate Change and Sustainable Energy Policy (CCCSEP) and Global Buildings Performance Network (GBPN).

Central European University (CEU) projections predict that the composition of floor space in residential and commercial purposes would be 85% and 15% respectively by 2050.

"Lock-in" period for the building is at least 50-60 years. Adopting energy efficiency measures during the construction of new residential buildings would yield effective results than to retrofitting of the same building for energy conservation on a later stage.

There is a constant and remarkable growth trend that has been observed in electricity consumption levels in India, and the extrapolated trend demands the energy efficient implications in electric energy consumption (See Figure 2)

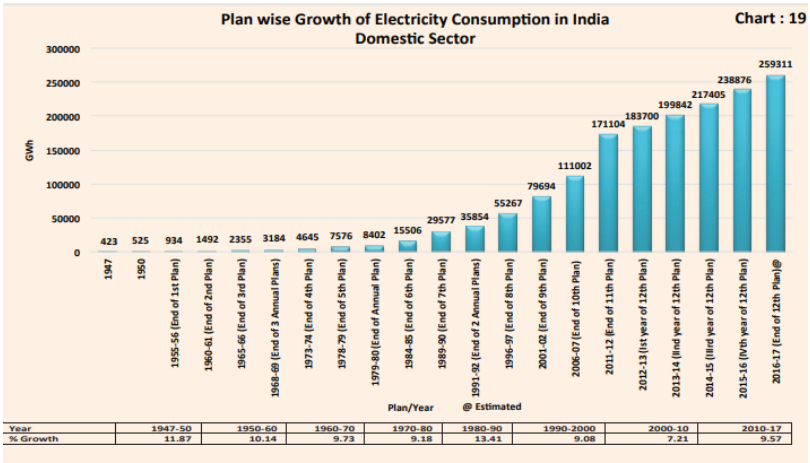

Figure 2. Plan Wise Growth of Energy Consumption in India
(Source: Ministry of Power, Government of India, 2017)

As per Central Electricity Authority, 2013 the consumption of energy increased 80 TWh in 2000 to 186 TWh in 2012 (i.e. comprises 22% of total electrical consumption) in India only for domestic purposes. The expected household use increase from 650 kWh in 2012 to 2750 kWh by 2050 per annum (See Figure 3b).

As per the Climate Works Foundation, 2010 the residential sector consumes 21% of total electricity consumption. Only ceiling fans and lighting comprises 62% of energy in residential sector (Centre for Environmental Planning and Technology' (CEPT) University, 2014)

Space cooling requirement is predicted to be exponentially increased from 2020 to 2050 in urban households. By 2095, projections state that the demand shall be tremendously increased not only in urban areas but also in rural areas (See Figure 3a) (Chaturvedi, Eom, Clarke, & Shukla).

It is necessary to carryout recognize and understanding the potential savings in the residential sector.The outdoor climate, building construction and materials, ventilation, air movement, etc. are the considerable variables for energy consumption in the buildings.

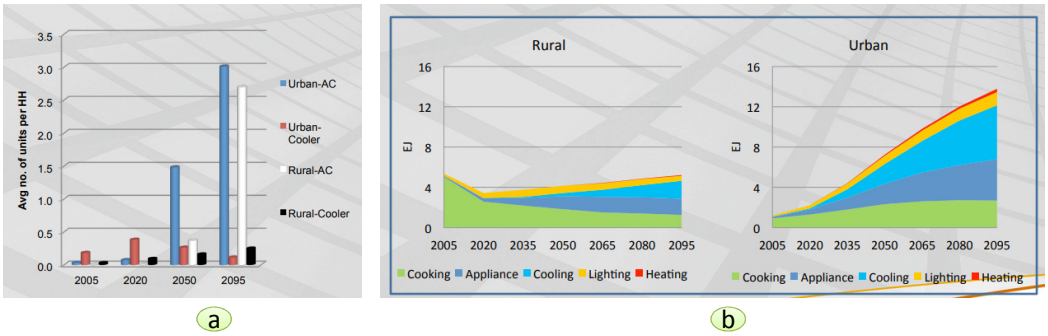

Figure 3. Household Energy Consumption in India
(Source: Chaturvedi, Eom, Clarke, & Shukla)

Growing demand for floor area and urban migration, expects doubling of floor space by 2030 in India. Besides to this the energy demand for buildings is increased.

The increment of affordability on consumer goods resulted in purchasing potential of consumers. Thus results in changes in energy consumption patterns. Remarkable increase in the usage of more electrical appliances affects the energy performance index in buildings.

Energy efficiency can be achieved by adopting appropriate design considerations which accords local climatic context. Similar implications in designing the external walls, fenestration and roofs being major catalysts in defining comfort criteria within building envelope, shall give sustainable results.

BUILT ENVIRONMENT IN WARM HUMID CLIMATES IN INDIA

India with its diversity in climatic regions, accommodating a vivid variety of design strategies accustomed to respective climatic conditions. Majority of the regions across India are characterized by warm-humid climatic conditions. Various climate specific design strategies both vernacular & technological are being adopted in designing and construction of built environment. Existing scientific approach of arriving at the context specific appropriate design strategies is in vogue resulting in making the building 'climate responsive'. Reinforcing these applications with energy efficient practices shall yield more sustainable results. Probable design strategies thus anticipated, requires an established link in between climate character and energy implication.

A prior understanding on the typical character of warm-humid climate is essential to discover its interrelation with energy matrix.

Characteristics of warm-humid climate

- Hot
- Sticky
- Continual presence of dampness
- Air temperature is moderately high 210C – 320C
- High humidity in all seasons
- Heavy cloud and water vapor act as shield for direct solar gain.
- Moisture in air with moderate and heavy rainfall favorable for vegetation growth as plant cover reduces reflected radiation, thus lessens the heartening up of ground surfaces.
- Wind speed is low and consistent.
- Low variance in between ambient air temperature and skin temperature results in considerable variation in body conduction and convection (Koenigsberger, Ingersoll, Mayhew, &Szokolay, 2015).

APPLICABLE ENENRGY EFFICIENT DESIGN STRATEGIES

Performance of the building influences the behavioral impacts of energy efficiency and vice versa. A pre-fabricated scientific approach in designing and execution as well in operation and maintenance of any building would accord an effective and efficient energy management, thus results in making the very building energy

efficient. Similarly, collective effort starting from a household to all the citizens shall give rise to energy efficient built environment. Understanding of general principles for built environment in warm-humid climate, a detailed critical analysis of success case examples which were designed and executed by Tata Energy Research Institute (teri) across India especially in warm-humid climatic regions, and inferring from various energy related codes and guidelines in India reinforced the knowledge quotient that is required in formulating the recommendations of various applicable strategies in designing residential buildings and built environment to achieve energy efficiency in ward –humid climatic region.

Neighborhood Layout

Group of buildings, if placed in series facing the prevailing wind direction the wind flow will be curbed by the first row (Koenigsberger, Ingersoll, Mayhew, & Szokolay, 2015). The ambient air flow retards with this type of arrangement of building blocks (See Figure 4a).Staggered arrangement of blocks with respective longer sides perpendicular to the prevailing wind direction within subdivided plots is desirable to let free air movement through all the blocks placed in the locality without becoming wind blocking masses (See Figure 4b).

Form and planning

To avoiding the slow movement of air or stagnant of air, the building is necessary to elevate on stilts. Orientation of the building ought to catch whatever ambient air movement around it so as to accord indoor air quality and cross ventilation. Cases where buildings cannot be oriented for wind direction, screen walls and projecting wing of a building can redirect of air movement towards the building. In warm-humid climate, the rooms need to be planned in a single row with shaded verandahs and cross ventilation. Plan forms shall be generally elongated in nature perpendicular to wind direction which assures thorough fare for air movement within the building. Articulation of rooms in series provided proper cross ventilation.

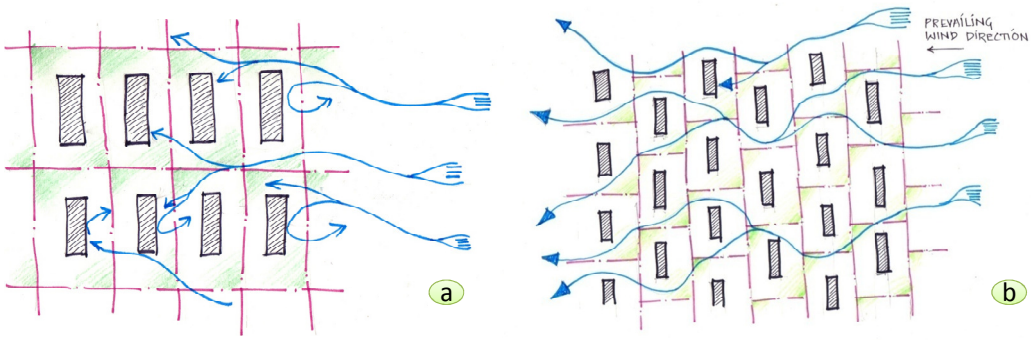

Figure 4. Articulation of Building Grain
(Source: Author)

An attic floor can be provided in place of open terrace such that the vertical wall placed towards prevailing wind direction above the terrace to redirect the wind downwards, further into the building (See Figure 5a). Preferably, the dominant characteristics of the building shall be openness and shading devices.

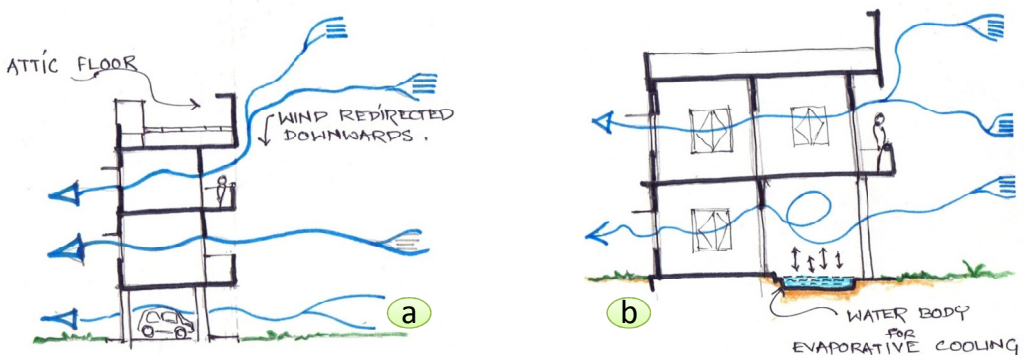

Figure 5. Wind Movement through Building
(Source: Author)

Providing shade on the wall surfaces and openings with broad over-hanging eaves will be more beneficial. A water body created in the stilt floor, with its evaporative cooling character makes ambient air cooler (See Fig 5b) (Majumdar).For low-rise buildings, orientation for wind and high-rise buildings, avoidance of sun is more advisable.

External spaces

The basic requirements of external spaces are

- shading
- Free passage of air movement.

Buildings elevated on stilts to create open spaces under the buildings to use as shaded outdoor spaces.

Open spaces surrounding the building foot print shall be provided with dense ground cover and tress so that the surface absorbs the radiation from the sun without reflecting onto the ground surface, further heartening up the ambient air. Better to avoid any built mass for providing shade in the eternal environments. If such places are required, it is advisable to design patios or semi open pavilions with pergolas and covering up with trellis (See Figure 6a&b). Green roofs, Terrace gardens, trellis onto the pergolas, green covers onto the open docks etc., shall effectively reduce the solar heat gain in the built environment (TERI, 2011).

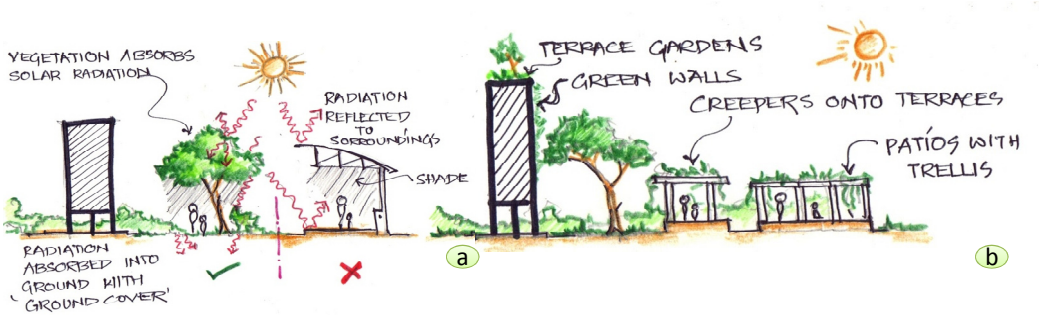

Figure 6. External Spaces in Built Environment
(Source: Author)

By providing paling fences and screen walls, which do not permit direct view but allow the breeze to penetrate, provides privacy with free passage of air through the perforations. The material can be used louvered timber boards or overlapping arrangement of boards or planks (See Figure 7a&b).

Roofs

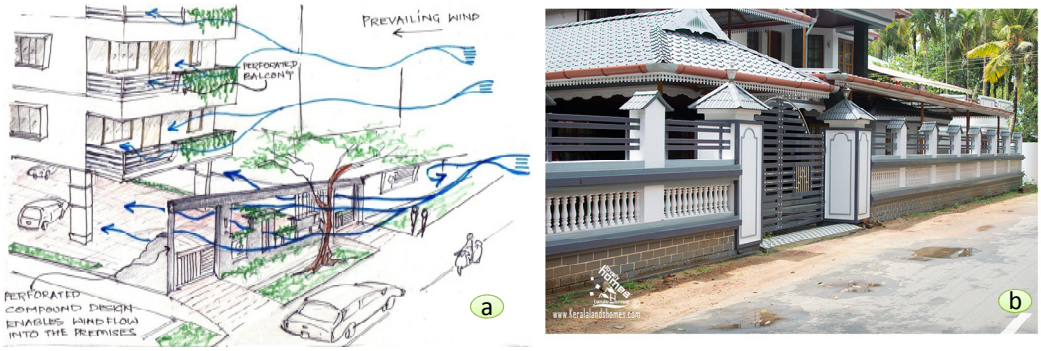

Figure 7. Perforations in Walls for Wind Thoroughfare
(Source: Author; Land and Homes, 2015)

Using the reflective upper surface, double roof construction with roof space ventilation, and ceiling with its upper surface highly reflective and good resistive insulation can achieve both roof and ceiling is low thermal capacity.If using pitched roof material is corrugated iron, asbestos cement or bright aluminum, by using insulation boards with a u-value around 1.5 W/m2 deg C. (i.e. a roof ceiling over all u-value of 0.8 W/m2 deg C) to prevent excess temperature in indoor places (Koenigsberger, Ingersoll, Mayhew, &Szokolay, 2015). The shaded vertical walls need not be insulated, but un-shaded walls with reflective qualities on the outer surface will prevent inner surface temperatures. The materials with low-thermal conductivity shall be used for insulation purposes. Usage of glasswool (See Figure 8e) as an insulation material in the buildings especially in between

roofs and false ceilings (See Figure 8b) with its reflective surface facing roof soffit (See Figure 8c) shall give an anticipated result.

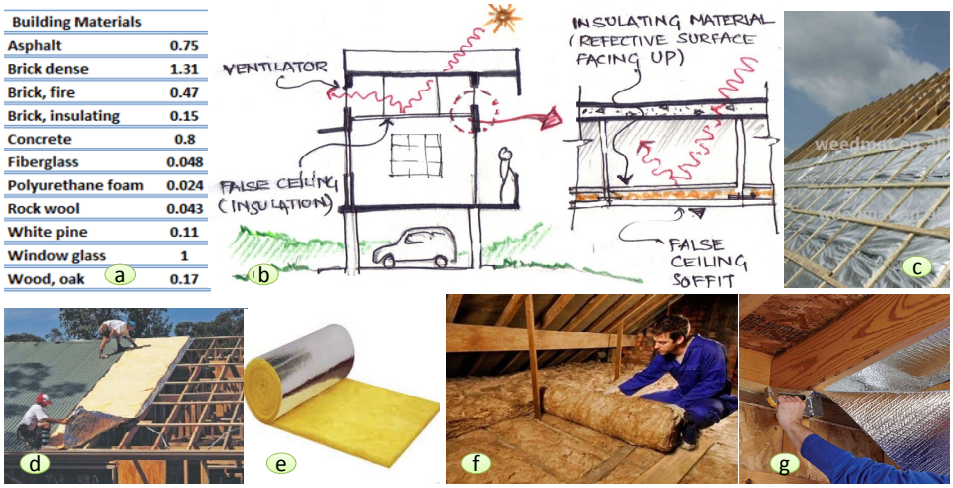

Figure 8. Roof Insulation

(Source: info@nuclear-power.net; Illustration by Author; alibaba.com, 2018; Alan, 2018; Eastcoast Suspended Ceilings, 2018; busianews.com, 2016)

Ventilation

Ventilation ought to be provided for exchange of air, temperature and humidity of the room. Provision of proper ventilation facilitates sensible air movements across the body surface. To drop down 20C of the ceiling temperature, provision of ventilators at the roof space is recommended.

Fenestration

Glass is one of the most extensively used building materials across the globe. The judicial selection of glass for specific context yields advantageous results. Areas where solar heat gain is not a prime requirement, glass fenestration with required thermal performance requires a special application. The heat or light thus incident onto any glass surface either will be driven away by movement of air or energy get radiated onto the glass surface. The property of ability of a given material to radiate energy is defined as emissivity. Radiant energy thus captured by the window is one of the prime factors for heat transfers. Thus lowering emissivity of window panes will be able to reinforce insulating properties of window. Thus, "Low e-glass" can be an appropriate choice where a thin transparent coat that reflect long wave and short wave radiations from the Sun which turns to be a very effective insulation medium as a part of fenestration(See Figure 9a&b) (Vitro Architectural Glass, 2010).

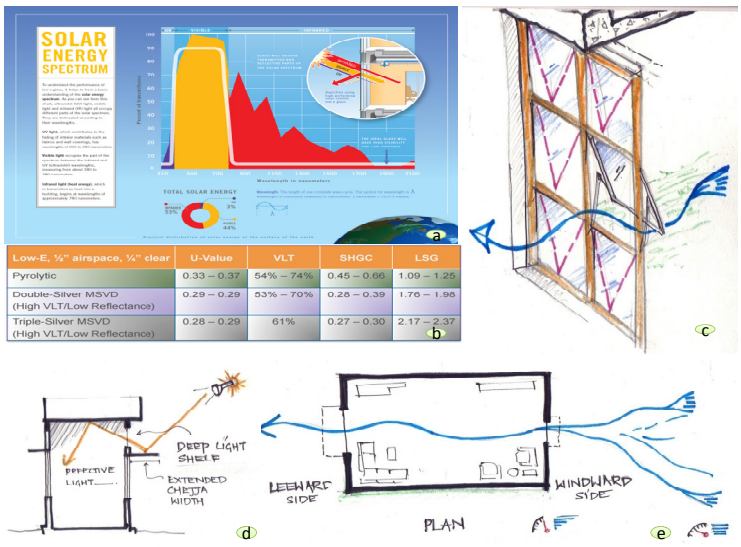

Figure 9. Fenestration Design

(Source: Vitro Architectural Glass, 2010; Illustration by Author*)*

Configuration of fenestration plays a major role in determining the indoor air quality and movement. Shading devices and masses which channelizes as well redirects the ambient air into the buildings. Smaller openings onto the inlet of air i.e., façade facing prevailing wind direction and larger openings onto the opposite side assures an accelerated fee movement of air in the indoors (See Figure 9e). A controllable mechanism such as a window with open able horizontal sashes will be able to allow desired quality if wind without compromising at the indoor light quality (See Figure 9c). A deep light shelf provided in the form of clerestory opening assures an emphasized diffused light into the interior with the multiple reflections of incident light rays (See Figure 9d). Solar Chimney would be an effective solution to allow diffused light into the building if rooms were articulated parallel to one another resulting in wider intermediate distance between two external walls (TERI, 2011).

Wind & air movement

Air movement plays an important role for the comfort in indoor places. To achieve this air movement building should be oriented to catch the air and openings should be provided for the air movement. For free passage of air, the door and window openings should be large.

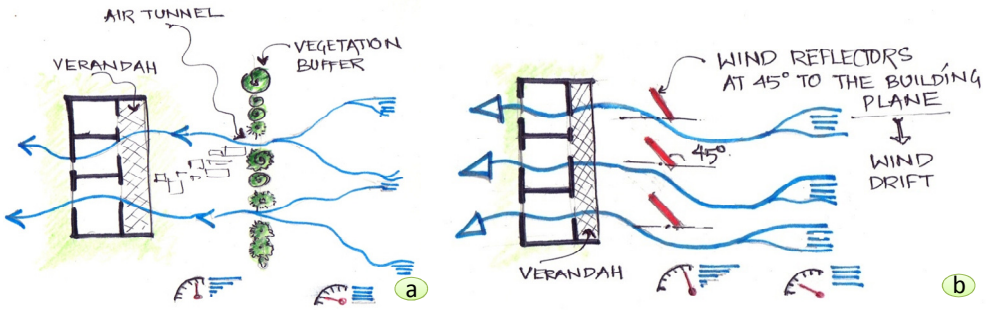

Figure 10. Wind Flow across the Building
(Source: Author*)*

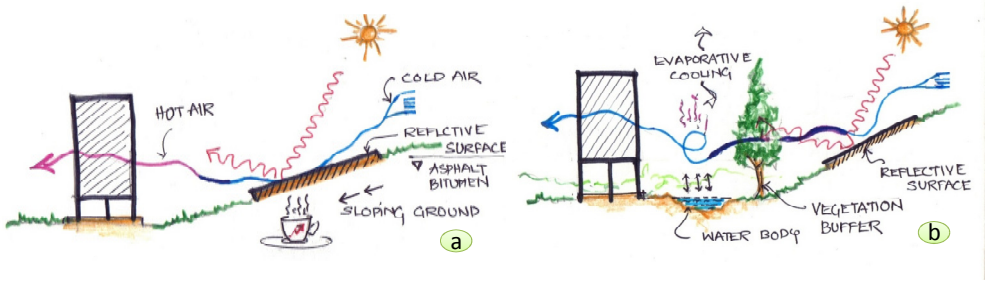

Figure 11. Heat Gain and Wind Flow in the Surroundings
(Source: Author*)*

Landscaped spaces with vegetation hedge/buffer shall be designed perpendicular to the prevailing wind direction, but care must be taken in articulating the spacing of trees; such that few trees can be grouped in a row providing with wider intermediate spacing at regular intervals thus resulting in air drift towards the building (See Figure 10a).

Series of standalone channeling walls erected at 45o angle to the prevailing wind direction would also accelerates the wind speed that flows towards the building (See Figure 10b) (Koenigsberger, Ingersoll, Mayhew, &Szokolay, 2015).

Some considerations must be taken in air flow movement, because the air movement influenced by the topographical features, by the orientation of the building and position of surrounding buildings and other obstruction as well as the air flow should not pass over hot surfaces before reaching the building (See Figure 11).

Radiation – Insulation – Shading devices usage

'Diffused radiation' is more desirable i.e., shading devises ought to give more coverage to the building core in order to obstruct most of the sky along with the sun. 'Wind flow' ought to be preferable criteria for low rise built forms, as wind movement is more influential nearer to the ground surface. 'Avoidance of Sun' ought to be preferred criteria for high rise buildings, as shading is a huge issue at higher altitudes. As solar geometry is

unalterable, a judicial articulation of building elements for skill full usage of wind such as screen walls/wing is desirable. Earth beaming is an effective tool in designing basements and lower floors (TERI, 2011).

OPERATION AND MAINTENANCE

The process of gaining energy efficiency within a building and its surroundings could be attained by both active and passive measures throughout the life cycle of the building. The following is the recommended checklist for observing energy conservation during O&M of a building. Recommended checklist above ought to be strictly observed by architects, planners, builders, contractors, service providers, investors, technocrats etc.

- Mandating Energy Conservation Building Code (ECBC) application
- Awareness, understanding application of guidelines proposed by various agencies such as IGBC, GRIHA, SVAGHIHA etc., to achieve energy efficiency.
- Usage of Energy efficient building materials
- Energy rated appliances and installations
- Green applications in built environment
- Building Information System & Management
- Intelligent Building Systems
- Judicious usage of conventional/nonrenewable energy resources
- Adoption of 'Reduce-Reuse-Recycle'. Etc.,
- Formulation and implementation of various guidelines and codes for achieving energy efficiency in residential buildings shall be effectively executed with the following strategies
- Conducting capacity building programs for technocrats
- Conducing awareness programs to general public
- Streamlining building codes and byelaws and stringent application
- Incentives and reward systems for the followers and levying penalties for violators

CONCLUSION

Effective formulation and implementation of energy efficient measures in residential built environment would bring phenomenal and pragmatic changes in the energy sector. Energy thus conserved shall be effectively used for essential accomplishments. Added attributes of energy efficiency to the climate responsive architecture facilitates the building industry to achieve the anticipated results. Judicious management of energy resources along with strategic application of climate specific design solutions would mitigate the threat from exploited energy consumption. Constructive repercussions shall be evident in the lattice of socio-environmental-economical domains, thus leading to sustainable development. The code of conduct thus recommended shall be strictly followed by the government, technocrats, and all the households to minimize the adverse effect on the conventional climate change. Think globally and act locally.

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Measures to Deliver Energy Efficiency to the Common Buildings

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Abstract: Energy being the need of the hour and the future too, we have the responsibility to harness it carefully, and pass it on to the forthcoming generations. Due to rapid economic development and industrialization there is a serious hike in the energy consumption, and particularly the building sector (accounting the construction and operation) is constituting up-to 40 percent in the overall energy consumption, the global building sector needs to cut down energy consumption in buildings up-to 60 percent by 2050 to meet global climate change targetRef1. This alarming rise in the energy consumption along with its implications such as rising energy cost, increasing energy demand, energy supply concerns have led to the requirement of energy efficient buildings at large. Sustainable design/ construction techniques; and green building rating systems to measure the performance of the energy/ environmental aspects of the buildings could be the solution, but the limitation is the application in the commercial sector, which would always opt for conventional methods, due to various reasons. Hence the idea of this paper is to identify and establish simple steps/ techniques not more than 10, which when applied to the design and construction process shall make the building energy efficient during operation than the same being built conventionally. These steps shall be addressing the stages of building construction process such as site analysis, development of owner's project requirement, design process development, detailed design reports/ drawings, project execution, commissioning and post occupancy survey.

Keywords: Energy Efficiency, Common buildings, Passive architecture, Green building, Sustainable

INTRODUCTION

Energy being the need of the hour and the future too, we have the responsibility to harness it carefully, and pass it on to the forthcoming generations. Due to rapid economic development and industrialization there is a serious hike in the energy consumption, and particularly the building sector (accounting the construction and operation) is constituting up-to 40 percent in the overall energy consumptionRef1. This alarming rise in the energy consumption along with its implications such as rising energy cost, increasing energy demand, energy supply concerns have led to increasing efforts to improve the energy efficiency of buildings, and taking into account the climate change, the global building sector needs to cut down energy consumption in buildings up-to 60 percent by 2050 to meet global climate change targetsRef1. Hence energy efficiency in buildings is not an option but a mandatory requirement.

Green building rating systems are prevailing across the globe to rate the buildings based on its commitment towards sustainability, which makes the built environment sustainable by making it to follow a certain approach. But there is a wide spread speculation on the intentions of sustainability of these rated green buildings. If one has to investigate the reasons towards this speculation then the parameters to be considered are vested interest, marketing feature, market driven stature of the rating system etc., but that shall not be the focus of this paper. This paper is striving to establish a few steps to make any building project energy efficient irrespective of intervention of the rating system.

Step 1: Predesign: Understanding and Finalizing the Requirements

The first and foremost step an architect/ project consultant needs to perform before getting into the design table is to understand the requirements of the client and to arrive at the Owner's Project Requirement (OPR), this is similar to setting a vision for an organization, based on this OPR the further decisions could be arrived upon.

This is the stage where the basic questioning happens, such as the need and significance for the building in that location, and also the area requirement, at this stage, the team needs to have strong justifications for all these issues.

The architect should try to negotiate on the standards, such as providing natural ventilation over mechanical conditioning for areas which do not need the same, and try to relax the occupant standards such as for the air-conditioning and lighting – this needs to be site and operation specific as it should not interfere in the basic requisites for the indoor environment quality or operations. This step is important, as most of the building which is not sustainable is not anti-green just because of inefficient equipment's, but it's mainly because of over sizing/ overdoing.

This is also the stage while the architect could educate the client about sustainable design strategies for mechanical electrical and plumbing and also about renewable energy supplementation so that that is added in the OPR and gets devised in the later stages.

Step 2: Understanding the Site Conditions

Perform a detailed site analysis to determine the latitude, longitude, altitude of the site; climatic condition across the year; soil type; historic rainfall data (to plan the storm water discharge) wind pattern across the year; flora - fauna, potential views; urban form; previously landscaped area; existing trees. Document each parameter with a qualified team of professionals to understand its implication in the project planning and to use the specific data at the respective stage.

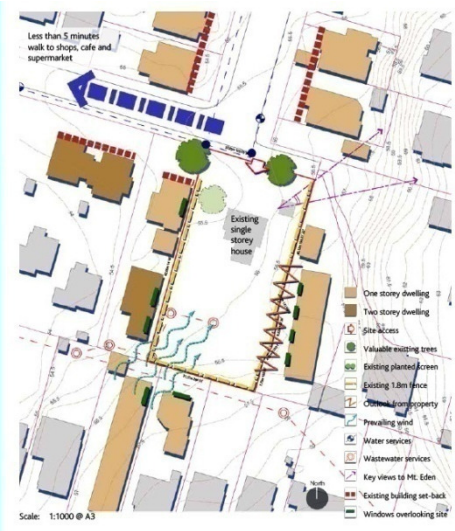

Figure 1. Site Analysis
Source: Auckland design manual, New Zealand

Step 3: Locating and Orienting Building within Site

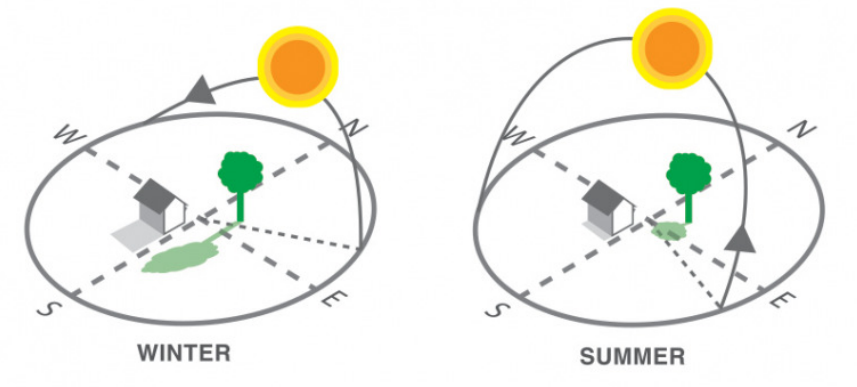

Figure 2. Sun path analysis
Source: Your home, Australia, Government of Australia

Decisions made in site planning and building orientation will have impacts on the energy performance of the building over its entire life cycle, orientation strongly aids to suit a building to its natural environment—the sun, wind, weather patterns, topography, landscape, and views. Sun path analysis is the key step towards effective orientation of the building. As the sun's path is dynamic based on the day and time, it should be done for the worst-case requirements of the site with reference to the climate, say for the tropical climate it should be done for the 21st June as it's the summer solstice, which is the longest day of the year.

Well oriented buildings could have an optimized thermal performance, maximized day lighting through building facades reducing the need for artificial lighting, let in light and fresh air and thus resulting in passive architecture, as well as reduce glare and overheating in the building interior. The orientation of the building should be based on whether heating or cooling is predominant requirement in the building. The amount of solar radiation falling on a surface and fresh air entering into the building varies with orientation. With reference to the orientation the solar shading devices needs to be designed for the extremities of seasons.

Step 4: Virtual Modelling And Analysis

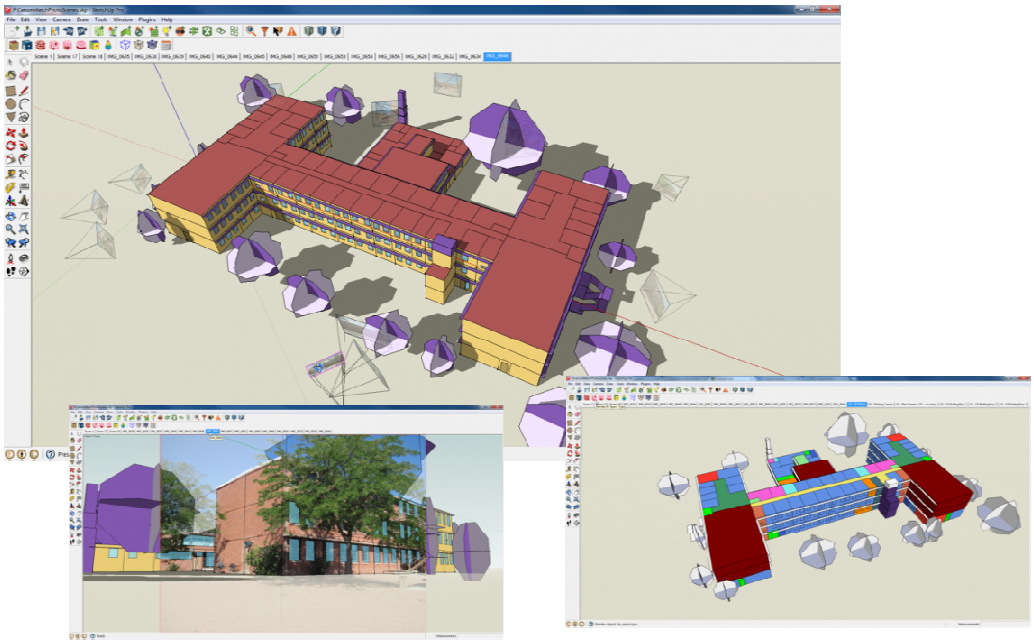

Figure 3. Building energy Simulation
Source: United States, Department of Energy

Virtual modeling tools for whole building energy simulation (WBES) could be used to simulate and understand the actual conditions to be prevailing. Modeling could be done for calculating the amount of daylight to be received in the living areas; calculating the thermal property of a building envelope, efficiency of a HVAC system etc... The whole idea of this exercise is to go to and fro and arrive at the right decisions with respect to building envelope (materials, respective thickness), openings (sizes, shading devices, glass property) efficiency of the equipment's (how much energy it could consume when compared to other typologies) and to calculate the overall energy consumption of the building in a year with reference to regular operation of the building along with its systems.

Step 5: Designing The Envelope

The envelope design (wall/ roof) is the most important aspect to impart sustainability in a built form, as it is the first element which communicates with the exterior environment. A badly designed envelope could increase the air-conditioning load of a building up to three times what it could have been with a sensible envelope and façade design. Apart from increasing the air-conditioning load, it could also deteriorate the living conditions. Whether it's going to be a 9" brick wall or a hollow concrete block, whether it's going to have an insulation layer or not? All these questions need to be answered at this stage, where the previous step of virtual modeling/ analysis plays a pivotal role, to quantify the results.

Step 6: Designing The Openings And Shading Devices

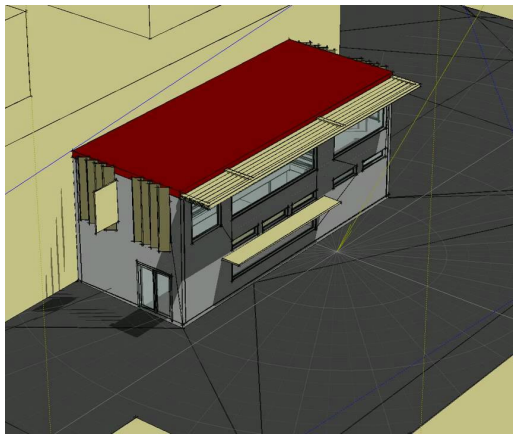

Figure 4. Design of openings and Shading devices
Source: Autodesk, Ecotect

Openings in a building are most important for three reasons one for bringing in daylight and the other for providing exterior views, and the third for ventilation purposes (in a natural ventilated building). At the same time over sizing/ wrong placing of openings can end up as a disaster i.e. it could increase the air conditioning load, light may be glaring and in case of naturally ventilated buildings wrong placing of openings may not allow ventilation to happen.

The opening sizes (area of the opening) could usually follow general thumb rule of 10 to 20% of the floor area of the space (based on climate zone), but again one could rely on simulation tools such as Autodesk Ecotect to strategically place the openings and also to design the shading devices correspondingly. Here the role of shading device is most important because it is going to decide the quality as well as the quantity of the light being received indoors, and these shading devices could cut off the direct sunrays and excessive glares in the indoor spaces.

Step 7: Selection Of Materials

'What it is made off?' is the key answer to lot of issues. The choice of material is the fundamental of sustainability either in terms of being cost effective (during construction and operation) or being environmentally friendly. When one selects the material, the following things must be taken into account i.e. Being energy efficient – for this the materials needs to be opted based on the previous steps elucidated above i.e. The material selected for the envelope should comply the thermal performance requisites and the material selected for the openings should comply with the daylight to be received in the living space.

The other aspect is in the perspective of sustainability: material selected for construction should be environment friendly as well, one needs to look at the life cycle cost of the material – and not just the cost of the material i.e. Kota stone flooring could replace a verified tile flooring due to the high embodied energy of verified tiles. So, the key towards this stage is selection of materials needs to be complementing the energy aspects and must be of low embodied energy – which means it would be environment friendly and a regional material, and would not be consuming virgin resources for its production, where as it would have recycled content within its ingredients.

Step 8: Selection Of Equipment's And Fixtures

'What makes it run?' is another key aspect one needs to have an eye with reference to sustainability; mostly it constitutes the mechanical electrical and plumbing divisions. This step should follow the hierarchy of having an energy efficient design, using low embodied energy materials for making the building and then opting for highly efficient equipment's and fixtures.

Changing a conventional air-conditioning system to an energy efficient air conditioning system can reduce the air conditioning energy bill at least by 50%. Similarly using low flow water fixtures can reduce the water consumption in buildings, having a sewerage treatment plant could rejuvenate the water and it could be reused

for secondary purposes such as irrigation and toilet flushing. Proving an occupancy sensor could switch off the air conditioners/ lights when people are not present. And having a Building Management System (BMS) to monitor and control the end users would bring a change in the energy consumption during operation.

Step 9: Supplementing Renewable Energy

Energy production being lesser than the consumption, shifting to renewable energy is an ideal choice, but at present the cost of renewable energy would be on the higher side when compared to the energy provided from the grid, but we could strongly hope the re systems to become more efficient and also more economical to install in the near future. So, one could evaluate opting for: building integrated photo voltaic, mini wind turbines, and bio methanization on a building level. Even today we could find 'Net Zero' buildings in India – i.e. Buildings which produce all of their energy requirements (on annual average) by itself, though it may consume electricity from the grid at some point, say in a year – on an average it would be net zero. We could even see some demonstrative strategies of building being 'Net Positive' where the buildings produce excess of energy than its operation and provide the excess back to the grid.

Step 10: Commissioning And Monitoring

Commissioning is an important aspect if the building is air-conditioned and/or being equipped with complex systems. It enables to run a check from design to operation of the systems. A commissioning authority (CxA) is ideally required to be involved from the predesign stage onwards and their task extends even beyond the completion to regularly monitor the performance of the building system as its perceived. Any difference is supposed to be reported by the CxA and must be provided with resolutions to troubleshoot the findings.

Apart from findings and resolutions of complex MEP systems, the CxA has the main responsibility to check the design basis report and the design proposals provided by all consultants to match with the owner's project requirement formed during predesign stage. So, it's not just a task of findings and solutions but also to be involved in the design process as an active member and help the client to meet the desired output.

CONCLUSION

Implementing the proposed steps towards energy efficiency in a common building shall increase the energy efficiency of a common building to a significant degree (the exact percentage savings in energy shall be determined in further process of the research) further research could be a ratification measure to understand the level of energy efficiency one could achieve in a project by following a set of steps which could be implemented by any project team without any major investment or change in the approach. This research could open up more avenues for the building teams to accept, adopt and mandate the steps to deliver energy efficiency to the commons.

We could design and construct a building which could be energy efficient during operation, but the major question is "What is the comparison in a yardstick? Could the same comfort standard be achieved in an alternative way?"

One needs to understand the point that strategic climate responsive design with an effective envelope incorporating natural ventilation could provide almost a similar comfort zone of an air-conditioned space to the user, the same holds good for lighting, i.e. Instead of CFL's one could opt for led lights but the underlying point is usage of daylight is going to cost us nothing in operation and it's going to be much more comfortable rather than the artificial lighting.

In a nut shell one need to strive towards the overall intention of making an 'energy efficient buildings as a 'sustainable building' which delivers the purpose to the point and costs light on earth.

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Gender differences in preference to perceive the entrance edifice of Higher Technical Institutes in Tamilnadu

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Abstract: The prime objective of this study is to examine whether there is difference between the genders in preference to perceive the entrance edifice of selected higher technical institutes in Tamilnadu. This study attempts to explore the factors that are responsible for significant difference between the male and female in noticing the entrance design features of technical institutes in Tamilnadu. The analysis revealed certain physical factors that induce preference among Female and male observers in perceiving the entrance edifice of the Institutes. The study further indicates that key physical feature variables could be articulated to achieve an experience that is desirable for the observers.

Keywords: image perception, preference, gender difference, Novelty, Legibility.

INTRODUCTION

In the present competitive environment for institutions imparting higher technical education. There exist several strategies in practice in order to stand out from their competitors. In light of this fact, one important and prevalent strategy is to make a powerful statement through the impression of the institute's building in general and in particular through the entrance edifice of the Institute. The physical features and design articulation of the entrance is explored, in order to draw the attention of all the stakeholders of the institute at the very entry point itself. This study attempts to examine whether gender difference exist in preferring entrance edifice and image perception about the preferred physical setting. Perhaps, it examined whether an Institute's entrance design element can be responsible for causing gender difference in preference and perception of image of the institute.

Over view of the study variables

The selected variables are from Kevin Lynch's 1959 form qualities, Berlyne's (1974) collative properties that are presumed and applied to understand the variations in preference to perceive the entrance edifice of Higher Technical Institutes in Tamilnadu.
The variables are 1) Legibility and 2) Novelty respectively.

Legibility

Ease with which people can conceptualize key elements and spatial relationships within an environment.

Novelty

The extent to which the attributes of built form has not been experienced before and so is interesting for the observer within the field of vision.

OBJECTIVES

- Determine whether an Institute's entrance design element can be responsible for causing gender difference in preference and perception of image of the institute.
- Provide an understanding on form qualities of the Institute's entrance design element that could induce gender difference in preference of the entrance edifice.
- Provide an understanding on Berlyne's collative properties of the Institute's entrance edifice that could induce gender difference in perception of image of the institute.

RESEARCH METHODS

Materials and methods

In order to understand how Females and Males perceive the physical structure and design elements of an entrance, photos of the entrances of various educational institutions were shown to a group of male and female comprising of college students and staff in order to confirm their familiarity with the settings.Table:2 Shows the sample images of the entrance edifice of the Institutes from three different regions in Tamilnadu

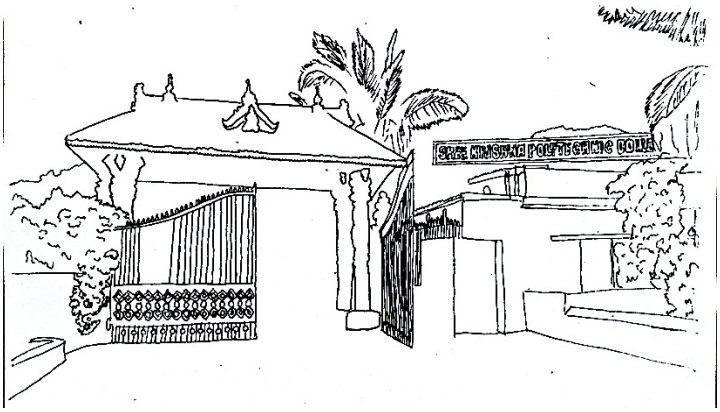
Semi-structured interviews of the participants (includes both genders) were conducted to create effective survey questionnaires (see Appendix-I) consequently survey were conducted among students of both genders and with the general public, local residents and visitors to the institutes. The results of the surveys provided us with useful data about the differences in gender perception of image and their preference of the settings. They listed visual meaning, emphasis, Identity, novelty, uniqueness, cultural association, symbolic content, signifying status, connotative meaning, and ease of comprehension, attention getting features, social expression and associative value as important aspects in drawing attention of the observers to perceive the entrance edifice. Among these variables Legibility and Novelty were very prominent in driving the difference among the observers.

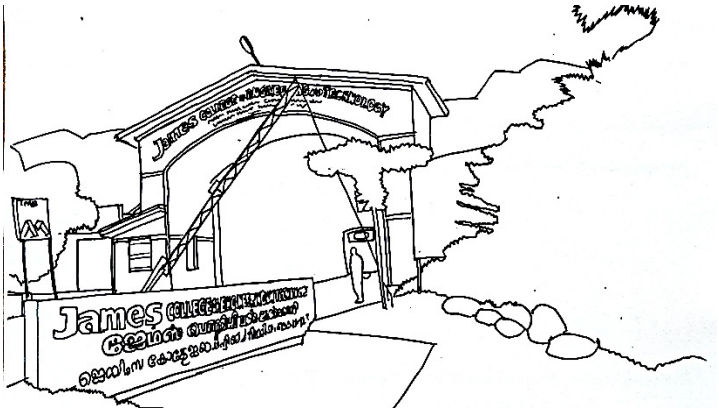
The respondents were students (both Female and Male) of the Institute, Staff members, and general public, from selected three regions of the study areas in Tamilnadu--north, central and southern regions with a total of 585 individuals (Table 1) wherein Females 275 and Males 310 were surveyed. From our study data, it is demonstrated that there exists gender difference in preference to perceive the entrance edifice of the higher technical institute

Table1. Distribution of Female and male respondents in the study area

Region	Northern region	Central Region	Southern Region	Total No. of respondents
No. of Female respondents	95	80	100	275
No. of Male respondents	115	75	120	310

Table2. The images of the entrance edifice of the Institutes from three different regions in Tamilnadu

No.	Entrance Image	Physical Attributes
1.		This entrance is framed by post and beam construction with characteristics of slope roof structure symbolizing certain socio-cultural meaning through its design elements.

2.		Post and beam construction frames with a huge porch like structure forms the entrance with single access way. The institute's name is displayed across the top of the beam.
3.		This entrance structure is supported by steel frames with central Huge Arch way for entry and exit. The institute's name is displayed along the arch structure.

HYPOTHESIS

In order to fulfil the study objectives, the following hypotheses were developed and tested through correlation tests.

Hypothesis

H1: The gender difference in preference to perceive the entrance edifice of an institute depends on the clarity of the form of the entrance design elements.

H2: The gender difference in preference to perceive observe the entrance edifice of an institute depends on the innovative physical form of the built structure of the entrance.

RESULTS

From the results of the correlation analysis it is clearly evident that there is significant difference between genders in preference to perceive entrance edifice which is driven by the physical attributes of the entrance edifice design.

Table3. Correlation values of Novelty and legibility in different regions

Gender: Female			
Correlation values			
Variables:	Northern region	Central region	Southern region
Novelty	0.85	0.83	0.81
Legibility	0.79	0.80	0.83
Gender: Male			
Correlation values			
Variables:	Northern region	Central region	Southern region
Novelty	0.78	0.80	0.79
Legibility	0.72	0.76	0.80

From Table 3 the data analysis of the Correlation values proves the hypothesis (H1 & H2) that the variables Legibility and Novelty have strong correlation with the Image perception of both the genders. Perhaps, this indicates that the physical quality: Legibility and the Collative property: Novelty are the most powerful factors that could drive their preference in perceiving the entrance edifice of the higher technical Institutes among Male and Female Observers irrespective of regions in Tamilnadu.

CONCLUSION

This study results strongly indicate that, in-order to attain a socially desirable and sustainable design of entrance edifice, the knowledge and insight on the visual and preferential patterns from both the genders are indispensable in achieving complete sustainability in the process of designing physical features for entrance edifices in future.

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APPENDIX- I

Questionnaire format

My preference to observe the entrance edifice of an institute depends on the clarity of the onphysical features and ease of perceiving the entrance design elements.

Strongly Disagree	Disagree	Agree to Some Extent	Agree	Strongly Agree
1	2	3	4	5

My preference to observe the entrance edifice of an institute depends on the newness and innovative articulation of the features in the entrance structure.

Strongly Disagree	Disagree	Agree to Some Extent	Agree	Strongly Agree
1	2	3	4	5

A self-sustainable regenerator to support the plants in water scarce urban areas

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Abstract: Water Scarcity is always associated with negative repercussions for the plant life which ends up affecting the entire ecosystem. The water scarcity causes wilting, evolutionary developments, reduction in photosynthesis, transpiration, and respiration. Water scarcities in cities are mostly due to unplanned urbanization and half of the world's largest cities experiences water scarcity. This leads to a question, whether there is any possibility to grow plants in water scantiness urban environments? Even if it gets water, will it will be an eternal source? The idea of this paper is to protect the plant life from acute water scarcity in water scarce areas by creating a self sustainable regenerator. The design has a circular base which holds the plants with high evapotranspiration rate. The base is surmounted by a trellis which has the shape of a single curve that is broad in the center and tapers to a point at each end. The trellis has a material with high water retention capacity as its outer covering. It also supports the plants on the base to ascend to the top which enhances and magnifies its curvature. This combination effectively creates an artificial Nano-ecosystem with its own individual characteristics, where the available water is retained in the form of humidity. A dehumidifier converts the atmospheric moisture into water completing the cycle. It is suitable for all climatic conditions but works more efficiently on high humid areas. The designs are estimated to create enough water daily to sustain the setup under promising climatic conditions.

Keywords: Self-Subsistent Installation, Dehumidification, Urban sprawl, artificial engineered ecosystem.

INTRODUCTION

Due to population growth in cities, it becomes increasingly important for a compact and sustainable urban development to mitigate urban sprawl. The urban areas can be warmer than the surroundings, which is known as the urban heat island effect. The two factors causing this effect are the increase in dark surfaces of the urban landscape and the lack of vegetation. The dark surfaces reradiate thermal infrared radiations and absorb heat directly from the sunlight. On the other hand, lack of vegetation worsens this situation. As the city expands, the urban heat island expands, both in geographic extent and in intensity. It is important that the green spaces in such urban environments must be designed to meet the varying temperature.

Such green spaces are man engineered ecosystems or artificial Nano-ecosystems with its own individual characteristics. These ecosystems enhance the productivity of natural processes with human intervention disturbing the natural cycle. Here, the artificial ecosystems are not the contradictions of the natural systems. It is only the proportions and speeds of the ecological interactions that can be interfere for the advantage of man. These ecological interactions may have adverse effects on the natural ecosystem and water scarcity is one of the consequences due to such interactions.

One of the main reasons for the water crisis at Cape Town is due to unplanned urbanization. The water scarcity will further increase as people are moving to cities at an unparalleled rate. This condition is also prevailing in our neighbourhood. Chennai which is a rapidly urbanizing city located in the south eastern coasts of India, a city affected by the negative repercussions of unplanned urbanisation. Chennai city has an average temperature of 93°F or and 78% relative humidity. The common characteristic feature between both the cities is that, they are situated on the coastal zones. Coastal zones are within 100 Kilometers (62 miles) from the coastline and elevation below 100 meters (328 feet). About 23% of the world's population lies on the coastal zones. There are 24 coastal cities with population in excess of 5 million people and 10 cities more than 10 million people including metropolitan cities like Los Angeles, New York, Sao Paulo, London, Mumbai, Shanghai and Tokyo.

METHODS AND MATERIALS

To construct a self-sustainable installation which is independent of the outside environment, we carefully observed and reconstructed an artificial Nano-ecosystem within its framework. The framework comprises of a circular base and a trellis. The circular base holds the plants with high evapotranspiration rate. Here, tires are reused with proper insulation. The base is surmounted by a trellis which has the shape of a crescent. The trellis is surrounded by a material which has a good water retention capacity. It also supports the plants on the base to ascend to the top which enhances and magnifies its curvature. This combination creates an artificial Nano-ecosystem with its own individual characteristics, where the available water is retained in the form of humidity. A dehumidifier converts the atmospheric moisture into water by the process of dehumidification, which is the eternal water source for the plants. Venturi effect is also created by positioning the constricted ends of half plastic bottles along the curvature of the trellis, accelerating the air into the regenerator.

The preliminary design was based on condensation of water vapor in the air between two soda PET bottles. The rate of condensation in the recycled bottles was greater to the side facing the trellis. The advantage of this design was it can be hung above the ground surrounded by the trellis without any proper support. The condensate is collected in a collection bottle, which must be covered to protect the water from being evaporated.However, the condensate thus produced was insufficient to sustain the entire installation. A solution to the PET bottles is a dehumidification unit that comprises of 12v cooling fan, 12v Peltier module, heat sink, water collection container and a solar panel. In the dehumidification unit, water is being pulled from the air by means of 12v cooling fan.



Figure 1. (Left) The constricted ends of the half bottle createventuri effect inside the installation. **(Right)**The preliminary circular profile was exhibited at Kalashetra, Chennai, Tamil Nadu.
Source: Author, 2018

The dehumidifier consumes electricity to condensate a considerable amount of water. Ambient dust appears if the dehumidifier runs without a filter. When operated without the filter dust will eventually plug in spaces between heat sink and eventually burns out. Hence, there is an absolute need for an air filter.

Chrysopogonzizanioides, commonly known as vetiver has a high-water retention capacity, is placed along the curvature of the trellis (Chomchalow, N. (ed.) 2000). English ivy is planted on the base which is surmounted by the trellis enveloped with vetiver. This combination efficiently creates an artificial Nano-ecosystem which retains the available water within the framework in the form of humidity. This humidity is converted into water, thus completing the cycle. Efficient irrigation systems are implemented to prevent water loss, the rest of the water is stored in a repository.

Table 1. Few Suitable plants with high evapotranspiration rate (Source: Author, 2018).

Plant Name(s)	Sunlight Requirements	Water Requirements	Evapotranspiration Rate(ml/hr)	Spacing	Region
Aganosmacaryophyllata	Full sun	Normal	1.2	90-120cms	Coastal
Allamandacathartica	Full sun	Normal	3.3	1.2-1.8m	Coastal
Aristolochiagrandiflora	Full sun shade	Normal	0.9	2.4-3.0m	Tropical
Beaumontiagrandiflora	Full sun	Normal	3.2	2.4-3.0m	Coastal
Bignonia purpurea	Full sun, Semi shade.	Normal	1.6		Tropical, Sub-Tropical
Bougainvillea	Sun shade, Dry area	Less	2.7	1.8-4.7m	Dry
Clerodendrumsplendens	Full sun and Evergreen	Normal	1.1	1.2-1.8m	Warm and Humid
Ficus ripens	Full sun	Normal	1.9	40-50cms	Coastal
Hederacanariesis	Partial shade	Normal	1.9	90-120cms	Coastal
Jacquemontiaviolacea	Full shade	High	3.5	90-120cms	Coastal
Muehlenbeckiacomplexa	Full sun, Partial shade	Average	1.8	30-38cms	Coastal
Pyrostegiavenusta	Full sun, Semi shade	Normal	1.3	90-150cms	Tropical, Sub-Tropical
Vernoniaelaeagnifolia	Full sun, Partial shade	Average	0.9	15-30cms	Tropical
Parthenocissusquinquefolia	Full sun, Semi shade.	Normal	2.9	90-120cms	Mediterranean

Less water requirement is about 1 L/sqm and during summer 2 L/sqm. Normal water requirement is 2 L/sqm and during summer 3 L/sqm. Average water requirement is 2.5 L/sqm and during summer 3.5 L/sqm. High water requirement is about 5 L/sqm and 7.5 L/sqm during summer days. Here, L/sqm stands for liters per square meter per day (Table.1). The water requirements depend upon number of plants planted per square meter area of the soil.

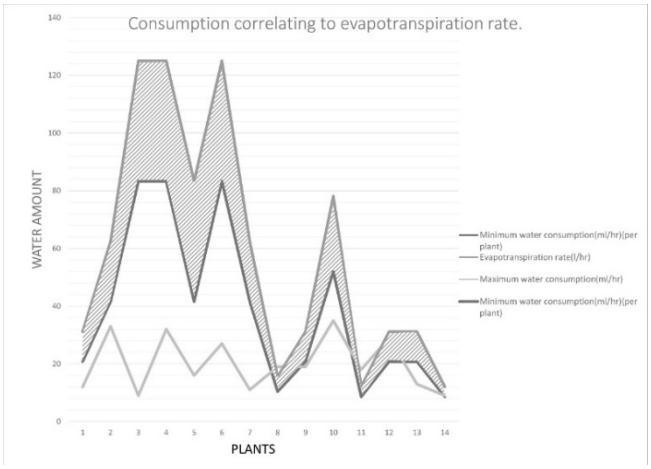

Figure 2. The graph showing the water consumption of the plants correlating to their evapotranspiration rate. *(Source: Author,2018)*

The shaded region on the above graph suggests the water requirements range of the respective plants. (Figure.2). More than 99.9% of the water used by the plants is drawn through the roots and transpires through the leaves, about (0.1%) of water is only used by plants to produce plant tissues.

RESULTS

The plant's water needs are influenced by environmental, regional and weather changes. There are several ways to determine the consumption of water by the plants. Their water uses differ from day to day and a constant check must be ensured for their protection.

The designs are estimated to create enough water daily to sustain the setup (6.51 liters a week) at an example climatic condition of Chennai. The initial water requirement for the entire structure is 2 liters per day after regular intervals, for a tropical semi-arid region. High humid or coastal areas require no or less initial water, but arid and semi-arid areas have their respective initial water requirements. The preliminary design of PET bottles gives 46 milliliters of water in 8 hours, i.e. 138 milliliters of water per day. A series of bottles could increase the water generated exponentially. However, there was insufficient amount of water for the plants and condensate can contain dissolved chemicals such as BPA (Bisphenol A) that makes water carcinogenic. The following design uses a dehumidification unit to generate water from thin air. The total water generated by the dehumidifier is 40 milliliters of water per hour or 799ml-930 milliliters of water per day. It is influenced by presence of humidity inside the installation and from the outside due to venturi effect.

The English ivy absorbs about 40%-50% of the initial water provided, i.e., 0.8-1 liter and vetiver absorb about 30%, i.e.0.6 liters. Normally, English ivy consumes 1L-1.5L (Sela, G., n.d) of water each day with evapotranspiration rate of about 1.9 milliliters of water per hour or 43 milliliters of water per day (Salama, M., et al. 2015). The lost water is retained in the vetiver which has a water retention capacity of 26 milliliters of water per hour or 630 milliliters of water per day. The humidity inside the installation is maintained at 584 grams per cubic meter. About 10%-20% of the water is either evaporated or absorbed by the soil. Therefore, total water generated by the dehumidifier is approximately 93% of the minimum water requirement of the English ivy.

DISCUSSIONS

Theoretical treatise can be no substitute for a practical experience, so we designed a concrete structure to make it suitable for all climatic conditions. The basis of the design is to harvest the moisture in the atmosphere and convert it into water by the process of dehumidification, which is in turn used by the plants. Using dehumidifier condensate, to water plants can be a debatable topic. Some studies suggest that dehumidifier condensate water is perfectly useable, even for consumable plants. Unlike water from taps and wells, the condensate contains no dissolved minerals. There are almost no detectable metals, and as long as the air entering the dehumidifier is filtered, there are no excessive organic decay products. The preliminary form is a single curve that is broad in the center and tapers at each end with a circular base. This configuration can be altered depending on its surroundings. A flat profile can be used in balconies, windows for a real cold breeze in the summer days and also behaves as a visual barrier. A semicircular profile can be used in public parks, pedestrian walks and other urban environments. This design was exhibited at the Reciprocity fest, Kalakshetra Foundations, Chennai; titled "THE GREEN MACHINE", dated 11/2/2018 (Figure.1). Several variations were done since then.

If the dehumidifier condensate can be used for even consumable plants, why can't our design support such plants? The above narrative answered reasoned responses to our question. Such variations in our design can sustain plant life for consumption even in water devoid areas. It requires nutrients for their growth, since the condensate is demineralized. Man engineered ecosystems can sustain life even in the extra-terrestrial conditions.

Developed cities could afford to build a desalination plant or could find alternative solutions to overcome water scarcity, but developing and under-developed cities might not. Wealthy residents of the water scarce areas can cope with the crisis by drilling bore holes into the aquifer, but a poor resident may not. The solution to water crisis should not depend upon the economic conditions of a city or a resident. Our design does not satisfy the needs of the people during the water shortage but in turn acts as an eternal water source for the plants during the crisis. Since plants help in the recovery of the ecosystem, focusing on the protection of the plants during the crisis can help greatly in recuperating the deteriorating ecosystem. The above scenario is a best example that emphasizes importance to support the plants in water scarce urban areas.

CONCLUSION

Explaining the specific qualities of our design and possibilities of optimizing them was our prime intention. "Ecosystems can recover from some variations, but big variations can cause irreversible harm". They have evolved under fluctuating circumstances, but humans have increased the magnitude and speed of fluctuations beyond many ecosystem's capacity to adapt (Zetland, D. (2014):88,89). Even though they could recover from some variations, the recuperated ecosystems might not be the same as their former self and the procedures involved might not be sustainable. The change is inevitable and it must meet the needs of today without compromising the ability of future generations to meet their own needs.

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Comparison of Daylighting in Courtyard House and House without Courtyard

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Abstract: Day light is considered as the natural light that enters into the space. It avoids glare and other effects caused by direct sunlight. It also influences factors such as energy conservation, sustainable practice, safety and security. Chennai, which falls under hot and humid climate zone gets abundance of sunlight for nearly 12 hours per day and a moderate wind breeze. In traditional houses, courtyard –a space enclosed by a building that is open to sky, was the key element for their house design which was climate responsive and has a passive strategy. Courtyard was used as light well and microclimate modifier. It also holds importance in sociocultural factors. The major goal of this paper is to compare the daylighting achieved in courtyard houses and house without courtyards in Chennai, under clear sky conditions, so that the standard lighting requirement is achieved, by just altering the opening position and sizes. The average temperature and luminous intensity is noted at the work plane of height .75m from the ground. The daylighting in courtyard house, located in Mylapore; and house without courtyard located in Tambaram were studied and analyzed. The paper concludes with the evaluation of daylighting using dialux software, analysis was drawn about the effect of daylight in the users and its result is summarized.

Keywords: passive strategy, daylighting, courtyard, hot humid climate lighting Assessment using dialux software.

INTRODUCTION

"Even a room which must be dark needs at least a crack of light to know how dark it is."- Louis Kahn

Architects integrate daylighting considering factors such as building envelope, building orientation, floor plan, site, climate etc. Daylighting is also being influenced by properties of materials. In a residential building daylight is been used immensely in kitchen, living, bedroom. But in the modern residential buildings, open plan is being used where all the activities is carried out in single room. Daylighting is important for human physical and psychological wellbeing. Courtyard is used as a passive cooling strategy in hot and humid climate. The brightness of the clear sky changes time to time. So the solution of giving large size windows does not increase the effective illumination required for the space considered. Illumination level inside a space is also determined by an important factor which is the color of the surface which should be light in color in order to reflect the daylight. The indoor daylight depends upon size, location of window, room size, interior finish and external obstruction present outside the building.

The objective of this work is to compare the daylighting in both the cases, calculate and compare daylighting in each designated room with specified Indian standards for lighting. Dialux software tool is used to stimulate the illumination level inside a room to analyze daylight.

CASE STUDIES

The House with a Courtyard:

Description
Location: Mylapore, Chennai.
Timing: 11:00 A. M.
Average Weather: 34° C; Clear Sky.
Climate: warm and humid

Its plan is rectangular with a courtyard of size 5.3 m x 4 m surrounded by rooms in an L-shaped fashion. There is less corridor space and slight level difference of 5 cm exists. The courtyard is surrounded by square shaped bedrooms, a rectangular shaped room, a rectangular kitchen and a foyer space. No windows were found in the

bedroom on the periphery wall, indicating that they were lit by the light from the courtyard and the utility space. The kitchen contains a chimney and a small opening at the top for ventilation and way for the smoke, along with one skylight in the middle of the room.

The courtyard was adorned with various plants. It also served the purpose of a rain water harvester and captured ample amount of light. The store room didn't have any window except skylight allowing just 3 to 5 lux into theroom.

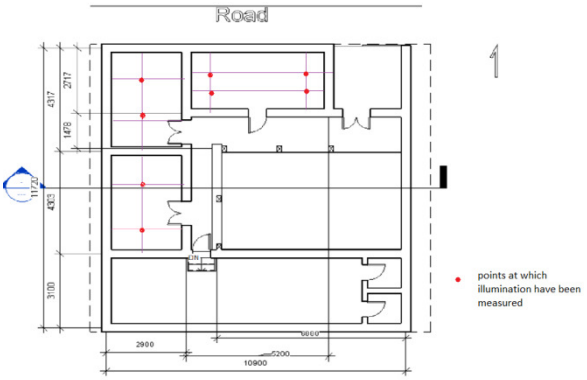

Figure 1.Plan Showing Courtyard house of Mylapore.

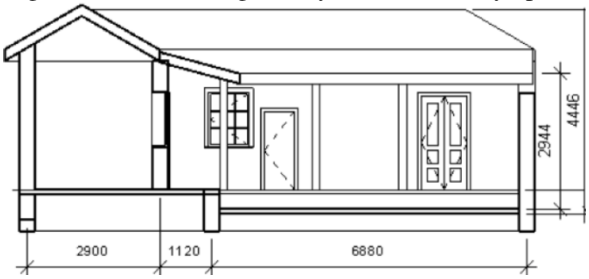

Figure 2. Section of Courtyard house, Mylapore.



Figure 3. Showing the interior of Study Area.

CASE STUDIES

THE house without courtyard

Location: Tambaram, Chennai
Time: 11.00 A. M.
Average Weather: 34° C; clear sky.
Climate: warm and humid

The plan was square shaped with light projections on the east and west sides. The room on the east was well lit and used as a study room. The kitchen was well lit with a good number of windows. Daylighting was less in bedrooms which brought a cosy and comfortable feel to the space. Room 2 was used as a Dressing room.

Despite the absence of a courtyard, each space was well lit with windows and ventilators. The kitchen was particularly well lit since food preparation and clean up requires adequate quantity of light to prevent burns and cuts. The actual food colour to be perceived was also achieved by the presence of a good number of windows

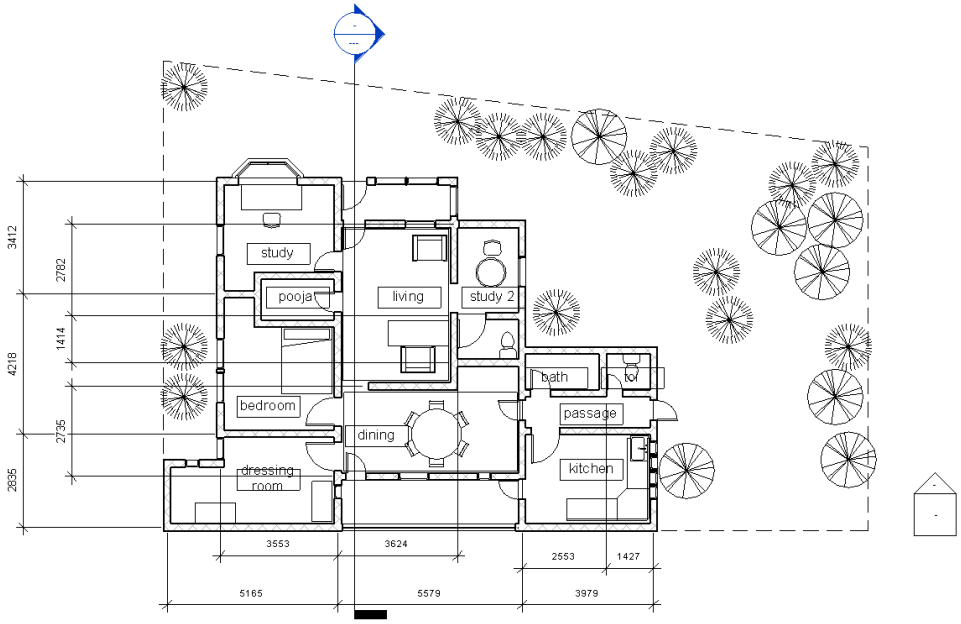

Figure 4: The detailed floor plan of case 2.

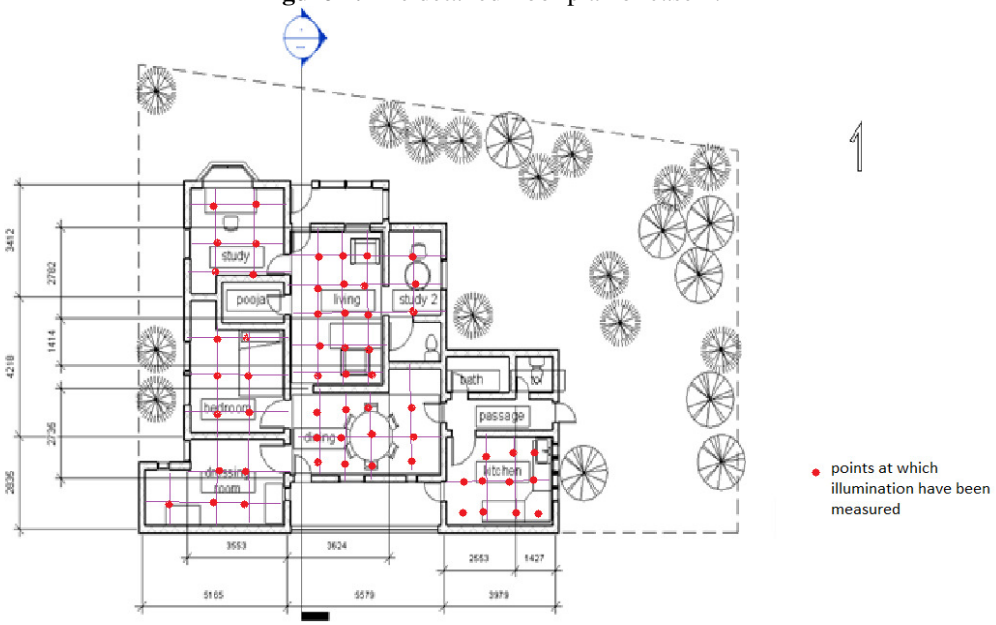

Figure 5. Plan with points in which illumination have been measured

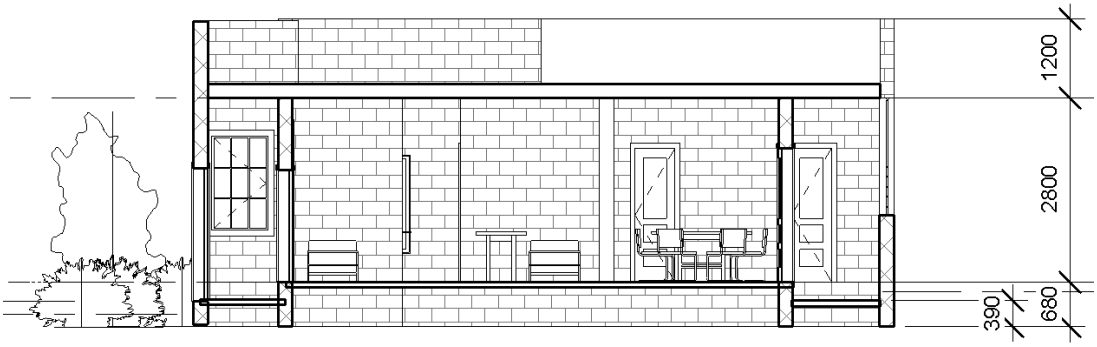

Figure 6. Section of the case

FIELD SURVEY METHODOLOGY:

The field research was conducted during the month of July. Daylighting data was collected through lux meter in the corners and in the Centre of the rooms. Data collection focused on the horizontal working plane level 0.70 m above the floor on all essential places like bedroom, hall, kitchen, passage etc. at 12.00 noon. No additional or artificial lighting was used during measurement. The model of the house was imported in dialux to calculate and analyse the daylighting level in each room. According to IS: 2440.1975 the external available horizontal illumination which may be assumed for design purposes in the country may be taken 8 000 lux.

Table 1. Day light factor percentage for case study 1

LOCATION	DAYLIGHT FACTOR PERCENTAGE
Kitchen	2.5
Living room	0.625
Study	1.9
Circulation	0.313

Daylight factor and lux level obtained through site study is verified using Dialux simulator. These have been changed according to standards given in NATIONAL BUILDING CODE 2005 and IS: 2440.1975 by altering windows position, sizes and shading devices. The average of measured illumination is calculated.

$$\text{Daylight factor} = \frac{\text{Inside illuminance}}{\text{Outside illuminance}} \times 100$$

Table 2. Day light factor percentage for case study 1

Kitchen	0.43
Bedroom	0.4
Store room	0.025

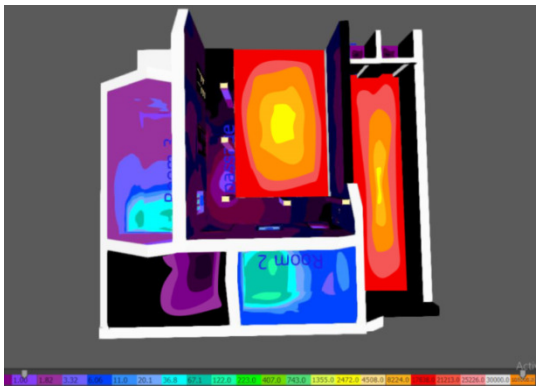

Figure 7. Daylight calculation in courtyard house

Table 3. The acquired daylight factor for house without courtyard:(in percentage)

Kitchen	1.3
Living	0.58
Bedroom	0.375
Dining	0.6
Study	0.85

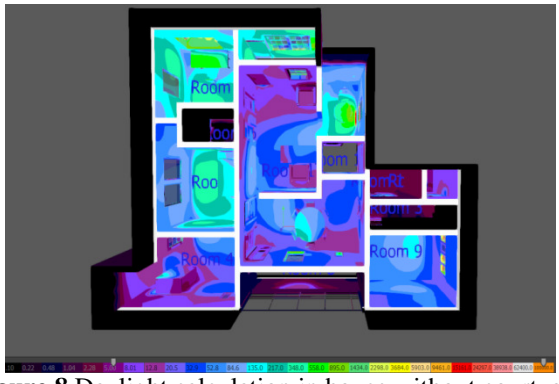

Figure 8. Daylight calculation in house without courtyard

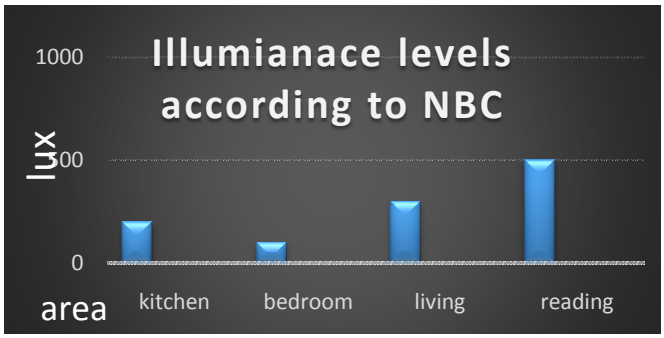

Figure 9. Illuminance levels according to NBC

EXPERIMENTAL ANALYSIS

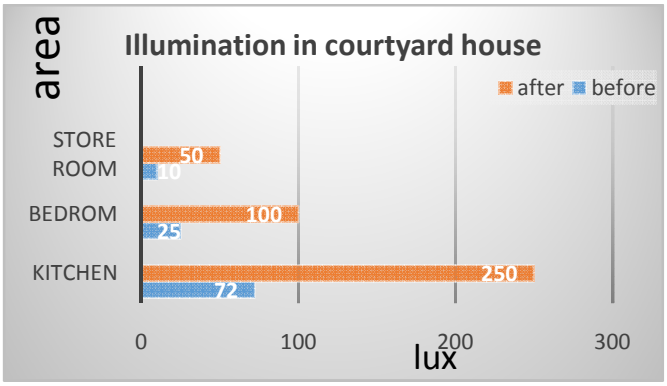

Figure 10. Graph representing daylighting in courtyard house before and after adding openings

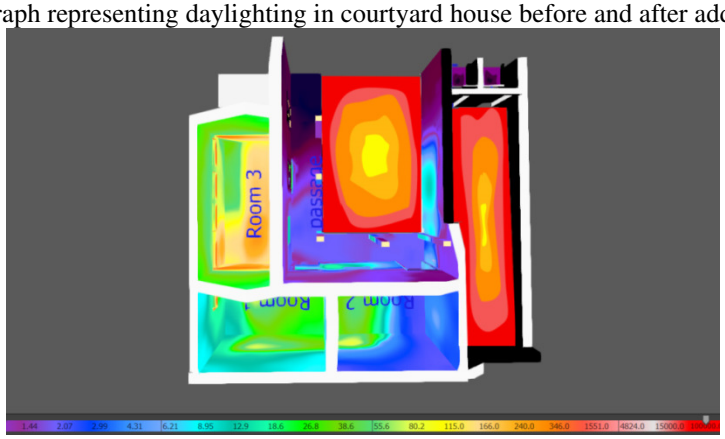

Figure 11. Daylight calculation in courtyard house after adding additional openings

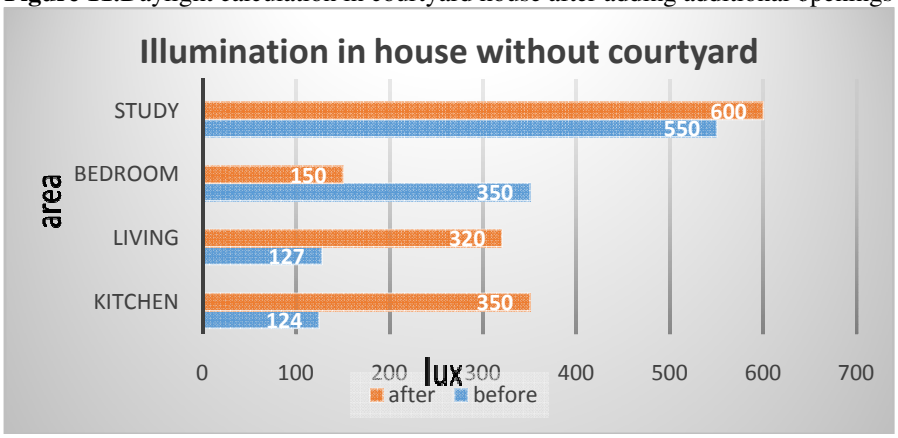

Figure 12. Graph representing daylighting in house without courtyard before and after adding openings

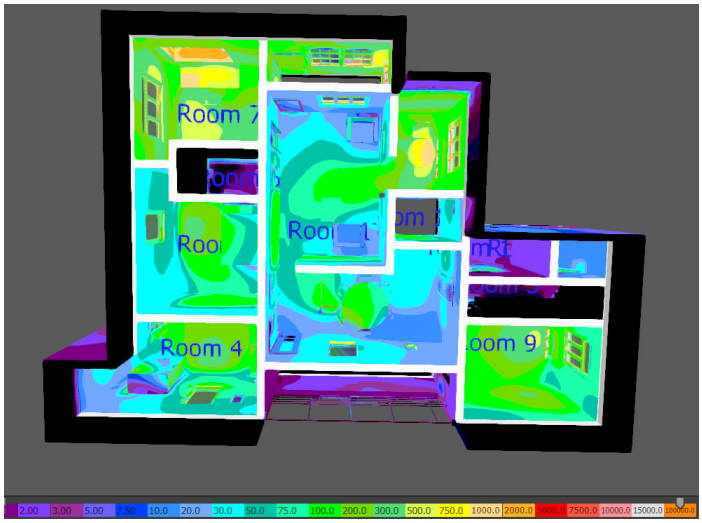

Figure 13. Daylight calculation in house without courtyard after adding additional openings

The taller windows give greater penetrations, while broader windows give better distribution of light when positioned along the same, adjacent or opposite walls.Broader windows gives effective results when they are provides with the sill heights of 1.5 to 1.8.Openings have been given and results have been generated so as to achieve standards.

The daylight in a house without courtyard in the living room is very less as compared to that of courtyard house. In the case of courtyard houses the courtyard act as a light well which makes the passage around the courtyard brighter. Whereas after adding additional windows with a sill level of 1m makes the rooms in the courtyard house brighter. The effect of courtyard brings in more diffused light and but not heat.

Whereas in house without courtyard the light is not reflected through ceiling so only the portion of the house near the window gets direct or diffused light, the rooms deep inside cannot get diffused light or it is in very less percentage.

CONCLUSION

Courtyard is an open space letting in abundant light required. Whereas in houses without courtyard the region near the openings are well lit than the interior spaces. In modern context, due to population explosion, courtyards have been diminishing. Courtyards bring in ambient lighting as well as good ventilation and act as a microclimate modifier. Implementation of courtyard or atrium in conventional can be done so as to improve the quality of light and to ensure all places are well lit and by the way it consumes only less number of artificial lights which acts as a sustainable element.

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Environmental design strategies in practice: Need of green spaces in urban context

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Abstract: Urbanization in India has accelerated a series of urban transformations in the densely populated urban areas, which has resulted to the dearth of green open spaces in India. Due to the startling necessitate of residential and commercial segments to accommodate the population and its demands, the urban landscape went through numerous forceful changes for a long time to perk up the quality of life after compromising the availability and accessibility of green open spaces. This insidious erosion of public open spaces has resulted in the formation of urban heat islands, climate change as well as urban ecosystem imbalance which further aided to natural calamities; furthermore, henceforth affected the urban morphology over and above the livelihood of people both physically and emotionally. In this paper, we take a look at the essentiality of open spaces in the urban areas in the present situation, since it is getting vanished off from the nature; meantime the inhabitants are longing for open spaces in order to befall alive healthy, specifically in Hyderabad city. In another case there are open spaces still in intact in Indian towns and cities which are needed to be protected. Open green spaces are proved to be a great advantage to our atmosphere, but the people who are living in the urban area are deprived of it due to be short of green space or land. The open green spaces act as a filter to pollutants and dust as well as provide shades therefore the lesser level of hotness in urban areas reduces erosion earth into waterways, which results reduce the air contamination and effect of health. From this paper we can recognize the significance of open spaces in the urban cities; along with that we elucidate why people need open green spaces in the urban areas against the impact of its unavailability in all the urban and metropolitan cities as well as the inevitability of open spaces for the well-being of the human beings, by providing green space, water features, come up with new design schemes

Keywords: urban landscape, urban morphology, open space

INTRODUCTION

In ancient India the streets of big cities, like Mohenjo-Daro or Harappa were laid out in perfect frame work like courtyard, backyard, and veranda. All the houses were protected from sound, odors, animals, birds and thieves because of the green space and town planning of the municipal, and even the people were healthier both mentally and physically also they had more green space around the houses, in that most of activities like gathering, festival, marriage, and marketing public bath had been happened in the open green space therefore the people had good relationship with one another and they had partaken all the good and bad activities in the societies. Those time people had no pollution but they got good air, rain, weather, plants, trees and agricultural area. But in modern contest the urban green space is considered the lungs of the cities.

In this modern world the open green space is decreased due to urbanizations, people don't have time to think about the green space because of their life style and busy schedule towards their earnings, at the end they depend on the artificial green space in their home but that never satisfy them mentally, physically and psychologically, therefore they in search of green space like resort, garden, amusement park and beech. The psychologist stats that the people those who are living in the urban without open space and the green space have more psychological issues like stress, frustration, anxiety, sad, obesity, depression and loneliness when they compare with the same targeted group those who have open green space therefore the psychologist say open and the green spaces are the natural therapy of the people.

More open green space within a city's borders can get better in the urban atmosphere by giving good air, rain, weather, and health. The open green space goal is to help and control air value and weather by dipping energy utilization by facing the warming effects of covered surface recharging groundwater provisions and safeguarding lakes and streams from contaminated excess. Therefore the urban area will face many difficulties for urban development. By bringing many housing, educational institution and hospitals, due to this all the open green space will be destroyed for the multipurpose of buildings so people will lack more green and open space, because of that the population will face more air pollution, water pollution, contagious illness, weather change, more density, more traffic, stress, obesity, depression, and so on, therefore the architecture has a big role in designing and planning a open green space buildings in the urban area.

URBANIZATION IN INDIA

The design and planning of towns, cities, and villages has been done on a scientific reasons and scientific base in India, even in Vedic times. Ancient principles underlying the planning of an ancient Indian village more or less resembled those of the modern garden cities. Even cities were strong, and houses were Group houses and single and double courtyard houses which were based on climatic reasons and activity based. But in India the due to urbanization Migration happened to urban areas for the better livelihood. Also drastic changes in construction and land use pattern. Open space need is more when people increase, but open space importance ignored.

In early days, even they were considered the pollution effect. In Indus valley time except main streets, in all internal streets were narrow and no openings exposed to streets, that also very narrow openings for privacy factors and to control dust and heat. In today's context people needs are changed, practices are changed, because of well advancing technology, even civic cense matters, which made cities more vibrant and polluted. Ultimately people's health affects and it leads to environment disaster. Green space provision in urbanized areas is highly difficult and changes according to the needs, that is inevitable. So we need the role of designers and planners to act according to the context which demands for the welfare and the protection of environment and people.

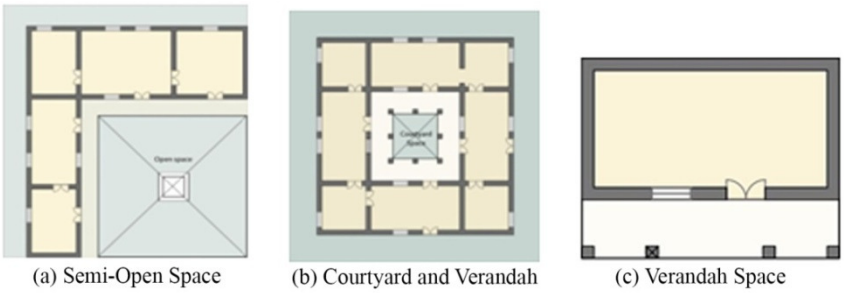


Figure 1. Traditional houses in relation to open space and semi open space concept.

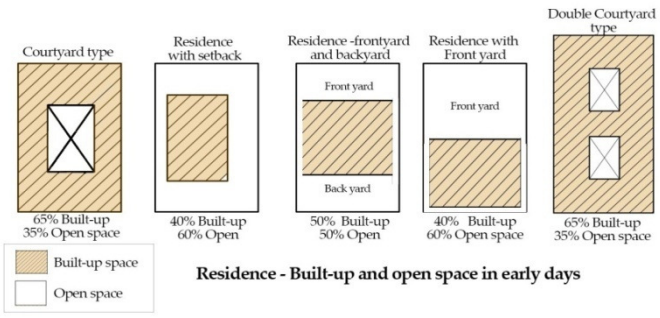


Figure 2. Open space Concept in early days, Traditional houses related to open space and semi open space

A century back courtyard type houses were 65% built up, 35% of open space, residence with setback 40% of built up space and 60%open space, residence with courtyard and backyard 50% built up space 50% of open space, residence with front yard 40%buuilt up space and 60% open space, double courtyard type 65% built up space and 35%open space. It shows importance of open space is proved.



Figure 3.Cities early days (scattered) and recent days (dense). Source: The Author

REVIEW OF THE LITERATURE -1

Introduction

The topic of the literature is Factures Influencing Perceptions and Use Urban Nature, the author of the literature are Somajita Paul and Harini Nagendra, the paper was reviewed on 5th February 2017; accepted on 12th April 2017 and published on 18th April 2017, this paper talks about the park visitors and the importance of the green space in Delhi.

Body of the Literature Review

This study focused on the national capital territory of Delhi, couple of years back people enjoyed the park which is located near to the national capital territory, they had good time with the family in the park as a stress buster, but at present the city is more populated that is the reason the park is more crowded and polluted therefore people expect more green space in the park for their amusement, stress out, and workout because they don't have any green space in their residential area, now they realize the important of the green space in their residential area.

Conclusion of the Review

As per the conclusion of the litterateur review the examination of park users is extremely large, therefore the essence of park is very much important for the people. The review of the study adds that the developed cities like Delhi need more green space to bring the people from the stressful and mechanical life of corporate sectors, as per the psychologist green space in the urban area become the therapy of stress reducer among the people.

REVIEW OF THE LITERATURE -II

Introduction

The topic of this literature is Advancing Sustainability through Urban Green Space; the Authors of the Title are Viniece Jennings, Lincoln Larson, and Jessica Yun, the paper is received on 23rd 2015; Accepted on 2nd February 2016 and Published on 5th February 2016, this topic talks about the Urban green spaces which provides collections of benefits, or bionetwork services, which supports our physical, psychological, and social health. But it is not equally distributed in many cases in the diverse urban population.

Body of the Literature Review

Most of the time people demonstrate the nature of the environment as "Green Space" because of the greeneries of the nature, parks, gardens, hills, forest. People connect their life with the nature stating if there is good green space then they have good health, because they get good air to breathe, and there won't be any contamination of the air and pollution.

Conclusion of the Review

Evaluating the role of ecosystem the urban place need more green space in order to bring the healthy environment in the urban cities that may avoid the pollution and illness, even we can see in the urban cities due to lack of green space people bring artificial green space which does not give any satisfaction like the original. Finally for the sustainable urban development, the research compels the green space as a vital part of the urbanization then the wellbeing of the humanity will be very healthy.

CASE STUDY ON HYDERABAD CITY

Introduction

In Telangana Hyderabad is the capital city which was the former capital of Andhra Pradesh. Capturing exactly 650 kilometers (250 sq mi) all along the banks, it is having a inhabitants of concerning 6.7 million and a municipal inhabitants about 7.75 million. But standard elevation of 542 meters (1,778 ft), also Hyderabad is located in the hilly areas with multicultural and linguistic people. People are inhabited here for the purpose of occupation and education; moreover here people get good cultural diversity.



Figure 4. Map showing the location of Hyderabad

The Earlier Stage of Green Space in Hyderabad

In the earlier stage Hyderabad had more green space, and it was not polluted, people had healthy environment and they enjoyed the green space, they had good community relationship in the open space by helping each other and partaking in all the activities. but due to the urbanization most of them sold their land for the big price for malty national company and for the industry, therefore all the green space were removed without any planning of green space, even the parks where people use to relax has been destroyed and build big buildings.



Figure 5. The earlier stage of green space in Hyderabad.

Present Stage of Green Space in Hyderabad

Due to the urbanization of Hyderabad, it is more crowded with both population and construction, people are deprived of green space, due to that pollution of water, air, and noise are increased, people are very stressful and now under the threat of poisonous black carbon particulate from the industry which is mixed in the air. As per research Hyderabad has revealed high concentration of black carbon in the atmosphere an indication of unchecked uses of fossil fuel at homes and increase in the city, this is due to the population and pollution.



Figure 6. Present stage of green space in Hyderabad,

Population Characteristic

When we compare the population from 1971 to 2017, there is tremendous of growth in terms of population, Components of Growth National Census, Hyderabad is 10.86 million. Five folded multiplication in 50 years. That may bring the great disaster to the Hyderabad city due to population and pollution, if we don't protect the green space in Hyderabad for the development of the city.

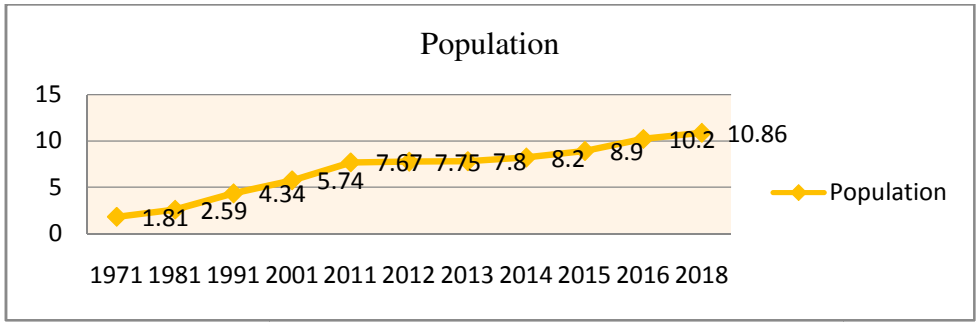


Figure 7. Graph showing Growth of Population in Hyderabad City (in millions)
Source: Census of India 2011, Population of Hyderabad 2018

Analysis of Urban Growth and Green Space of Hyderabad

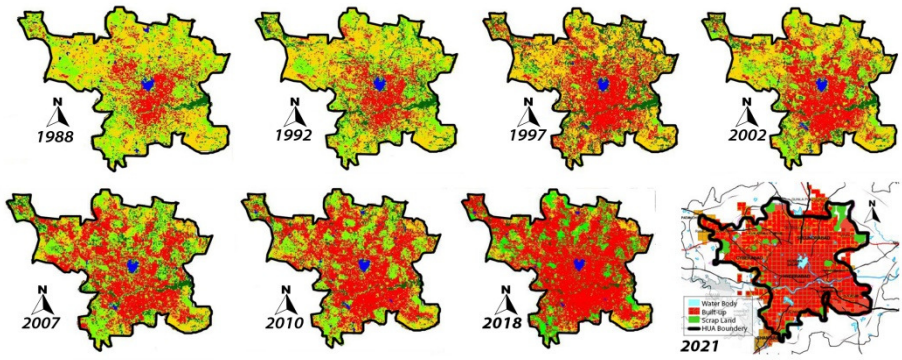


Figure 8. Maps showing the change in Land cover map of Hyderabad.
Source: Yaswitha et al., City Development Plan - Hyderabad

In 1989 Hyderabad had more green space and agriculture land, which had been reduced gradually because of the urbanization during the time of 1989 to 2018, due to that the city become high in density. Even the water resources are decreased, at present half of the open area has been converted to the development of the building due to economic development.

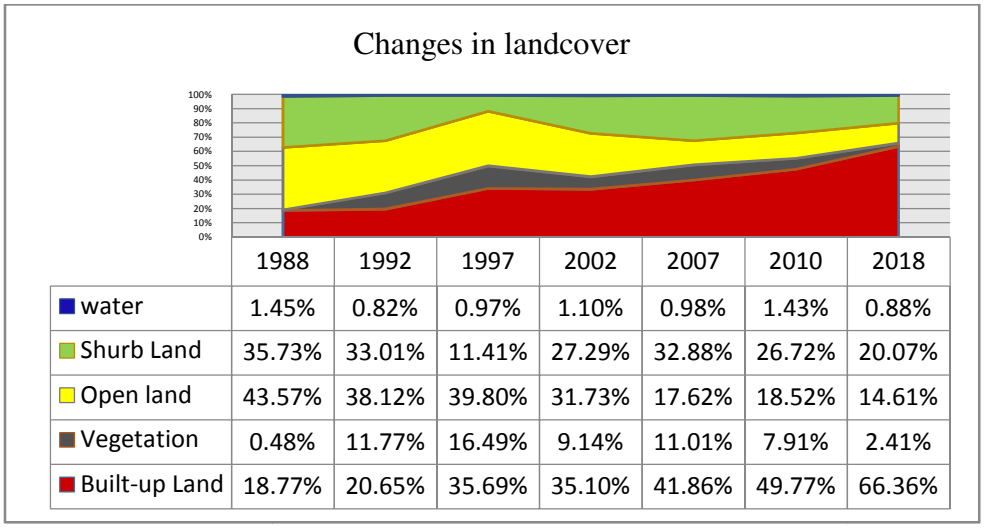
The below map will portray the changes of green space from 1988 to 2018, when we look in to the changes from 1988 to 2018 we can see the rapid changes in terms of the population and the development of the city, also it portrays the problematic situations of the city. At the end there is another map is located that is the prediction of 2021, that shows the approximate population without green space how the city is going to be dense. That conversion is given below LU/LC map

Population of Hyderabad In 2018

The population of the Hyderabad is not easy to judge because every year the population is increasing due to the development and the economic growth of the city, people come around the country for their occupation and for their education, due to the corporate sectors and their development Hyderabad is capturing the young people's heart and mind to work for the better salary, therefore the population is increasing day by day.

Population Density Which Changes Land Cover Of Hyderabad

The population density is 18,480 persons per square kilometer. The city is one of the speediest growing metropolitan areas in India, which has provoked various issues in terms of basic issues of livelihood like water, shrub land, open land, vegetation, and built up land. Here, there is a risky rise in Hyderabad's ghetto populace, which is accredited to incompetent municipal masterminding and additional prominent regional to urban immigration.



	1988	1992	1997	2002	2007	2010	2018
water	1.45%	0.82%	0.97%	1.10%	0.98%	1.43%	0.88%
Shurb Land	35.73%	33.01%	11.41%	27.29%	32.88%	26.72%	20.07%
Open land	43.57%	38.12%	39.80%	31.73%	17.62%	18.52%	14.61%
Vegetation	0.48%	11.77%	16.49%	9.14%	11.01%	7.91%	2.41%
Built-up Land	18.77%	20.65%	35.69%	35.10%	41.86%	49.77%	66.36%

Table 1. Changes in Landcover of Hyderabad over years
Source: Yaswitha et al., City Development Plan - Hyderabad

How Population Affect the Environment of Hyderabad

There are many ways which are affecting the environment of hydrabad, but the main one is population, due to that the city is polluted, pollution brings more complicated illness to the common people, there won't be proper guidelines' to eradicate the pollution from the cities. Vehicles are increasing every day and omitting the toxic pollution which even leads the people to cancer.

Air Pollution and Its Causes with Map Notification

Thirteen areas of city where affected by air pollution, and it has crossed the threshold limit. So that the board has admitted, that the air in these areas can cause breathing discomfort to people with lung and heart ailments. The areas are balanagar, uppal, jublihills, paradise, charminar, jeedimetla, Madhpur, MGBS, Rajendranagar, Nizam pet, Pashamylaram, olaram , Nacharam and ICRISAT, suffer from poor or bad air quality.

The air of the area has turned hazy because of smoke emitted by vehicles. Developing skin problems and persistent cough Pollution in the air is evident, as we can literally see the pollutant float in the air. Especially these areas do not occupy any green space that also one of the main reason for the air pollution. Many people are having chronic skin illness and asthma due to this air pollution.

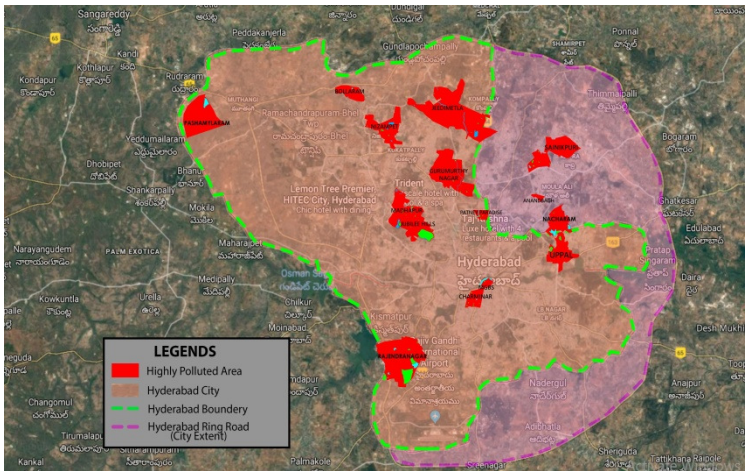


Figure 9. Map Showing thirteen areas of the city which are highly polluted.
Source: The Author

Table 2. Estimated Emission inventory for Hyderabad, 2006.
Source: (Guthikuna, November, 2008)

	PM	SO2	NOx	CO2
Vechicular Activity	8410	6304	39262	6400337
Paved Road Dust	3272	0	0	0
Unpaved Road Dust	4279	0	0	0
Industries	8985	4606	5070	654,717
Domestic	1845	667	545	83,485
Waste Burning	810	0	0	0

Evaluation of Health Effects Due To Pollution

Findings of Problems

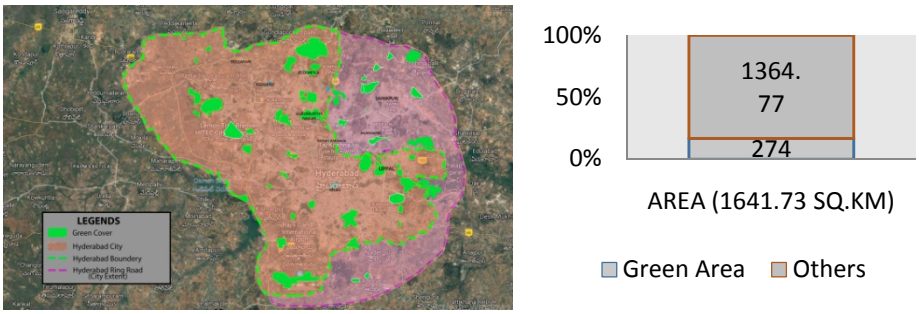


Figure 10. Percentage of Green Cover in Hyderabad City. (Source: The Author)

As per this map we can find the exact green space of the Hyderabad city and the deprivation of the green space and its effects. Due to the urbanization of Hyderabad, it is more crowded with both population and construction, people are deprived of green space, due to that pollution of water, air, and noise are increased, people are very stressful and now under the threat of poisonous black carbon particulate from the industry which is mixed in the air. As per research Hyderabad has revealed high concentration of black carbon in the atmosphere an indication of unchecked uses of fossil fuel at homes and increase in the city.

SOLUTION AND CONCLUSION'S

Some decades back, when we look in to the urban area of India we could not find much population so the outcome is, there were green and open spaces in all the houses, institution, hospitals, industry, multy complex, schools and colleges. So the urban area was not polluted therefore people enjoyed the weather, water, trees, gardens, and air, also they had green belt around the cities, that helps the people from the noise, pollution, contagious sickness, smell, dust storm.

But at the present scenario there are many problems are arising due to the urbanization. Due to this urbanization the population is increasing day by day with in the limited area for the better education, jobs, hospitals, and business. Therefore all the green belts and open green spaces are demolished and buildings are formed in the name of education, hospitals, industries and apartment, this action causes the air pollution, water pollution, heat, insanitary, illness, contagious sickness, mental stress, loneliness, depression and natural calamities. To remove these unavoidable evils form the urban area people need open green space in all the building as per the concerns of the architectures and the professional like doctors to bring the healthy environment in the urban area therefore there must be a strong urban planning with the green space to avoid all these upcoming disaster.

Land cant increased, increase of population and needs are inevitable, can come up with solutions solid waste managing level, strict design controls, should not damage the existing available green open space, provision of more water sprinklers ,cascades, water bodies by reuse of waste water are some of the design and planning criteria. So conclusion in result the city of Hyderabad having 4% green open space , in order to make green on ground ,propose multi layer of green terraces ,though how we are doing flyovers with no options, for the welfare of environment and public.

City planners should relies, instead of bigger parks at out skirts or somewhere festal small parks at every 4 to 5 km radios to day to day community interaction also to refresh the air at frequent levels for new development.

Even we can introduce domestic parks. Parks can communicate and can give an experience at community level. Propose climate responsive species. Use climate responsive material instead of glass which more causing the energy and environmental disasters. Biological corridors should provide and along with promenades for the safety of society. Involve local people in implementation.

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Urban Regeneration and sustainability Challenges in Tamilnadu

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Abstract: At present each city is stuck to identify the way how present urban needs can be solved in sustainable manner. The challenges it envisage on day today aspect is lot more to handle, each city is to think on multiple perspective for its development such as integration of latest technology into day today public service, decentralizing high urban density, streamlining the urban sprawl in each city, conservation of historical monuments, retaining cultural establishment of each space, support each development with basic urban infrastructure, planning for efficient transit model, sustainable & energy efficient strategies, supporting for its economic development, etc., The present urban need should not only focus its development on economic front but also on social need. With rapid urbanization in city some inadequate mechanism for governance at the local & regional level is happening and persistence of poverty, social discrimination through slums, imbalance in density of population & its infrastructure model. This paper is to bring the challenges in urban regeneration & sustainability model in Tamilnadu& to relate such situation with other regional or global development with examples.

Key words: Urban regeneration challenges, rapid urbanization, sustainable development, smart city.

INTRODUCTION

Urbanization is the major challenge of the 21st century. It is persistent in many developed nations such as Europe, US, Germany; they had felt its intricate influence in their development. Now countries like India, China, Nigeria are urbanizing at a much faster pace. Delhi being projected to attain the most populous city in the world around 2028 (As per world urbanization prospects 2018) and as a wholesome India is to add largest number of urban dwellers by 2050 (according to new united nations estimates).It is also projected, 68 percent world population is to live in urban areas by 2050 and at present 55 percent of the world's population live in urban areas. The world urban population is expected to be highly concentrated on few developing countries like India, Nigeria and also in developed country like China. All three countries will jointly hold 35 percent of world urban population between 2018 and 2050. India will have added 418 million urban dwellers, China 255 million and Nigeria 189 million by 2050. Indian population in rural area was the majority during 1950 which decreased due to the influence of urbanization resulting in population migration to cities for urban need. Now India has accounted for substantial urban population growth, where small & medium towns have much higher growth than mega cities. In recent years metropolitan cities declined in its growth at its center but grow in its periphery.

The problems faced by such sharp peak urban development in countries like India will necessitate the need of urban regeneration in sustainable manner. The distribution of urban population within states and union territories is such that the capital city leading in the front with 97.5 percent and union territory Chandigarh holding 97.25 percent. Tamilnadu continues to be one of the front runners with 48.4 percent of its population living in urban areas followed by Kerala and Maharashtra. Total urban population of Tamilnadu accounts for 9.27 percent of Indian urban population.

An accelerated pace of growth rate in urbanization would give a chance of spillover of urban neighborhood & relative commercial expansion along peri-urban areas. This is a natural real estate phenomenon, when density of local areas is more cities naturally expand to its periphery to reduce capital land cost. Increase in urban density is through inflow of population from local towns nearby, who can only afford lesser cost to settle down in peri-urban areas. Naturally this kind of unorganized settlement along city periphery will influence the formation of smaller new towns at city vicinity. Unorganized settlement will lead to the need of land conversion or transformation with no basic infrastructure support. In general these urban expansions in mega cities or smaller towns are not supported with necessary basic infrastructure around its periphery, which subsequently lead to haphazard urbanization where settlement occurs before infrastructure of those spaces are planned or identified. When proper planned settlement does not happen retrofitting is done now & then wherever problems pops on, like flooding due to improper storm water drain, unavailability of ground water, etc.,

From recent study by the World Bank – India Urbanization Review: Urbanization beyond municipalities (2012)– urbanization in city centers is concentrated with high economic activities and large number of new towns is developed along city periphery. Transformation of land use by local authority regardless of the fact whether they are meant for expansion of local water bodies and not being aware of the consequence of each conversions as a wholesome. These unorganized developments will settle down with timely basic infrastructure need, not being aware it will necessitate an expensive retrofit in future.

TRENDS IN URBANIZATION

Even though we talk about urban growth in metropolises as a primary trend in present scenario, but actual trend setter is the growth of towns and its conversion to a small city by increase in population and economic activity. Urbanization in Indian cities started from 1991 and it was to the peak during 1996 to 2007 and each urban city stabilized in their growth pattern in subsequent years, where the city core was formed and the focus was to handle high population density & its correlative influences in urban space. At present after the announcement of smart city implementation in identified cities from 2015 by central government, the urban growth factor in smaller town tops up the list of urbanization to adopt themselves to commercial need and neighborhood settlement. Policy maker should plan for the smaller towns which are being converted to a city with very short span of timeline with no infrastructure support. Conversion of towns in to smaller cities in very less time period need to be addressed in large, than only concentrating on growth of mega cities. Census 2011 notes that number of towns in India increased from 5161 in 2001 to as many as 7935 in 2011.

URBAN REGENERATION

To overcome the crises which today's society face it is highly necessary to identify a sustainable mode of development with very simple implication process knowing available potential resource of the society, identifying important or high priority need of the society like decentralizing the urban density, ample provision for urban breathing space to have intact development still lining its day today needs, improving the quality of life, using all natural resource available in the locality, understanding human value of each space and maintaining economic balance with proper governance in urban regeneration process.

In some condition it might need to revitalize distress urban areas, greater effort in identifying ways to link local cultural needs in the urban renewal plans, upgrading & integrating all core service systems such as solid waste collection &disposal, sewage system, storm water drains, drinking water supply, sometimes provision or establishment of desalination plants, energy production & distribution systems with smart technology. Even though technology updates on every moment but the core idea of urban regeneration should be to integrate all its update with end user comfort.

For safe sustainable urban regeneration, governmental bodies and planning authorities should ascertain that plans made for overall national level urban development are transferred to the next authority of regional level planning followed by state level, city level and urban center level planning. Transfer of planning principles to subsequent lower level bodies will ensure a systematic approach to wholesome development and the system will ensure that all basic infrastructural support are there at each level of planning. Prime focus shall be made on the provision of urban infrastructure plan, integration of all services, with primary focus on mass transport loop system, providing transit hubs and mass transport node which helps in connecting people to urban center to its periphery. These kind of infrastructure support in metropolises helps in city expansion, urban density distribution, balance in real estate land value, balance sustainable energy model. Planning recommendation and module developed by authorities will depend on location front, established culture, historical importance of a space, industrial existence, etc.

Tamilnadu being surrounded by water towards its east & south has identical development at each location based on established culture along sea shore, historical connectivity around temples, work culture based settlement around high vegetation area, etc., Identifying urban regeneration module based on identical activity of each city is highly necessary. Public involvement in developing urban regeneration module for each city will have an edge on identifying local need which can be either cultural, historical, industrial, economical, natural, technology, etc.,

FAR DISTRIBUTION – URBAN REGENERATION AND SUSTAINABLE DEVELOPMENT IN METROPOLISES

An exponential increase in inflow of population from adjacent or nearby towns for the past 2 decades increases the density of population at urban centers. High density of population forces to lower the floor area ratio (FAR) at urban centers to decentralize densification. This act of lowering FAR leads to the expansion of city to accommodate urban population inflow resulting in unmanageable urban sprawl for which the city does not have the capacity to support its expansion. Cities like Ahmedabad and New Delhi are exploring the possibilities of permitting higher FAR & higher buildings along major economic corridor or along mass transport corridors which enables to support higher density with necessary basic infrastructure. This model can bring in some mixed development along economic, IT, Industrial corridors (general industries) where residential settlements can happen to upper floors and commercial activities at lower levels – limiting the travel distance and supporting to have much social &family time.

Cities such as Chennai, Mumbai, New Delhi have exponential urban growth for pass few decades. Cities are exposing themselves to develop their periphery in all direction with possible infrastructure connectivity. FAR was generically applied as singular blanket throughout the city with very little variation which forced for city periphery expansion. Preparation of frame work to provide maximum FAR value in city center and evaluating benefit of additional FAR provision versus increase in infrastructure of that space is necessary. Brazilian cities were adapting such methods to compare government received benefits on higher FAR in cities with the expenditure to strengthen existing urban infrastructure.

The Ministry of Urban Development (MOUD) brought in smart cities in 2015 to strength the urban infrastructure and to integrate technology into the smartness of the city, governance strategies, promoting high density, mixed use, area based development that is inclusive and sustainable. The mission guideline is to integrate technology in day today activity of individuals. This advancement enables individual to interface between departments to understand the status of their use, claims, to control energy based on their need. Zoning laws in New York City has continuously evolved to keep up with urban trends and technological advancement. Smart city development shall consider such trend updates in their governance of each city, flexibility module in urban regeneration system developed. Cushion in economic need for implementing trend updates is necessary to reach its practicality.

RETAINING LOCAL CULTURE AND HISTORICAL IMPORTANCE OF A SPACE DURING URBAN REGENERATION

When any urban development is discussed about our mind only focuses on the economic, political, social and infrastructure development of the city. We normally miss out to understand the important need for local prevailing culture, established from decades together. Cultural fabric is a collective identification of a space; it shall be given more primness in a sustainable urban development module. Involvement of localities during module formulation will give comprehensive guide line and integrate cultural establishment of the space rather than focusing only on economic value of the space. For example northern part of Tamilnadu capital city, Chennai will establish different culture when compared with southern part of the city. This kind of varied cultural system within each area will unknowingly have small change in the need of urban spatial need during each occasion. Cultural fabric of the space should eminently focus on such local need in an efficient and to full extent.

Historical importance of the space is to be well kept similar to its cultural need. Historically high important public spaces are retained, renovated with the same essence; identity of such important space should be established during any sustainable urban regeneration modules. Sometimes cultural & historical importance is strongly bound with other by its existence for a longer period. Tamilnadu has many historical important spaces formed from time immemorial, distributed all around in each city. High participation of Tamil scholars or historian of each locality will play a pivotal role in framing principles on local historical background.

CONCLUSION

Tamilnadu has variety of cultural system followed in each city, generic sustainable regeneration model cannot be applied here until local challenges are addressed in each city either on cultural value, historical value, local urban needs, etc., Districts which had topped urbanization growth in Tamilnadu state (as per census 2011) are Chennai, Kanniyakumari, Coimbatore, Thiruvallur, Kancheepuram, Tiruppur, Madurai, The Nilgris, etc., Sustainable urban regeneration model in larger sized or well developed cities to follow different strategies when compared with rest of the cities, Example Chennai, Coimbatore are established city model where city faces the issue on peri-urban development, higher density in city center, higher land cost model, development of urban poor, lack of mass urban transport system to connect its boundary to its center in lesser time. Whereas the other smaller cities will have to deal on creating urban centers, economic corridors, job opportunities based on available local human resource, retaining all prevailing cultural and historical system.

India has developed very few planned cities; the unplanned cities in general started its development either by the presence of historical monument or formed along the river beds as part of trade activities. Each town formed by the presence of some historical monument followed by an established cultural system in its locality. Very few towns were to establish economic need and expanded due to population inflow. Now expansion of each city integrates the adjacent towns as peri-urban areas. Present day study informs that peri-urban area growth in urban density is higher than the urban centers. It is right time to bring in urban regeneration model which are sustainable, following local cultural system, retaining historical importance of each space. At the same time supporting urban development by basic infrastructure need. Tamilnadu is to establish a Master plan for its state on sustainable urban regeneration module supported with proper economic plan –mix of funding from all global level supporters, urban mission supporter from central agencies, public private partnership (PPP) module implementation on smaller scale. Proper funding system will establish to plan integrated and sequential implementation of identified urban regeneration module for each city.

For Metropolis or high density urban center cities will have to debate and understand uniform distribution of FAR versus provision of higher FAR along identified transport corridor and economic corridor. FAR establishment will have substantial impact on real estate value of land and affordability margin of individuals will be determined. These values are highly sensible in nature and should be handled in wise manner with research on it pros & cons of implementation. State government should undertake statewide analysis of above scenarios.

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Alternative Sustainable Energy Sources: Geothermal Energy as an underexplored alternative

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Abstract: This paper aims to search the alternative energy sources which are sustainable with respect to various parameters. The various energy sources available are astral energy, storm power, Biomass energy, Hydrogen, Hydropower, Ocean energy and geothermal energy etc. Each energy source will have its own advantages and disadvantages with respect to feasibility and efficiency, based on different parameters. Identifying Geothermal energy as an under explored, potential alternative energy source which can yield clean and sustainable power for a variety of uses without burning the conventional fuels, and gases or exploiting the forests and catering to both manufacturing and household energy requirements in different segments of the globe. This document also reviews the best practices of geothermal energy plants both in India and abroad to understand its potentials in order to implement and explore it in a more effective manner. This paper also finds the strategies and different ways to reduce the huge gap between supply and demand of energy sources needed for the sustainable growth and development of mankind

Keywords: Alternate energy sources, geothermal energy, Potential source, Parameters, Strategies

INTRODUCTION

Our day today activities demand high quantities of energy sources and are mostly met by our conservative vestige fuels such as gasoline, petroleum, diesel, kerosene etc. In about 40years, it is predicted that, we will have a huge shortage of oil and natural gas. They are equally harmful and causing environmental issues by giving out harmful by-products. Excessive use of Fossil fuels increases the greenhouse gases which in turn increase the temperature of the Earth. So we will have to search for alternative energy sources for sure which are renewable and sustainable at the same time. To solve this problem, we need to restrict and gradually abandon the fossil fuels and encourage renewable energy sources. Naturally available sources i.e., unconventional ones such as solar, wind, biomass, biogas, tidal energy etc. They only require basic storage system for energy which can be further used for fulfilling our requirements at micro as well as macro levels.

As an impact of the IT industry in the state this region has emerged as popular tourist destination because of its proximity to Bangalore the state capital and IT hub. Several tourist facilities have emerged including home-stays and time-share resorts to cater to the tourists who flock here typically in the summer months to enjoy the pristine beauty of the environs.

WHAT IS GEOTHERMAL ENERGY?

The Geothermal energy being an alternative potential energy source caters to both manufacturing and household energy requirements. Geothermal power is the clean energy source, of the other unconventional ones. “Geo” indicates “Earth,” “Thermal” indicates “Heat”. So, geothermal energy can be clearly said as “Heat or warmth Energy from Earth”.

Being hygienic and self sustainable, possessions of Geothermal power vary from low ground to boiling water and hot rock deepness of which varies from few miles to downward even deeper to the tremendously high temperatures of magma or molten rock.

The use of Earth’s internal coating heat as an energy source started in the early period of 20th century. Italy was the first to generate electricity from this in 1904. In last three decades geothermal energy has seen much progress in usage throughout the world. Traditionally this clean source of energy was used to heat up the houses and water. In present scenario, it is largely being used to produce electricity to cater the needs of increasing population.



Figure1. Geothermal power plant in Reykjavik, Iceland
Source: A publication on geothermal energy and its potential in India

Geothermal power plant in Iceland (Fig. 1) has been using its subversive reservoirs of vapour and hot water to produce electricity and also utilized directly to heat and cool buildings.

HOW IS GEOTHERMAL POWER PRODUCED?

Electricity is produced when steam passes through a turbine and activates the generator. Unlike conventional energy plants, geothermal energy plants use vapor, created out of reservoirs of hot water which are set up inside the internal Earth's surface.

Dry steam can be used to generate electricity and it is the ancient type of power plant using geothermal power. Flash-steam plants are the alternative power plants which make use of natural sources of underground hot water and vapour

Table.1 Benefits Of Geothermal Energy

Available	It is readily available unlike other sources of energy. challenge lies in recognising its sources and adopting methods to use it.
Dependable	It is available inside the earth and is uneffected by the weather changes. Hence it is a reliable resource.
Green	It emits very less green houses gases as its production doesnotneed combustion , infact in many cases geothermal power plants operate on zero emissions.
local	Many energy resources require harnessing and shipping to various places across the globe but geothermal energy is locally available where there is need and requires no shipping.
Affordable	Many experts are of opinion that this form of energy has more initial investment but will save money in long run for instance many researches claim that it saves upto 80% on ones bills.
Clean	It is claimed to be comparitively clean sytem as majority of sytems emit only water vapour, although few emit very small amounts of nitrous oxides ,sulfur dioxide, and particulates.
long lasting	Geothermal power plants can last for decades or even centuries. when reservoir is maintained and managed properly rock's rate of its heat renewal is balanced with amount of energy extracted.
Compact System	Space occupied by Geothermal plant and system is comparitively less to that occupied by other power plants.

LIMITATIONS OF GEOTHERMAL ENERGY

Apart from the advantages geothermal energy has few limitations. In case of improper harnessing of the energy it can produce harmful pollutants. Inappropriate drilling in to the earth May cause formation of hazardous minerals and poisonous gases.

GEOTHERMAL PLANTS

Hydrothermal possessions which are having both water and heat are used in geothermal plants. They need high-temperature (300°F to 700°F). Water heat resources which are available either in dry vapor wells or in boiling water wells. These possessions are obtained and used by drilling wells deep in the earth and piping hot water or steam to the upper surface. The steam or hot water gives power to the turbine that in turn produces electricity. Geothermal wells can go down to two miles deep.

The Basic steps of the system can be stated as follows: (figure 2)

Hot or Boiling water is pumped from deep subversive well in presence of high pressure

Pressure is dropped as water reaches the surface which in turn changes water to steam

This steam spins a turbine connected to generator which consequently generates electricity.

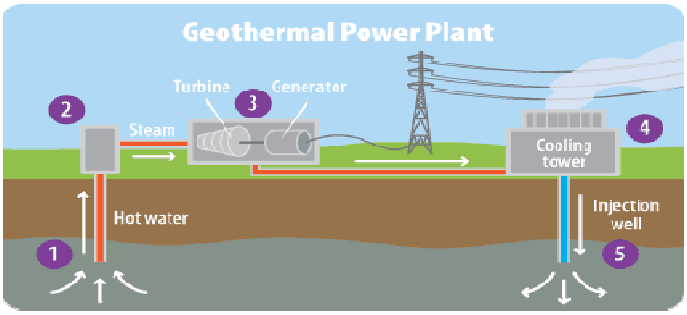

Figure 2. Production of geothermal energy through hot water.
Source: students guide to global climate change

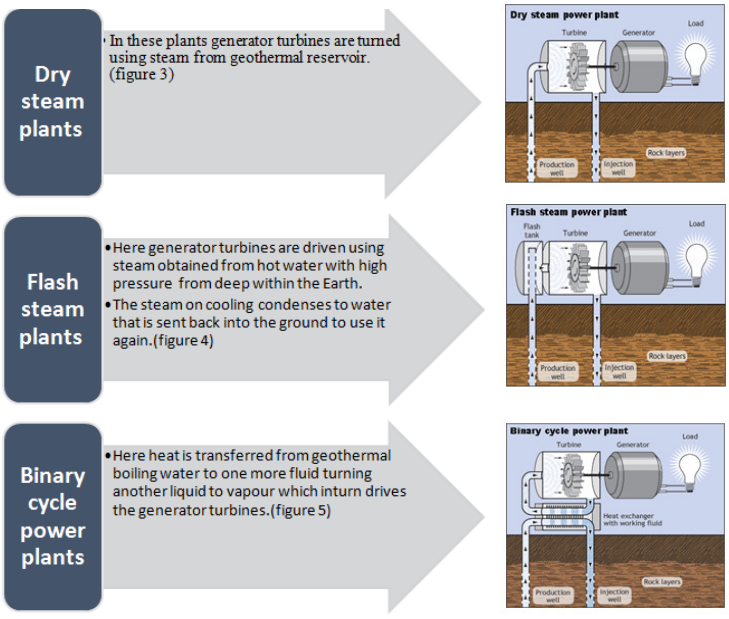

Figure 3. Dry Steam Power Plant **Figure 4.**Flash Steam Power Plant **Figure 5.** Binary Cycle Power Plant;
Source: U.S. Energy Information Administration

CASE STUDIES

INDIAN CONTEXT: GEOTHERMAL EXPLORATIONS IN GUJARAT- A CASE OF DHOLERA

Dholera is a place near Dhandhuka village of Ahmadabad. The Thermal springs in Dholera are situated along the edge of Sourashtra Peninsula which falls in the area of Cambay Basin. The pattern of the soil in Dholera, consists mainly of every other layers of gravel to coarse grained sand and mud. The four hot water springs within a radius of four Km present in Dholera are located over high gravity area. The springs of Gujarat have the maximum geothermal flow pace.

The geothermal site at Dholera has been extensively explored and carried out the geothermal activities to enhance the potential prospects. The Geochemical analysis is done to identify the properties of hot water springs in Dholera which helps to identify the nature of geothermal re servoir.

The most promising geothermal sources of energy are located in the region of Ladhak,a place called Puga and another source 40 KM away from Puga, known as Chumathang.Both are in the state of Jammu and Kashmir. The hot Spring temperature range in Puga valley range from 30 degree C-84 degree C and discharge up to 300 litres/min.Around 34 boreholes of depths ranging from 28.5m to384.7m have been drilled to get hot water in Pug valley.Chhumathanghot waters are quite similar to that of Puga Valley except the high value of Ph.(source: Geothermal energy and its potential in India by:Oumprakash Sharma and poonamtrikha) Both the springs have both shallow and deep reservoirs.

INFERENCES

It is very clear from the Indian context that there is an extensive scope for the potential development of geothermal energy which needs to be harnessed with proper guidance and methods.

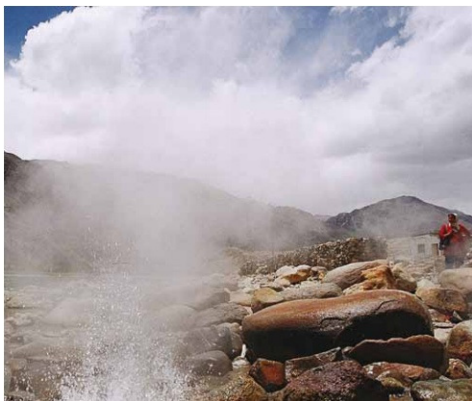

Figure 6. Chhumathang hot spring located near 40 Km north of Ladhak
source: Geothermal energy and its potential in India

INTERNATIONAL CONTEXT

GEYERS, CALIFORNIA

Geysers field of Geo thermal energy is located in California State, USA. The basis of heat for the vapor reservoir is a huge molten rock chamber of 6.4 km below the surface, and greater than 13 km in dia. It is the major producer of geothermal power in the globe. There are total of 350 wells from which steam is drawn from under the earth's surface. Located in Maya Camas Mountains, 116 km north of San Francisco the total area of fields is 30 sq. miles (78sq. km).

Geysers are a dry steam field which is formed from a Grey wackle sandstone pool. It is believed to be a magma which is rich in silica and is solidified after cooling. It is capped with a heterogenous blend of less permeability rocks.

The foremost Private energy plant in Geysers was originated by an owner of a resort which produced about 250 Kw of total energy for the lighting of the resort. It was developed in 1921.

In late 1980s inefficient power plants were shut down as it was realized that the flow of vapor over the geothermal field had come down and the recharging of the geothermal basin was not happening speedily to cater to the essential steam supply.

The waste treatment plants of the city of Santa Rosa and the lake county, supply treated wastewater of 18 million gallons everyday to Geysers geothermal reservoir, which in turn is used for power generation.



Figures 7. and 8. Different views of geysers in California source: Wikipedia the Geysers

West Ford energy plant situated in Geysers field of geothermal energy was established in 1988.

20% of the green energy is produced in California from Geysers and it is considered to be the most reliable source of energy in the state.

CONCLUSION

As it can be concluded that Geothermal energy is really useful to use rather than burning tons of fossil fuels as it can be reducing the number of carbon emissions by burning conventional energy sources. It is self-producing, sustainable, and is an endless source of energy to meet future demands. So, we would use this over conventional fossil fuels as it is more reliable, cheaper and easier to function. With proven technology and abundant resources, geothermal energy has proved to an important measure in reducing the level of greenhouse gases. Government's policies and measures needs to be implemented to maximize the potential of geothermal energy sources above all other conventional nonrenewable ones.

More Initiatives should be taken by the Government organizations and NGOs to promote earth's heat energy and utilize to the maximum extent, in order to create a healthy and pollution free surroundings, and also to reduce the huge gap between supply and demand. For example, giving incentives to the organizations for making use of earth's heat energy to produce the electric power.

FUTURE OF GEOTHERMAL POWER

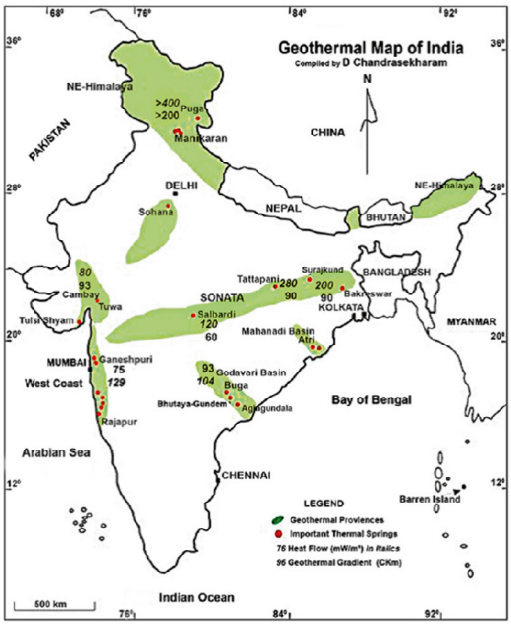

Figure 9.shows potential for geothermal energy in India
Source: Renewable energy: A comprehensive overview of renewable energy status in India

Figure 9.shows the potential sites of earth's heat energy production across India. The evaluated potential for earth's heat energy in India is approximately 10,0000MW (Source: India Energy Portal 2013). 350 sites of geothermal energy in India have been identified by Geological Survey of India. It is known that the earth's heat energy produced can be directly used for low category heating and can be directly utilized in commercial and Industrial buildings very effectively.

It is expected that geothermal plants will increase supplies around the globe at a rapid clip. The energy production may reach about 140 terawatt-hours in 2020.

India has targeted 1000MW geothermal power production by December of 2020 and this energy is utilized to electrify the villages of India.

So, Summing up the future of this clean sustainable basis, it could be one word "MORE".

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Strategies for Floodplain Management in the Development of Coastal towns: Case of Flooding and Disaster mitigation in Honnavar

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Abstract: Coastal areas especially the floodplains are constantly shaped by the forces of water. These areas are subjected to both erosion as well as sediment deposition which lead to the formation of new landforms. In recent times human activities and unchecked urbanization have been affecting the floodplains especially the downstream areas. In the present scenario of climate change and extreme rainfall events as in the recent scenario of Kerala and Coorg floods it becomes imperative to develop efficient strategies for the development of flood plains. From earliest times places of water have fascinated humans. These regions were easily cultivable due to higher fertility of the soil. Due to this settlements were shaped around these places of water. They grew into sites of industry, trade and commerce. These sites are also important because of their attractiveness and visual interest. Honnavar is a port town on the west coast of India. It is a part of the District of Uttara Kannada in the state of Karnataka. It was a significant port town with a long history of trading with the Arab world as well as several European countries. River Sharavati forms an estuary here as it joins the Arabian Sea. It is subjected to annual riverine flooding in addition to the risk of coastal flooding. The fishing community which forms a significant population of the town is settled historically along the coastline near the mouth of the river and are affected by the floods. The construction of Linganamakki dam in the upstream has significantly impacted the coastal ecosystem of Honnavar. The Honnavar municipality has recently proposed the preparation of master plan for Honnavar. This paper will look at effective strategies for river water management in the development and disaster mitigation in Honnavar.

Keywords: Coastal Areas, Floodplains, Environmental Conservation, Dam management, Disaster Mitigation

INTRODUCTION

Coastal areas are environmentally sensitive areas. The coast includes floodplains, mangroves, tideflats as well as marshlands. Coastal areas also include coral reefs. There are several beaches and dunes on the coast. Coastal areas perform many functions. They are subject to erosion and they also act as filters. They are subjected to pollutants from the many industries on the coast. There are many organisms which live on the coastal areas which are dependent on the coast for food, nourishment and nesting spaces. There are many industries along the coastline which rely on the locational advantage of the coast. There are ports and the shipping industry which needs the waters of the coast. The coastal areas are also important centers of recreation.

Some of the largest cities of the world are located along coasts. The coastlines around the world have many cities with population of more than a million people. These large sections of population around the globe are at risk sea level from both sea level rise and climate change. The phenomenon of climate change has been causing extreme weather events which affect the coasts the most. With the urbanization of the coastal areas the coastal ecosystems have been subjected to damage. The deltas and plains along the coast have always been good for cultivation due to its high fertility. The low lying areas on the coast are also at risk of coastal inundations due to cyclones and storms. River flooding during the monsoons is another important aspect.

Mangroves which are classified as forests include trees and shrubs which grown in the waters of estuaries. They can grow in the saline water and are important assets which protect coasts from inundations and tsunamis. But mangroves are cleared for the wood and used to grow shrimps. Mangrove forests have been destroyed for making human settlements and have also got transformed to agricultural land. The losses of mangroves have put the coastal areas in danger of extreme weather events.

Other than population pressures governmental policies at national and local level as well as reasons of economy. Tourism has impacted coastal areas in a significant way. Shrimp ponds, bull trawling, fishing, pisciculture which are sources of livelihood to the local population have also caused detrimental effect on the coastal ecosystems.

Honnavar is a Class 4 town located in the Uttara Kannada District. It has served as a natural harbor and has historic significance. With the development of nearby Karwar into a major port on the west coast of India, Honnavar has lost its importance in the last couple of centuries and has been relegated to a small fishing town. Honnavar also faces the issues faced by other coastal towns on the west coast such as coastal erosion and

accretion, Loss of mangroves and annual flooding during monsoons with the Sharavati River overflowing its banks and displacing the local population settled along its banks.

The Honnavar Municipality is currently working on preparing a master plan for the Local Planning Area. In this context it is important to understand the unique characteristics of this coastal town and implement necessary strategies and planning policies in the master plan.

FACTORS AFFECTING COASTAL AREAS IN INDIA

CASE OF HONNAVAR

Honnavar is a harbor town located on the west coast of Karnataka state. It is part of Uttara Kannada District. It has a long history of trading with both the Arab world as well as with several European countries. Honnavar is situated at the mouth of Sharavati River where it meets the Arabian Sea.

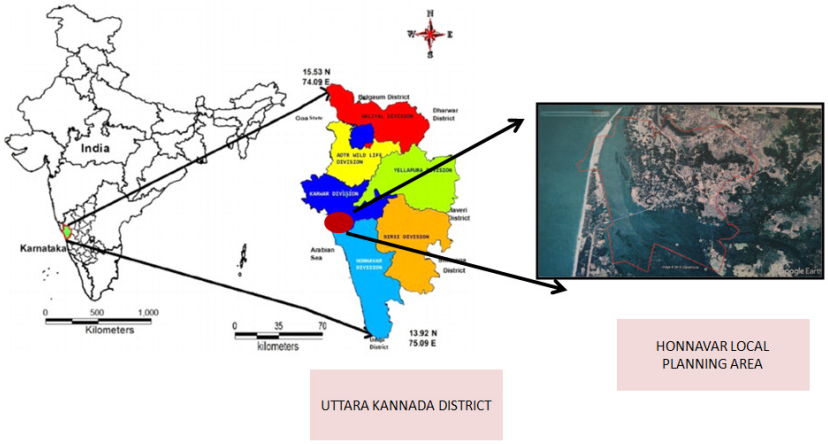

Figure1. Location of Honnavar
Source:Kollarath, 2018

Honnavar Municipality spans an area of 9.2sqkm and has a population of 19109. It has a density of 40 persons/hectare. As per URDPFI guidelines Honnavar can be classified as a class 4 town.

BACKGROUND

Honnavar was under the Kadamba dynasty between 11th and 14th centuries after which period it became a major trading port under the Vijayanagara Empire. During the 15th century Honnavar was invaded by the Saluvas of Gersoppa. Hyder Ali took control of the town of Honnavar during the 17th century and by the 18th century the whole of Uttara Kannada region was under the rule of Tipu Sultan.After Tipu Sultan's death in 1799, Honnavar came under the English and it became part of the Madras Presidency. During the year of 1862, the Kannada District was split into into North Kannada and South Kannada thus making Honnavar became part of the Bombay Presidency.Honnavar is a natural harbor as the depth of the Sharavati River here allows ships to easily navigate in these waters.



Figure 2. Growth Pattern of Honnavar
Source :BMSCA

Honnavar was part of a major maritime trading zone. Honnavar developed as an important exporter and supplier of pepper in this zone. This led to a strong merchant economy with the town developing in the south western tip close to the mouth of the Sharavati River which continues to be the oldest and the densest area in the Honnavara Municipality.

ENVIRONMENTAL ISSUES IN HONNAVAR

Honnavar faces all the issues which are concerns in other coastal towns and cities. The issues can be classified into

1. Degradation of coastal ecosystems
2. Depletion of mangroves – Mangroves have been converted to shrimp farms and has been harvested for wood.
3. Decrease in salinity of water due to fresh water released from upstream Linganamakki Dam affecting the marine ecosystem
4. Coastal pollution
5. Untreated Sewage being the main cause of concern in Honnavar
6. Coastal Hazards
7. Shoreline changes – Study of the coastline shows changes in the coastline during the past few decades.
8. Coastal Erosion – There has been loss to property, paddy fields due to erosion.
9. Tsunami – Even though East coast of India has been subjected to Tsunamis, the occurrence of Tsunami in the West coast is not ruled out. Adequate precaution for the same has to be taken.
10. Cyclone – Fishermen getting trapped in Cyclones and boats capsizing are common occurrences in this region.
11. Floods – The release of water from Linganamakki dam causes annual flooding
12. Landslides – The steep slopes of the ghats on which the highways have been constructed are susceptible to landslides.

IMPACT OF LINGANAMAKKI DAM ON THE COAST OF HONNAVAR

Linganamakki Dam is located in Kargal in Sagar taluk across the Sharavati River.The construction of the dam has had a significant impact on the Sharavati River Basin which has become fragmented as a result. A large portion of forest area has been converted to agricultural land. This has resulted in loss of biodiversity as well as degradation of forests.

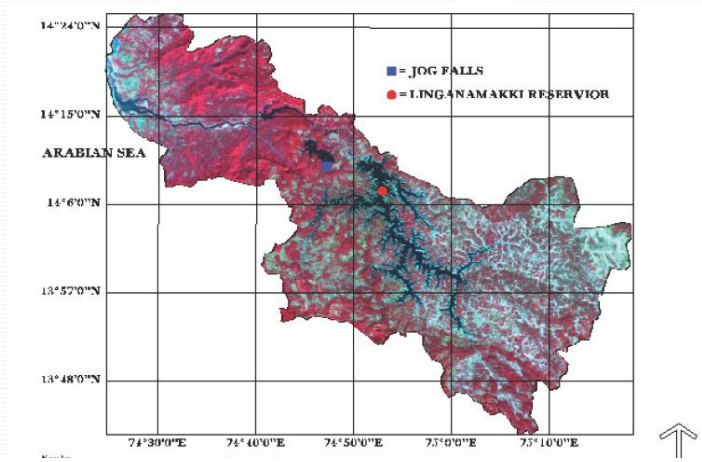

Figure 3. Location of Linganamakki Dam
Source : http://wgbis.ces.iisc.ernet.in

Honnavar Taluk which is situated downstream from the Linganamakki dam has also had to face the impact in the form of flooding every year whenever the water is released from the dam.

ISSUE OF FLOODING

Honnavar has been a historical port town which has been continuously inhabited for many centuries. Honnavar has been mentioned as early as 247 AD by the Greek author Periplus as 'Naoure'. It has a long history . It was an important commercial centre and carried out trade with many countries. The life of the people of Honnavar

have been strongly linked to the river and the sea with most of the communication with the outside world historically happening through the waterways and the sea. Traditionally the fishing community and other major trading centres have settled along the Sharavati River. Western Ghats run along on the eastern side of Honnavar due to which it has elevated terrain on the eastern side. The highest point in the municipality is at 34m above the sea level. It slopes down to the estuary where the low lying areas are at sea level.

The construction of the Linganamakki Dam has affected the lives of the people who have traditionally been living along the water edge. Every year as the water from the dam is released these people are displaced as the river floods their home. This has become an annual event where the local population are forced to abandon their homes till the water level comes down. It impacts the quality of life of these locals who are forced to abandon their homes every year.

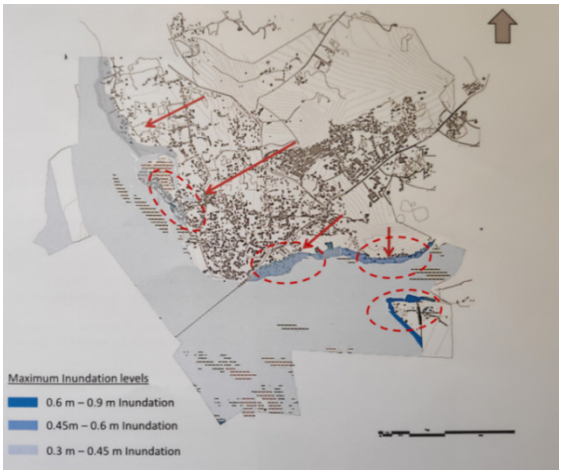

Figure 4. Flooding in Honnavar
Source : Kollarath, 2018

The areas circled in red are the areas which are prone to flooding annually. As can be seen from the above map these are the areas which are prone to flooding every year. In spite of that as can be seen from the map there are a lot of residences in these areas which are continuously affected by the flooding events. Development activities are also not possible in this area due to CRZ regulations. The condition of housing and sanitation in this area is therefore severely affected.The flooding was presented in 2018 by the timely action of dam authorities. The river floods every year during the south west monsoons. This year the authorities were able to keep the water level down in the dam before the monsoon season started such that the dam was able to hold the water during the monsoons. They could achieve this through controlled release of the water from the dam in advance before the onset of the monsoons.This shows the importance of water management of dams for disaster mitigation in coastal towns.

EXISTING COASTAL ZONE MANAGEMENT IN KARNATAKA

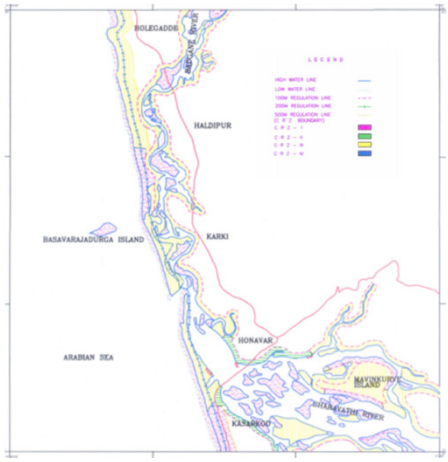

Figure 5. Coastal Zone Management Plan Map of Honnavar
Source: karnataka.gov.in

Coastal Regulation Zone (CRZ) Rules 2011 is the primary tool for coastal management on the Indian coast. CRZ classifies coastal area into four zones based on the High Tidal Line (HTL) and the Low Tidal Line (LTL). The permissible activities are defined under these zones.But towns such as Honnavar already have a sizeable population living inside the Coastal Regulation Zone. There are strict guidelines on the activities permissible under CRZ. But in this situation these guidelines don't get translated on the ground as a significant number of people are already living in this area. Floodplain management also needs to be incorporated into the Coastal Zone Management especially in the case of a city or town such as Honnavar which is located downstream with a major dam upstream Floodplain management also needs to be incorporated into the Coastal Zone Management especially in the case of a city or town such as Honnavar which is located downstream with a major dam upstream.

CONCLUSION

In the present scenario of extreme weather events and more intensity of rain in less number of rainy days management of the water released from dams become extremely important. The recent floods in Kerala during September 2018 have conveyed the significance of dam and river water management. Huge dams such have not been a part of historical landscape. Coastal towns such as Honnavar which have been historically linked to the water front needs to be equipped to deal with the impact of such structures.

There is a need to do hazard mapping in coastal areas and relocate the socially vulnerable population located along the waterfront. The development authorities need to leave adequate area for floodplain management when preparing the master plan for the town and look at planning the green infrastructure in such environmentally fragile areas instead of giving precedence to only economical development.

Waterfront areas susceptible to flooding should be made into a no development zone and instead used for flood management. This will improve the overall quality of life of the inhabitants. It is important to identify areas for environmental conservation in the master plan which will include the floodplains , and riparian zones along the Sharavati River, mangroves and the forest areas coming under the Honnavar Municipality and prepare strategies for this zone which should also prescribe the permissible activities in this zone.

The mangrove population which acts as a strong barrier against coastal inundations and tsunamis have been affected because of the fresh water being released from the dam upstream. It has also reduced the population of salt water fish in the area, thus affecting the livelihood of the fishermen. The dam has affected the coastal ecosystem. Effective dam management is also an important aspect to be considered for environmental conservation of coastal ecosystems and disaster mitigation.

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Google Maps

Assessment of Thermal comfort on comparison of Vernacular and Contemporary residence under natural condition: Srirangam, Tamil Nadu

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Abstract: In process of modernization, the recent buildings are constructed without considering the thermal comfort parameters. The temperature and humidity of most of the modern buildings are mechanically controlled. Most of the energy consumed by the building industry is mainly used for mechanical thermal comfort. Due to rapid changes in technology like development of automobile industry, globalization and population growth, there is an adverse effect on the environment like changes in climate and scarcity of resources. Thus, alternative solutions for removing the negative impact on the environment without compromising the need of the future are being explored. Recently, a thought process about the solutions from the construction that ages decades back can be an answer for the key challenges of the future has gained attention among the Architects and researchers. This paper attempts to study settlements around the Temple town of SriRangam of both Vernacular and Contemporary buildings to verify if the traditions of vernacular architecture of the city provides comfort even today, to create sustainable settlements culturally and environmentally. Also, to extract the key challenges and supporting parameters in today's context. Vernacular and contemporary residence of the same region is evaluated for thermal comfort by means of questionnaire survey and software simulation using IES software. The results show that there is slight difference in thermal comfort in both the types of residences. The solutions to overcome the differences and to achieve maximum thermal comfort in this region are discussed.

Keywords – Thermal Comfort, Vernacular Residence

INTRODUCTION

Vernacular architecture is the Traditional Architecture built by the people for themselves using locally available materials with Low to No technology. This architecture was initially followed on trial and error basis, which was later, tailored to perfection satisfying the structural, aesthetical and environmental aspects. This architecture is derived using the local available materials such that the building is intervened with the environment. Those buildings have also withstood the climatic variations. Since the user of the building was the designer, every need of the user was given importance and the chances of discomfort were very less. The main significance of Vernacular architecture provides a vital connectivity between the human and the environment.Developing countries have less socially sustainability and more conventional sustainability that is being imposed on the buildings. (Pocock, Steckler, & Hanzalova, 2016). On Contrary during the Post-Independence, the architecture in India has undergone many changes leaving behind the traditional ways of construction. Buildings were visualized only as built up spaces serving the purpose. Human connectivity with the building and the environment was rigid. Indeed, the aesthetic pride was given more significance than the soulful living of a building. The climate, culture, environment connection did not reflect on the buildings till the beginning of 20th Century. The consciousness of conserving for the future started up after climatic changes, the natural crisis and hike in prices. Meanwhile the development in technology led to the fact that any building envelope can be converted into a thermally comfortable environment with the use of electronic appliances. Hence, two residential Buildings under natural environmental conditions are compared on Thermal comfort: a residence with vernacular techniques and a contemporary residence, both of which located at Sri Rangam, Tiruchirapalli. The result gives us a vision of which building technique serves more thermal comfort under natural conditions. Tamil Nadu Location and Tiruchirapalli location (See Figure 1 - 2)

AIM OF THE RESEARCH

This research aims to find out the impact of design techniques used in a building on the thermal comfort of an occupant by comparing vernacular and contemporary residence of same climatic zone under indoor natural conditions.

LITERATURE STUDY

Understanding the thermal comfort of an individual requires more professionals like psychologists, philosophers, engineers, architects, sociologists, etc. to think in all dimensions of an individual like cultural, behavioral aspects and person-environmental relationship. (Rupp, Vasquez, & Lamberts, 2015)More refined adaptive comfort models are to be developed in consideration with the energy management and optimization of the smart energy buildings. (Enescu, 2017)The phenomenon of active behavioral adaptation with respect to the change in clothing level has a role in the thermal comfort of an individual. (Yu, Li, Yao, & Li, 2017)The difference in heights and the exterior environmental conditions does make a difference in the thermal comfort of the occupant in the indoor environment. (Thapa & Ajay Kr.Bansal, 2018)Adaptive Comfort Standards that promote energy savings and help with the buildings to work with nature and to decrease the energy crisis and global warming are required. (Mishra & ramgopal, 2013)Changes in window position and opening alter the air movement inside and outside a building which increases or decreases the indoor air temperature. (D.Prakash & P.Ravikumar, 2015)Apart from the technology to heat and cool a space, a person's condition of mind and cognitive state is essential for his/her thermal comfort in an environment (Lala, 2017)The comfort zone should be extended to adapt the change with new thinking on comfort also considering the global warming and climate change. (K.Akande & A.Adebamowo, 2010)

RESEARCH OBJECTIVE

To study the different methods and techniques of sustainability used with reference to vernacular buildings in Sri Rangam.

- To study the parameters that influenced the transition from vernacular to contemporary setting.
- To assess the thermal comfort in traditional houses of Sri Rangam.
- To evaluate the thermal comfort of modern houses of Sri Rangam.
- To compare the thermal comfort of traditional houses with modern houses of Sri Rangam.
- To arrive at a feasible strategy on applying Vernacular features in contemporary setting.
- To identify the challenges in implementing sustainable factors in the current scenario.
- To arrive at a strategy for conservation of energy efficient traditional residential building of Sri Rangam.

LIMITATIONS

This research is limited to finding the occupant's thermal comfort in Vernacular and contemporary residential building. This study is confined to study the thermal comfort of Vernacular and Contemporary residence building in warm and humid climate region of Sri Rangam, Tiruchirapalli. Comparative analysis of Traditional building is carried on an individual Contemporary residence and Vernacular residence of Sri Rangam, Tamil Nadu. This research is limited from finding the thermal comfort of the occupant under mechanical conditions. This research is limited from evaluating the energy consumption of the buildings.

STUDY AREA

ABOUT TIRUCHIRAPALLI

The geographical location of the selected area of Tiruchirapalli is 10.75˚ N, 79.10˚ E in South India. The elevation of the city is of 57 m above the Mean Sea Level (MSL). The city is located in Cauvery delta region, which is 320kms from Chennai and nearly56 kms from the city Thanjavur. As given in National Building Code (NBC) of India, the city is classified as warm humid climate zone. The monthly average climatic data of Tiruchirapalli is obtained from Tiruchirapalli weather station. During May – July, the maximum average temperature is 37 ˚C. Similarly the average minimum temperature is 21 ˚C during November – January. The minimum and maximum temperature, wind velocity, relative humidity and the rainfall data are collected from the Tiruchirapalli Weather station for Tiruchirapalli climate. Tiruchirapalli Map (See Figure 3) and Tiruchirapalli fall under the warm humid climate according to climate zone map (Figure 4) of India published by NBC 2005.

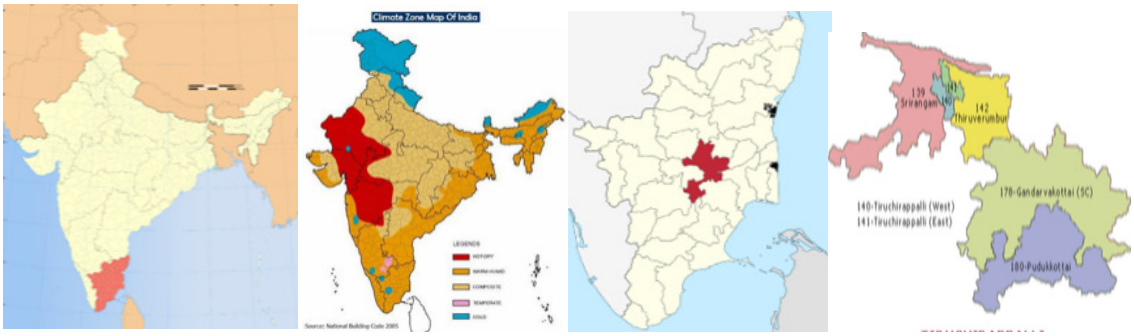


Figure 1, 2, 3 & 4. India Map with Tamil Nadu, Tiruchirapalli Map, Climate Zone map of Tamil Nadu Located Map with Tiruchirapalli India.

About Sri Rangam

Sri Rangam (Fig 1.5.2.1) is a Heritage temple town which has been inhabited for the past 1300 years along the river Kaveri.The arrangement pattern of this temple town is unique. It has seven concentric rectangular enclosures. The enclosures are of huge thick walls around the temple complex. The deity is present at the innermost sanctum. The inner 5 enclosures constitute the temple. The outer 2 enclosures are of settlements. At present the dwellings which are more than 50 years old are still in use in this place. (See Figure 5 -7)



Figure 5, 6 & 7 Sri Rangam Site View, Vernacular Residence, Contemporary Residences
Source: K.Marliya. 2018

METHODOLOGY

BUILDINGS DESCRIPTION

A vernacular Residence and a Contemporary residence of the same locality are being selected for the study. The vernacular residence was being occupied for the past 58 years and the contemporary residence for the past 7 years immediately after construction. Both the selected residences are of North orientation, linear floor plans and one storied building. Details of the building with floor plans(See Table 1)

OCCUPANTS DESCRIPTION

The data of occupant's gender, age, occupation, average time spent in each room per day and their type of activity are being collected and analyzed. From the given details of the occupants, it is noticed that the living room and bedroom is being occupied for the maximum time of a day. Of which the living room is occupied for maximum time during the daytime. (See Table 2 to 5). Most of the occupants of all dwellings prefer the living room to thermally comfortable, as they consider it as the socio-culturally important space. (Singh, Attia, Mahapatra, & Teller, 2016)

QUESTIONNAIRE SURVEY

A pilot study of the occupant's thermal comfort survey was conducted using a questionnaire. Questionnaire Survey given in Appendix 1.The questions were based on the parameters that influence the thermal comfort of an occupant such as metabolic rate, radiant temperature, air temperature, humidity and wind velocity. The occupants were allowed to settle for 15mins and then the questions were explained to them. This helped in reducing human error during survey. The field measurements were taken at the same time with reference to the questionnaires. The Questionnaire survey was conducted for summer during the month of May and for winter during December for a period of 5 successive days. The survey was conducted randomly over 148 individuals which includes 72 from Vernacular houses and 66 from Contemporary houses. The occupant's well being based on the parameters of indoor environmental quality such as SBS, thermal, visual, acoustic etc also takes in account in evaluating the overall comfort of an occupant.(horr, et al., 2016)

SOFTWARE SIMULATION

Building simulation for adaptive thermal comfort should consider the weather data for the region and occupant behavioral study to identify the influencing factors. (Attia & Carlucci, 2015). The building simulation analysis was conducted using IESve software to evaluate the thermal performance of a complex building system. (Padovani, Hes, & Maclaughlin, 2011).The Simulation was conducted using IESve Software to evaluate the overall Thermal Comfort of an occupant for both the residences annually. The parameters such as relative humidity, air temperature, wind speed are compared for both the residences. The building attributes such as density, specific heat capacity, thickness and thermal conductivity are the inputs given for all the building elements along with Tiruchirappalli weather data. (See Figure 8 - 12). These values are been extracted from Energy Conservation Building Code. This Simulation result is being compared with thermal comfort range mentioned by ASHRAE 55.

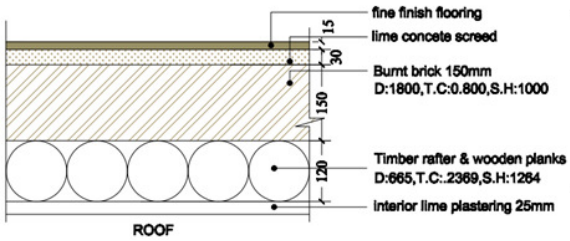


Figure 8. IESve input – Vernacular residence roof
Source: K.Marliya. 2018

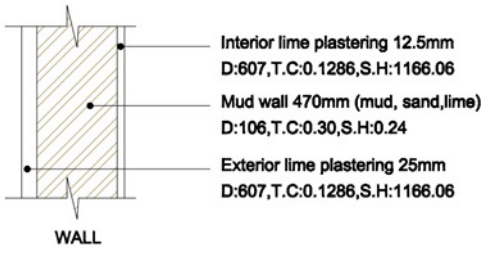
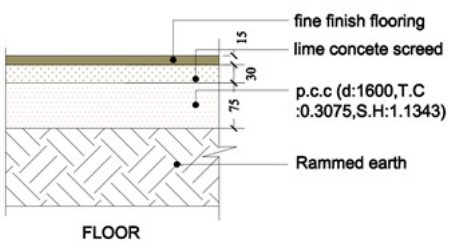


Figure 9. IESve input – Vernacular residence wall
Source: K.Marliya. 2018



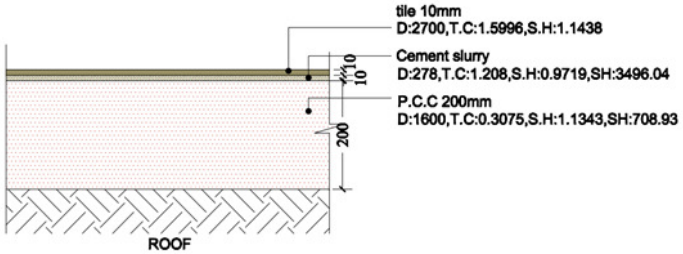


Figure 10 & 11 IESve input – Vernacular residence floor and roof, IESve input – Contemporary residence roof
Source: K.Marliya. 2018

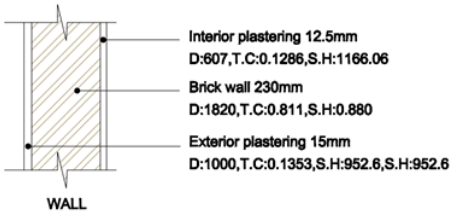


Figure 12.IESve input – Contemporary residence wall
Source: K.Marliya. 2018

RESULTS AND DISCUSSION

QUANTITATIVE ANALYSIS

The questions were based on the parameters that influence the thermal comfort of an individual. These questions were framed as 7-point sensational scale and 5-point preference scale according to ASHRAE 55. Immediately after a transition, the thermal sensation of the participant tends to change. (Wu & Mahdavi, 2014)

INDOOR AIR TEMPERATURE

From the Analysis, it shows that for the Vernacular residence, the maximum occupants feel slightly cool and neutral about the indoor air temperature. (See Figure 13 & Table 6). For the contemporary residence, the maximum people sense the indoor temperature to be warm and hot. The wall thickness and materials like adobe and lime stone plastering reduces the heat transfer from outdoor to indoor thereby resulting in reduced indoor

temperature in the Vernacular residence. The materials and the reduction of direct sunlight favored the differences in air temperature for the vernacular residence. The occupants who have control over the heating and cooling facilities have higher tolerance level of discomfort up to 2°C and likely prefer the neutral vote. (Lao, Cao, Zhou, Li, & Zhang, 2014)

RELATIVE HUMIDITY

From the responses, the sensation of humidity seems to neutral for both the types of occupants. (See Figure 14 & Table 7)

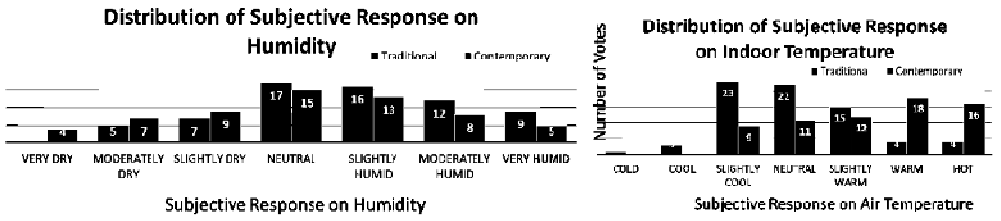


Figure 13 & 14 Distribution of Occupant Response on Indoor Humidity, Distribution of Occupant Response on Relative Indoor Air Temperature

AIR MOVEMENT

The openings are entirely different for both the residences. Still, the occupant's preferences are neutral on air movement for both the residences. (See Figure 15 & Table 8). In case of discomfort, the maximum occupants preferred for a ceiling fan as an active techniques' alternative in both vernacular and contemporary residence. As Trichy has high humidity level, the preference for air cooler is less. (See Figure 16 & Table 9)

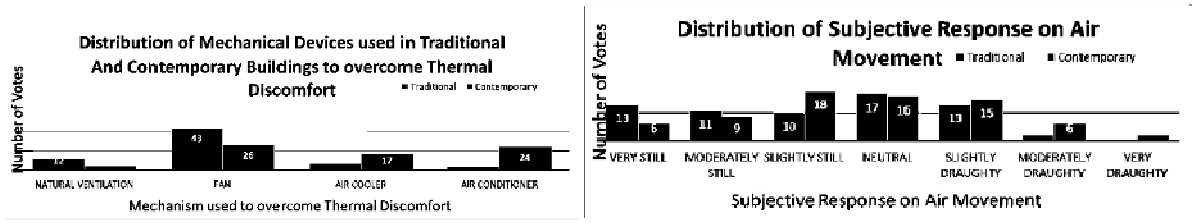


Figure 15 & 16. Distribution of Occupant Response on preference of mechanical devices to overcome thermal discomfort, Distribution of Occupant Response on Indoor Air movement

THERMAL COMFORT

From the survey, it is evident that the vernacular residences are more thermally comfortable than the contemporary residences for the climate of Tiruchirapalli. (See Figure 17 & Table 10)

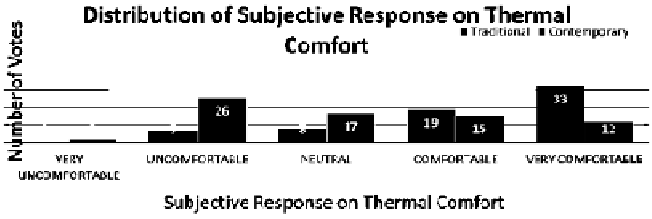


Figure 17. Distribution of Occupant Response on Thermal Comfort

The thermal comfort of the occupant also depends upon the indoor air temperature and the occupied time of the occupant. (Yu, Yang, & Zhu, 2015)

SOFTWARE SIMULATION

On comparing the hourly yearly mean temperature data of the indoor of the vernacular residence with the outdoor, the results show that the indoor air temperature of the residence ranges between 26.5°C to 30°C. Whereas, the range of outdoor temperature is between 26°C to 35°C.(See Figure 18). The indoor relative humidity of the vernacular residence varies between 50% to 75%. Whereas, the outdoor relative humidity ranges between 40% to 95 %.(see Figure 19)

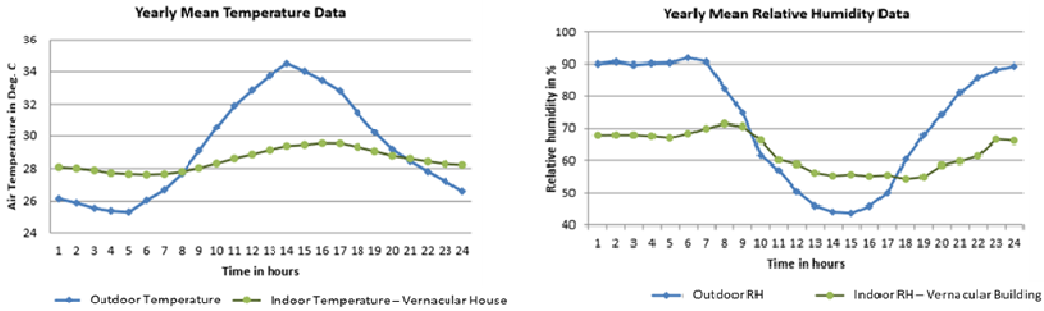


Figure 18. Left: Yearly mean indoor and outdoor temperature data for data for Vernacular building; Right: Yearly mean indoor and outdoor relative humidity

On comparing the indoor air temperature of vernacular residence and Contemporary residence with exterior air temperature, the range of the indoor air temperature is between 29°C to 35°C. Thereby, vernacular residence is cooler and warmer during summer and winter seasons compared to contemporary residence (See Figure 20). On comparing the indoor relative humidity of the vernacular and contemporary residence with the outdoor relative humidity of Tiruchirapalli, the results show that the contemporary residence has relative humidity ranging from 65% to 80%. (See Figure 21)

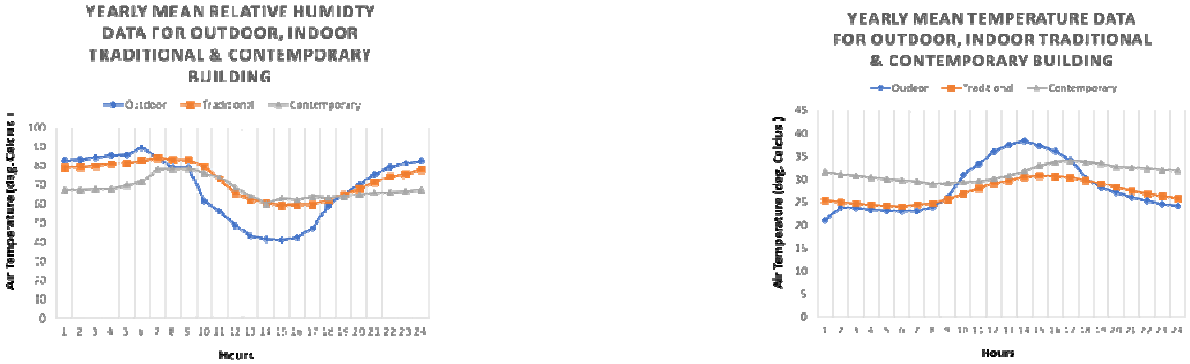


Figure 19. Left:Yearly mean indoor data compared to outdoor for traditional and contemporary building Right: Yearly mean indoor data compared to data outdoor data for traditional and contemporary building

According to ASHRAE 55, the indoor operative temperature for thermal comfort is between 19°C to 26°C. Hence with IESve simulation, the total discomfort hours are calculated for both the contemporary and vernacular residence for a year. The discomfort hours for Contemporary residence are more compared to vernacular residence. (See Table 11 & 12). The quality and standard of living can be improved by increasing the comfort of an occupant and also saving the energy consumption in a national economy. (Awainati, Fahkroo, Musharavati, Pokharel, & Gabbar, 2013)

CONCLUSION

The thermal comfort of a building can be altered with proper orientation of the building, micro climatic space near the building and use of light colors on the walls for less heat absorption. (U.Haruna, Musa, Tikau, & Yerima, 2014). Although, the building attributes and design of both the Vernacular and Contemporary residences are nowhere similar and of different period of construction, the difference in Human Thermal Comfort is very less. Constructing a Vernacular house to achieve thermal comfort carries certain barriers like wastage of carpet area, high maintenance, skilled labourship etc. Still residences can be built with the present-day context satisfying the human thermal comfort using certain design strategies of the particular locality. Recommendations suitable for constructing thermal comfort residence in Tiruchirappalli region are as follows:

- Avoiding water bodies, as the humidity is high.
- Courtyard spaces for stack effect.
- Clerestorey windows for stack effect.
- Cross ventilation for sweeping the hot air out.

- Rat trap bond gives a thermal insulation to the interior spaces.
- Designing the shading devices cuts down the direct sunlight penetration inside the building.
- Preferable fenestrations to Floor Area Ratio are 15 to 20%
- Light colored building and exterior is desirable
- Landscaping and green area helps to create microclimatic zone.

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Post Occupancy Evaluation of Hostels at NIT, Trichy

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Abstract: Buildings are basically designed for protecting people from surrounding weather conditions. However, today people expect more from the buildings. They expect the buildings to be functionally suitable for present needs and also to be able to adapt to the new changes in uses. Building performance is directly connected to the building end users. The level to which a building's performance satisfies its occupants decides the quality of the building throughout its life. A quality, comfort, healthy and safe building will definitely prove to be a potential to the users. Hostels are one of the most important spaces in an institution, as it acts as a home, away from home. Students tend to spend most of their time in hostels. It has direct influence on the physical, psychological and physiological aspects of student's life. The quality of hostel facilities provided in a campus will greatly improve the institution's performance. A well comprised hostel should take care of physical and psychological needs of the students residing. Being a place where students from different background, with different priorities, different lifestyles and culture comes together, hostels should be able to provide a satisfying environment to all its users without compromising on any edge.

Keywords: Hostel, Students, Comfort, Satisfaction level

INTRODUCTION

Student housing facilities should offer complete and all-round living experience in terms of security, privacy and living environment (Yusof, Najib, Osman, 2011). The quality of housing facilities provided for students is an essential and key factor in determining the overall experience in the campus. The sense of belonging it creates is important to keep the students motivated (Hassanain, Sedky and Saif 2010).This Post-Occupancy Evaluation (POE) aims to gather and examine key insights about the facilities' technical performance, functionality and operational processes. To understand the social, aesthetic and functional preferences of the students that is specific to their gender differences. The objective was to find out the demands that were gender specific and how males and females looked at the same facility provided to them. This report sets out to elucidate the findings of the Post Occupancy Evaluation of the Hostels at National Institute of Technology, Tiruchirapalli, carried out during October 2108, synthesizing survey responses from 44 males occupying Jasper hostel and 67 females occupying Opal-D. The study is limited to one hostel block for males (Jasper) and one hostel block for Females (Opal – D) and it does not include any responses from the management.

LITERATURE REVIEW

Till date, in the past few decades various studies have been carried out rating the performances of the hostel facilities and also listed out various parameters necessary to assess the performance of hostel facilities. Torres, Antonini and Park (2008) in their study sets out that the essential features of student housing facilities as bedroom, bathroom, laundry room, pantry, study room, meeting room and lobby. Adewunmi and Ogunba (2010) listed out 29 performance criteria 13 components and support services for identifying the gap in supply-demand, and assessed the overall performance of the building. Hassanain (2008) carried out a study in Saudi Arabia on student housing facility and examined the performance and satisfaction level based on five technical and five functional performance requirements which included thermal, visual and acoustical comfort, IAQ, fire safety, room layout, furniture quality and proximity of hostel to other facilities. It is evident that these parameters vary according to the users (age, gender, course, etc.,), location and climatic factors and other contextual factors.

METHODOLOGY

WALK THROUGH

A preliminary naturalistic observation was made by a walkthrough to understand the spaces in hostel and photo documentation was done, which was further used in forming the questionnaire.

QUESTIONNAIRE SURVEY

To know the response from a large sample space, hard copy of the questionnaire was distributed to the students. Out of 100 questionnaires distributed 67 was collected from female hostel and 45 out of 70 from male hostel. The questions spoke about parameters such as spatial adequacy, aesthetic appeal, sanitation, amenities provided, comfort parameters, services etc.

INTERVIEWS

To get a clear idea of what the students feel about and expect from the building, interviews were conducted with few students to know things that were beyond the questionnaires

Table 1. Mean values of respondents in each hostels for various variables

Variables	Mean of Male respondents	Mean of Female respondents	Standard Deviation
SPACIOUSNESS			
Lobby	3.86	3.94	0.87
Room	3.95	3.91	0.88
Toilets	3.51	3.18	1.06
Common room	3.19	3.52	1.18
Courtyards	3.74	3.97	1.01
Corridors	3.93	3.73	0.88
Terrace	3.79	2.64	1.22
Cloth drying space	3.30	3.00	1.19
Utility space	3.58	3.24	1.02
AESTHETICS			
Lobby	3.72	3.42	0.98
Room	3.77	3.21	1.06
Toilets	3.12	2.58	1.03
Common room	2.72	2.55	1.10
Courtyards	3.67	3.48	1.02
Corridors	3.81	3.30	0.97
Terrace	3.28	2.42	1.16
Cloth drying space	3.05	2.94	1.17
Utility space	3.49	3.03	1.04
ASPECTS OF ROOM			
Spaciousness	3.74	4.00	0.97
Furniture Arrangement	3.40	3.76	0.99
Furniture quality	3.00	3.25	1.09
Storage Space	3.60	4.00	0.97
Interior finishes	3.02	2.88	1.11
COMFORT PARAMETERS			
Protection from sun	3.84	3.73	0.89
Summer indoor temp	2.93	2.91	1.21
Winter indoor temp	3.28	3.58	0.91
Ventilation	3.53	3.76	1.06
Air quality	3.58	3.79	1.04
Noise	3.60	3.91	1.04
Natural daylight	4.16	4.00	0.91
Artificial light	3.84	3.97	0.84
Cleanliness	3.53	3.58	0.91
Privacy	4.07	3.55	1.03

AMENITIES			
Internet facility	3.67	2.97	1.04
Drinking water facility	2.07	2.94	1.19
Laundry	2.47	3.00	1.14
Recreational facilities	2.51	2.55	1.10
Sports facilities	2.91	2.73	1.10
Parking	3.70	2.97	1.11
SERVICES			
Fire safety	2.91	3.30	1.11
Lift	4.21	3.36	0.85
Staircase	4.09	4.03	0.72
Power backup	3.84	3.94	1.05
TOILETS			
No. of Toilets	3.47	2.76	1.09
No. of Bathrooms	3.47	2.82	1.11
Cloth washing area	3.23	2.73	1.07
Cleanliness	3.21	2.91	1.03
Water Supply	3.72	3.52	1.04

RANKING OF COMFORT PARAMETERS

The students were asked to rank these comfort parameters based on their preferred importance. It was obvious the gender difference had greater impacts on their choices and ranking.

Male Hostels Respondents Ranking	
Ranking	Comfort Parameters
1	Cleanliness
2	Ventilation
3	Air quality
4	Summer indoor air temperature
5	Protection from sun
6	Noise
7	Winter indoor air temperature
8	Privacy
9	Artificial light
10	Natural day light

Female Hostels Respondents Ranking	
Ranking	Comfort Parameters
1	Ventilation
2	Summer indoor air temperature
3	Air quality
4	Cleanliness
5	Privacy
6	Protection from sun
7	Noise
8	Natural day light
9	Winter indoor air temperature
10	Artificial light

Table 3.4.1 Male Hostels Responding Ranking **Table 3.4.2**Female Hostels Responding Ranking

The Rankings seems to be in coherent with the mean values of the respondents. Males ranked Cleanliness as the most essential comfort parameter, wherein females ranked ventilation first. Females gave more importance to privacy than males. Both Males and Females seemed to care the least about artificial lighting in their living environment.

OBSERVATIONS AND FINDINGS

As far as the spaciousness is considered, though there was not much change in architectural planning and spatial arrangement there was considerable difference in the rating of Females and males. This implied that female were more particular about the spaciousness of toilets and utility areas than males also they gave more

importance towards the aesthetic aspects of the building; both males and females expressed their dissatisfaction towards interior finishes and furniture quality. As evidence to the high discomfort expressed during the summer month, many students were found to use air coolers and table fans. This also had impact of the effective usable area of the room. Natural light has the highest mean in both the cases meaning that most percentage of people is satisfied with it. In terms of privacy, the mean value of female hostel respondents is lower than that of male hostel respondents. From which the inference can be drawn as females demanded for more privacy than males. Compared to the other parameters evaluated, most of the students were dissatisfied with the amenities provided in hostels. The most dissatisfactory factor was recreational facilities for females and drinking water facilities for males. Thought he toilets provided were according to standards, they dissatisfaction towards the no of toilets. Both in male and female hostels, higher percentage of students were satisfied with the safety factor inside the building. In male hostel most students' satisfactory level was neutral in terms of how building was able to meet their overall needs. In female hostels, higher percentage of students were said to be satisfied in this case.

CONCLUSION

The main objective was to investigate the level of satisfaction with several facilities and services that were provided in male and female hostels. The findings from the survey indicate that occupants are generally satisfied with the facilities and services available. The study recommends effective POEs and maintenance management practices for the institution's hostel facilities to improve the comfortability of users. As the study was conducted with the basic objective of identifying the preferences and responses pertaining to gender, though the mean values of parameters like aesthetics, functionality was lesser in female hostel, there was no much significant standard deviation between the responses of males and females except for a very few parameters. Hence while designing hostels, the gender factor plays a major role and the amenities, spaces, aesthetics can be done by understanding these gender specific preferences. Considering the overall responses of the students, almost all the parameters has a mean value of 2.75 and more, which means that all the factors were to the satisfactory level and neutral level. From the obtained values, it is known that the gap between supply and demand is not much and the existing gap can easily be filled with few design implementations, ensuring no gap between the user's requirements and building providers.

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Energy Performance Optimization for Contemporary House in Hot Humid Region

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Abstract: This study focuses on creating green design optimization process and evaluating whether it can be used in the design process to achieve a high energy performing building and to derive optimal parameters for the hot humid region using green design optimization process. To derive the optimal parameters, Optimization design variables and parameters which are related to hot humid climate and that are suitable for existing building condition is taken into consideration for simulation process. Optimal Parameters are identified based on energy consumption results obtained using simulation. Identified process of green design optimization and optimal parameters can be used to design buildings with high building-performance, Zero energy building design in hot humid region.

Keywords: High building- performance, Design optimization, Optimization Objectives, Optimization design variables, and parameters.

INTRODUCTION

Energy performance optimization is a process to achieve a high energy performing building. Optimization for green architecture design is a decision-making process to achieve a high energy performing building using climatic design parameters. Optimization is the process of adding different design options to building design to achieve a better product (i.e. building). Different options of optimizations are changing the orientation of the building, alterations to building envelope, adding a shading device, opening size, adding insulation to the building materials used. Energy performance Optimization mainly focuses on a product (i.e. building) which consumes low energy. Green design Optimization includes options based on the climatic design parameters based on the building's location. The best option identified can be used to design a high energy performing building or Net Zero Energy Building or green buildings.

Optimization can be done by manual simulation method or using computer simulation methods. Design optimization done manually includes many kinds of calculations. In a computer simulation different software like green building studio, e-quest, energy plus, eco-tect can be used. These softwares help in adding different options to the existing model and give their respective energy output to analysis further.

METHODOLOGY

From Literature Review methodology to do optimization process was identified. The methodology to study the energy performance of an existing building is referred from architect Simos Yanna's papers. Climatic design parameter for hot humid region is referred from book "Climate responsive architecture" by Arvind Krishnan and ECBC envelope design for the warm humid region. To validate Green design optimization process and to identify optimal parameters the Green design optimization process is done to an existing contemporary house in hot humid region.

LIMITATION

Building performance evaluation and Green Design Optimization process is done to one contemporary house of the hot humid region to find the optimal parameters for increasing the Energy performance of a building.

DESIGN OPTIMIZATION

Design optimization is a design decision making process, to achieve a better building design. Attia S explains that "Building performance optimization is a process that aims to select the optimal solutions from a set of available alternatives for a given design or control problem, according to a set of performance criteria and

constraints"3. Design optimization can be done in the early stages of the design process to achieve the goal of Net Zero Energy in a Building.

Data to be provided by the designer to the simulation engine are Optimization objectives, Optimized design variables, Optimized design variable parameters2,3.

The optimization objectives can be either single or multiple13,3. Single or multiple objective optimizations is done depending upon the objective function required for the project3. All the optimization is done for certain function. The optimization objective functions can be cost, Energy usage, environmental impact, comfort based on thermal and lighting2. In an optimization process, if one objective function is considered then it is termed as single objective optimization. When more than one objective function is considered then it is termed as multiple objective optimizations.

Optimized design variables are the different alterations that can be done to architectural elements like wall, floor, openings, etc. Building design can be categorized into 5 categories 13. They are opaque building envelope, transparent building envelope, shape and form of the building, type of mechanical system and operation of mechanical system. Opaque Building envelope which covers overall thermal conductance of the exterior wall (U-value), wall insulation and the thermal resistance of wall. Transparent Building envelope which covers glazing type, window size, shading devices, glazing type can be single or double glazed with different U-values, window wall ratio and shading device design with the concern of internal lighting and thermal comfort. Shape and form of the Building which covers different angles of orientation in the site depending upon wind movement, changes done to the massing of the building. Type of mechanical system which covers sensor based mechanical system like HVAC and lighting, installing a mechanical system which consumes low energy. Operation of mechanical system includes proper maintenance of the mechanical system13.

Optimization parameters differ for each design variable. Hence it can be termed as design variable parameter. These parameters can be changed to achieve the optimization objective function. To fix with the design variable and parameter study on existing climatic condition is required. Optimization design variable parameters are different options associated with the design variable used. (Table no: 1)

Table 1. Design variable and its parameters for existing building (Source: Sahddy Attia, 2013)

Design variables	Physical quantities	Design parameters
Orientation	In degree	Depending upon wind movement
Shape	Depending upon site dimension	Depending upon wind movement
Floor height	In meters	2.5, 3, 3.5
Window wall ratio	In percentage	0, 30, 45,
Shading device size	Ratio to window height	1/4, 1/2, 3/4,
Wall U- values (exterior)	W/sq.m k	1.4, 1.3, 1, 0.7, 0.5
Roof U- values	W/sq.m k	1, 1.2, 1.4
Floor U- values	W/sq.m k	1, 0.9, 0.8, 0.7, 0.6, 0.5
Single clear glazing	W/sq.m k	1, 0.75, 0.5, 0.25

OPTIMIZATION PROCEDURES FOR EXISTING BUILDING

Optimization Procedures for an existing building depends upon the energy performance of the building. Through study on the building must be done first before doing optimization. The steps are as follow:

Step1: To know about existing building condition performance evaluation of building is done using cognitive, empirical and simulation method1.

Step2: The designer must define the optimization function, design variables and its parameters based on the existing building performance. Based on the optimization functions the process can be named as a single design objective or multiple design objectives. For an existing Building only, few design variables can be considered13.

Step3: Optimization process done using simulation software with identified design variables and parameters 13.

Step4: If the objective functions are satisfied, the design variable and parameter associated with the objective function will be used in design. If the objective function is not satisfied, Step 3 will be repeated with different design variable and parameter, until the objective functions are satisfied13. The repetition process can be done manually or automatically by the simulation engine.

Design optimization categories that can be considered are limited for existing Building. Optimization objective can be considered are Envelope, comfort, lighting, renewable energies, systems. Optimization design variable that can be considered are transparent Building envelope, opaque Building envelope, mechanical systems. Here few design variables like orientation, floor height are neglected because changes done to these design variables can deform the existing structure. Parameters associated with design variables can be used for optimization of existing building (Refer Table 1).

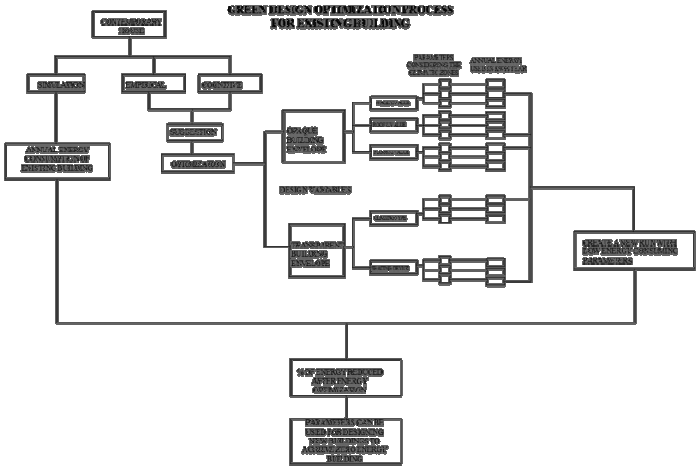
PERFORMANCE EVALUATION OF BUILDING

Evaluating the performance of a building related to energy during the operation phase of a Building is known as performance evaluation of a building. There are different methods in evaluating Building performance. Simos Yannas's research paper on architecture for sustainable environment design explains about cognitive, empirical and simulation as methods to evaluate building performance1.

Cognitive analysis means documenting existing Building and basic observation observed in site1. Empirical analysis means the performance of a building is measured using instruments like Lux meter, Anemometer1. Computational Simulation means a model of the Building is done with exact dimension and material in software and simulated for the climatic condition. Simulation results are in the format of charts, charts can be taken for analysis. Computer simulation to find Energy performance can be done with software like e-quest, eco-tect, and Revit green building studio1. A model of Building with the note on materials used for construction is required for Energy simulation.

CLIMATIC DESIGN PARAMETERS FOR HOT HUMID REGION

Chart 1. Green Design Optimization process



Climatic parameters for Hot Humid region from the book 'climate responsive design' by Aravind Krishnan are roofs with over hangings, projected eves to cut down solar radiation entering room11. Fenestration area should be large to get good natural ventilation, Scattered windows with large over hangs would be desirable in reducing the amount of solar radiation entering room11. Shading devices with decreasing section can be used increase air speed11. Internal finishes- Light colored surface increase day light Occupant comfort levels11.

Climatic parameters for Hot Humid region from ECBC building envelop design for Hot Humid climate are insulating walls and roofs with low U-value, light colored coating for high reflectance, air leakages should be reduced. For Windows glass with U-values can be used. Prefabricated window and seal the joints between windows and walls. Glazing with low SHGC can be also used.

HOUSE FOR OPTIMIZATION

To validate the Green Design Optimization process, the process is done for a contemporary house to check whether the optimization process helps in making decision in regarding to the energy usage of buildings, to obtain optimal parameters and to check the percentage of energy can be reduced on using the arrived parameters in the design a high energy performing used. E-quest software is used for the optimization process in this research.House selected for optimization process is in Nagarcoil. It's a capital town of Kanyakumari district, in Tamil Nadu state, India. This region has humid summers with maximum temperature of 34o C. During winter season the average temperature is 22 °C.



Figure 1. Floor Plans for the selected contemporary House

COGNITIVE ANALYSIS

Table 2. cognitive analysis for the selected contemporary House

Objectives	Observation	Evaluation
Lighting	Rooms other than those have curtains get enough day lighting	Curtains can be used temporarily
Thermal	Thermal comfort is achieved only through mechanical ventilation	Building envelops can be changed to get required thermal comfort without mechanical ventilation
Renewable energies	Renewable energies are not used in the operation of building	Renewable energies can be installed to make the building to function off grid
System		
Lighting	Manually operated	Automatic operation can increase the energy performance of the building
HVAC	Manually operated	Automatic operation can increase the energy performance of the building

From Cognitive analysis, it is found that more energy is required for achieving thermal comfort using mechanical ventilation and for lighting.

EMPIRICAL ANALYSIS - LIGHTING

Indoor lighting is analyzed using Lux meter. It is found that hall and living areas in the ground and first floor doesn't get much natural lighting. For the spaces which do sent get good natural lighting, lighting comfort is achieved through electrical bulbs, which consumes more energy.

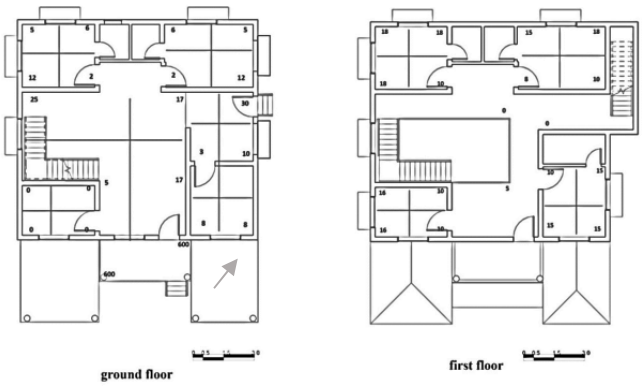


Figure 2. Lighting analysis using a lux meter

EMPIRICAL ANALYSIS – TEMPERATURE

Indoor temperature is noted for 5 days using a hygrometer. The temperature ranges from 27.2o C to 31.3o C. That is higher than comfortable indoor temperature. Hence mechanical ventilation is required to maintain thermal comfort.

Table 3. Indoor Temperature readings using a hygrometer

TEMPARATURE		
	min	max
Day 1	31.3	32.6
Day 2	29.4	33.4
Day 3	29	33.4
Day 4	28.4	33.4
Day 5	27.2	33.4

SIMULATION

Simulation is done to check the lux level and Energy usage of the building.

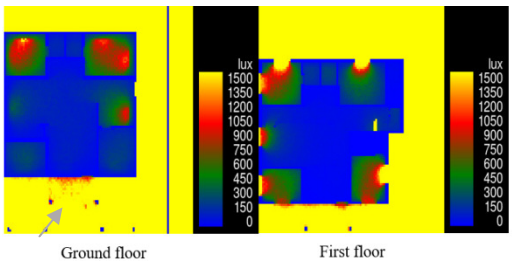


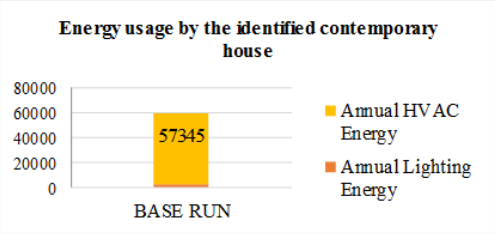
Figure 3. Simulation results from Revit insight

Simulation can be done using Revit Insight to check the lighting level. In Ground floor, car porch gets a good amount of natural lighting. Bed room and dining area get a considerable amount of natural lighting as there is only one opening in the car porch side. Pooja room and the kitchen don't receive a good amount of day lighting. Living and hall also doesn't receive any day lighting (Figure 3). In the Second floor all the rooms except the family living area receives a good amount of day lighting. Adding sky lighting to the roof can improve lighting performance in the family living area. For hall and living sky light can be added to the roof. For pooja and kitchen a window can be added to other side wall.

Simulation to check the energy usage of the building is done using E-quest. Observations from E-quest Analysis is over all energy is mainly used for space cooling i.e. annual HVAC energy usage is high (Table5). With energy used for space cooling as fiction, optimization objective, design variables and parameters can be selected to reduce the cooling energy used by the building.

To get minimum energy usage for space cooling, optimization objective can be used is building envelope, as building envelope gets maximum amount of energy from the sun. Design variable can be used are transparent and opaque building envelope. Transparent building envelope includes glazing type used and shading device type and depth. Opaque building envelope includes walls, roof, and floors.

Table 4. Energy usage for existing parameters - simulation results from e-quest



GREEN DESIGN OPTIMIZATION

From the simulation results most of the energy is used for space cooling, i.e. the energy consumption for HVAC is high (Table 5). Form the cognitive, empirical and simulation results of the identified contemporary house, optimization objective considered is Building envelope, the objective function is reducing the energy used for HVAC, the design Variable considered are transparent and opaque building envelope. Parameters associated with the identified design variables are changing u vales of wall, roof, changing the size and types of shading device, changing the glass types used.

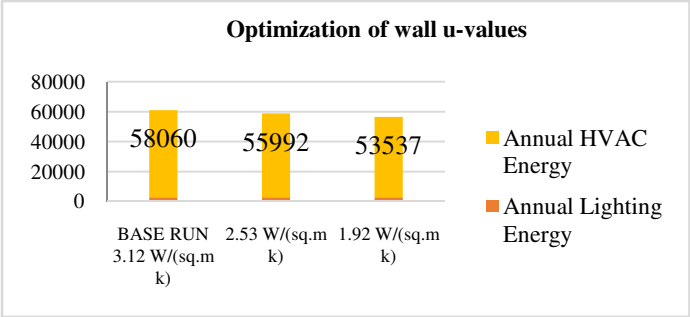
Based on the identified objectives, design variables and parameters, optimization process is done in E-quest simulation software using the DOE-2 model generated from green building studio and weather data file of the place were building is located.

Base run for each design variable is done using existing parameters. Other runs are done from the inferences of climatic design parameters for hot humid region (ECBC norms and Climate responsive design by Aravind Krishnan) like low U-Values, shading devices, Low SHGC values.

OPTIMIZATION ON OPAQUE BUILDING ENVELOPE - OPTIMIZATION OF WALL U-VALUES

Wall as design variables and different U- values as parameters, all other design variable is kept constant. Run 1 (Base run) is done with existing parameters cement plaster finish+ brick work + cement plaster finish with U-Value- 3.12 W/ sq.m k, Annual energy used is 6,29,24 kWh. Run 2 is done with U-value 2.53 W/ sq.m k (Cement plaster finish+ brick work + cement plaster finish+ plaster board), Annual energy used in run 2 is 6,08,55 kWh, percentage of energy saved is 3%. Run 3 is done with U-value 1.92 W/ sq.m k (Cement plaster finish+ brick work + cement plaster finish+ 2 fiber board), Annual energy used in Run 3 is 5,83,82 kWh, percentage of energy saved is 7%. The parameter cement plaster finish + brick work + cement plaster finish+2 fiber board saves a higher percentage of energy. U- value: 1.92 W/ (sq. m k) (Table 6).

Table 5. Optimization results of different wall U- values, e-quest simulation results

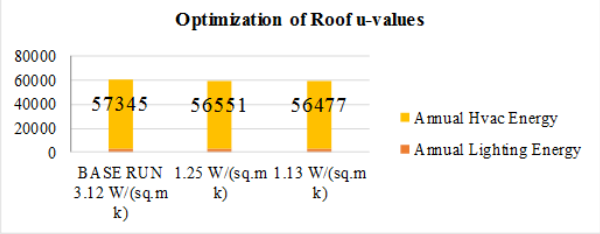


OPTIMIZATION ON OPAQUE BUILDING ENVELOPE - OPTIMIZATION OF ROOF U-VALUES

Roof as design variables and different U- values are used as parameters, all other design variable is kept constant. Run 1(Base run) is done with existing parameters reinforcement concrete with U- Value- 3.35 W/ sq.m

k, Annual energy used is 6,29,24 kWh. Run 2 is done with u value 1.25 W/ sq.m k (Reinforcement concrete + 2 fiber board), Annual energy used in run 2 is 6,21,30 kWh, percentage of energy saved is 1 %. Run 3 is done with u value 1.13 W/ sq.m k (Reinforcement concrete + with wood wool slab), Annual energy used in run 3 is 6,20,55 (kWh), percentage of energy saved is 1 %. The parameter used in Run 1 and Run 2 shows 1% energy reduction (Table 7).

Table 6. Optimization results of different roof U- values, e-quest simulation results



OPTIMIZATION ON TRANSPARENT BUILDING ENVELOPE - OPTIMIZATION OF WINDOW GLASS TYPE

Window Glazing Type as a Design variable and other Design Variables are kept constant. Run 1(Base run) is done with existing parameters single clear glass, Annual energy used is 6,29,24 kWh. Run 2 is done with Single glass with low e-value, Annual energy used in run 2 is 6,14,61 kWh, the percentage of energy saved is 2 %. Run 3 is done Double glass with low e-value, Annual energy used in run 3 is 6,12,79 (kWh), the percentage of energy saved is 2%. A parameter that shows maximum energy savings are single glass with low e-value and double glass with low e-value (Table 8).

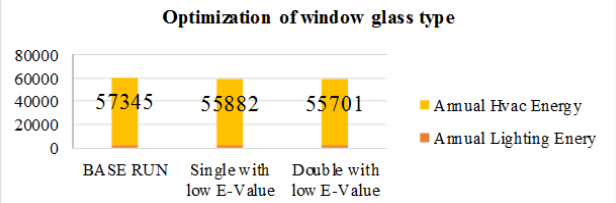
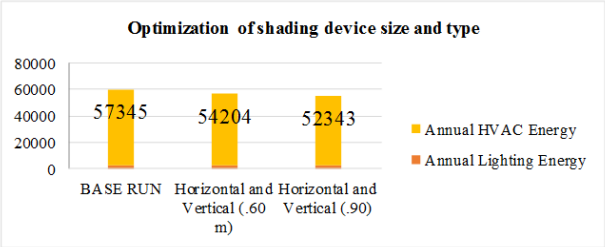


Table 7. Optimization results of window glassing types, e-quest simulation results

OPTIMIZATION ON TRANSPARENT BUILDING ENVELOPE - OPTIMIZATION OF SHADING DEVICE SIZE AND TYPE

Shading device as design variable and other parameters are kept constant. Run 1(Base run) is done with existing parameters – Horizontal shading of .60 m, Annual energy used is 6,29,24 kWh. Run 2 is done with Horizontal and Vertical Combined with a width of .60 m, Annual energy used in run 2 is 5,97,82 kWh, the percentage of energy saved is 5 %. Run 3 is done with Horizontal and Vertical Combined with a width of 0.90 m, Annual energy used in run 3 is 5,79,21 (kWh), the percentage of energy saved is 8 %. Parameter that show maximum energy saved is horizontal and vertical shading of .90 m (Table 9).

Table 8. Optimization results of shading device size and type, e-quest simulation resultts



PARAMETERS FROM GREEN DESIGN OPTIMIZATION PROCESS

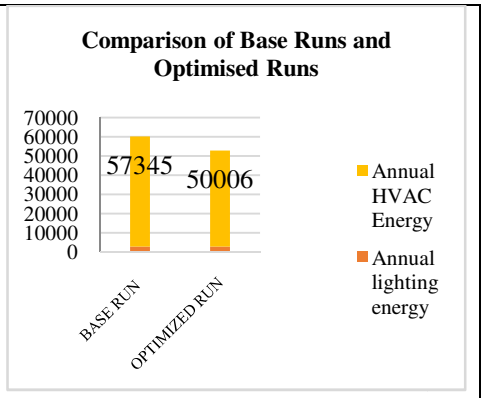
It was found there were changes in space cooling and the energy required for lighting reminded same as the design variables. The following parameters were noted with maximum energy savings are Wall U-value 1.92 W/ (sq.m k), Roof U-value - 1.13 W/ (sq.m k), Shading device type – over hang and fins on both sides with depth of .90m. Glass types are double glass with low e-value, single glass with low e-value. From this parameter base run

and optimized run using the parameter is compared, there is 16% of energy savings after the application of Green Design Optimization Process (Table 10).

Wall materials associated with U-value – 1.92 W/ (sq.m k) are wall cement plaster finish + brick work + cement plaster finish+2 fiber board. Roof material associated with U-value 1.92 W/ (sq.m k) is Reinforcement concrete + 2 fiber board.

Table 9. Comparison of optimized run and base run using the parameters achieved from Green design optimization process

Comparison of optimized run and base run using the parameters achieved from green design optimization process	
	HOUSE 1
Base run	6,29,24 kWh
Optimized run	5,28,56 kWh
% of energy saved	16%



CONCLUSION

From the above Green Design optimization process done to the contemporary house it is evident that there is a considerable amount of energy reduction is noted. The base run with actual parameters of the existing building is 6,29,24 kWh and the energy usage of the building from the parameter achieved from Green Design Optimization Process is 5,28,56 kWh. 16% of energy reduction is noted by Green Design Optimization Process. Optimal parameters derived are Wall U-value 1.92 W/ (sq.m k), Roof U-value - 1.13 W/ (sq.m k), Shading device type – over hang and fins on both sides with a depth of .90m. Glassing types are double glass with low e-value, single glass with low e-value.

This study concludes that green design optimization can be used in the design process to reduce the annual energy demand of the building through the optimal energy performance noted from the optimization results. In this research, Building Envelope is used as Optimization Objective, Energy Usage by the building is used as Objective function, and optimal parameters based on Building Envelope are derived only for Hot Humid Climatic Zone. This Green design process can be also done for other climatic zones with other objectives like thermal comfort, Day lighting, etc. and Objective function like cost, environmental impact, etc.

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Green practices and sustainable facilities management at Tirumala temple town

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Abstract: Human settlements associated with religious touristic quality are considered as religious towns or cities. Visiting a spiritual space and offering rituals associated depict the community spirit of being environmentally aware and proactive. These holy places maintain pure and clean atmospheres to ensure peaceful way of offering prayers. Coincidentally, the elements of nature that they worship become the basis for sustenance of our ecology. These places of congregation, experience a large influx of pilgrims. Services provided are utilized by residing population as well as those visiting. Such occurrence increases economy of the religious town by encouraging the flow of pilgrims. On the other hand, inefficient provision and management of basic services affects the overall environment surrounding the temple town, resulting solid waste piling, deforestation, traffic congestion, insanitary conditions etc. Sustainability focuses on progress contribute to socio-economic development emphasizing technological capacity building based on the cultural patterns. Our focus in this paper would be to understand and demonstrate the 'Sustainable Practices Policy', as green temple town, transportation, climate protection, waste reduction and recycling, sustainable foodservice and water efficient systems. Discerning various practices followed at 'Tirumala temple town' advocating sustainable theme through co-operation and devotional services. Considering, key components of sustainable temple town management according to IGBC norms. The qualitative study does comparative analysis and prescribes suggestive guidelines as benchmarks encouraging -friendly sustainable practices.

Keywords: sustainable practices, green temple town, facilities management, eco-friendly, sustainable strategies

INTRODUCTION

Human habitats are recognized by a specific prevailing activity that occurs along these surroundings. Settlements allied with religious implications are recognized as spiritual or temple towns. A huge influx of religious tourist movements is experienced on daily bases along such places, thereby inciting the economy and environment of the town. The temple down develops due to the presence of temple. Subsequently, civic infrastructure in coordination with administration keeps developing to cater to the needs of provision and maintenance of various facilities for residing and floating population. Established institutional structure often referred to as the temple trust maintains the temple and its premises. Local municipal authorities in synchronization with the trust foresee the wellbeing of the town regarding aspects such as utilities, economy, mobility and overall environment.

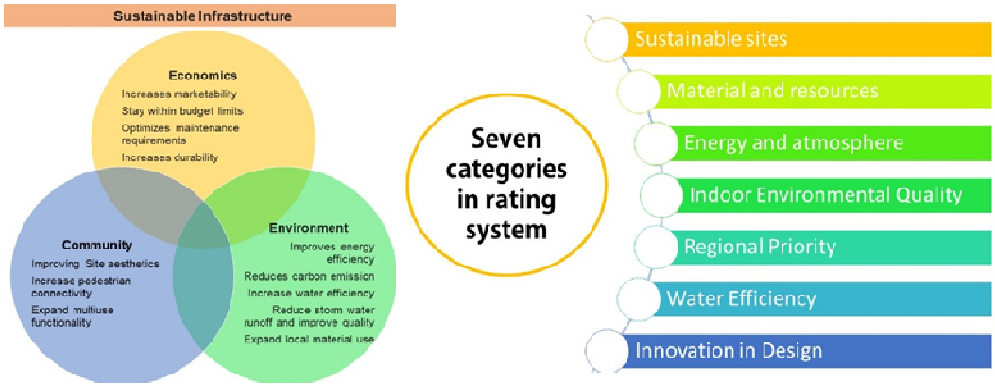

Figure 1. (towards left): Showing main components for 'Sustainable Infrastructure' of built environment. Source: Graphic developed from book - Sustainable Design (A Critical Guide), by David Bergmen & S.BrySarte; (towards right): Showing the major categories in rating system, Source: Graphic developed from book - Design with nature, Ian Mc Harg

(Williams), Sustainability is a complex term, but basically it means realizing the resources required for meeting the needs of the present and utilizing them without exploiting and compromising the accessibility of forthcoming generations. A green development is an element of sustainable design development, which would be useful under any weather conditions.

Research method and literature review

The explorative study involves qualitative analysis. Data gathered through primary sources through conversations and interviews of relative officials at Tirumala Tirupati Devasthanam (TTD) at Tirumala and Tirupati, Indian Green Building Council (IGBC) at Hyderabad. Secondary and tertiary information is gathered through the relative documents provided by the above said institutions and also supported by the filtered information available through relative websites. The collected material is further processed and analyzed understand the green practices followed. Conclusions are made with certain suggestive measures. (Williams)

Administration of Temples

(Rao.D, 1998)Temple towns are formed as a product of communal worship practices. Construction, maintenance and administration of these places of worship is undertaken by the patronage of Kings under their reign within the jurisdiction of the kingdom. Temples in southern region of India flourished between 9th – 15th centuries. As the temple serves as a common social ground for community religious activities its development, maintenance and allowances are granted by collection of endowments. Endowments department is delegated the duty to manage the temple funds for the progress and welfare of the temple and also the town associated. They are responsible to recruit and manage the resources required for the smooth functioning of the developmental and restoration activities. Periodic checking with a transparent accounting system administered. The temple trust is bestowed with the responsibilities to look into the civic needs of provision of accommodations, public amenities, water supply and sanitation, transportation facilities and food. Correspondingly, public parks, establishment of educational and medical institutions along with book publications must be done for wellbeing of both temple and community. Periodic checks must be conducted by the managerial institutions to notice the existing issues and mainly to alleviate illegal violations or intrusions. On the whole, the entire development and up keeping of the temple town is done by efficient management through effective administration supported by unambiguity and consecutive inspections.

Green Temples Guide – An environmental guide for Hindu Temples and Ashram

(Martin Palmer, 2015), the book has been launched by both, The Alliance of Religious and Conservation (ARC) and the Bhumi Project (based in Oxford, UK). It mainly aims on creating awareness among various eco-friendly practices among various temple towns across India. More than 30 such religious towns and ashrams have been studied and various sustainable initiatives followed have been documented. The book emphasizes on the importance of green temples and the relative philosophy associated with it. A variety of solutions are suggested with respect to the development of temple grounds and building. Diverse methods on energy efficiency, water and waste management have been detailed out. A toolkit for implementing these sustainable methods suitable to the local context is advised. Environmentally suitable ways to manage civic infrastructure. The book also accentuates the managerial and economic issues, various bodies involved in taking care of the temple and the associated town's welfare, safety and overall health. Finally, a self-evaluated, checklist on how green a temple and its premises are provided. These sacred towns with eco-friendly examples create a ripple effect, hence proving substantial improvement in coming course of years.

Tirumala temple town

Tirumala is the notable famous religious temple town in India. It is located at an elevation of 980m approx. It is up the hill at a distance of 26.8 sqkms from the city of Tirupati city (Chittoor district, Andhra Pradesh). Pilgrim inflow of 80,000 – 1, 20,000 is approximated on daily bases. Tirumala is also referred as hill town is managed by Tirumala TirupatiDevasthanam (TTD) trust in coordination with Municipal Corporation of Tirupati (MCT). The religious trust TTD governs and manages divers institutions related to civic infrastructure, finance, education, medical, press, canteen, channel etc. under the supervision of Executive Officer (EO) heads, assisted by Joint Executive Officer (JEO).

For the purpose of maintenance and engineering, Tirumala is demarked into four zones. The civil works department handles assorted departmental services related to water supply and sewerage system, storm water drainage, solid waste management, public facilities and health. Transport and forest are undertaken by respective delegated departments coordinating with TTD, just the same way the information and public relations is tackled by public relations department. A well organized, resourceful institution is observed along the temple town with supportive delegate departments with effective reporting procedures updating the existing issues and also discussing progressive future decisions.

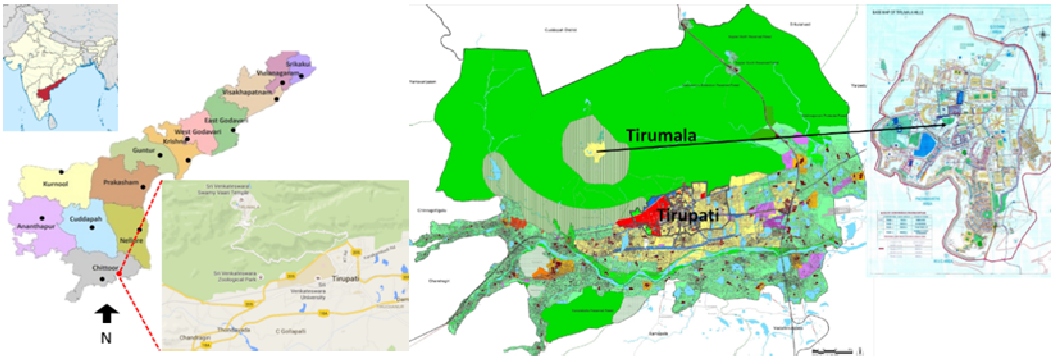

Figure 3. Location of Tirumala – Tirupati Andhra Pradesh, India (towards left), Map of Tirumala-Tirupati (towards right) Source: Maps India.com and Google earth, offices of TTD and Tirupati Urban Development Authority

IGBC green place of worship rating

(IGBC Green Places of Worship Rating System, August, 2017), Concerns about environment and sustainability all are affected by built surroundings. Users, corporations, building professionals, managerial entities and local governments often are the major stakeholders. Meeting the requirements of rating system provides with a metric evaluating the investment while setting the priorities of immediate and long term concern. (Bergman), rating system verifies and quantifies sustainable design and construction and helps to observe and identify issues such unrecoverable and unnecessary costs. These guidelines are viewed as marketing tools and also as a way to lower operating costs.

The main purpose of green place of worship is to promote the idea of eco-friendly practices, greening the place of highest sanctity will eventually serve as stepping stone in the big green movement.



Figure 4. Showing 'IGBC REVERENT' secured by various temples across India Source: IGBC AP, 2018

The sustainable aspects of green places of worship are addresses in rating system under the following modules –

1. Site preservation
2. Water conservation
3. Energy efficiency
4. Health and hygiene
5. Innovation

From the image below it is evident that IGBC REVERENT rating has been awarded to Tirumala around the year 2017.

Analysis of Tirumala considering IGBC Green place of worship rating modules

Post registration 40% points are to be achieved by the new or existing place of worship for 'IGBC REVERENT' rating level. A detail checklist consists of required certificates and other details are requested submission to proceed further calculations and supported by relative site visits to release the review.

A detail checklist of the above mentioned module is evaluated in tabular form and relative supportive qualitative data is updated for the purpose of understanding the awarding of 'IGBC REVERENT' rating for the temple town of Tirumala, considering the innovative green practices.

Table 1. Site Preservation (Source: (Martin Palmer, 2015), IGBC AP, Primary source, websites: www.tirumal.org, 2018)	
Greenery within Site	460 acres of landscaped ornamental gardens. Productive nursery grows seeds from a variety of indigenous trees and plants.
Preservation of Local bio-diversity	Forestry department of TTD has planted more than 44 lakh (4.4 million) trees to restore vegetation.
Preservation of Top Soil	Haritha project to conserve soil
Universal Design	Special provisions are made for differently abled and senior citizens within the premises.
Access to Public Transport	Provision of public transport buses conveniently running all along the temple town at regular time slots. Proposal has been made regarding usage of electric cars for public transportation
Heat Island Reduction	Presence of lot of trees and shades along places assigned for parking and resting.
External light fixtures	Switching to usage of solar street lighting
Signage's /Display on Green Education	Provision boards promoting importance of environment, greenery and cow welfare. Accessible Information centres and signage all around the temple town

Table 2. Water Conservation (Source: IGBC AP, Primary source, 2018)	
Rainwater Harvesting	Haritha project to conserve soil and rainwater, improve the groundwater and plant new forest in a 29,500 acre area in the hills.
Water Efficient Plumbing Fixtures to meet UPC	Underground Drainage System is a network connected to four localized sewage treatment plants with a collective capacity of 9.50 MLD spread across Tirumala. Water treated is used for maintaining gardens, nurseries, parks and forests and also refilling underground storage tanks
Water Efficient Landscaping	Tirumala has a well-connected Underground Drainage System (UDS) network connected to four localized treatment plants with a combined total capacity of 9.50 MLD. Treated water is utilized for a number of non-potable purposes such as maintaining and developing all gardens, parks, nurseries and forest area in the town and also replenishing storage tanks for groundwater

Table 3. Energy Efficiency (Source: (Martin Palmer, 2015) IGBC AP, Primary source, websites: www.thehansindia.com, 2018)	
Energy Efficiency	TTD's power consumption is met by wind power (28%) and by solar power (38.5%) by the new 100 kilowatts solar power plant at Kosuvaripalli. The wind turbines harness wind to generate 7.5 megawatts of power every day, an additional development of a windfarm is under process.
Solar Cooking System	Solar operated community kitchen prepares and serves food for 25,000 pilgrims approx., through this carbon emissions are reduced by 1.2 tonnes per day.

Table 4. Health and Hygiene (Source: (Martin Palmer, 2015), IGBC AP, Primary source, 2018)	
Segregation of Dry & Wet Waste	30 tons of waste (approx.) is collected. Waste is segregated. Wet waste is fathered processed to develop manure to be used at TTD's nurseries.
On-site Organic Waste treatment & Reuse	Floral waste collected from temple is processed into perfume products or dyes extraction. Usage of plastic is banned. TTD has setup a recycling plant that cruses 150kg of plastic bottles on daily bases. These are made into pipes and are sold to farmers at subsidized pricing for micro irrigation.
Hygiene Facility	Streets of Tirumala are cleaned twice everyday by the outsourced staff of health and sanitation department. They also take care of housekeeping services (Facilities management services) for the accommodations provided by TTD. Public toilet and hot water provisions along 15 places coving the entire temple town is checked by sanitary inspector for ensuring maximum hygienic conditions

The temple received an identification as a future 'Low – Carbon Footprint City" by European Aid and Development which works under the European Commission for being constantly innovative approach in implementing green solutions. The temple also sells the emission reduction credits to Swiss Green Technology enterprise, Good Energy Inc. The temple is developing reserve forest to become carbon sinks. Small dams are set up to help recharge aquifers A series of watch towers are strategically arranged and devoted structured forest department with efficient firefighting department are alerted to be vigilant about forest fires (Martin Palmer, 2015).

CONCLUSION

The study gives insights on preaching and practicing the sustainable eco-friendly practices, backed up by periodic checking through efficient managerial measures. Formulation of Vision, preparation of objectives, assigning timelines and appropriating/ devolving suitable measures to reach the set objectives. Analyzing the current and future trends and requirements and addressing the issues with appropriate measures. Devising of a strategic facilities management plan along with the details of the members and institutions or organizations involved for holistic development and sustainability of temple.

Conducting Environment Impact Assessments along with energy and water auditing to assess the current usage and predicting the requirement for the forthcoming years. Organizing and regulating the vehicular movement through the temple town, prohibiting congestion and encouraging the switch to public transport. Banning plastic usage and encouraging usage of biodegradable alternates. Initiatives to create awareness among the public regarding green methods off devotion and spirituality. Emphasizing and encouraging community service. The benefits of sustainability and green building practices in facilities management are well intertwined. Beneficial effects such as - reduction in energy consumption and waste leads to increase in productivity. The quantifiable outcomes are a result of organization's leadership.

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Stakeholders' perception on Adaptive reuse of Heritage Buildings and its Challenges towards the Sustainable Approach

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Abstract: Since the architectural, cultural and economic benefits, the adaptive reuse of heritage buildings is looming around the world. The objective of this paper is to examine the stakeholders' perception for adaptive reuse of the heritage buildings on sustainable development. Stakeholders are widely acknowledged in the various fields of sustainable developments. Especially when it comes for heritage buildings, the stakeholders' roles are vital. The stakeholders in this study were chosen from three heritage towns of Tamil Nadu. The total of 56 respondents was surveyed who reside in the historical core of the selected heritage towns. The paper presents the challenges with the adaptive reuse of the heritage buildings for the sustainable approach from the stakeholders' perception. Though the adaptive reuse of heritage buildings possesses eminent recognition, the respondents encountered certain challenges of heritage buildings adaption and reuse. Thus, the perceptions of the different group make the study more influential and contribute in the decision making to the sustainable development of heritage towns.

Keywords: heritage town; adaptive reuse; sustainability; heritage buildings

INTRODUCTION

Heritage buildings of the region/place have its own unique, diverse qualities of architecture, social and cultural. India is a country with rich and diversified cultural heritage. Indian cities, towns and settlements have a unique cultural heritage that lies in its urban settings with the glimpse of the old crafts, rituals and festivals. The accelerated rapid urbanization, along with the influence of globalization in the recent decades causes the pace of change in its urban settlements (UNESCO, https://ihcn.in). These towns and cities are confronted with the pressure of urbanization and uncontrolled development. The heritage buildings are replaced with the new construction in which the social and cultural essences of the towns have extinguished. Thus, the heritage towns are in need of urban generation with sustainable development.

The sustainable development refers that ensuring a better quality of life for everyone, not only at the present but also to the future generation. Since the architectural heritage provides the valuable impression of our history, culture and social life of the region or place to the next generation Therefore, it is necessary to integrate the sustainable approach (Bullen & Love, 2010). The conservation of architectural heritage should be the integral part of the sustainable development. Recently, all over the world, the architectural heritage has been preserved by means adapting and reuse the existing heritage buildings.

The stakeholder perception must be considered as significant while the demolition of built heritage solely decided by them. Though the heritage buildings are assorted as a valuable asset, these buildings are demolished for commercial purposes and new developments. Why can't be the heritage buildings adopted and reused? Hence, the main objective of this paper is to examine the stakeholders' perception for adaptive reuse of the heritage buildings towards sustainable development. The interviews were taken in the three heritage towns of Tamil Nadu with the total of 56 respondents. The stakeholders' perceptions were specifically substantial for achieving the sustainable development in the architectural heritage settings.

LITERATURE REVIEW

Adaptive reuse

Adaptive reuse is a globally emerging concept towards achieving sustainability through conservation of existing heritage buildings (UNESCO, 2007).The term 'adaptive reuse' can also be referred by other names such as retrofitting, rehabilitation, refurbishment, remodeling, conservation and adaptation. Plevoets & Cleempoel,

2011, defines that, when a building is 'retrofitted' or 'adaptively reused' the major change in the building will be its function; the other changes may be carried out by redesigning the circulation route, or interior design or orientation; adding or demolishing a smaller part of the building without spoiling its originality.

The recent theories of adaptive reuse are approached by three methods, namely, typological, technical and architectural strategies. If the buildings are categorized by its existing use and adapted for reuse, then it is typological approach. In technical approach, aspects of the building like the improvement of fire resistance, acoustical and thermal performance, damp penetration, condensation and timber decay; are addressed from a technical point of view (Plevoets & Cleempoel, 2011). The opportunity of adaptive reuse of the building with the existing use may be acquired for restoration and adaptation to appropriate new uses. It would demonstrate the social sustainability, which gives the glimpse of the past and carries the valuable assets to the future generation.

Adaptive reuse on Sustainability

Adaptive reuse of heritage buildings can be seen as a fundamental component for achieving sustainability by extending the life of the building and help preserve its value, thereby promoting environmental, social, cultural and economic welfare of the community as well (Ulusoyet.al, 2013). The major environmental benefits of adaptive reuse of historic buildings are low embodied energy, and low carbon emissions. The economic benefits are achieved by low embodied energy as the energy required for the production of building materials, mining, and transportation is totally reduced (Ragheb et.al, 2017). The action of reconstruction and demolition of heritage buildings has been neglected in the adaptive reuse (Sigmund, 2016). Ayman and Heba (2018) explained the relationship of sustainable approaches and the advantages of adaptive reuse as shown in the table 1.

Table 1. The relationship between the Sustainable approach and the advantages of adaptive reuse *(Source:Ayman and Heba, 2018)*

Sustainable approach	Advantages of adaptive reuse
Environmental	• Environmental Enrichment • Reduced the consumption of resources, energy and emissions • Enhancing the demand for preserving existing buildings • More neighborhood spaces • Getting better energy embodied in buildings for long periods
Economic	• Economic development • Cost-effectiveness • Expanding the life cycle of buildings • Retaining the community properties as the value to resources
Social	• Sense of Place, place attachment, identity and vitality • Enhancing the visual aspects of the built environment • Conservation of the heritage • Decreasing consumption of land and urban slump • Rejuvenation and regenerations of urban heritage with technical benefits

Role of stakeholders in adaptive reuse

The stakeholders' engagement is vital, especially the residentsofthe sustainable development and the conservation of built heritage. Their participation has to be highly recognized to retain and intact the built-cultural heritage of the town. Recent studies on adaptive reuse of buildings, shows that the increase in number of parties ready for adaptation end up with complexdecisions on adaptive reusedue to the different perspectives (Douglas, 2006).

The stakeholders' like the owners, developers, producer, investors, marketers, architects, engineers are involved in the adoption decision making. Mohamed and Alauddin(2016) clearly explains the problems faced by the stakeholder in the decision making process for retrofitting of buildings. Likewise, Grenville (2007), Hoffman (2006) also explains that the stakeholders' perception should be integral for the sustainable development and policy making.

METHODOLOGY

The above literature review gives the overview of the advantages of the adaptive reuse for the built heritage on the sustainability. The role of stakeholders in the heritage building adoption also discussed. The primary data were collected from the stakeholders through the direct interviews and group discussions. The three significant heritage towns of Tamil Nadu were selected for the study; they are Kanchipuram, Kumbakonam and Madurai. These towns are diverse from the types, i.e., Madurai is the heritage city; Kanchipuram is Municipality town; and Kumbakonam is the special grade municipality town. The total of 56 respondents, were interviewed for the study. The stakeholders were limited and categorized as house owners, commercials (hotel-building owners, shop owners) and professionals (Architects, Conservationists, Engineers). In this case, the stakeholders of each category were selected by specific criteria's as shown in the methodological framework for this study (see Figure 1). The respondents were provided with 20-30 minutes for the discussion during the interview.

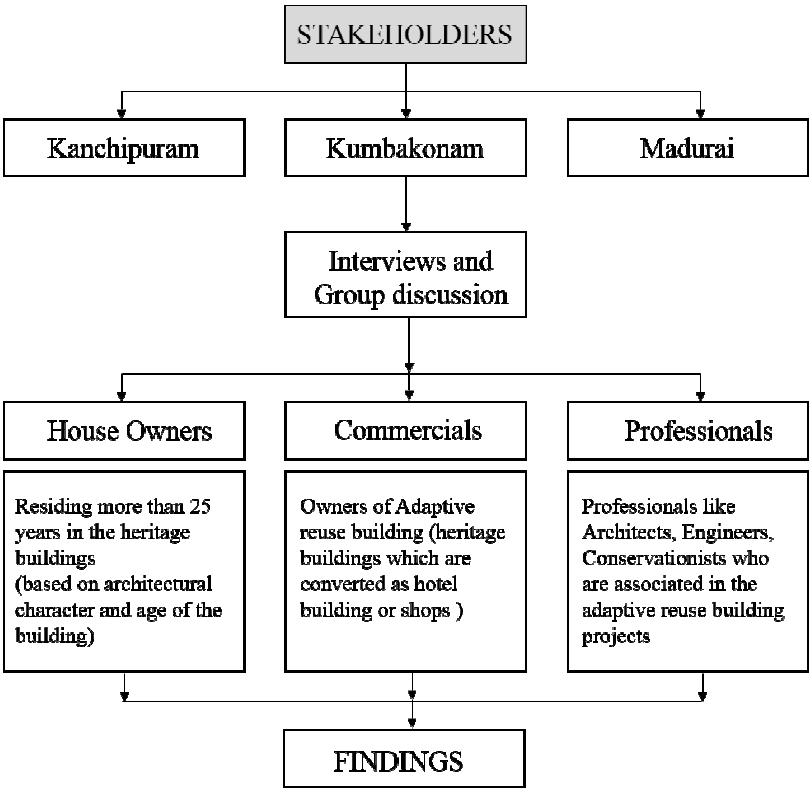

Figure 1. The methodological framework for the study

FINDINGS AND DISCUSSIONS

The findings from the interviews and discussions with the stakeholders noted. The results are consolidated and reviewed from each category according to the preponderance of the respondent's perceptions. In the following Table 1 shows the findings of the interview, discussed with the respondents. The graphical representation of the findings from the three historic towns indicated in the bar chart (see Figure 2).

Table 2. The consolidated results from the interviews with the stakeholders

Stakeholders' Category	Identified Challenges with the adaptive reuse from the Stakeholders Perceptions	Total Percentage
House Owners	Non-availability of Original materials	78
	No skilled labors	82
	Required more maintenance	91
	Aesthetically not fit with the other new buildings	68
	Economic viability	89
	Not supporting with new technologies and amenities	55

Commercials & Professionals	Inadequate spatial requirements for service like HVAC, fire safety, etc.	91
	Risk in replacing the materials	58
	Incompatibility with the re-use from the existing building use	83
	No assured profits	79
	High depreciation valueoverthe few years of adoption	68
	Unclear Building Ownership	48

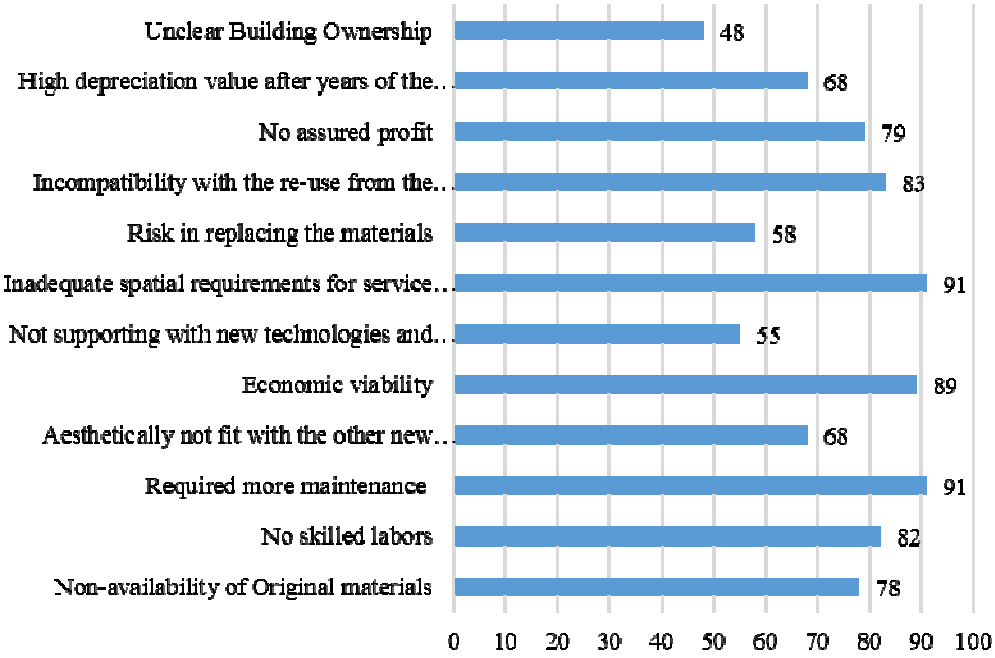

Figure 2. Bar chart showing the results of the interviews from the Stakeholders

Perceptions of the house owners

The common challenges with the adaptive reuse were sorted from the house owners of three heritage towns through the interviews and discussions. Since the architectural, cultural and economic benefits, the adaptive reuse of heritage buildings is highly recognized in the sustainable development (Bullen & Love, 2010; Clark, 2013; Manewaet al, 2016; Yung et.al, 2012). Furthermore, in heritage towns/cities, the adoption and reuse of the heritage buildings provided the opportunity of continuity in the community's social life, sense of belongings identity and place attachment. Still, some of the challenges of adaptive reuse overcome its sustainable benefits. The interviewees also clearly pointed the challenges from their perceptions towards the adaptive reuse. The 78% of the respondents perceived that the vernacular building materials are limited in the market and also expansive which not economically viable (89%). The 82% of the house owners indicates the inadequacy of skilled labors. The requirement of skilled labors is substantial for the conservation works. Very few numbers of labors only doing the conventional works in which the outcomes cannot be predicted as we expected.

The interviewees addressed the aesthetical aspects (68%) also. They believed that older buildings may not be coinciding with the modern built environment. In most of the adaptive reuse buildings, the originality of the materials convinced due to the unavailability. In that case, the aesthetical values are extricated from the buildings. The 55 % of respondents considered that the traditional buildings are not supporting the technological innovations. However, the maintenance of the heritage buildings (91%) is the real challenge among the residents as it requires regular monitoring and adequate services.



Figure 3. The interior of the adaptive reuse hotel building in Kumbakonam

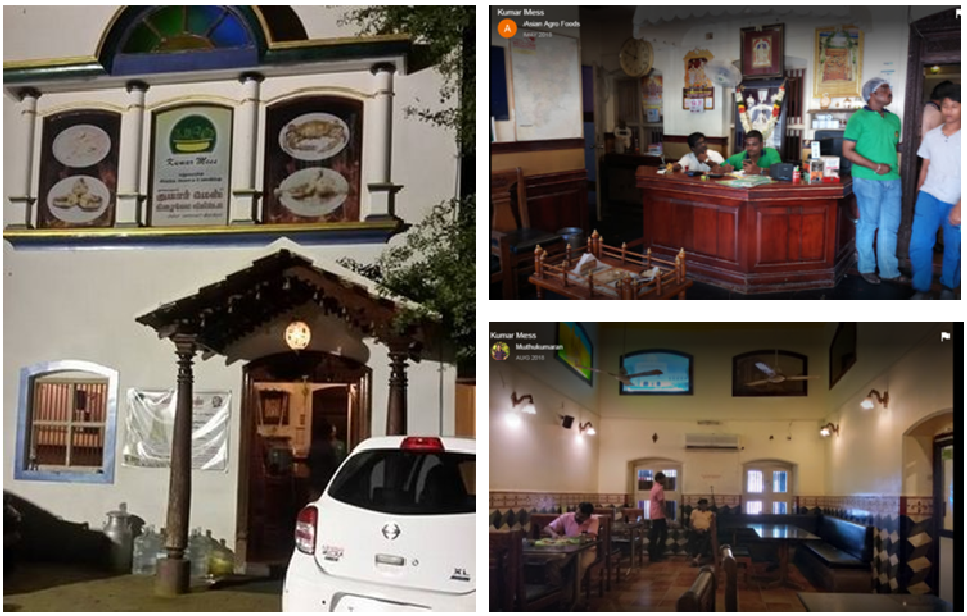

Figure 4. The exterior and interior view of a retrofitted hotel in Madurai

Perceptions from the commercials and professionals

The perception of the house owners and commercials may vary, the house owners look the buildings or property with the sentimental value. The commercials look out the building in the marketing and profitable aspects. When converting the buildings into hotels or shops, it meets serious challenges. The commercials (91%) stated that the spatial requirement of the existing heritage buildings are not adequate for the present-days service amenities like HVAC, fire safety, etc. And, also, the risk of restoration (58%) of the existing materials or antiquities of the heritage buildings, are high. With all these risks, they do not assure profit. The business competition boosts and desperate the customers choices, as such, the adoption and reuse of the buildings, have

uncertainty in the loss and gain. The respondents (68%) stated that after the adaptation of the buildings, a few years later, the depreciation value becomes high due to the age of the building and its use.

The professionals mentioned that the re-use of the heritage building sometimes incompatible (83%) with the existing building use and totally delineate the socio-cultural value of the building (see Figure 3).While doing the restoration or renovation works, mostly are not taken sincere efforts of preserving the significant values of the building. The successful cases of adaptive reuse are very few; the figure 4 shows the views of the retrofitted hotel building in Madurai. In which, the heritage essence of the building retained

CONCLUSION

The heritage towns and its urban settings are alive because of its built-cultural heritage. In a developing country like India, the people are more attracted towards high rise buildings, modern construction techniques and materials like glass, steel and concrete, that the value of old buildings are deteriorating slowly.In most urban areas, the residents of old houses are easily enticed with a handsome amount of money by builders or marketing agencies and forced to sell the houses. The results from the study show that the respondents were more concerned about the profits from the building and less maintenance cost. The respondents emphasized the challenges on adaptive reuse of heritage buildings. Hence, the study was very useful in understanding the perspectives of the stakeholders on adaptive reuse of buildings. Although the government of India has taken many initiatives towards heritage conservation of historic buildings, it has not reached the common people. It is very important to sort out the practical issues faced by the stakeholders in order to mitigate the challenges to bring out a sustainable development.

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Fostering Sustainable Development through Bioregionalism - Learning for Cities of Today and Tomorrow

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Abstract: Indian Cities have been by and at large in size and nature oriented. With increase in social and environmental problems that we need to combat, invisible problems such as social cohesion, green community planning, resource consumption patterns etc. at the forefront of sustainable development. There is a dire need for renewal from holistic point of view, as cities have thrived along for centuries with characteristic of growing population and our current development process sucks reserves and available resources from an area and abandons it without replenishment and dumps waste into the environment to top it all. In our methodology, we revisit Bioregionalism- a movement initiated in the 17th century where people were connected to their land, nature and institution. From a Bioregionalistc point of perspective, it opposes the consumerist habitude where there is dearth of stewardship towards the environment. This perspective thus, seeks to match ecological and political boundaries, Strengthen the unique ecology characteristic of the bioregion, Maximizing where possible consumption of locally produced foods where possible, ensure the wide usage of vernacular materials, techniques and technology where it is possible, recognition of plant species and maximizing native variety of the bioregion and encouraging practices that holistically pronounce sustainability within the bioregion. With this theory in mind, practical approaches of practices in Auroville, a quintessential township in the Union territory of Pondicherry in Tamil Nadu is discussed in depth for a wide eye perspective of the characteristics, importance, threats and learning's for cities of tomorrow which endeavor to push its key sustainable approaches.

Keywords: Sustainable Development, Ecology, Bioregionalism, Vernacular, Green Community Planning, Sustainable Systems, Environmental resources

INTRODUCTION

With exponential rise of globalization and expanding westernization model of our cities today, an augmented triad of development progress and growth need to be revived in the current 20th century. With increase expansion of risks and inequalities between countries and region between regions and countries and tremendous metamorphosis of a considerable amount of the global ecosystem, this phenomenon comes as a confrontation to the gradually losing ground. Bioregionalism constitutes the intensification of reconnecting societies within a bioregion and puts fourth strong principles by placing people at its core value of sustainable community planning with environment concerns. This knowledge of theory and practice would challenge the way cities are perceived with more focus shift towards sustainable systems development.

METHODOLOGY

The goal of this paper is to thoroughly examine Bioregionalism through Architectural Research Methods (Groat 1982) by using Qualitative Research and Case study methodology the application of the thought in Auroville, Pondicherry and its successful practical sustainability. In this two phase method of inquiry, the first phase of the study talks about Bioregionalism, its definition and Characteristic advantages and highlights the six main areas of concerns that need to be addressed. The Second Part of it, addresses the case study in consideration of Auroville as a Sustainable Township model to explain Bioregionalism traits and provide strategies and measures to cities of today and tomorrow and justify why cities must work as an ecosystem as opposed to the consumerist accession.

DEFINITION

In the context of sustainable development, a bioregion is an area which can be defined an area whose natural conditions influence the configuration of human occupancy that goes beyond political and social boundaries. Bioregionalistic planning engages in employment of specific techniques and methods to restore enhance and maintain ecology and natural biodiversity of the local environment. When ecosystem and human communities extend beyond political limits, there is apt and adequate consideration for spatial scale, governance by its stakeholder's participation and socio-economic development which results in balance of sustainable systems. Through passing down of lessons gained from indigenous practices, there is integrated holistic development at all scales.

6 MAIN AREAS OF CONCENTRATION

A detail bioregionalistic mapping was done in the context and classified into 6 categories as suggested in the literatures that serve as the standardized area of concerns that need to be addressed for a holistic systematic development. This involves participation from all spheres of stakeholders such as workers, grassroots communities, policy makers, academia, non-profiteers, business and practitioners etc., using their inputs a plan of development model was assessed, and that is different from the traditional economic development process. By doing so Bioregionalism integrates local economies with the ecology on contrary to traditional systems of development which sucks in the process all reserves and resource from the local area and ends up dumping and creating landfill and no regard to wise supply of resources.

1. Shelter
2. Water
3. Food
4. Energy
5. Infrastructure
6. Environmental Conservation/Rehabilitation



Figure 1. Areas of Concentration; Source: Author

IMPORTANCE IN THE CURRENT ERA OF CLIMATE CHANGE AND URBANIZATION

Globalization is a reality where capitalism is the trend ruling. For instance any factory produced product could be broken down to its constituting parts each manufactured and assembled from various sources that could lead to unsustainable and in turn cause harm to the environment, affect the local economy and subsistence of indigenous people. Urbanization has resulted in detrimental effects of human health and productivity as well. To counter balance this adversity, it is not too late to practice this approach on all scales.

PROFILE OF AUROVILLE

Location and Regional Setting

The universal township of Auroville is along the east coast of India 6kms north from Pondicherry. The circular form of this township has a radius of 2.5km radius embracing 20sq.kms area. The ideal township started around early 1930's by 'The Mother'

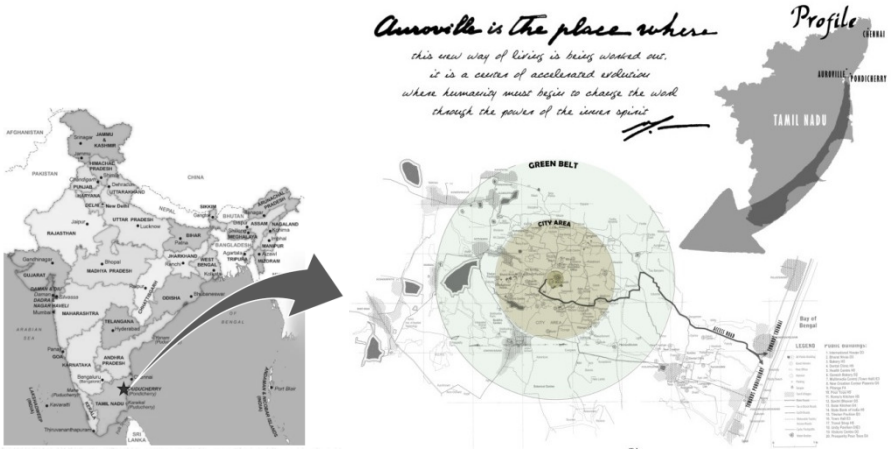


Figure 2. Location Map of Auroville; Source: auroville.org

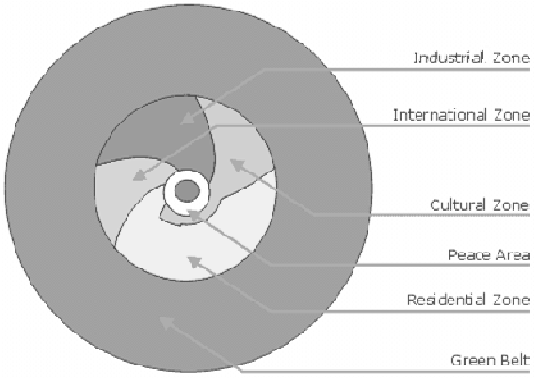


Figure 3. Designated Zones; Source: auroville.org

Climate and Physical Characteristics

Auroville experiences tropical dry climate with seasonal heavy rainfall. The township elevated at a height of 50m above sea level slopes down from centre to periphery. Soil erosion is prevalent due to uncontrollable surface run off.

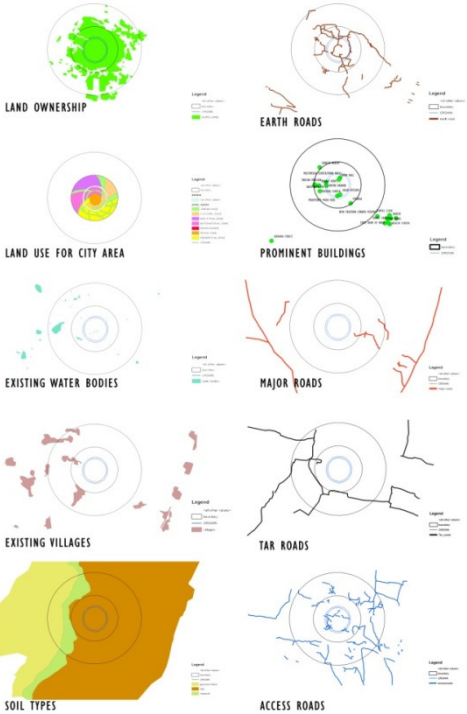


Figure 4. Bioregion Mapping; Source: Author

Existing Land use

Barren land of Auroville has been properly planned and developed productively by the efforts of its residents. Twelve percent of the entire township is used for urban habitat development and the remaining area 88% of land is utilized for agriculture and plantation purposes. The residents collaborated with the nearby villages and later by the government developed check dams (watershed management) and also replanted trees to prevent soil erosion and regenerate the barren land (Waste Land Regeneration). The entire township is zoned into 5 major zones of residential, international, industrial, cultural and green belt.

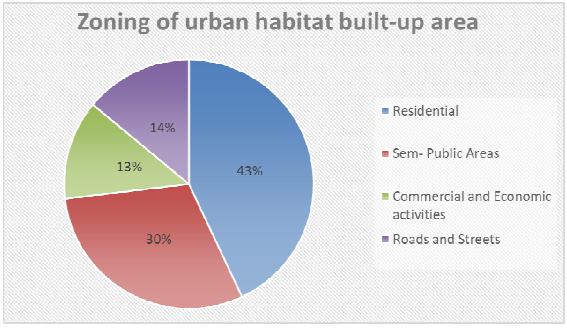


Figure 5. Auroville zones percentage chart; Source: Author

Governance

The governing body of Auroville is a separate legal entity comprising of three authorities -



Figure 6. Governance in Auroville Flowchart; Source: Author

Economy of Auroville

Economic Aims

1. Create cashless economy for ease of use
2. Within Auroville and between Aurovillians to eliminate exchange of money
3. To ensure contribution is in the form of money, work or service
4. Sustain and establish a self-sustaining city with 50,000 people
5. To ensure one of the major and most elementary entity is to provide for everyone's basic needs and not prioritize according to notions of equality and right.

6 MAIN AREAS OF CONCENTRATION BASED ON BIOREGIONALISM

1. SHELTER

Space

Land and property remains a collective asset in Auroville. No person owns a house or land in it. Spaces hence play an important role for bringing people together. They are the platform for Community development and Culture formation. Hence accessibility of such spaces is very important. Hence we looked into the 'space' aspect through places where communities interact. These are the places where they progress as communities and invite cross-culture interaction.





Figure 7. Luminosity; Source: Author; **Figure 8.** Luminosity; Source: Author

COMMUNITY

What is Community in Auroville? Auroville in itself is a community. It itself is a symbol of a 'unified' community guarded which was given by charter of Sri Aurobindo and Mother's philosophy. Apart from this, Auroville has innumerable communities based on nationalities, gender, residential area, age, working connections, etc. Each person comes under multiple community circles which all lead towards the 'Auroville' as a common community. Communities are a group of people having particular interests, characteristics or philosophy. We have attempted to understand Auroville communities based on the places where they live, where they work and common spaces where they meet for leisure related activities.

Residential Communities

These are the communities which are formed by the virtue of people living collectively in a 'community'. There are innumerable residential communities in Auroville. Following is the list of such communities

Table1. Residential Communities found in Auroville

Sl.No	Residential Zone	Cultural Zone	Industrial Zone
1.	Arati	Gaia	Dana
2.	Arka	Kalabhumi	Horizon
3.	Aurodam	Samarpan	Kottakarai Farm
4.	Line of Forcce	Shakti	Kottakarai Orchard Pony
5.	Bliss	Silence	Farm
6.	Madhuca	Sincerity	Existance
7.	Centrefield	Transformation	Felicity
8.	Prarthna	Success	Fraternity
9.	Creativity	Utility	Gokulam
10.	Courage	Simplicity	Grattitude
11.	Grace	Solitude	Hakyon
12.	Innovation	Yantra	Herimitage
13.	Prayarthna	ShakiLoka	Hope
14.	Samasti	SidhartahaFarma	La Ferme
15.	Shailam		Light
16.	Sukhavati		Meadow
17.	Reve		New Creation
18.	Vikas		Promesse
19.	Victory		Protection
20	Youth Camp		

There are psychological references to the naming of these settlement practiced in the township. In the early sixties and seventies the mother gave the names to these settlements. Later on a person, who wishes to live in a land or a new plot, finds his inspiration in the township cultivates the sense of place and names it according to

his choice which continues till present as a practice. The above list is an exhaustive one and is updated constantly with the upcoming of new settlements. These communities are formed based on the income, nationalities, interests, etc. We visited few of these communities and discussed with the residents their perception about 'Community'. We visited Citadine, Aspirations, Courage, Maitree, and Luminmosity to name a few. Here is a brief understanding of the few communities which we visited:

Luminosity: It has 12 Studio apartments with Offices on the ground floor. It has a common terrace with washing space for all. It is a sustainability focussed housing looked through climate responsive design. High income groups are the target group for the housing. We see lack of social interaction among the residents and a high sense of privacy among them.

Creativity: *There* are 24 Houses with 5 converted into Guest houses. They share a Community kitchen as well as dining space. They also have common Courtyard Spaces and activities are organised for children in these spaces. But mostly these spaces are not used. We noticed lack of initiative towards community interaction.

BUILDING MATERIALS

The Auroville Earth Institute founded by HUDCO Government of India is a building science centre founded in 1989. This centre is responsible for the majority of experimentation, testing, cost effective methods and passive design material innovations. Its mission in Auroville is:-

1. Revival of traditional skills borrowed from vernacular, indigenous and ancestral traditions of raw-earth
2. construction
3. Reducing need for manmade materials substituting it with modern technologies of stabilized earth
4. To empower and thus enable to make and build their own dwellings
5. Develope cost effective techniques to construction making it affordable to all
6. Respecting mother earth and acknowledging the fact that resources are limited hence their wise usage
7. To demonstrate that building material which is earth can be used to create eco-friendly, modern, progressive and safe habitats.

Various building materials and Techniques

Unique sustainable building materials and techniques are always used in Auroville, such as – fire bricks, ferro-cement, terracotta, bamboo, rammed earth, and compressed stabilized earth blocks.



Figure 9. Construction Techniques; Source: Auroville Charter; **Figure 10.** Earth Construction projects; Source: Author;



Figure 11. Construction Techniques and materials; Source: Auroville Charter;

2. FOOD

The distinct quality of Auroville is the complimentary symbiotic development based on mutual benefit of both urban and rural areas. This is realised by the appropriate amalgamation urban amenities with surrounding green belt. The green belt can be further utilized for food production, forestry, water and soil conservation, and overall sustainable development of both village and urban areas. A wide variety of cropping pattern is yielded ranging from indigenous traditional trees to medicinal orchard along with farming of paddy.

The main services the farm provide for at Auroville

A wide variety of cropping pattern is yielded ranging from indigenous traditional trees to medicinal orchard along with farming of paddy. Vegetation and farming are developed through organic eco – friendly techniques. A collective economy of serving and receiving is practiced to uphold the spirit of community. Facilities to experiment and learn new techniques for growing healthy produce are always researched.

3. ENERGY

Sustainable energy approaches such are usage of solar and wind energies form community to individual level is developed through creating energy awareness, conservation and efficiency programs.



Figure 12. Standalone Solar PV Cells; Source: Auroville Charter; **Figure 13.** Integrated residential slope rooftop Solar PV Cells; Source: Author;

Current Scenario

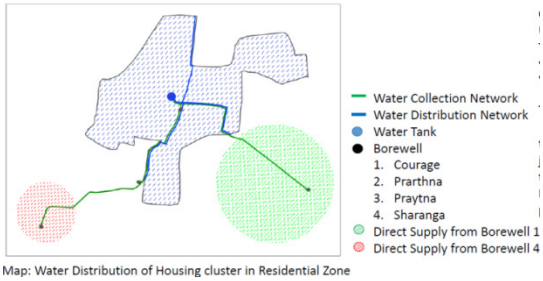
Considering community level, solar kitchen is provided which converts solar energy to produce steam to assist for the requirements of community cooking. More than 200 residential accommodations are run by solar (photo voltaic cells) and wind power. The large solar energy grid (solar power plant) converts the solar energy into electrical energy and directly supplied to the consuming loads. The excess and deficit in the energy consumption is managed accordingly. Currently, 30 wind mills located at varying heights at various locations, wind pumps are also sophisticated for the ease of pumping water. Two wind generators within the township is capable of generating 4 kWh of power under optimum conditions. The biogas generator generates energy required for the needs of nearby villages. Such efficient usage of solar, wind energy paved path to the establishment of 'Centre for Scientific Research' (CSI)



Figure 14. Solarbowl-cooker in Community Kitchen PV Cells and Windmill; Source: Author;

4. INFRASTRUCTURE

Further initiatives regarding road connectivity, encouraging traveling within the township through mode of cycle and walk. Promoting the idea of cycling through creating tourist trails. The Segregating the vehicular parking by accommodating large storage yards along the outer ring road. The approximate water requirement of Auroville is around 1,70,000 liters per day. Ground water is the main source water for aurovillians, the effective storm water management and presence of check dams assist in the regulation of water supply needs and also prevents rain water runoff. These techniques aids in replenishing the ground water reserves (through water percolation) as well as preventing soil erosion. More than 50 decentralised waste water treatment plants are developed all along Auroville.



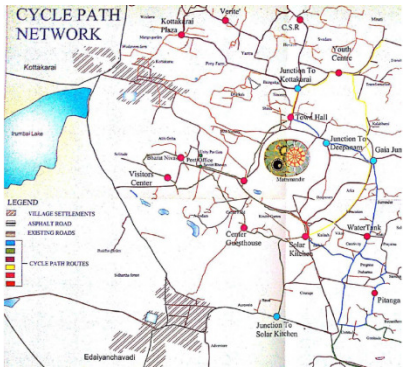




Figure 15. Water Distribution Map, Source: Auroville Charter
Figure 16. Cycle Path Map, Source: Auroville.org
Figure 17. Cycle rider, Source: Auroville Author

5. ENVIRONMENTAL CONSERVATION/REHABILITATION

Unremitting research always happens at this sustainable township allied to the development of innovative technologies suitable for better infrastructure. Active experimentation of numerous water conservation and recycling techniques are developed and practiced along with solid waste management. All of these simple day to day practices create a bigger and better impact on the environment in the long run.

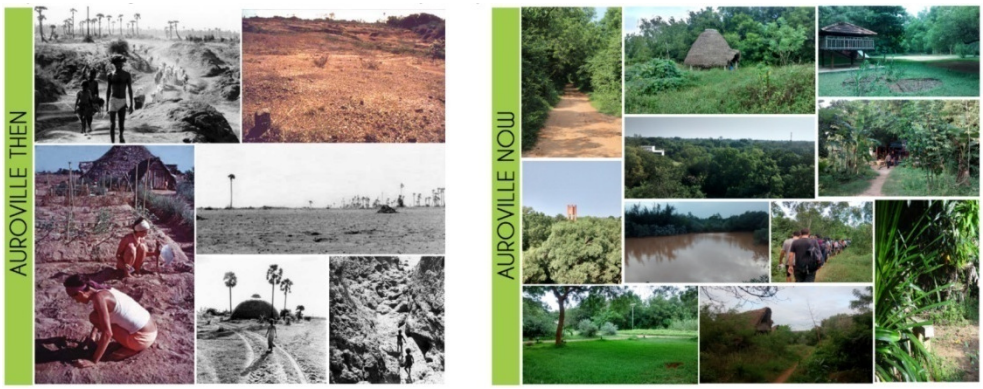


Figure 18. Evolution images of barren land to reclaimed lush biodiversity, Source: Auroville.org

Garbage separation at source based on the bio-degradable quality to recover wet waste which is furthered processed as fertilizers for the gardens. Eco-sanitation refers to the technique of separating the excreta and processing it to be utilized for the purpose of manure production. Replacing the use of plastic bags with adaptable alternatives such as paper and cloth. Reuse of unwanted items such as old papers etc. to be donated to organization run by women. This aids in promoting women empowerment as those unwanted items are created into crafts and jewellery, to be sold at profit. Abiding by the schedules of the community service provision to save energy. Composting methods used –

Vermicomposting techniques include, Bokashi – powered releasing microorganisms, which further breakdown the waste and create manure and fertilizer liquid, Khambha – Composting done in portable earthen pot,

Windrow – layers of organic waste aerated and left to nature to carry its order,Woven mesh of metal basket in which waste is dumped for decomposition and a Composting pit.



Figure 19. Environmental Rehabilitation Techniques, Source: Author

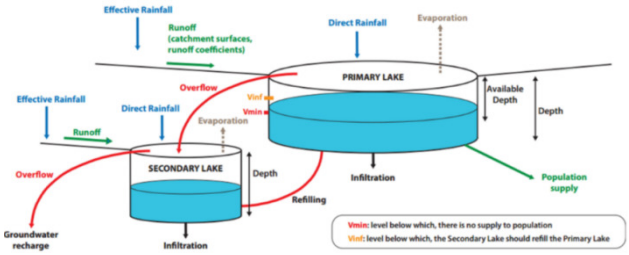


Figure 20. Water Distribution System, Source: Auroville.org



Figure 21. Bioswale, Source: Author; **Figure 22.** Zero waste water drainage system, Source: Auroville.org





Figure 23. Waste Segregation Techniques; Source: Author

Auroville practices rainwater harvesting, water conservation, water recycling. Abating the usage of fossil fuels for energy production by switching to solar and wind energies. Proficient solid waste management techniques. Promoting afforestation by replanting and developing the green belt. Such initiatives stipulates hope for constant innovation with the support of research and development through effective management. On the whole the entire air quality of the region is maintained healthy. Development of city parks and green corridors promotes space for recreation and also assists social and environmental wellbeing in association with nature.

LEARNINGS FROM CASE STUDY

As awareness gained from the context, we must look at all systems as comprised of set of diverse, natural and integrated sub-systems run by ecological principles and laws. The sustainable paradigm recognizes s humans on species who work in cooperation with laws in coherence that lead to a sustainable future. These principals and laws form the spine of all long-term economic, agricultural, technological, political and human development with constant feedback loop in place. It falls under a unique biogeography area that shares economic, historic, cultural characteristics distinguished by interconnected and independent ecological resources which results in a positivist economical and overall development of the township. Sustainable bioregional planning observed here, acts as an alternative model and a tool that embraces ecological and biodiversity processes as essential planning principles. Hence on the outset Auroville is a fine example of bioregional planning that attempts to:

1. Promote development in appropriate areas economically
2. Counteracts and addresses environment pollution that rises due to consumption locally
3. Develop a sense of community and place
4. To foster sustainable materials and construction technology usage
5. Acquire alternate resources and storage for off grid usage and less dependency on environment
6. Restoration of carrying capacity of ecology and revival of damaged ecosystems
7. Participation, role to play by representative of all groups
8. Cashless economic model

CONCLUSION

Looking from a visionary point of view for the future, with the advent of globalization set to increase as much as the awareness of people, there would be a lookout for alternatives. Bioregionalism would help in fostering the consciousness of a place and looking at ecology from a global archeology point of view. Such innovative concepts must gain acceptance in practical application through implementation with the local planning authorities. Bioregionalism could lead to a bigger global movement, where practitioners would help to construct new institutions and precincts and create newer ways to live in harmony amongst nature.

Thereby these following strategies and measures help us build the reality construct between local and global to minimize the damage to the ecology as much as possible:

1. Encourage cultivation of native plants of the bioregion
2. To ensure ecological and political boundaries match
3. To highlight the unique nature of ecology in the bioregion
4. To encourage consumption of locally produced foods
5. Appropriate use of locally available materials where possible
6. To live in harmony with the bioregion through sustainability
7. To create a bioregional map of the region with its intrinsic qualities that acts as a powerful tool in understanding the story and help in implementing policy development.

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REVITALIZATION OF THE URBS THROUGH URBAN FARMING - AN IDEATION OF TRANSFORMATION IN THE CONTEXT OF CHENNAI CITY

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Abstract: Food is an important factor for a healthy living. Cities are overcrowded because of lack of jobs in rural and suburbs. Due to high population density, people experience traffic congestion and long commuting hours contributing to air pollution. The urban lifestyle has become fast-paced resulting in less interaction with fellow humans and nature. It has become very unhealthy and unnatural. Currently, food seems more like a compulsion and culture rather than a necessity for healthy living. Urban dwellers consume food with ingredients that has longer food miles which in turn leads to many problems like pollution, fuel consumption, traffic, etc. Producing food at the place where they live, eliminates the above mentioned problems due to shorter food miles. The necessary space for farming within urban limit needs to be answered in order to get sufficient food. Literature reviews were done under the topics of food system, urban farming, and farming typologies, plants that can be grown here at Chennai and about the population and food requirements of Chennai. Literature case study of urban farming practices in abroad and in India was studied. Urban pockets and under-utilized spaces were identified for urban farming and two sectors from Chennai were selected for the study. The first is a residential area and the second one is a traditional settlement which is a commercial sector, was analyzed to understand its potential and implement urban farming. Resulting production areas were found and the capacities of self-sufficiency of those particular sectors were analyzed. The first case produced surplus food whereas the second case could not meet the demand and hence required technically advanced farming practices to satisfy the food demand. Producing food at the same place where we live brings in many environmental benefits like green space, cool buildings, biodiversity, etc and social benefits like food security, employment, health and wellbeing and economic benefits.

Keywords: Urban regeneration, food, farming, health, wellbeing

INTRODUCTION

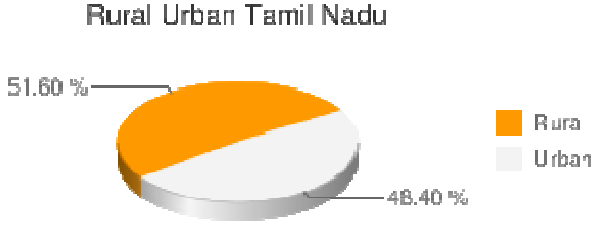
Chennai geographically positioned to the eastern India on the coastal regions of Bay of Bengal stands as the capital of Tamil Nadu. It is an outset city with vast development in culture, economic and education. According to 2011 census, there is an absolute increase in population in urban areas (refer Table 1) than in rural areas which is first ever in any census taken after India's independence. The growth of rural population is steadily declining since 1991 and the steady increase in urban population is mainly due to migration, natural increase and the new areas included under urban areas.

Table 1: Urban Rural distribution (Census,2011)

	2001 (In Crores)	2011 (In Crores)	% in 2011
India	102.9	121.0	
Urban	74.3	83.3	68.84 %
Rural	28.6	37.7	31.16 %

There is an increase of 91 million in urban areas (Census 2011). The state Tamil Nadu ranks third with 34 million people living in urban areas contributing to 48.4%, of which Chennai holds 13.39% of the states urban population.

Figure 1. Urban Rural % in Tamil Nadu (Census,2011)



Central pollution control board as on January 28, 2018, Chennai falls under moderately polluted cities with air quality index of 154 due to increased industrial areas and vehicular traffic.

FOOD SENSITIVE APPROACH TO URBAN PLANNING

Food is a very basic need for humans to function. Food needs to be healthy and nutritious enough for humans. It needs to be adequate and accessible by diverse sectors of people irrespective of economic condition, safe and free from inorganic chemicals, culturally appropriate and local and needs to be tasty.

"If clean drinking water and public sanitation were the main obstacles to social progress in the 19th century city, a healthy diet and access to fresh food for all promises to be one of the hottest issues for the 21st century" (Castles H)

"It is time for the architectural and urban design planning professions to support and enhance the city's multiple functions as dining room, market and farm" (Karen Frank)

The growing trend in urban planning is Food sensitive planning. It is a planning approach which addresses the various stages of food system, to create places to meet the urban food need. Food system is nothing but the cycle followed between the production and consumption. This approach not only helps to develop a sustainable food system but also to improve the livability of the city.

URBAN FARMING

It's a new outlook on the process of growing food in the urban farm which contributes to the revenue generation. This in turn reutilizes the leftover pocket spaces in the surrounding subjected to environmental viability. This sustainable approach towards the production involves new challenges and opportunities between the farmer and the local government.

URBAN FARMING: HISTORY

1710 French ribbon farms: Ribbon farms also called as strip farms, these are linear long food production along the water ways or the roadways

1890 Potato Patches: Pingree (Mayor) introduced "*potato patch* plan," This system allowed poor to use vacant plots for growing food.

1917-19 Victory gardens: Victory gardens orwar gardens, it was created for defense purpose where public parks and private residences were cultivated with herbs, vegetables and fruits in US, Germany, Australia, Canada and UK during World War I

1930 Thrift Gardens: The subsistence gardens in American cities during the1930s were created in response to an economic crisis and intended to help meet residents' immediate need for food.

1940 Liberty gardens: Liberty gardens, also called war gardens

URBAN FARMING: TYPES

Kitchen Garden: Small scale food production in building setbacks and pockets inside a small/large plot Eg. Residential garden, Institutional garden, Demonstration garden.

Allotment Farming: Plot based food producing Eg. Community gardens, Victory gardens

Edible Landscape : Food production as part of landscape designEg. Edible park, Edible schoolyard, Edible Streetscape, Edible residential landscape

Small- Scale Farm : Food production landscape, occasionally integrated with alternative programs, enclosed and unenclosed. Eg. Market farm, communally - managed urban farms, demonstration/educational farm.

Large - Scale farm : Food producing landscape of large scale. Eg. Market farms, Communal farm, Demonstration/Educational farm.

URBAN FARMING TECHNIQUES

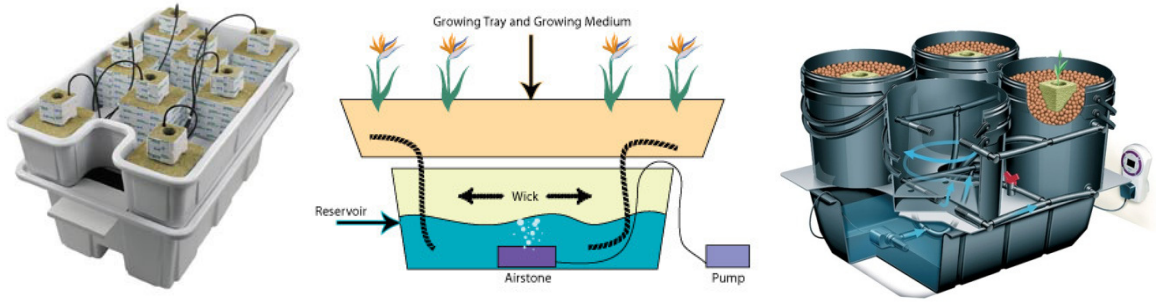
Square Foot Gardening: It is the method discovered by Mel Bartholomew in 1970s for greater harvest in lesser space. It is a farming technique, where plants are arranged with more number of 1 foot by 1 foot blocks put together. Different vegetables are planted in each block, the number of plants on each block depends on the growth structure of each vegetable. The intensity of growth depends upon the soil quality and the use of compost.

Hydroponics: Is a technique of growing plants in nutrient dissolved water solution without the presence of soil. The plants grow faster and bigger since its necessary nutrients are directly fed. There six types in hydroponics such as deep water, nutrient film technique, aerophonics, EBB and flow, Wicking and drip system.

Fig. 2: Deep water,Nutrient film,Aerophonics (www.fullbloomhydroponics.net)



Fig. 3:EBB&Flow,Wicking, Drip system (www.fullbloomhydroponics.net)



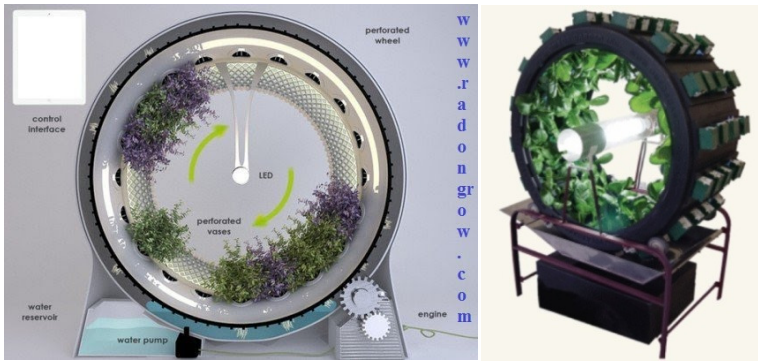
Urban Cultivators: is a kitchen garden system which automatically grows greens, herbs and vegetables indoor.

Fig. 4: Urban cultivators (www.urbancultivator.net)



Rotary Garden : Is designed to hold 3" x 3" root medium and can accommodate upto 80 plants. It is chain driven and rotates 24 hours a day. It manages the light, water and temperature by itself and can send water level details to a smart phone.

Fig. 5:Rotary garden (www.gadgetreview.com, radongrow.com)



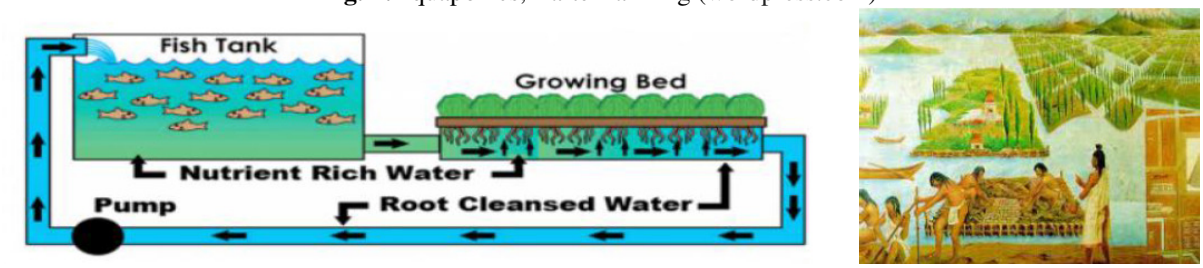
Vertical Farming: Growing plants in a vertical direction generally uses hydrophonics method. It is usually incorporated in urban areas, sometimes as high as a skyscraper, may or may not include livestock.

Fig. 6: Vertical farming (inhabitat.com)



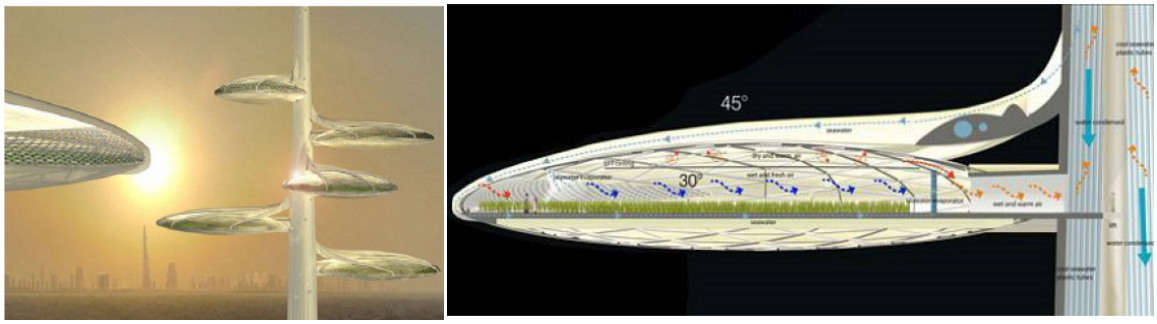
Aquaponics :It is similar to hydroponics with water as the growth medium. It also comes under aquaculture, where the nutrients needed by the plant is provided by the wastes produced by the fishes and the clean water needed for the fishes are provided by the plants.

Fig. 7: Aquaponics, Rafter farming (wordpress.com)



Seawater Farming: 'Seawater Vertical Farm' is a structure which could be built on the sea. It utilizes sunlight to distill the seawater and provide fresh water to plants which are grown in the same tower. The entire process works in a passive way all around the year to produce food.

Fig. 8:Seawater farming (www.inhabitat.com)



CHENNAI - SUPPLY

Chennai's Koyambedu Market Complex which extends over 295 acres with more than 3100 shops takes care of the city's perishable goods supply. The market receives about 100,000 visitors and 14,032 vehicles including trucks of 2350 no.s, two wheelers, four wheelers, etc,.The total weight of perishable goods received per day accounts around 23000 tonnes and a wastage of 200 tonnes per day is being produced due to inadequacy of cold storage facilities. (Koyambedu Market Committee)

CHENNAI: IDENTIFICATION OF POCKETS FOR FARMING

Identifying a large piece of land for farming in a urbanized city is not possible instead pockets are identified and using urban farming technologies greens, vegetables and fruits (limited) can be grown inside the city limit.

Table. 2:Urban pockets and Farming techniques (grace,2018)

POCKETS	FARMING
Roof tops with flat roofs	Container farming, Square foot gardening, Aquaponics
Balcony spaces in all building typologies	Container farming
Setback spaces in all building typologies (excluding parking and service lines)	Container farming
Public parks	Edible Landscape, Conventional farming
Vacant pockets inside campuses (Institutional & Educational)	Edible Landscape/community garden, Conventional farming
Unbuilt Spaces/Vacant lots	Container farming
Railway lines set backs	Edible Landscape, Conventional farming
Canal	Aquaponics
Sea	Seawater farming, Hydroponics
Less used streets with wider lanes	Linear farming
Building facades	Hydroponics
Religious premises/ government / private premises	Edible Landscape/community garden, Conventional farming

VEGETABLE NEED PER PERSON PER DAY

A healthy individual needs 300 grams of vegetables every day. It means Chennai needs 8.2million * 300 grams of vegetable supply every day I.e 2,46,000 tonnes of vegetables.

URBAN FARMING - 100 SQ. FT PROTOTYPE

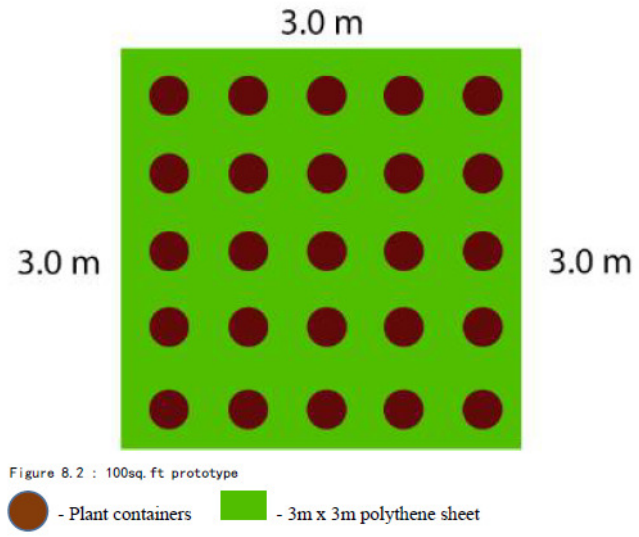


Figure 8.2 : 100sq. ft prototype

Plant containers are arranged in a 5 x 5 grid with a interval of 30cm (Dimension of the container is 28cm x 28cm x 28cm).

Technically any vegetable can be grown in a container provided the grow bag is large enough to accommodate the roots. Leafy greens, brinjals, tomatoes, chillies, bush beans, cluster beans, onions, radishes and bhendies are generally well suited for container culture and Tamilnadu culture.

CASE STUDY 1: BESANT NAGAR

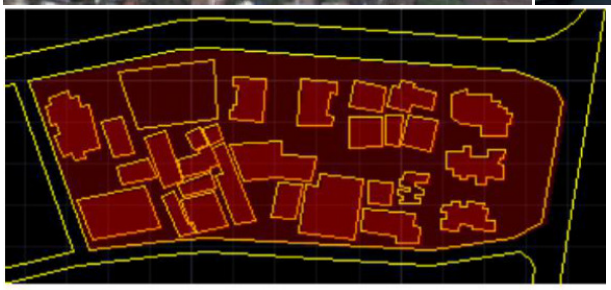
Originally designed as Residential zone. Later there were more number of apartment came up and it is slowly getting converted as office and commercial spaces because of its easy accessibility to road and sea.

Fig. 9: Study area (Google map)



Fig. 10: Study area - photographs





Total Sector Area - 5074m2

Open Vs built up area



Land Use

Pockets Identified for Urban Farming & Typologies

- Residence (15families) - rooftop & set backs - 525m2 + 135m2
- Apartment (240families) - rooftop & Balcony - 1800m2 + 120m2
- Commercial (55 persons) - rooftop - 345m2
- Park - Edible Landscape - 263m2
- Temple - community garden - 63m2

  100 sq.ft is needed for 4 persons - Total number of families - 255 + 14(workers) approx.
- Total area for urban farming -- 3251m2 - 34,993 sq ft. - 349 families can be served with vegetables SELF SUFFICIENT for residents and for workers (commercial)
  Food for 80 FAMILIES could be sold out

CASE STUDY 2: RATTAN BAZAAR, PARRY'S CORNER

It is a highly congested commercial area with no/less open spaces.

Fig. 11: Study area (Google map)



Fig. 12: Study area - photographs



The only pocket which could be put to use for urban farming is the roof top of the shops accounting a total production area of around 83m2

* 100 sq.ft is needed for 4 persons - Total number of families -120 approx.

Total area for urban farming -- 83m2 - 93 FAMILIES CAN BE SERVED WITH VEGETABLES

27 families i.e 108 persons cannot be served by the rooftop farming

In this case this community needs to adapt a advanced farming technique say vertical farming (Hydroponics / Aquaponics)

REVITALIZTION THROUGH URBAN FARMING

Chennai city being the third most urbanized city in India, has cons like air pollution, Noise pollution, Vehicular traffic, less social interactions, higher temperature, unemployment, etc.

Urban farming leads to simpler food miles which in turn reduces vehicular traffic. Food mile is the total distance travelled by the food to reach the plate.Nitrogen dioxide and microscopic particulate matter(PM) present in air are very harmful and they contributes to air pollution. One of the study concluded that the proper placement of plants in urban areas can reduce the concentration of NO2 and PM by 40 and 60 percentage respectively(Environmental Science & Technology).

Noise pollution is reduced with the use of more number of plants . Plants which are used in the perimeter is much more effective in reducing the noise pollution than the plants kept in the center. Plants has the tendency to absorb, reflect and refract sound waves resulting in lesser noise and echo.

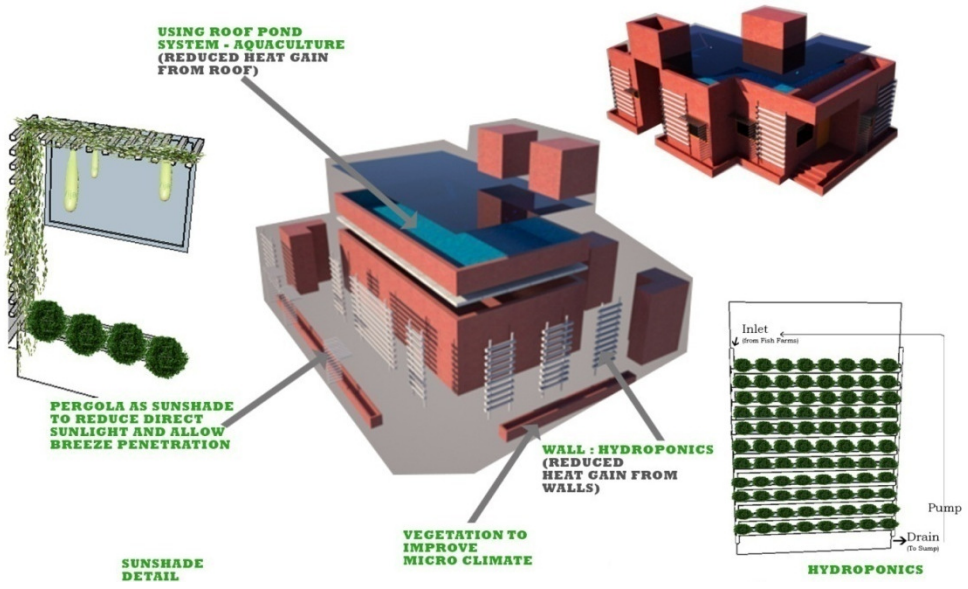
Urban farming also addresses the heat gain and regulates the temperature inside and outside of the building. It is a productive passive sustainable technology to reduce the heat gain by the building.

The once terrace and the vacant plot has not only improved the micro climate of the place but also has become a place for people gathering and social interactions to happen making the city more live, healthy and happy.

URBAN FARMING AND ENERGY EFFICIENCY

Using the combination of aquaponics and container gardening in a building to reduce the indoor temperature of a building which in turn reduces the energy consumption.

Fig. 13: Urban Farming in a individual structure - reduction in heat gain



BENEFITS OF URBAN FARMING

Urban farming has the potential to bring productive uses back to urban lands while creating jobs, social capital and green spaces (UNDP 1996). The city being the production yard, the food need is satisfied with local and quality food and at the same time aesthetically improving the neighborhood, improving the air quality and also creating opportunities and awareness among the people.

Environmental Benefits

The practice of urban farming results in relatively cooler buildings,decreased runoff, enhances biodiversity, improves air quality, lessens air andnoise pollution due to fewer food miles, makes the more greener,etc.

Social Benefits

Urban farming encourages place making, aesthetics, provides employmentopportunities for farmers and others who got migrated to urban limits for job,ensures food security, makes the place as social capital, encourages communityliving and ensures healthy and nutritious food for urban people.

Fig. 14: Urban Farming - Social and Environmental Benefits



CONCLUSION

Urban dwellers are indirectly being away from fresh and healthy food than rural dwellers. The rural farmers tends to sell away their agricultural land due to lack of labor, money, etc,.and started migrating towards urban areas for jobs. Combining the above two situations, Farmers who needs job opportunity can be give agricultural jobs to provide the urban dwellers with sufficient fresh food.

The present day techniques for urban farming allow a family to fulfill its vegetable need by just 100sq.ft piece of pocket. This pocket can be very easily identified in the dwelling unit itself like rooftop, setbacks,

balcony,etc. There are few other pockets like public parks, streets, railway set back lines, etc,.where community farming can be done.

Two study area was taken in Chennai, Besant nagar(5704m2), a residential layout where there were more open space and pockets could serve its locality with sufficient food and it can even serve around 80 families. The second case, Rattan Bazaar (1092m2), a commercial neighborhood where there were no or less open space and no proper pockets could be identified for farming except rooftops could only solve the food necessity by 70% and remaining families could be served by using some advanced urban farming techniques or by buying food from nearby neighborhood where the production is excess.

This work clearly states that Chennai locality can be food self sufficient (Vegetable) if everybody spends some time/money. Urban farming not only provides us with food but also environmental andsocial benefits. It also helps Chennai to generate revenue and to ensure food security.

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ENVELOPE DESIGN - OPTIMIZATION OFAN EDUCATIONAL BUILDING AND ITS IMPACT ON ENERGY PERFORMANCE IN A WARM HUMID CLIMATE

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Abstract: While the world's energy requirements are growing annually, India's energy requirement would be higher in the future as well. The buildings that are being constructed today consume a large amount of energy and other natural resources, leading to serious environmental problems. In developing country like India, it is necessary to increase the energy efficiency in buildings with a limited amount of energy reserves. These strategies need to be evolved and analyzed to reduce energy consumption and thus reducing India's role in environmental degradation. A building which has comfortable indoor environment and reduced co2 emissions will cause very little damage to the environment. A building envelope is the physical interface between the conditioned (inside) and unconditioned (outside) environment of a building. This contributes in heat transfer between the building and outside. Since the major concerning body is the educational buildings, a detail study has been carried out in an educational building in Department of Architecture, in NIT Tiruchirappalli campus. Since the study area experiences warm humid climate, the cooling loads required to make the indoors comfortable need to be reduced. This has a huge impact in reducing the energy consumption in the building. To achieve comfortable indoor environment with lesser cooling energy, different parameters of the building envelope which contributes to internal heat gain has to be studied. Studies by different researchers show that the Building materials and insulation, Window wall Ratio, Orientation and glazing materials contribute in heat gains of the building. This study helps us find out which combination of parameters is best performing in terms of heat gain and energy performance.

Keywords: Building envelope, Envelope parameters, Energy consumption, Warm humid climate, cooling demand, educational buildings.

INTRODUCTION

World energy utilization levels have officially raised worries over the extreme use of resources and consequent natural effects. The building energy use is commonly in charge of 20-40% of every nation's aggregate utilized energy. It is predicted that by 2050, the overall energy demand for building division can increase more than 50% from now (IEA,2013). The building sector is developing at a rapid scale in India. The nation predicts 40 billion m^2 of new development through 2050(Chaturvedi et al., 2014). Usage of building energy increases by 8% annually and it takes 33% total energy (Rawal et al., 2012). Due to the rapid increase in population and income, it is expected that this trend will continue and it became a big challenge for the Indian policy makers. Consequently, it is basic and critical to concentrate the examination on energy performance of the buildings. This may help in the execution of buildings in the future which can be used in initial stages of their planning with the incorporation of bye laws and development control regulations. As more than 50% India's floor area is yet to be built, it is necessary for us to follow energy efficiency strategies in the upcoming buildings.

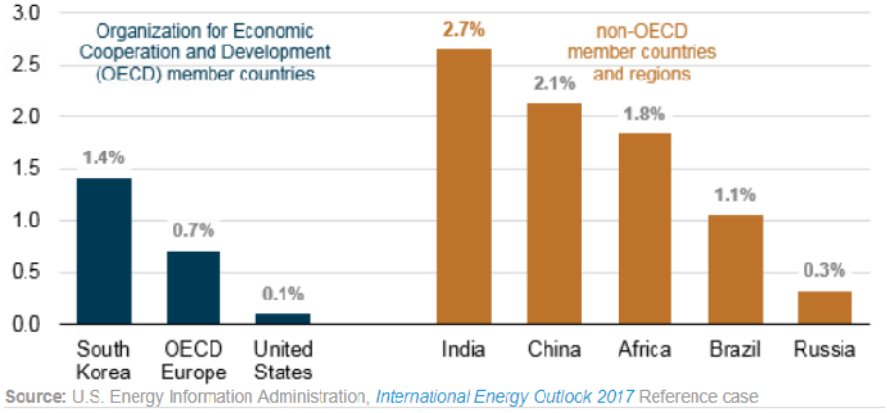


Fig.1 Average annual change in buildings energy consumption, 2015-2040

An energy efficient strategy needs to be evolved and analyzed to reduce energy consumption and thus reducing India's role in environmental degradation. A building which has comfortable indoor environment and reduced co2 emissions will cause very little damage to the environment. The reduction of energy utilization also reduces the electricity charges.

BUILDING ENVELOPE AND HEAT TRANSFER

A building envelope is the physical interface between the conditioned (inside) and unconditioned (outside) environment of a building. This moderates the weather conditions within indoor and outdoor environment. It plays a major role in maintaining comfortable indoor environment and energy performance for heating or cooling the space. Generally, the tropical climate experiences more hotter days where the energy required for cooling will be high. The amount of heat gained or loosed by the building occurs through the different elements of building envelope such as walls, floor, roof and fenestrations. Building envelope is the major source of heat transfer which occurs in walls and roof by conduction, through glazing by radiation and heat loads are gained through convection. Other heat loads inside the building could be fans, lights and other equipment. The building materials and insulation materials used for construction having less U value or thermal transmittance has a very important role in heat conduction. R-Value of a material varies depending on the mode of heat transfer. The higher the R-Value of a material the better its insulation.

WARM AND HUMID CLIMATE ZONE	
Thermal Requirements	Physical Manifestation
Reduce Heat Gain	
Decrease exposed surface area	Orientation and shape of building
Increase thermal resistance	Roof insulation and wall insulation
	Reflective surface of roof
Increase buffer spaces	Balconies and verandas
Increase shading	Walls, glass surfaces protected by overhangs, fins and trees
Increase surface reflectivity	Pale color, glazed china mosaic tiles, etc.
Reduce solar heat gain	Use glazing with lower SHGC and provide shading for windows. Minimize glazing in East and West

Fig:2. ECBC User guide, Envelope characteristics of warm and humid climate zone

LITERATURE REVIEW

ENVELOPE AND ENERGY USE

Noura et al, (2017) studied different parameters of building envelope and their impact to the thermal performance of tall buildings in Jeddah. He found that Conductive heat gainwhich occurs due to high solar radiation can be eliminated by insulating the walls and a reduction in 77% of cooling loads could be achieved. K. J. Chua and S. K. Chou (2010) found that the Envelope Thermal Transfer Value is correlated to the annual energy required for cooling and reduction of ETTV from 50 to 45 W/m2 /yr can save upto 2.5% in cooling loads in Singapore buildings.

Dimoudi (2013) investigated 77 different school in northern part of Greece. He collected the heating and electricity energy data from all school buildings for a few years and found that adding insulation to the external walls can reduce energy consumption up to 13%. Al-Homoud (2004) studied the impact of building envelope thermal design and observed that efficient building envelope design especially thermal insulation can reduce the size of air-conditioning system which helps in lesser energy consumption in hot climates.

WALLS & ROOF

Al-Maimani,(2002) studied insulation and its effect on annual energy consumption in hot-dry climate of Madina, Saudi Arabia. Three villas with two floors had been selected for the study. Each of the villas are assigned one floor without insulation and the other with insulation materials. It was found that the annual energy usage has been reduced by 48-80%only by insulating the walls and roofs.

According to Amitava et al, materials with greater thermal mass in multi-layer walls and roofs can keep up the internal thermal comfort, in both extreme climates of buildings which are located in composite climates. In the case of warm climate, during hotter days the effects of external thermal stress could be possibly reduced.

FENESTRATIONS & GLAZING

The window-to-wall ratio and its effect were investigated by Nasrollahi et al (2013) in the warm and dry climatic region of Iran. It is observed that the best window ratio for heating, cooling and lighting is 80%, 10% and 40% respectively. The optimum WWR is 50% which can reduce electricity consumption and if shading devices are provided more energy can be saved. Juanjuan(2009) found out the outer window impacts in reduction ofbuilding energy use is greater than any other aspects. If low-E glass is used, annual energy demand can reduce up to 19.36% and if shading device is combined with it, then annual energy demand reduction can go up to 33.89%. A simulation study by Singh and Garg, 2009 was done onfive climatic zones in India. This involved a total of 10 different types of glass and noticed that the annual savings in energy performance by a window depends on both thermal conductivity as well as SHGC values. It also has a significant role in physical parameters such as orientation and climatic conditions and depends on the building parameters such as insulation level, floor area, etc.

It was found by Baglivo(2017) that in warm climates low-emissivity glass helps in reduction of heat loads during summers.This can improve the operative air temperature for about 20Cduring hot seasons and significantly 0.50C deduction in winter seasons. He suggests that to minimize the window surfaces for a warm climate is always good to maintain a comfortable range indoors.

SOFTWARE

The researches which were conducted based on the energy performance based on envelope parameters have used software for the simulations. The research conducted by the following researchers, Konstantina Leonidaki, Elli Kyriakia(2014), Tzempelikos and Athienitis (2007), Ingy El-Darwish , Mohamed Gomaa(2017) have been conducted and evaluated with the energy plus software. Other softwares like IES- VE have been used by Shaghayegh Mohammad and Andrew Shea (2013) in their research on building envelope study. E- QUEST is used in the research conducted by Chi-Ming Lai and Yao-Hong WanG (2011). Izael Da Silva and Edward Baleke SsekulimA (2011) used ECOTECT software in their study. Baglivo and Paolo Maria (2017) used TRANSYS is their study on Envelope Design Optimization.

METHODOLOGY

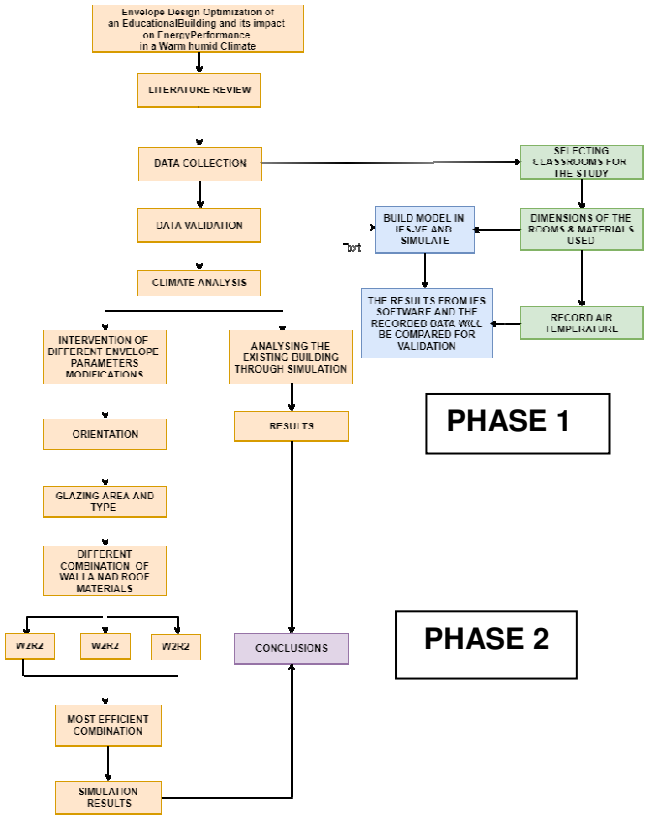


Fig:3: Detailed methodology of Phase 1 and Phase 2

Building description



Location	**Department of Architecture, National Institute of Technology, Tiruchirappalli.**
Geographic location	10°45'39.6"N, 78°48'35.9"E
Climate Region	Warm humid climate
Building Type(s)	Educational
Project Scope	Classroom Sample
Simulation Software	IES-VE
Date of study	20.11.2018
Weather	Partially sunny

Fig:4. Site plan of the building

The building chosen for the study is Department of architecture in NIT Tiruchirappalli campus. Two classrooms from the second floor located at two different directions has been studied to validate the data. The selected classroom is measured completely to find its dimensions, positioning and number of openings. The materials used for construction of walls, floor, roof and windows will be noted. The type of glazing and its properties will also be recorded. Air temperature inside each classroom is recorded with the use of hand-held meters.

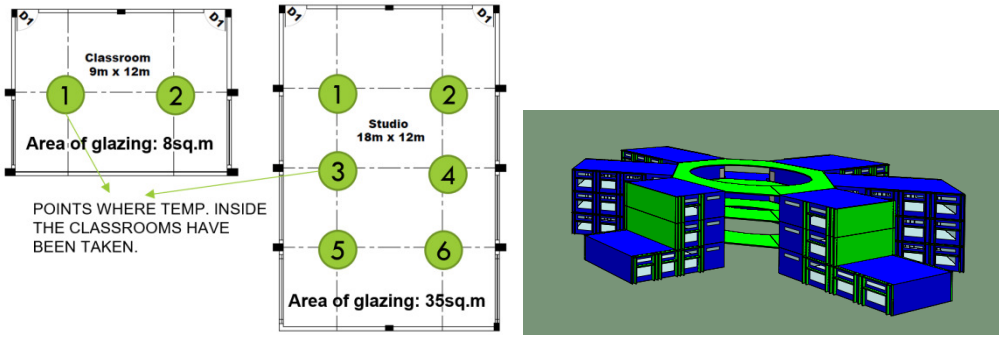
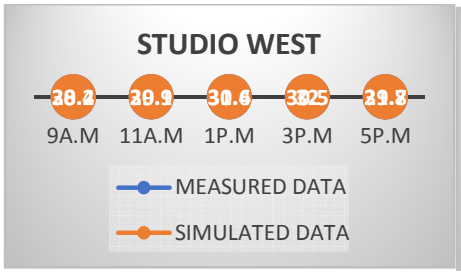


Fig:5. Plan of the rooms to be studied

The points in Fig.5 indicate the location of measurements taken inside the room. The average of these points inside each room is taken to find the average temperature at an interval of two hours from 9:00 AM to 5:00 PM. The readings were taken in a close environment. IES-VE software is used to model and simulate the classrooms. The data from the simulation of each rooms shows that north and east side classrooms have lesser temperature than the south and west side classrooms whereas the difference comes around 0.7 deg. C.



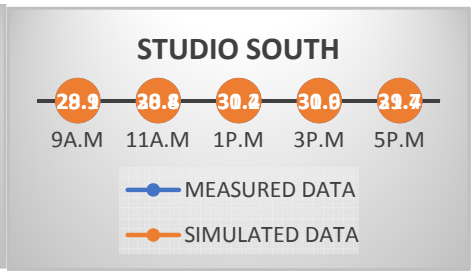


Fig.6. Air temperature South classroom Fig.7. Air temperature West classroom

The materials and their properties are assigned. The simulations are done for the particular day when the physical measurements have been taken. Then the hourly results generated by the simulations and the average air temperature of the classrooms which were recorded will be compared. The comparison results will be taken for the validation of the software. The points of recordered temperature and simulated temperature for the particular date have been plotted in a graph, Fig.6&7 where the curve of both measured data and simulated data are parallel. This condition is applied to both west and south classrooms. Thus, the data coincides with measured as well as simulated ones.

AIR TEMPERATURE

Climate consultant software is used to analyze the temperature data of Tiruchirappalli throughout the year.Monthly low air temperature can be observed in the months of December, January and February where the temperature drops below comfort level. Monthly high air temperature can be observed in the months of April and may where the temperature rises above comfort level. Considering the average monthly temperature, march to June is the hottest season, other months fall under the comfort zone. These are the months which require protection from sun to avoid heat gain (overheated period).

	Jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
Dry Bulb Temp Avg. Daily	25.204	27.002	30.192	31.852	32.47	31.122	30.369	30.239	29.334	28.015	26.3001	25.174
Dry Bulb Temp Avg. Daily Low	20.723	21.446	24.358	25.923	27.094	26.663	26.51	26.003	24.58	24.897	23.4567	21.613
Dry Bulb Temp Avg. Daily High	30.381	33.139	36.435	38.407	38.197	36.71	35.387	35.761	34.66	31.648	29.6167	29.242

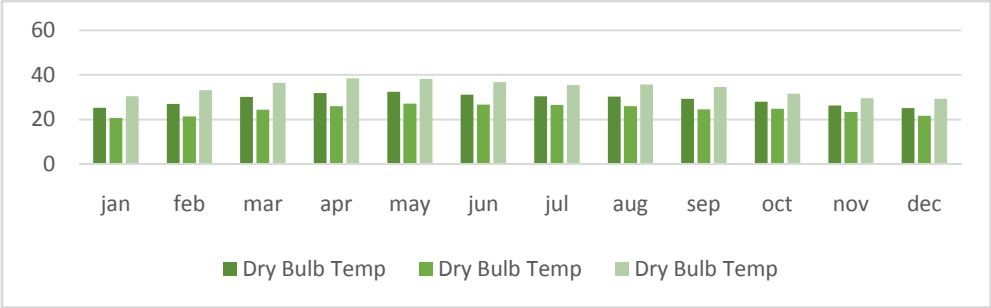


Fig:8 air temperature (12 months) data Tab:1 air temperature (12 months) data

According to Adaptive Comfort Model in ASHRAE Standard 55-2010, the comfort operative temperature is taken between 23.1°C-30.5°C. It must be noted that when seen along the lines of average daily temperature from Table 1, only April to June can be considered uncomfortable. However, when taking into consideration the average daily high, February to October is considered uncomfortable. The peak temperatures during the summer months are very high. December to February is considered uncomfortable because the average daily low temperature is below the operative temperature range

	HEATING REQUIRED (%)	COOLING REQUIRED (%)	COMFORTABLE PERIOD (%)
JAN	22.5	0	100
FEB	0	0	100
MAR	0	36.20	63.80
APR	0	82	28
MAY	0	95.50	4.50
JUN	0	71	29
JUL	0	40.20	59.80
AUG	0	45.16	54.84
SEP	0	25.45	74.65
OCT	0	0	100
NOV	0	0	100
DEC	0	0	100

Tab:2 heating and cooling requirement based on the daily temperature data

As per the results in tab.2. majority of the year needs cooling during daylight hours. The hottest day recorded was in April 30th with a temperature of 41.8°C and the building envelope which is to be designed will have the characteristics to manage the hottest temperature of the year.

SIMULATION FOR PILOT STUDY

A pilot study has been carried out to understand the impact and feasibility of the research.

ELEMENT	Set 1- base case specification	Set 2 – modified specification
Floor	100mm thick concrete slab on ground	100mm thick concrete slab on ground
Ceiling	150mm thick concrete floor, 25mm screed, 12mm ceramic tiles	150mm thick concrete floor, 25mm screed, 12mm ceramic tiles
Roof	10mm plaster, 150mm thick concrete, 30mm clay tiles	Roof with insulation
Wall-external	230mm solid brick with 10mm plaster on either side	Aerated concrete block
Wall-internal	Inner walls- 115mm solid brick wall with 10mm plaster either side	Inner walls- 115mm solid brick wall with 10mm plaster either side
Windows	Single pane glass with timber frame	Tinted glass
door	40mm thick solid core timber	40mm thick solid core timber

Table 3: material specifications for base case model and modified model

Two sets of simulation are done. The first set has two classrooms one oriented to the south and one to the west with materials assigned based on the existing condition. The second sets of simulation are done for the same classrooms but with materials which has lesser U values. The weather data of Tiruchirappalli is taken and simulations are done for hottest day 30th of the month of April. The readings are compared in a graph and analyzed. Orientations are changed to find the impact of each material on indoor temperature.

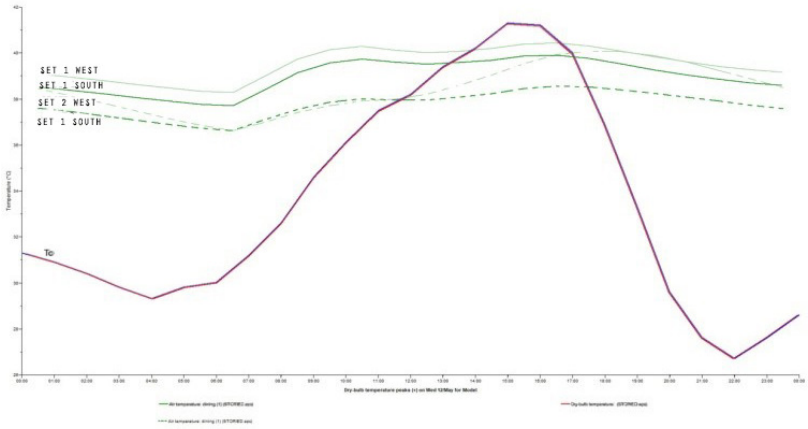


Figure 9: Graph showing temperature data of each room with different material specifications

CONCLUSION

From the figure 9 it is observed that there is a significant decrease in indoor temperature in the modified model when compared to the base case model.

This simulation and outcome are only a pilot study to find if there is a difference in temperature by using efficient material and to validate the software. In upcoming phase, a model is developed based on a standard with which simulation with different combination of parameters is carried out to evaluate and quantify the envelope efficiency and thermal performance.

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Role of Metro in Sustainable Development of A City-Case Study of Bengaluru

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Abstract: In the scenario of ever increasing urban population which threatens to destabilize the city it is clearly understood that the DECENT URBAN MOBILITY FOR EVERYONE should clear the city from its traffic vows. The population of Bengaluru today has reached 11 million and trips per day exceeded 100 lakh. With the BMTC shouldering more than half of the total traffic load with more than 6000 buses, the rest 5.5 million trips are by private vehicles. The metro records a daily ridership of 3.15lakh commuters. In Bangalore the reason of introducing metro rail is to move people away from its CBD and ensure or remove the time gap in reaching the workplace from the existing nodes and sub-nodes. The BMR revised FSI on metro corridor and 500mbuffer along the Metro surely will help in the sustainable development of the city Bengaluru.

Keywords, Sustainable Development, Bengaluru, Namma Metro

INTRODUCTION

Among the ten recommendations to be on the way forward by Europe Union study the most important aspect is decent urban mobility for everyone. In the scenario of ever increasing urban population which threatens to destabilize the city it is clearly understood that the decent urban mobility for everyone should clear the city from its traffic vows .The solution should energy efficient, less air and noise pollution, fast and also a mass rapid solution. Metro kind of takes the person to the doors of places of CBD in an urban scenario also frees the commuter from the parking problems faced in the CBD. The air conditioned and cleaner spaces maintained by the metro also encourages one to travel in this made than any other public mode of transportation. This paper discusses the role of Namma metro in the Sustainable development of the city Bengaluru.

THE INDIAN SCENARIO OF METRO

India started to embrace the Metro Projects in 13 cities of total length of 537 km to help itself from the traffic problems of the CBD and to help in connecting with the nodes of the cities. The metro projects in line up are about 595kms in stages of planning and appraisal.

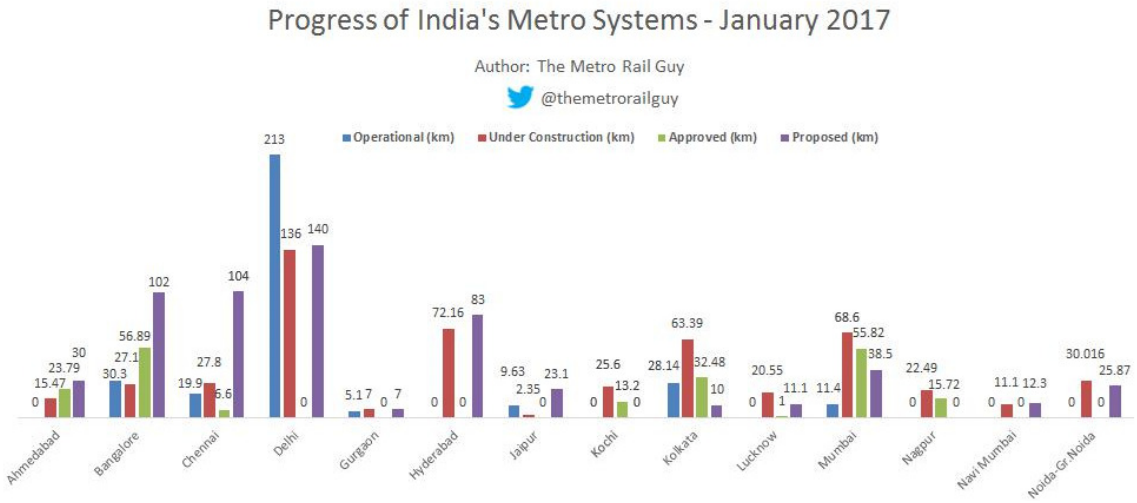

Figure 1. Progress of India's Metro System

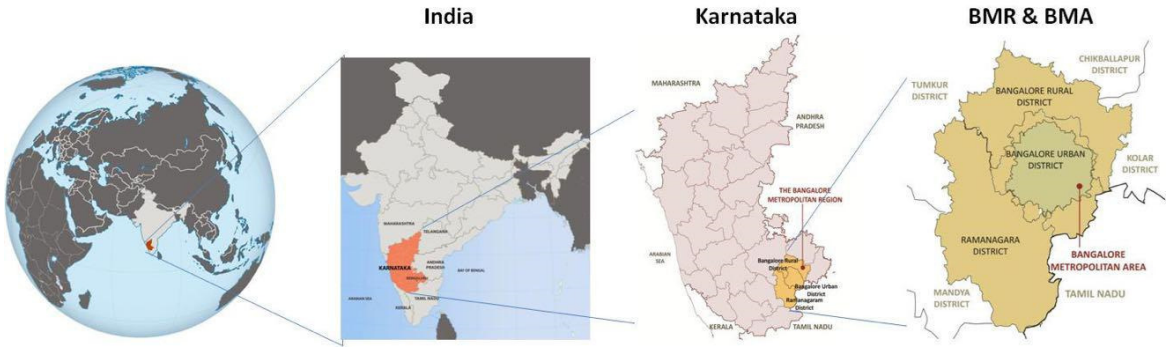

Figure 2. Location Maps of Bengaluru
(Source: Revised Master Plan for Bengaluru - 2031 (Draft): Volume-3)

BENGALURU-CASE STUDY

Bengaluru ranks 5th in population of the country, with its Linkages, climate cosmopolitan nature, friendly and multi-lingual (Due to Migration) people growing in a fast pace. The total extent of the Bengaluru Metro Region is 8,005 sq. km comprising of twelve taluks.

Bengaluru: Traffic and Transport Problems-Present Scenario

Bengaluru, originally a medieval town developed from the fort defined by the Kempegowda towers developed in a circular fashion aided by the five road transport corridors which are connected radially by ring roads. Traffic jams and speed dropping and congestion are the present order of the city. The competence of transport corridors are not in par with the speed in which the fibre optics cable of the IT Industry and real estate development.

The Silicon Valley of India is not able to come in terms of the private vehicle of the people. The population of Bengaluru today has reached 11 million and trips per day exceeded 100 lakh. With the BMTC shouldering more than half of the total traffic load with more than 6000 buses, the rest 5.5 million trips are by private vehicles.

DECISIONS FOR THE BETTERMENT OF THE PRESENT SCENERIO

The significant features of the development policies which gain the importance of this paper and sustainable development are

- Consideration on more Mass Rapid Systems like Metro, Monorail etc. in the planning stage itself for better and result oriented development and
- The introduction of demand management systems like parking charges, increasing restriction, corridor pricing etc.

Proposed Metro Networks

As per the development guidelines, a complex grid of radial and ring systems have been proposed complimenting the metro phase 1 and 2 Apart from the Phase -3 which includes Airport link of 29.5 kms, two ring road Metros are also proposed. One being 62.6.kms Outer Ring Road Metro and 106 kms of peripheral Ring Road Metro. It is very evident that 321.9 kms of Metro is expected to play a significant role in the sustainable development by being a mass-rapid system.

Sailent Features - Namma Metro

- Third Longest in the Country
- The first underground metro line in South India.
- Two colour-coded lines, with a total length of 42.3 kilometres serving 41 stations.
- Mix of underground graded and elevated stations using standard-gauge tracks.
- An average daily ridership of 3, 15,000 commuters.
- By 2023, the system is expected to complete its phase 2 network and provide connectivity to the city's important tech hubs of Electronic City and Whitefield which offers the scope of the sustainable development of Bengaluru and the role of Metro in achieving the goals.

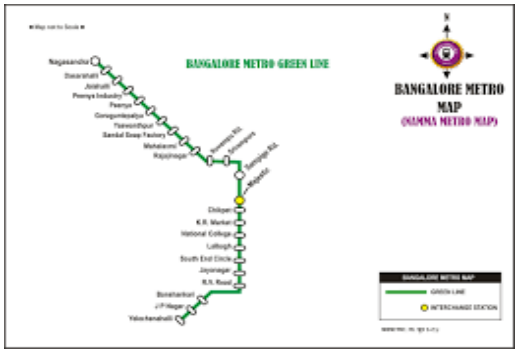

Figure 3. Phase-1 Green Line
(Source: Namma Metro, Bmrcl)



Figure 4. Phase-1 Purple Line
(Source: Namma Metro, Bmrcl)

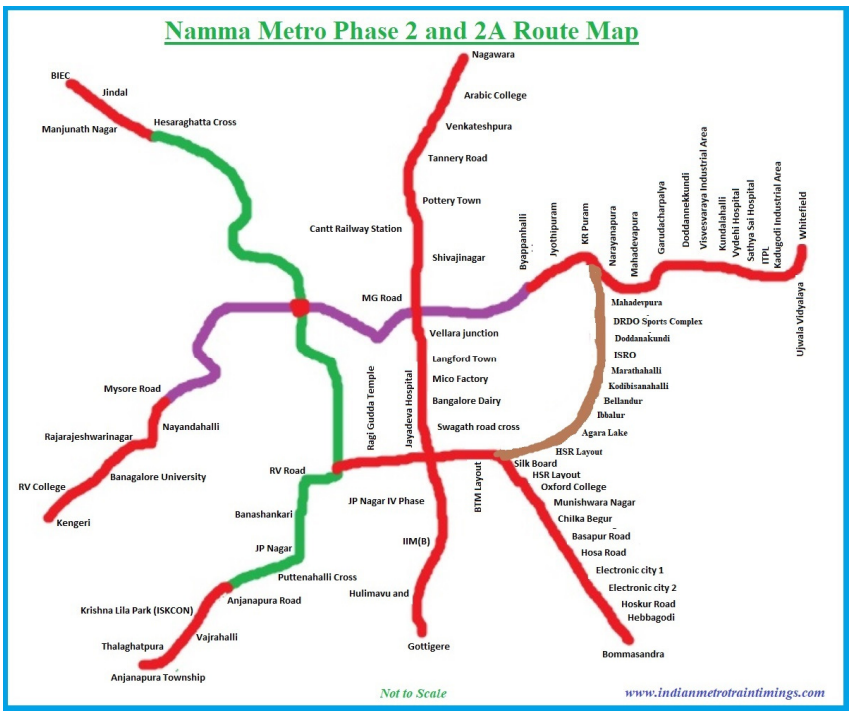

Figure 5. Phase 2 and 2A Route Map
(Source: Namma Metro, Bmrcl)

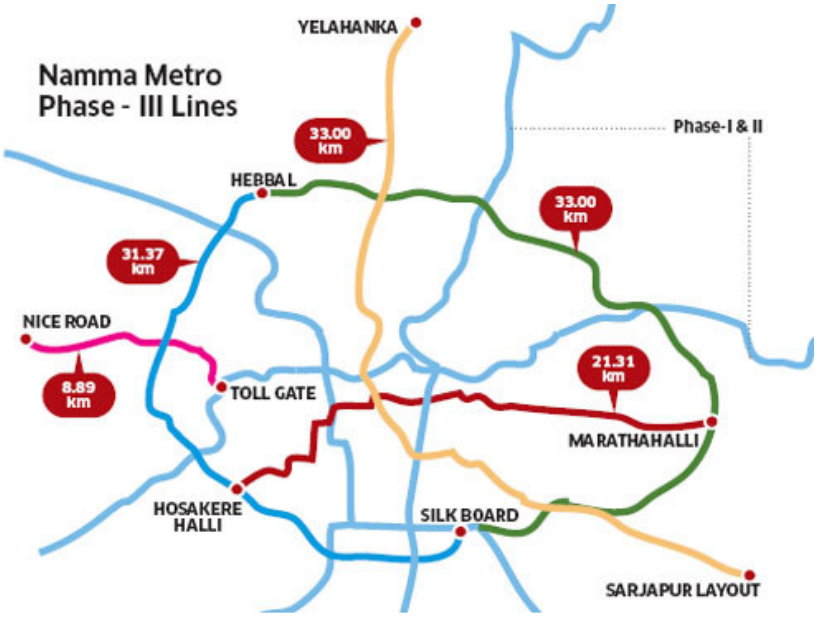

Figure 6. Phase 3 Route Map
(Source: Namma Metro, Bmrcl)

INFLUNCE OF METRO ON THE NEIGHBOURHOOD

It has always been a fact that improved connectivity especially by rails will result in the increase of the density of that region. But in the case of Bangalore the sole reason of introducing metro rail is to move people away from its CBD and ensure or remove the time gap in reaching the workplace from the existing nodes and sub-nodes. The development guidelines

- Proposes the neighboring property to NAMMA METRO to have a higher Floor Space Index (FSI) as a part of the considering the socio-economic damages done during the construction period.
- As a part of the regulations to analyze the land use implications of potential metro rail projects, a buffer of 500 meter on either side of the metro rail alignment is considered along the proposed metro rail line Bangalore's phase I project.

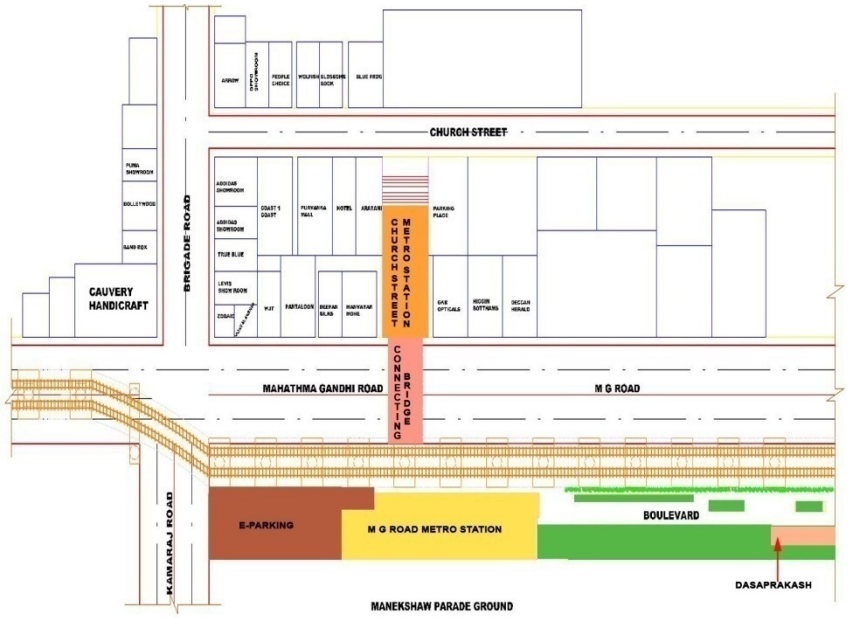

Figure 7. Plan of M.G.Road Metro and surroundings

MG ROAD-METRO-ROLE IN THE SUSTAINABLE DEVELOPMENT

The Internet Search Engines today deliver for M.G.Road only about M.G.Road Metro station Junction, though the actual M.G.Road starts from the Trinity Junction on the East to the Queens Circle on the West. The M.G.Road has lost its charm and nature to the Metro Junction. The Right handed Stretch of M.G.Road from Queen's circle to Brigade Road (Cauvery Circle) was a fairly wide open till the metro came in due to the parade grounds on one side, though the hospitality people Taj and Oberoi occupied the Trinity Junction.



(a) **(b)** **(c)**

Figure 8. (a) Connecting Bridge; (b) Elephant Ambari; (c) Church Street

The Broad MG Road was offering a fore ground to the shops on the left hand side as we move towards from Brigade Road (Cauvery Circle) from Trinity (Figure9b). Now with Metro intruding the vision the foreground and the setting for the shops is lost. The Same holds good for the shops ahead of Cauvery circle but the Metro station offers great views of the shops and the flying Metro Train also gives a Glimpse to the commuter.

The MG Road Metro Junction has also something more to offer the commuter. The cafe's, the boulevard by GNA architects, the fountain lounge with parking (Figure 9a), Elephant Ambari(Figure8b) reminding of the grand Dasara and culture, Outlet, the boulevard (Figure10c)with walking and getaways and replacing the pink boguanvilla with multi coloured boganvilla truly give the Bangalorean a place to rest and enjoy the M.G.Road without having to get into the outlets. On the urban context the open boulevard was a positive space as against the negative shopping facade in the opposite side. The low lying boulevard is replaced by a higher boulevard competing with the shops on the other side with the metro intercepting the middle as shown in Figure 9b.



(a) **(b)** **(c)**

Figure 9. (a) Fountain lounge with parking; (b) Framed Vista of MG Road; (c) Church Street Station Building

We also have a connecting bridge which takes you the other side of M.G.Road (Figure8a) and to the Church Street station (Figure 9c) which frames to a smaller scale as shown in Figure.8. In another words the M.G.Road metro junction is an open mall owing to the climate of the Bangalore city. Some vertical garden and change in texture can help the M.G.Road gain its image and importance. Coming to the core subject of the conference Metro at M.G.Road has certainly removed significant personal vehicles of those who have their work places on

M.G.Road. The significant reasons for choosing Metro are faster connectivity, improved frequency, higher parking charges and lesser parking slots.



(a) **(b)** **(c)**

Figure 10. (a) Landscaped Walkways under Metro; (b) Bougainville Boulevard; (c) Landscaped Walkways under Metro

The traffic congestion is mostly due to the vehicles pass by the M.G.Road as it is still the important spine in the city. The brigade road with the improved pedestrian ways and the newly done up Church Street with cobbled stones as shown in Figure 8c(which house the shifted many age old stores from M.G.Road like Indian coffee house, Gangaram's. G.K.Vale's, etc...) and the Cubbon Park etc promote pedestrian commuters who leave their personal vehicles at other metro stations.

CONCLUSION

For the enormous growth of the Cities especially when the population crosses 10 million the sustainable and green option for transport has proved to be Mass Rapid Transport systems like Metro integrated with the hierarchy of other transport networks. The Location, Design and Operation of such Metro systems and the Metro Station will knit a special place in the Urban Fabric of the city. By virtue of its proximity to Cubbon Park, Brigade Road, Church Street, the M.G.Road metro station has promoted Pedestrianism which certainly helped in decongestion thus aiding the sustainable development in heart of the city.

The M.G.Road Metro really showcases that such stations with their design, value added facilities and implementation would help in decongesting the city thus enabling sustainable development of the city – Bengaluru. The Phase 1, Phase 2, Phase 2A and Phase 3 lines connecting other proposed Metro Corridors together will enable green, fast, and convenient mode of transport to help the city to achieve sustainable development. Some demand management systems like parking charges, increasing restriction, corridor pricing etc. will also render to choosing Metro over private vehicles.

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Namma Metro, Bmrcl 2018

Analyzing the relationship between Land Use - Land Cover and Rainfall-Runoff using an integrated Geospatial - Empirical SCS-CN Approach in Tiruchirappalli City

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Abstract: The challenges in hydrology are prediction and estimation of surface run-off. The spatiotemporal fluctuations in Land Use/Land Cover play a prominent role in surface run-off. The precise estimation of runoff is a vital task in an urban area for proper urban watershed management. A watershed is a determining component for forecasting and management of land and water resources. The runoff in a basin depends on types of soil, land use, land cover, and rainfall. The traditional process of calculating surface run-off using composite curve number is very tedious and proceeds much of the hydrologic modeling time. Therefore, Geographic Information Systems (GIS) is now being used in integration with the SCS-CN method for estimating runoff. The curve number depends upon parameters such as soil and land use characteristics, which can be analyzed using satellite data on a large scale. This abstract tries to explain the methodology adopted in modeling the surface runoff in Tiruchirappalli City using the GIS-based SCS-CN method. The result shows surface run-off quantity in various Land Use –Land Cover, and soil type.

Keywords: Land use-Land cover; SCS CN; Tiruchirappalli City; Geographic Information System; Rainfall

INTRODUCTION

The Land Use-Land Cover (LU/LC) variations and its effect in the surface run-off is a recent topic in the area of urban hydrology. The lu/lc and rainfall are the critical parameters used for estimating surface run-off. In earlier days, the lu/lc changes and its effect on the surface run-off were mainly studied through experiments in which the results are not credible, So there is need of some hydrologic models. The hydrological models are used with a improved approach in recent years, to identify the impact of lu/lc changes. The large-scale rainfall run-off modeling requires many data to work with, which is practically impossible to acquire the required data needed for the modeling process. So a distinct method should be used for modeling.The Soil Conservation Service(SCS) approach is developed by the United States Department of Agriculture (USDA)(1974) is used for increasing a method to relate the quantity of surface run-off from rainfall from the soil layer. The concept of the SCS-CN method is that the run-off is related to rainfall and soil layer through a factor known as Curve Number (CN) JohnsonR (1998). The SCS Curve Number at the present called as the Natural Resources Conservation Service Curve Number (NRCS-CN) technique is humble and gives better results by Stuebe and Johnston (1990).The Soil Conservation Services-Curve Number process is a trustworthy method, and it is by many researchers and some of the latest works related to the SCS-CN process is done by (Mishra et al., 2004; Mishra et al., 2014a; Ponce et al., 1996). Geograpgical Information System (GIS) is a capable and effective tool used for the preparation of maximum input data required by the SCS-CN model. Nayak and Jaisawal (2003) produced a good correlation between measured and estimated run-off using GIS. The Changes in lu/lc will have a prominent influence on rainfall-runoff relations Yang and Yu (1998).The run-off differs based on soil conditions Kim et al., (2002).In this study, the influence of lu/lc variations on run-off has been evaluated from the year 2007 to 2012 in the Tiruchirappalli City. The average rainfall and its variation in the city are noted for different years. The rainfall-runoff variation and its influences in land use/ land cover changes are analyzed by using SCS-CN model.

DESCRIPTION OF CITY

The Tiruchirappalli City, also known as Trichy shown in (Figure1), stays an urban watershed located in the Cauvery river basin. The City topography is flat, and the spatial level of the extent is between 10˚44’ 46” N to

10˚ 52’ 46” N Latitude and 78˚ 39’ 11” to 78˚ 44’ 13” E Longitude The River Cauvery and Coleroon crossing the Southern and Northern boundary of Tiruchirapalli city lie at an altitude of 78 m above msl. There are infrequent mountains found inside the city; with the noticeable amid them are Rock fort, Golden rock, and Thiruverumbur hill. The Cauvery to the West and North-West there are some reserve forests situated in the city. The Cauvery and Coleroon rivers flow through the city makes the Northerly part of the city much greener than other areas.

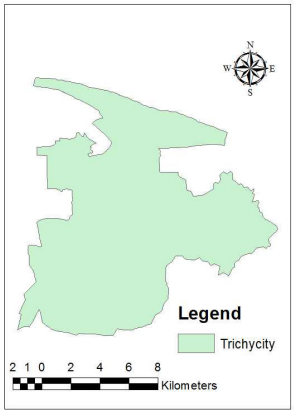


Figure 1. Location Map of Study Area

DATA ACQUISITION AND METHODOLOGY

DATA ACQUISITION METHODS

The flowchart shows the procedure adopted in the current work as shown in (Figure 2). The procedure involves data collection, model development, and run-off generation. The LU/LC map is acquired from Cartosat-Pan1 satellite data from NRSC Hyderabad. The Hydrological Soil grops are taken from USDA (United States Department of Agriculture).The DEM (Digital Elevation Model) is adopted for generating the slope map was obtained from the USGS website. The Rainfall Data got from State Surface and Ground Water Data Centre Chennai for the years 2000 to 2016.

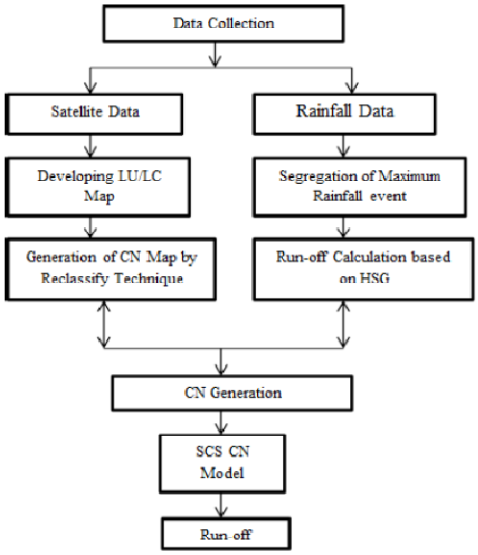
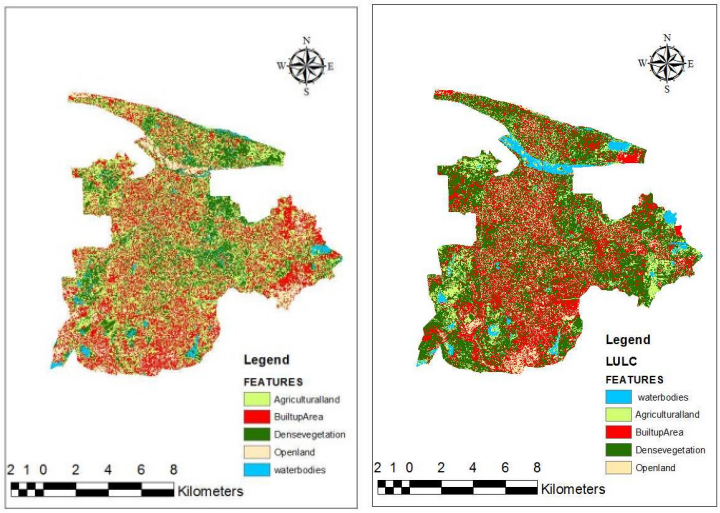


Figure 2. Flow Chart of The Work

METHODOLOGY

The Land Use- Land Cover map of the City is prepared from the Remote sensing obtained satellite image. The satellite image properties and data acquisition are shown in Table.1. The satellite image obtained is projected in UTM zone 44 WGS 84 for the Tiruchirappalli City. The 2007 image is considered as a base image, and it is matched with the 2012 image. The supervised classification method is adopted in this study. In supervised classification method, Maximum likelihood technique is adopted to classify the various LU/LC classes.

Table1. The Satellite Data Used in the Study				
S.No	**Data used**	**Date of Image**	**Resolution (m)**	**Path/Row**
1	Cartosat Pan-1	4 /1/ 2007	2.5	(553 -345)
2	Cartosat Pan-1	8 /3/ 2012	2.5	(553 -345)



(A) (B)

Figure 3. Land Use-Land Cover Map of the Tiruchirappalli City (A) 2007 (B) 2008

The LU/LC map is established for the years 2007 and 2012 as shown in (Figure 3) and its impact on runoff is identified. The different classes in the study area are agricultural land, dense vegetation, Open land, Built-up area, and Water bodies. The accuracy assessment of the classified images is finished once the classification is done. The CN of each LU/LC is adopted from the Indian conditions Kumar et al.,(1991) SCS-CN model calculates the surface run-off for these years. The lulc change and its influence on the run-off is calculated by considering the extreme rainfall happened in the City.

SOIL CONSERVATION SERVICE CURVE NUMBER (SCS-CN) MODEL

The SCS Curve Number method are often employed experimental approaches to evaluate the run-off from the basin (USDA 1974), and it is applied in this study. The infiltration loses are integrated with storage, and it is given by the relation (1)

$$Q = \frac{(P-I_a)^2}{(P-I_a+S)} \quad (1)$$

$$I_a = 0.2 * s \quad (2)$$

$$Q = \frac{(P-0.2S)^2}{(P-I_a+S)} \quad (3)$$

$$S = \frac{25400-254CN}{CN} \quad (4)$$

here Q is occurred run-off in (mm) in equation (3) , P stances rainfall in (mille meters), S denotes potential maximum retention (mille meters) as mention above in equation (4) and Ia represents the initial abstractions (because of evaporation,infiltration, interception) as shown in equation (2),CN stands for Curve Number value and it represents total CN as shown in equation (5) .The overall curve number for the city is obtained by calculating individual LandUse- Land Cover of the City. The calculated CN is used for identifying run-off in the City for the mentioned years.

$$CN=\frac{(A_1CN_1+A_2CN_2+A_3CN_3+\cdots A_nCN_n)}{A_1+A_2+A_3+\cdots A_nCN_n} \quad (5)$$

$A_1 + A_2 + A_3 + \cdots A_nCN_n$ it represents the overall area of landuse/land cover

The run-off is calculated by adopting the maximum rainfall event occurred in the city

Hydrological Soil Group

According to the U.S, Soil Conservation Service (SCS), the soils are categorized into 4 Hydrologic Soil Groups A, B, C & D based upon their infiltration capacity as shown in Table.1

Table 2. SCS classification (USDA 1974)

Hydrologic Soil Group	Soil Texture	Run of rate	Water spread
A	Fine-drained Sands and Gavels	Low	High rate
B	Reasonably thick, fine-drained	Moderate	Moderate rate
C	Clay loams, shallow sandy loam	Moderate	Moderate rate
D	Clay swell significantly when wet	High	Low rate

The Hydrologic Soil Groups (HSG) divides the soil into A, B, C, and D Satheesh kumar et al., (2017) and its distribution is noted in the study area. The soil A indicates the soil with low runoff potential with more infiltration rate. The B group soil shows reasonable penetration rate to fine drained rate of infiltration. The C group soil has moderate infiltration, and enough rate of water transmission and the soil of group D is characterize by very low infiltration and a very high runoff.

SLOPE CLASSES OF TIRUCHIRAPPALLI CITY WATERSHED

The slope is an essential measure for a run-off in the urban watershed. The more steep slope more run-off is experienced. The moderate and gentle slope experiences medium and low surface runoff. The slope map generated for Tiruchirappalli City is shown in Figure 5. Slope less than 3° considered as nearly leveled and greater than 15° was given importance because of run-off.

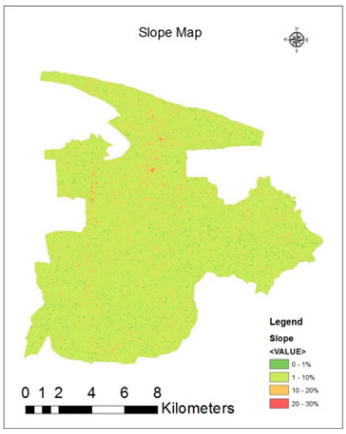


Figure 4. Slope Map

RAINFALL DISTRIBUTION

The rainfall distribution map for the study area is created by Inverse Distance Weight method. There are 5 rain gauge stations located in the City and the rainfall is measured in these gauges. The max average rainfall of 5 rain gauge locations are created and found that centre portion of City receives around 957.44 to 1062.18 mm. The spatial and temporal distributions of rainfall at sub-watershed are measured by using Geographical Information System methods. The maximum average rainfall and spatial distribution is shown in (Figure 4).

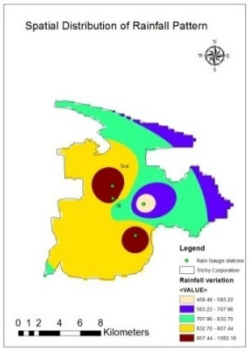


Figure 5. Spatial Distribution of Rainfall Pattern in Trichy City

The total city is divided into five land use classifications that stance for Agricultural land, Dense vegetation, Open land, Built-up area, and Water bodies. In mentioned 5 land-use classes surface run-off has been generated by SCS –CN method. Here the maximum rainfall event is used for calculating runoff from the existing lu/lc data for 2007 and 2012, since run-off is a function of rainfall and the future run off can also predicted with the existing maximum rainfall and LU/LC changes by using the equation (6) below by Deepak et al.,(2017).

$$F=\frac{\sum R_2}{\sum R_1} \quad (6)$$

The F represents the factor responsible for generating future run-off and the $\sum R_2$ is total run-off of 2012, $\sum R_1$ is total run-off of 2007

RESULTS AND DISCUSSIONS

LAND USE/LAND COVER CHANGE FROM 2007- 2012

The LU/LC for the Tiruchirappalli City is obtained from Cartosat image for the years 2007 to 2012 by supervised classification technique. From the study it is identified that there is decrease in agricultural land from 2007 to 2012 by 9.32%.The dense vegetation for the years 2007 to 2012 decrease by 4.4%.The open land in the study area increases this might be due to a decrease of agricultural and image acquisition dates at different seasons. The increase in the open land is noted around 32 %. The water bodies in the study area decrease around1.5%. This is due to lack of storability and dryness in water storage structures like tanks. The built-up area in the study area increases from 2007 to 2012 19.97 % of the whole area. The increase in built-up area might increase in run-off in the City.

Table 3. Percentage and Area of LU/LC of Years 2007 to 2012

LU/LC type	2007 Area(Sqkm)	Percentage	2012 Area(Sqkm)	Percentage
agricultural land	53.72	32.12	49.13	29.38
dense vegetation	50.57	30.24	42.68	25.52
open land	24.26	14.51	35.84	21.43
built-up area	28.48	17.03	35.59	21.28
water body	10.18	06.09	3.97	2.37

CN (CURVE NUMBER) CALCULATION

The weighted CN is calculated for the city as the Curve Number increases it indicates the run-off increases and the decrease in curve number show the decrease in overflow. The CN for the Tiruchirappalli City is calculated based on the Indian conditions. The run-off is calculated from the available rainfall data from the SCS –Curve Number technique from the period of 2007 to 2012. The weighted average Curve Number value and altered standards of Curve Number are formulated in Table.4 The CN increases from the year 2007 to 2012 indicate that the run-off increases with the increase of CN.

Table 4. Calculated Curve Numbers for Tiruchirappalli City

Land use-Land cover type	HSG	Assigned CN	Land use Practise	2007 Calculated CN	2012 Calculated CN
agricultural land	D	79	Straight row	25.37	23.21
dense vegetation	A	40	Dense	12.09	10.20
open land	B	89		12.97	19.07
built-up area	D	77	NIL	13.11	16.38
water body	Nil	100	NIL	6.09	2.37
Total				69.59	71.26

The Soil Conservation Services CN technique is considered to investigate the surface run-off for LU/LC of years 2007 and 2012. The average rainfall of last fifteen years is considered to calculate surface run-off to check impact of run-off from landuse land cover changes for different rainfall conditions. The normal yearly surface

run-off depth for the past 15 years in Tiruchirappalli City is around 655 mille meters multipled by the total region of the Trichy city (Area =167.14 m2) provides the full normal volume of run-off as (109635.4 m3), which is 0.6percentage of the complete yearly rainfall. The yearly rainfall and runoff for the period of 2001–2016 in the City is presented in Table: 5

Table 5. The Yearly Run-off from Rainfall

STATION	Years	Rainfall (mm)	$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$
Tiruchirappalli City	2001	685.100	564.933
	2002	593.100	475.188
	2003	863.100	739.805
	2004	891.300	767.614
	2005	1251.300	1124.060
	2006	637.900	518.819
	2007	732.100	610.976
	2008	961.400	836.831
	2009	630.199	511.310
	2010	752.799	631.288
	2011	963.200	838.610
	2012	641.999	522.819
	2013	602.199	484.038
	2014	615.36	496.849
	2015	1058.100	932.490
	2016	556.400	439.566

The calculated runoff in the City varies from 685.10–556 mm during years (2001–2016) The rainfall varies between 593.10 to 1251.30 mm shown in Figure (6).The average annual runoff calculated is around 655.94 mm with usual runoff volume for last 15 years is109635.4 m3. The rainfall-runoff correlation showed in Figure: 7and with a correlation coefficient (r) value of 0.99.

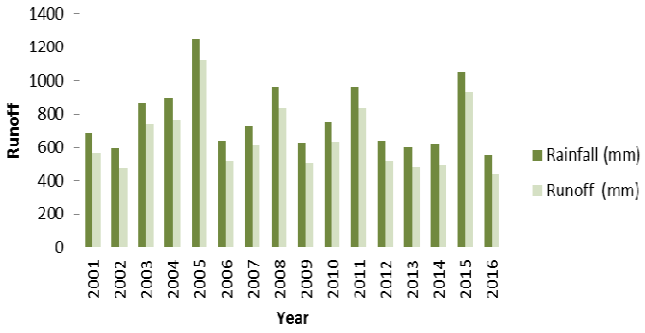


Figure 6. Precipitation and run-off variation in the City

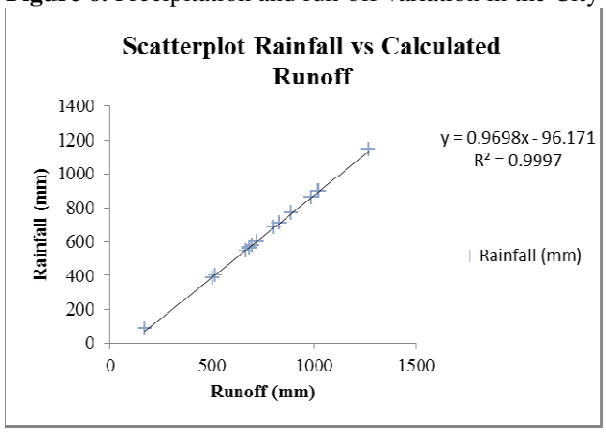


Figure 7. Rainfall and Calculated Run-off Relations

ANALYSIS OF RUN-OFF FOR CHANGE IN DIFFERENT YEARS LAND-USE CONDITIONS

The run-off of the year 2007 calculated as 687.42 mm from observed rainfall of 693.6 mm. In the year 2012 calculated run-off is 522.819 mm of observed rainfall of 641.9 mm. The influence factor of land-use land-cover is 0.79 between 2007 to 2012. This aspect can use for computing run-off for the next 10 years by using equation (6) is 1.15. The analysis shows the highest run-off is 1073.21 mm and the land-use transformation is measured highest runoff becomes 1377.10 mm. The effect of run-off due to land-use variation is 2.4 % in the next 10 years.

CONCLUSION

The SCS and CN model is adopted in current work. Here the SCS modeling is established from Landuse map generated by GIS. The monthly rainfall runoff is adopted for simulating run-off in the City. The quantity of runoff is around 0.6 percentage of the overall yearly rainfall experienced by the City. In SCS Curve number method HSG soil act as one of the parameters for generating CN number and it is measured as one of the parameters for calculating the runoff depth. In the Tiruchirappalli City, the calculated CN number increases from 69.59 to 71.26 for the years 2007 to 2012 shows the increase in CN increases run-off. Finally it is concluded that SCS CN approach is proficiently recognized an improved technique, which takes less time and has ability to hold large data set in addition the bigger area. The SCS measures required to be planned and applied in the urban region to control the runoff.

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A study on Embodied energy of recycled aggregates obtained from processed demolition waste

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Abstract: Environmental sustainability includes saving of natural resources, conservation of energy, reducing emission of greenhouse gases, obeying the 3R's (Reduce, Reuse and Recycle) rule and waste management. Construction and Demolition waste (C&D) generated in India is poorly managed by dumping illegally in open space, road sides and water bodies due to unavailability of recycling plant for processing. Processing the C&D waste to produce recycled aggregates (RA) substantially reduces the need and demand for natural aggregates. Many research studies and standard codes in India report that recycled aggregates can be potentially used in concrete production. In India very few have attempted to assess the sustainability by computing the embodied energy as a tool to address the environmental performance of recycled aggregates. Hence the present study attempts to assess and compare the embodied energy of natural aggregates with the recycled aggregates obtained from three case studies. The case study sites selected were in and around Bengaluru city. The embodied energy of recycled aggregates was computed considering the demolition energy, transportation energy and process energy. Two recycling techniques viz. dry processing system and wet processing systems were considered. The result shows that embodied energy of recycled aggregates from a wet processing system was 27-42% higher when compared to dry processing system. It is sustainable to use recycled aggregates, since it reduces the overexploitation of stone quarries, reduces the need of landfill sites and saves huge amount of natural resources.

Keywords:-Recycled aggregates, demolition energy, transportation energy, process energy, processing systems.

INTRODUCTION

The Construction sector is one of the largest consumer of resources (natural raw materials, fuel and water) and generator of pollutants during construction, operation and demolition phase (TERI, 2015). In India, construction sector was the second largest sector with regard to material usage in 2007, accounting for around 20% of all material demand (Dittrich M, 2012). The demand for natural aggregates is expected to rise in future since concrete will remain to be the most consumed material in construction. It is estimated that the construction industry will have a demand of more than 2 billion tons of natural aggregates by 2020(GIZ, 2016).Therefore, dependence on natural resources and extensive use of energy intensive construction materials can drain the natural resources and energy at faster rates, and can impose negative impacts on environment. Hence, measures have to be taken to conserve natural resources and energy which includes, minimizing the use of high energy materials, minimize the transportation and maximize the use of local materials and resources, recycling of construction and demolition wastes, utilization of industrial wastes and use of renewable energy sources(B V Venkatarama reddy & KS Jagadish, 2003).

High rate of urbanization is leading to enormous pressure for efficient utilization of the existing land (A Bansal, G Mishra and S Bisnoi, 2016). Buildings are being demolished before their design life to rebuild new, modern structures. As a result of demolition and reconstruction of buildings enormous amount of waste is being generated. For example the quantity of C&D waste generation in India is approximately 25-30% of total solid waste generated (DEPA, 2003) which accounts upto 23.75 million tons annually (CPCB, 2017). Disposal of this construction and demolition (C&D) waste in a sustainable manner is the biggest challenge today. Of the total waste generated in India, 50-60% is easily available for reprocessing. The fractions of concrete, bricks and mortar can be crushed and used as fine aggregate and coarse aggregate in concrete (CSTEP, 2016). The utilization of C&D waste, saves natural resources, reduce environmental impacts and reduction of dumping sites (A Bansal et al., 2016; Gagan et al., 2015). The use of non-renewable resources such as natural aggregates needs to be reduced by recycling and processing of C&D waste in such way that it can be used to replace the natural aggregates (Hannele kuosa et al., 2012). The replacement can minimize the gap between demand and supply of natural aggregates in construction sector (S.S Gaharwar, 2017).In India numerous research studies, standard

codes and C&D recycling plants have demonstrated that recycled aggregates produced from the C&D waste can be used in concrete production and road building application up to 20-30% as partial replacement with natural aggregates. Recycled coarse aggregates may be used in concrete for bulk fills, bank protection, pavements, sidewalks, kerbs and gutters (NBC, 2016), recycled aggregates in transportation infrastructure (Surya M, 2013), recycled aggregates in concrete production (Akash Rao, 2007), recycled aggregates in manufacture of building products like pavement blocks, kerbs, precast elements, hollow and solid concrete blocks at Delhi recycling plant (IL&FS, 2014), recycled aggregates in bricks and interlocking pavers (M D lela, 2016). However, in India very few have attempted to assess the embodied energy of recycled aggregates. Therefore, the present study attempts to assess and compare the embodied energy of natural aggregates with the embodied energy of recycled aggregates obtained from C&D waste. The building demolition sites selected were in and around Bengaluru city. Two recycling techniques have been identified for processing the demolition waste which includes i. dry processing system and ii. wet processing system.

CURRENT STATUS OF C&D WASTE MANAGEMENT IN BENGALURU CITY, INDIA

A study commissioned by center for study of science, technology and policy (CSTEP) in 2016 , estimated that the C&D waste generation in Bengaluru city is around 3600tons/day. C&D waste is poorly managed in India with unauthorized dumping waste on the lake beds, valleys and along highway roads leading to numerous environmental, safety and nuisance problems, in addition to under utilization of these valuable resources (CSTEP, 2017). As per survey conducted by CSTEP, it is estimated that only 10% of total C&D waste generated in Bengaluru enters authorized designated landfill site, 30% for leveling low lying areas and remaining 60% dumped in unauthorized. Figure 1 presents the existing C&D waste collection, transportation and disposal for Bengaluru city and its pictorial representation is showed in figure 2

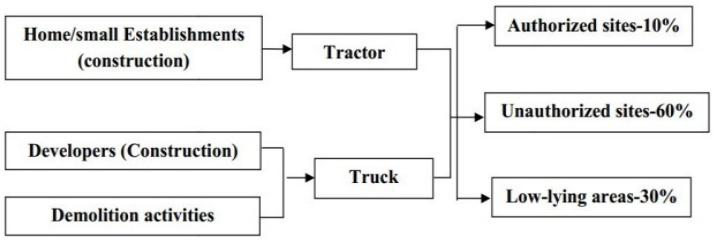

Figure 1. Schematic representation of C&D waste collection, transportation and disposal in Bengaluru city
Source: Center for study of science, technology and policy CSTEP, 2016

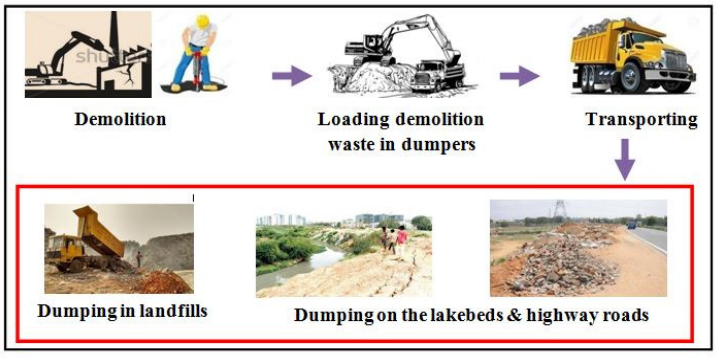

Figure 2. Pictorial representation of the current C&D waste management in Bengaluru city
Source: Rakesh S, 2018

The three case studies indicate that some of the valuable materials like steel, doors and windows and size stones are the only recoverable items whereas, concrete, masonry and tile waste are disposed in landfills, low lying areas, open spaces, road sides or water bodies due to lack of C&D recycling plant creating enormous nuisance and environmental problems in Bengaluru city. Therefore, the present study emphasizes an urgent need for recycling and processing demolition wastes to produce the recycled aggregates, such that it supplements the use and demand for natural aggregates. Figure 3 depicts the pictorial representation of proposed C&D waste management in Bengaluru city.

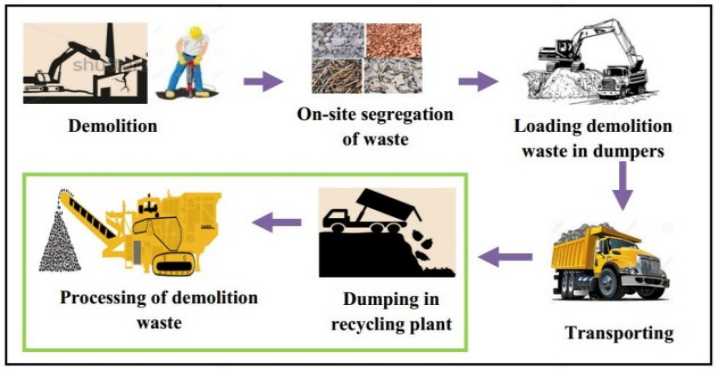

Figure 3. Pictorial representation of proposed C&D waste management in Bengaluru city
Source: Rakesh S, 2018

SCOPE AND OBJECTIVE OF THE CURRENT STUDY

The scope of the present study includes assessing the embodied energy of recycled aggregates produced from the processed demolition waste (only concrete, masonry and tiles waste) and comparing with the embodied energy of natural aggregates obtained from the earlier investigations.

METHODOLOGY

In order to structure the methodology for computing the embodied energy of recycled aggregates, the concerned system boundary of the process which is cradle to gate was adopted. The same is depicted in figure 4. It involves computation of demolition energy, transportation energy and process energy through case studies. For computing these energies, frequent visits needs to be carried out to the demolition sites, C&D recycling plant and natural aggregate production plants to observe and understand the process and collect the raw data pertaining to the machineries that were involved in the respective works. Further the energy source data of each machine operated using electricity, diesel or petrol and their electricity/fuel consumption rates needs to be obtained. Finally from the data collected, embodied energy of the recycled aggregates needs to be computed.

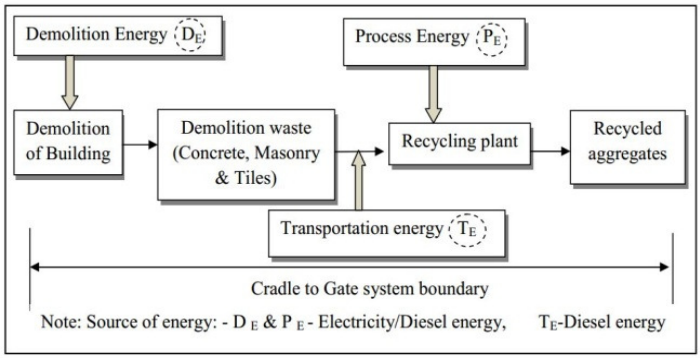

Figure 4. System boundary considered for computing the embodied energy of recycled aggregates
Source: Rakesh S, 2018

CASE STUDIES

The case studies include one institutional building and two residential buildings in and around Bengaluru city, India. The Institutional building (case study-Building 1, B1) was constructed in the year 1990 and demolished at the end of year 2017 after 27 years of its lifetime, in order to re-build a multi storey structure as per the need of the institution. It is a RCC (Reinforced cement concrete) framed structure with infill walls (G+2 storey).The total built up area of the building is 2291.62m², ground floor (938.32m²), 1st floor (683.09m²) and 2nd floor (670.21m²). External and partition walls were made of burnt clay bricks. Figure 5 shows the floor plan of building 1. The quantity of reuse, recycle and landfill materials of case study building 1 is presented in table 1. Residential building (case Study – Building 2, B2) was built in the year 1983 and demolished in 2018 after 35 years of its life time, in order to reconstruct a duplex house. It is a load bearing structure of G+1 floor with walls made of burnt clay bricks.

The total built up area is 167.22m². Figure 6 shows the floor plan of building 2. Table 2 gives the quantity of reuse, recycle and landfill materials of case study building 2. Residential building (case study- Building 3, B3) was constructed in the year 2003 and demolished in 2018 after 15 years of its life time, in order to construct an apartment. It is a RCC framed structure of G+2 floors with infill walls made of burnt clay bricks. The total built up area is 557.43m². Material quantity estimation could not be carried due to unavailability of architectural floor plan.

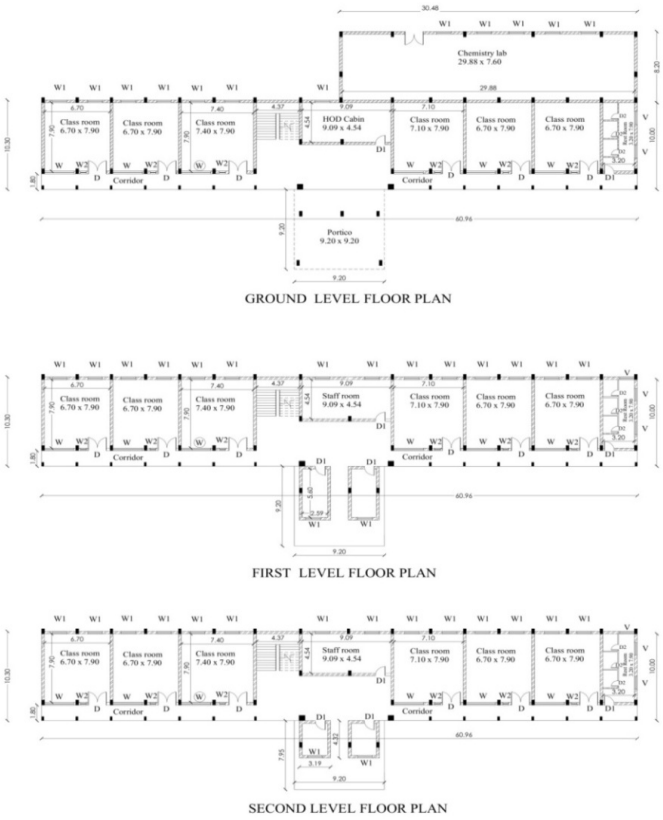

Figure 5. Floor plan of case study building 1
Source: Rakesh S, 2018

Table 1. Quantity of reuse, recycle and landfill materials of case study building 1			
Material	Type of disposal	Quantity(m3)	Percentage (%)
Concrete	Landfill	934.2	57.21
Size stone	Reuse (90 %)	237.31	14.53
	Landfill (10%)	26.37	1.61
Masonry	Landfill	407.65	24.97
Tiles	Landfill	14.37	0.88
Steel rebar	Recycle-100%	8.90	0.54
Wooden door's	Reuse- 100 %	2.98	0.18
Metal works	Reuse- 80 %	1.00	0.06
	Recycle- 20 %	0.25	0.02
	Total quantity =	1633.03	100 %
	Percentage (%)	Quantity(m3)	
Reuse materials	14.77 %	241.29	
Recycle materials	0.56%	9.15	
Landfill materials	84.67%	1382.59	

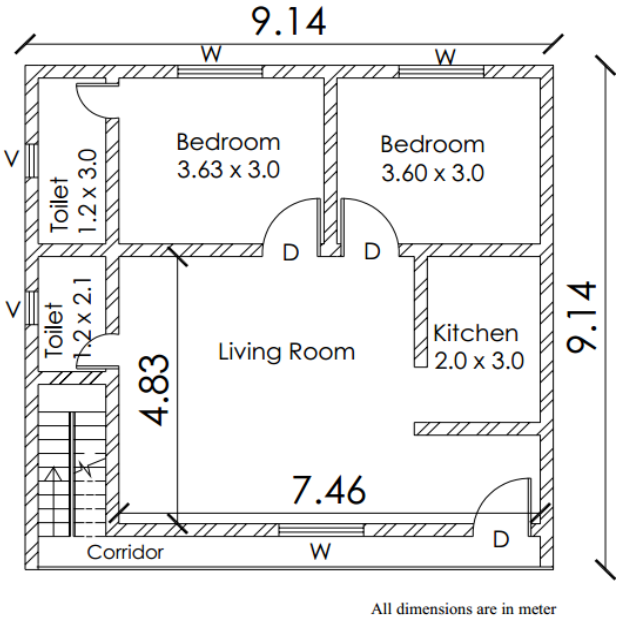

Figure 6. Floor plan of case study Building 2
Source: Rakesh S, 2018

Table 2. Quantity of reuse, recycle and landfill materials of building 2

Material	Type of disposal	Quantity, m3	Percentage %
Concrete	Landfill	25.0	17.44
Size Stone	Reuse	32.07	22.37
Masonry	Landfill	83.70	58.39
Tiles	Landfill	1.42	1.0
Steel	Recycle	0.03	0.02
Wooden Doors & windows	Reuse	1.12	0.78
Total quantity =		143.34m3	100.0

	Percentage, %	Quantity (m3)
Reuse materials	23.17	33.19
Recycle materials	0.02	0.03
landfill materials	76.83	110.12

ASSUMPTIONS MADE IN THE STUDY

In the present study fuel consumption rates (mileage) of demolishing machineries are based on information provided by the operators of respective vehicles as the empirical data for the fuel consumption rates is difficult to obtain because of the following reasons: i) manufactures are reluctant to commit to detail the fuel consumption rates of machineries. ii) site conditions such as grading, structural resistance, density of material and soil conditions have a major influence on fuel consumption rates and lastly. iii) age of equipment, condition, maintenance patterns and operator style will have significant influence on fuel consumption rates of machineries. Energy conversion factors for diesel fuel and electricity are considered as 38.70MJ/liter (Ed) and 16.30MJ/kWh (Ee) respectively (B Surekha et al., 2016, Varsha B N et al., 2017). For both the systems i.e. dry and wet processing system the plant capacity of 1000 tons per day (operating 8 hours per day) is considered for calculation of process energy. The technical specifications of recycling equipments i.e. production capacity, feed size, power consumption, total power consumption have been collected from the respective manufacturing companies (Gujarat Apollo 2012, Marsman ,2015, Duromech, 2012).

EMBODIED ENERGY ANALYSIS

DEMOLITION ENERGY

Demolition energy is defined as the energy required for dismantling the building and disposing of building materials (Manish Kumar Dixit, 2010).However, in the present study, the total demolition energy is computed in two parts: I. Energy required for the demolition of superstructure and substructure of the building and II. Transportation energy required for moving the demolition waste to a recycling plant. Demolition energy is thus computed by multiplying the total fuel consumed for demolishing the structure with the energy density of diesel fuel i.e. 38.7MJ/liter(Ed). The total fuel consumed for the demolition of building is computed by summing up the individual machine run times for a particular task multiplied by their respective fuel consumption rates. Fuel estimates were done separately for the superstructure and substructure demolition activity. Table 3 summarizes the fuel consumption estimates for building 1, 2 and 3 case studies. In addition to fuel used in building 3, electric powered hand held driller is used for RCC roof dismantling.

Table 3. Summary of fuel estimates

SL. No	Description	B1	B2	B3
a.	Fuel consumed in superstructure demolition and clearing of debris in liters (V1)	2352	72	936
b.	Fuel consumed in substructure (footing) demolition and clearing of debris in liters (V2)	2016	24	240
c.	Total fuel consumed in liters	4368	96	1176

The total fuel consumed in demolishing the superstructure of buildings 1, 2 and 3 was found to be 2352, 72 and 936 liters respectively , which is greater than the substructure demolition activity (excavation of soil and footing demolition) which when estimated was found to be 2016, 24 and 240 liters respectively. These fuel estimates are used for computing the demolition energy. Table 5 summarizes the demolition energy calculations for building 1, 2 and 3 case studies.

Table 4. Electricity consumed in Building 3 case study

	Duration		Equipment used		Power consumption rate, kWh	Electricity consumed (kWh)
	Days	Hours	Name	No's		
Roof dismantling	8	8	Hand held drillers	1	2	128
Total electricity consumed for roof dismantling (kWh)=						128

Table 5. Summary of demolition energy calculations

S. No.	Description	Notation	B1	B2	B3
a.	Superstructure				
	Fuel consumed , liters (Table 3)	V1	2352	72	936
b.	Electricity use, kWh (Table 4)	Ve	-	-	128
c.	Energy consumed, MJ DE1 = (Ed x V1) + (Ee x Ve)	DE1	91022.40	2786.40	38309.60
d.	Energy consumed ,GJ DE1/1000	-	91.02	2.79	38.31
	Substructure				

e.	Fuel consumed, liters (Table 3)	V2	2016	24	240
f.	Energy consumed, MJ DE2 = Ed x V2	DE2	78019.20	928.80	9288.0
g.	Energy consumed, GJ DE1/1000	-	78.02	0.93	9.29
h.	Total demolition energy ,MJ DE = DE1+ DE2	DE	169041.60	3715.20	47597.60
i.	DE in GJ	-	169.04	3.715	47.60
Energy conversion factors:- 1 liter diesel = 38.7MJ/liter (Ed), 1 kWh = 16.30MJ/kWh (Ee)					

Demolition energy for case studies building 1, 2 and 3 was found to be 169.04GJ, 3.715GJ and 47.60GJ respectively. It can be concluded that demolition energy computed for case study (building 1) was found to be 73.77MJ/m2. For buildings 2 and 3 it was found to be 22.22MJ/m2 and 85.39MJ/m2 respectively.

TRANSPORTATION ENERGY

Transportation energy is defined as the energy necessary for transporting demolition waste (concrete, masonry and tile waste) from the demolition site to the C&D recycling plant. Various steps are involved in computing the transportation energy which includes a) Estimation of quantity of building materials b) Calculating the volume of demolition waste generated and number of trips required for the transportation of demolition waste. In all the three case studies, dumpers of capacity 19 tons have been deployed for transporting the demolition waste to recycling plant and mileage of dumper is fixed based on the information provided by operators i.e. 3kmpl. c) Based on the survey map given by BBMP (local government authority); the designated C&D waste disposal sites and proposed sites for C&D waste processing plants (CSTEP, 2016), the transportation distance of 40km round trip is fixed for the calculation of transportation energy. d) Fuel consumed per trip and total fuel consumed for transporting the demolition waste to recycling plant are calculated and e) Transportation energy is computed by multiplying the total volume of fuel consumed with the energy density of diesel i.e. 38.7MJ/liter. Table 6 summarizes the transportation energy calculations for building 1, 2 and 3 case studies.

Table 6. Transportation energy calculations

S. No	Description	Notation	B1	B2	B3
a.	Average density of concrete, masonry and tiles, kg/m3	ρ ave	2000	2000	2000
b.	Weight of demolition waste carried by dumper, kg	W	17000	17000	17000
c.	Volume of dumper, m3	V	14	14	14
d.	Bulk density of demolition, waste , kg/m3	ρdw	1200	1200	1200
e.	1 round trip, km	D	40	40	40
f.	Mileage of dumper, kmpl	M	3	3	3
g.	Fuel consumed per trip, liters	F	13.33	13.33	13.33
h.	Energy density of diesel, MJ/liter	Ed	38.7	38.7	38.7
i.	Volume of Building materials,m3 (from table 1 and 2)	Vb	1382.59	110.12	---
j.	Volume of demolition waste,m3 Vdw = Vb x (ρ ave /ρdw)	Vdw	2304.32	183.53	812
k.	Number of trips required for the transportation of demolition waste, T = Vdw/ V	T	165	13	58

l.	Total volume of diesel consumed, liters Vd= T x F	Vd	2200	173.29	773.14
m.	Total energy consumed for transportation of demolition debris to C&D recycling plant, MJ, T E = Vd x Ed	TE	85140	6706.32	29920.52
n.	TE in GJ	-	85.14	6.71	29.92

PROCESS ENERGY

Process energy is defined as the energy required for recycling and processing the demolition waste to produce recycled aggregates. The process energy is computed in two ways which include a dry processing system and a wet processing system. Further, for each processing system the process energy is calculated in two phases: Phase 1 represents the pre-crushing that mainly consists of sizing the demolition waste as per the feed size of crusher by manual or mechanical means and loading into vibrating feeders by the aid of loaders and phase 2 represents the crushing phase that consists of crushing, processing and screening operations. The equipment which are powered by electricity, the electrical equipment energy is computed by summation of the individual equipment run time for a particular task multiplied by its respective power consumption rates.

DRY PROCESSING SYSTEM

The recycling process involved in dry processing system is similar to that of stone crushing process and involves machineries and equipment used in the stone crushing unit. In addition to these, magnetic separators are used to remove the scrap steel. The process involved is sizing, crushing, removal of scrap steel and screening it into different size fractions (20mm, 12mm and 4.75mm). Fig 7 presents the recycling process of demolition waste through the dry processing system. The process energy involved in the dry processing system is worked out. Table 7 and 8 gives the pre-crushing phase and crushing phase energy calculations of dry processing system respectively.

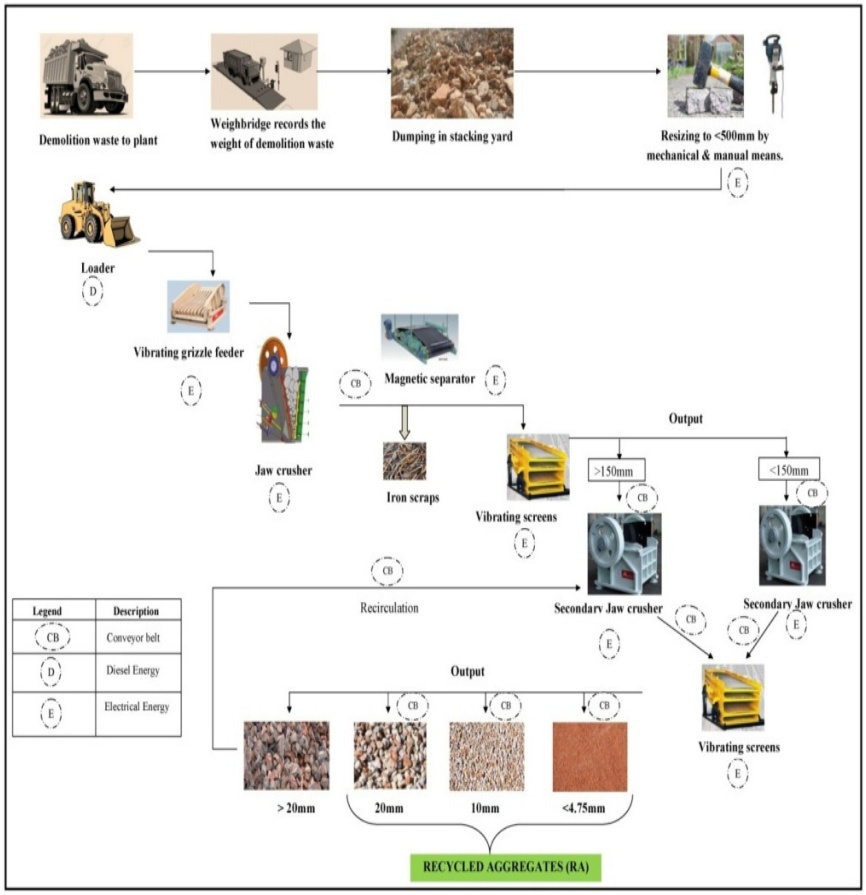

Figure 7. Pictorial representation of recycling process of C&D waste - Dry processing system
Source: Rakesh S, 2018

*Loader fuel consumption rate from Mario Klanfar, 2016.

Table 7. Pre crushing phase energy calculations - Dry processing system/Wet processing system

Equipment	Fuel / electricity consumption rate	Number of equipment	Fuel/electricity use for 8hrs	Unit
Loaders	15.07 liter/hr*	1	120.56	liters
Hand held drillers	2kWh	1	16.00	kWh
Total energy use (diesel and electricity) =			4926.47	MJ
Total energy use in MJ/t =			4.93	MJ/t
Conversion factors:- 1 liter diesel = 38.7MJ/liter, 1 kWh electricity = 16.30MJ/kWh				

Table 8. Crushing phase energy calculations - Dry processing system

Equipment	Production capacity (t/hr)	Feed size (mm)	Power consumption rate P – (kWh)	No of equipment	Electricity consumption for 8 hrs	Unit
Vibrating feeder	125	-	6.6	1	52.8	kWh
Jaw crusher	125	500	75	1	600	kWh
Magnetic separators	-	-	6.2	1	49.6	kWh
Vibrating screens	125	-	18.5	2	296	kWh
Secondary Jaw crusher	65	400	40	2	640	kWh
Conveyor belts	-	-	4.5	9	324	kWh
Total electricity use =					1962.4	kWh
Total energy use in MJ= 1962.4 x 16.30 =					31987.12	MJ
Total energy use in MJ/ton =					32.0	MJ/t
Process energy = Pre-crushing energy use + Crushing phase energy use (PE1)					36.93	MJ/t
Technical specifications of equipments Gujarat Apollo (2012), Marsman (2015) , Duromech (2012)						

WET PROCESSING SYSTEM

In wet processing, a stationary crushing unit (impact crusher) and vibrating screens are installed for dry processing of demolition waste whereas, for wet processing, rinsing screens, log washers, Evowash sand washer and thickeners are installed to improve the quality of aggregates. The procedure involved in wet processing system is upon arrival of C&D waste to the plant; the weight of incoming vehicle is recorded from a weighbridge and unloaded into stacking yard. Segregation of steel, bricks and plastic is done in a stacking yard by hand picking. Large concrete pieces are broken down to size less than 400mm by both mechanical and manual means such that it can be fed to primary crushers. The resized waste fractions are fed into a vibrating feeder to provide a regular feed to the crusher. The impact crusher of capacity 150tons/hour is used for the size reduction to less than 60mm fractions. Suspended magnetic separators are installed over the conveyor belt that connects impact crusher and vibrating screens to remove small rebar, binding wires and nails. The crushed material will be screened through vibrating screens. Greater than 60mm fractions is re-circulated for crushing whereas, less than 60mm fractions is sent to the feed hopper of the wet processing system. Aggregates from the hopper is fed to the Prograde rinsing screen, where aggregates are washed with water to improve the quality and to retrieve the fine particles which in turn is sent to dual sand Evowash. The rinsing screen is provided with a high pressure jet washing system which ensures thorough rinsing of the aggregates and removes a large amount

of the fines below 3mm from the feed. Aggregates from the rinsing screen is fed to the log washer where it undergoes intense scrubbing in wet state and removes the light contaminants such as wood and plastic. Aggregates from the log washer moves to the dewatering screen, where dewatering of water will takes place. From the dewatering screen aggregates moves to the Prograde sizing screen, where aggregates will be screened into different fraction of sizes (>20mm, 10 to 20mm, 3 to 10mm and 3mm to 75µ).Greater than 20 mm sized aggregates is sent back to the crusher for further size reduction and retrieved fine particles (< 3mm) is sent to the Dual sand Evowash to recover sand from the soil (< 3mm to > 75µ). The washed water and fines (<75µ) is fed into the aqua cycle high rate thickener for recycling. In Aqua cycle thickener, the flocculent is added in controlled quantities to aid the settlement of sludge. The settled sludge is sent to the filter press to squeeze the water. Filter cakes of 80% dry solids are dropped into bay as final waste which can be used for brick making or landscaping. Finally the recycled water is released from the thickener to water tank. Fig 8 shows the pictorial representation of recycling process of C&D waste by wet processing system. The process energy of wet processing system is worked out. Table 7 and 9 represents the pre-crushing and crushing phase energy calculation in a wet processing system respectively.

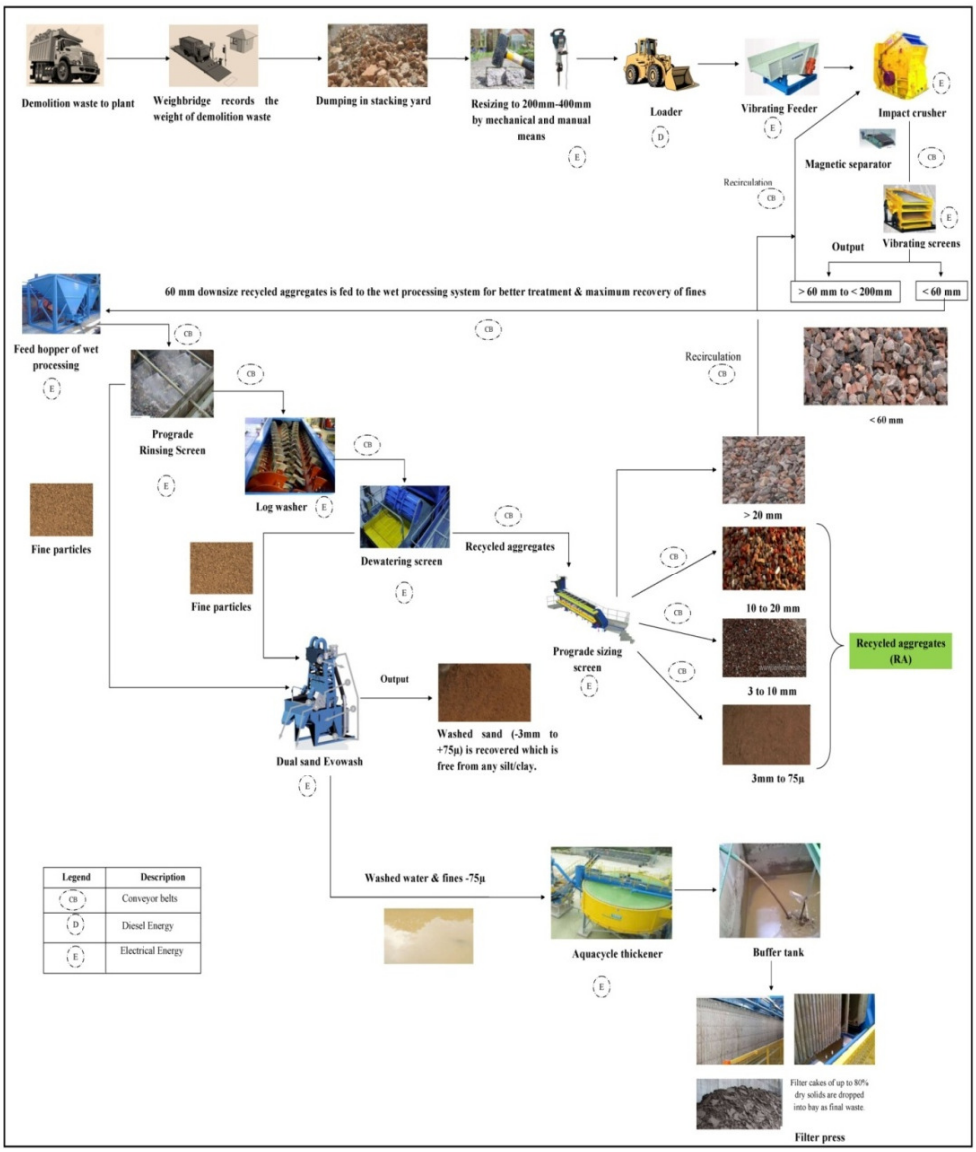

Figure 8. Pictorial representation of recycling process of C&D waste- Wet processing system
Source: Rakesh S, 2018

Table 9. Crushing phase energy calculations -Wet processing system

Equipment	Production capacity (t/hr)	Feed size (mm)	Power consumption rate - kWh (P)	No of equipment	Electricity use for 8hrs	Unit
Vibrating feeder	125	-	6.6	1	52.8	kWh
Impact crusher	150	600	185	1	1480	kWh
Magnetic separators	-	-	6.2	1	49.6	kWh
Vibrating screens	125	-	18.5	2	296	kWh
Conveyor Belts	-	-	4.5	3	108	kWh
Feed hopper	125	-	5.5	1	44	kWh
Prograde rinsing screen	150	-	15	1	120	kWh
Log washer	250	-	112	1	896	kWh
Dewatering screen	150	-	5	1	40	kWh
Dual sand Evowash	150	-	55	1	440	kWh
Prograde sizing screen	< 250	-	37	1	296	kWh
Conveyor belts	-	-	4.5	8	288	kWh
				Total electricity use in kWh =	4110.40	kWh
				Total energy use in MJ= 4110.40 x 16.30=	66999.52	MJ
				Total energy use in MJ/ton=	67.0	MJ/t
				Total process energy = Pre-crushing phase energy use (Table 7) + Crushing phase energy use (PE2) =	71.93	MJ/t
Wet processing equipment technical specifications from CDE global, 2016						

In the dry processing system, pre-crushing phase consists of breaking down of the large concrete pieces as per the feed size of the crushers by hand held drillers and loading it into vibrating grizzly feeder by the aid of loaders. This energy was found to be 4.93MJ/ton. Crushing phase energy which consists of crushing and screening operations was found to be 32MJ/ton. Therefore, the total energy (pre-crushing phase and crushing phase energy) for processing the demolition waste to produce recycled aggregates in a dry processing system requires about 36.93MJ/ton. Similarly for wet processing system, pre-crushing phase and crushing phase energy was found to be 4.93MJ/ton and 67.0MJ/ton respectively and the energy for processing the waste in a wet processing system (pre-crushing phase and crushing phase energy) requires 71.93MJ/ton.

EMBODIED ENERGY OF RECYCLED AGGREGATES

Embodied energy of recycled aggregates is obtained as the sum of demolition energy, transportation energy and process energy. The embodied energy of recycled aggregates is computed by considering the two processing systems i.e. dry processing system and wet processing system. The embodied energy of recycled aggregates obtained from the demolition of buildings in case studies 1, 2 and 3 has been computed. Table 10 gives the embodied energy calculations for all the three case studies. Embodied energy of recycled aggregates computed was found to be in the range of 88.68MJ/ton-135.63MJ/ton and 125.52MJ/ton- 172.48MJ/ton for dry processing system and wet processing system respectively.

Table 10. Embodied energy calculations

SL. No	Description	Notation	B 1	B 2	B3
a.	Volume of demolition debris, m^3 (from table 6)	Vdw	2304.32	183.53	812
b.	Weight of demolition debris that dumper carries, kg	W	17000	17000	17000
c.	Volume of dumper ,m^3	V	14	14	14

d.	Bulk density of demolition debris, kg/m³	ρ dw	1200	1200	1200
e.	Total quantity of demolition debris generated in tons (Wdw = ρ dw x V dw)	Wdw	2765.18	220.24	974.4
f.	Demolition energy in MJ (from table 5)	DE	169041.60	3715.20	47597.60
g.	Transportation energy in MJ (from table 6)	TE	85140.0	6706.32	29920.52
h.	Process energy -Dry processing system in MJ/ton (from table 8)	PE1	36.93	36.93	36.93
i.	Process energy–Wet processing system in MJ/ton (from table 9)	PE2	71.93	71.93	71.93
j.	Dry processing system:-Total energy consumed to generate, transport and process the Wdw tons of demolition waste by dry processing system to produce a recycled aggregates in MJ, E1 = [(DE + TE)+ (PE1 x Wdw)]	E1	356299.70	18554.98	113502.71
k.	Wet processing system:-Total energy consumed to generate, transport and process the Wdw tons of demolition waste by wet processing system to produce a recycled aggregates in MJ E2 =[(DE + TE) + (PE2 x Wdw)]	E2	453081.0	26263.38	147606.71
j.	Quantity of recycled aggregates produced in tons , η = 95% [15] (QRA = 0.95 x Wdw)	QRA	2626.92	209.23	925.68
k.	Embodied energy of recycled aggregates- MJ/t, dry processing system. ERA1 = E1 / QRA	ERA1	135.63	88.68	122.62
l.	Embodied energy of recycled aggregates- MJ/t ,wet processing system ERA2 = E2 / QRA	ERA2	172.48	125.52	159.46

RESULTS

The present study attempted to compute the demolition energy, transportation energy, process energy and embodied energy of recycled aggregates from the three case studies selected in Bengaluru city. The recycling processes considered are (i) Dry processing system and (ii) Wet processing system. The embodied energy of recycled aggregates per unit weight was computed by adopting both the systems.

The breakup of different types of energy namely demolition energy, transportation energy and process energy for the three case studies are presented in table 11. The results of embodied energy of recycled aggregates produced from the two recycling techniques are shown in table 12. The percentage variation for the three case studies by adopting the two types of processing systems is presented in figure 9.

Table 11. Breakup of different types of energy				
S.No	Type of energy	B1	B2	B3
i.	Demolition energy, MJ/m²	73.77	22.22	85.39
	Demolition energy, MJ/m3	73.36	20.24	58.62
	Demolition energy, MJ/t	61.13	16.87	48.85
ii.	Transportation energy, MJ/t	30.79	30.45	30.71
	Transportation energy, MJ/t/km	0.77	0.76	0.77
iii.	Process energy, MJ/t a. Dry processing system b. Wet processing system	 36.93 71.93	 36.93 71.93	 36.93 71.93

Table 12. Results of Embodied energy of Recycled aggregates				
S.No	Type of energy	B1	B 2	B 3
i.	Demolition energy, MJ/t	61.13	16.87	48.85
ii.	Transportation energy, MJ/t	30.79	30.45	30.71
iii	Process energy, MJ/t Dry processing system Wet processing system	 36.93 71.93	 36.93 71.93	 36.93 71.93
iv	Embodied energy of recycled aggregates, MJ/t η = 95%[15]			
	a. Dry processing system	135.63	88.68	122.62
	b. Wet processing system	172.48	125.52	159.46

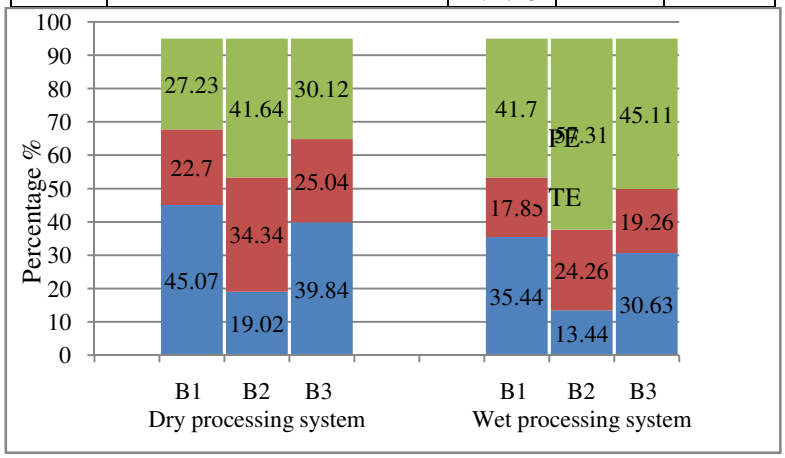

Figure 9. Percentage variation of different energies
Source: Rakesh S, 2018

COMPARISON WITH OTHER STUDIES

The findings of the present study is compared with earlier investigations and presented in table 13. It can be observed that the embodied energy figures are inconsistent due to dissimilarity in study area, various system boundary considerations, process involved, transportation distance, variation in energy source of machineries/equipment and energy calculations in terms of primary and delivered energy. Hence, it should be noted that a direct apple to apple comparison is not possible between different energy studies (Md. Uzzal Hossian, 2016).

It is noted that from the previous studies, the embodied energy of recycled aggregates is in range with 38.06MJ/ton to 250MJ/ton (Md. Uzzal Hossain et al., 2016, Stefania Butera et al., 2015, Marco Quattrone et al.,2014, Isabela Maria Simion et al., 2013, Andrea Blengini et al., 2010 and Milad Ghanbari et al., 2017) whereas, from the present study, the embodied energy of recycled aggregates produced by dry processing system is in the range 88.68 MJ/t to 135.63 MJ/t and from the wet processing system it is 125.52-172.48MJ/t . The variation in energy values from the previous studies and present study is due to differences in transportation distances, considerations of various system boundaries, waste management systems and recycling processes.

Table 13. Comparison with other studies

Author	Study area	EE, MJ/t	System boundary
Natural aggregates-NA			
Varsha BN et al.(2017)(Coarse & fine aggregates)	India Iran	119 96.40	Cradle to gate Process energy
Milad Ghanbari et al (2017)(Natural aggregates)	India	71	Cradle to gate
B Surekha et al. (2016) (Coarse aggregates)	Hong Kong	496-518	Cradle to site
Md.Uzzal Hossain et al.(2016) (Crushed stone)	Hong Kong	341	Cradle to site
Md.Uzzal Hossain et al. (2016) (River sand)	India	62	Cradle to gate
K. I Praseeda et al.(2015) (Crushed aggregates)	Italy	1664	Cradle to gate
Isabela Simion et al. (2013) (Natural aggregates)	India	220	Cradle to site
AVEI (Auroville Earth Institute) (Natural aggregates)[29]			
Recycled aggregates-RA	Iran	38.06	Process energy
Milad Ghanbari et al (2017)	Hong Kong	211-235	Cradle to site
Md. Uzzal Hossain et al. (2016)	Denmark	145	Cradle to site
Stefania Butera et al.(2015)	Brazil	39.76	Process energy
Marco Quattrone et al.(2014) (Recycled fine & Coarse aggregates)	Brazil	113.60	Process energy
Marco Quattrone et al (2014) (Recycled coarse aggregates)	Italy	246	Cradle to gate
Isabela Maria Simion et al.(2013)	Italy	250	Cradle to site
Andrea Blengini et al.(2010)	India	88.68-	Cradle to gate
Present study (RA from Dry processing system)	India	135.63	Cradle to gate
Present study (RA from Wet processing system)		125.52-172.48	

Md.Uzzal Hossain (2016) considered 85-95km transportation distance and cradle to site system boundary, whereas the present study considered 40km and cradle to gate. Marco Quattrone (2014) and Milad Ghanbari (2017) considered only the process energy and reported that the energy required to produce the recycled aggregates from the C&D waste by dry processing system involves 39.76 MJ/ton and 38.06MJ/ton respectively. From the present study, 36.93MJ of energy is required to produce 1 ton of recycled aggregates through the dry processing system. Md. Uzzal Hossain (2016), considered the sorting energy, whereas it was not considered in the current study. Hence the difference in recycling process resulted in variation of embodied energy values.

DISCUSSIONS AND CONCLUSIONS

The computed demolition energy for the three case studies (building 1, 2 and 3) are 22.22MJ/m² for case study building 2 (load bearing structure) and 73.77MJ/m2 , 85.39MJ/m2 for case studies building 1 and 3 (RCC framed structure). The variation in demolition energy results is due to predominate use of machineries at building 1 and 3, whereas at building 2 manual demolition (hand demolition) was adopted. Load bearing structures require less energy to demolish than RCC structures because of lower structural resistance requires comparatively less machine time. In case of RCC framed structures, considerable energy is required to dismantle the beam and column members to smaller pieces. Diesel Energy for transporting the demolition debris from the source of generation to recycling plant (40 km) requires approximately 31 MJ/t. Energy (Diesel and Electricity) for processing the demolition waste to produce recycled aggregates by dry processing system requires about 36.93MJ/t, whereas by wet processing requires about 71.93MJ/t. The embodied energy of recycled aggregates produced from dry processing system is in the range of 88.68MJ/t to 135.63MJ/t, whereas for recycled aggregates produced from wet processing system is in the range of 125.52-172.48MJ/t. The range of embodied energy of recycled aggregates from the literature is 38.06 MJ/t to 250MJ/t (Md. Uzzal Hossain et al., 2016, Milad Ghanbari et al., 2017, Isabela Maria Simion et al., 2013, Stefania Butera et al., 2015, Marco Quattrone et al.,2014, Andrea Blengini et al., 2010). The variation in energy values from the literature review and present study is due to the several factors explained in section 9 of this paper. The embodied energy of recycled aggregates produced from wet processing system is between 27-42%higher than that required for a dry processing system. Embodied energy of recycled aggregates obtained in the present study by cradle to gate approach is higher when compared to embodied energy of natural aggregates obtained from Indian literature which is in the range of 62-119MJ/ton (B Surekha et al., 2016, Varsha BN et al., 2018 and KI Praseeda et al.,

2015). Even though the energy content in recycled aggregates is higher, it is sustainable to use recycled aggregates as it saves a huge amount of natural resources.

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Local and Distortional Buckling Behavior of Cold Formed Steel Built Up Beams

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Abstract: This paper deals with numerical investigation of distortional buckling and local buckling behavior of the built up beams composed of sigma section was conducted. Cold formed steel has good scrap value and is recyclable making it a sustainable construction material. The sectional capacity of the plate elements are improved by the provision of longitudinal stiffeners. Doubly symmetric built-up sections, has the additional advantage of larger torsional rigidity. Hence the analysis deals with the structural behaviour of Cold-Formed built-up beams, composed of double sigma section connected by screws at web. The sections for parametric study were selected based on the Eurocode specifications (EN 1993-1-3 (2006)). The sections of constant length and three different aspect ratios were numerically analyzed with three different yield stresses such as 250, 350 and 450 MPa using ABAQUS software. Comparison was done for the numerical results from the ABAQUS software and the theoretical results obtained from the direct strength method. The sectional properties were obtained from GBTUL software and theoretical studies were done by Direct Strength method in accordance with AISI-S100:2012. Based on the acquired results, the numerical and theoretical results were compared and discussed.

Key words – Local buckling, Distortional buckling, Built up beam,longitudinal Stiffeners,Yield stress.

INTRODUCTION

The steel structures which are subjected to light and moderate loads, cast by hot-rolled sections tend to be uneconomical. The usage of cold formed steel (CFS) members reduces the cost of a building. Material hardness and ducltility are increased significantly by cold rolling and annealing respectively. CFS as a construction material has many advantages. As a uniformly manufactured product, the quality of CFS is also very consistent. That consistency translates into less scrap to haul off because there is less waste.

LITERATURE STUDY

The Literatures were collected based on the previous investigations in the research works of cold-formed steel built-up sections. Dolamune Kankanamge (2012) found European design rules to be conservative in comparison with the design rules predicted using Australian/New Zealand and North American. Hence, based on the available FEM analysis results, the equations were modified to give safe results. Ilker Kalkan (2011) investigated the distortions in web elements and suggested that inclusion of reductions for torsional rigidity is needed in existing code equations.

Mohammad Reza Haidarali (2012) studied the influence of web stiffner of CFS beams. In this paper, Yuanqi Li (2014) studied behavior of beam composed of two C-section by self-drilling screws at flanges . Wang L et al. (2014) investigated the simply supported beams reported about the failures and moment capacity, under both four-point bending and three-point bending. Liping Wang (2015) studied the distortional and local buckling behavior under bending on built-up sections with intermediate stiffeners. For assembled closed and open sections with web stiffeners under bending suitable design rules has been developed.

SPECIMEN LABELLING AND ITS PROPERTIES

The Built up beam double sigma section connected by screws at the web, thickness of section 1.5, 2.0, 2.5mm. Sigma sections were placed back to back at web portion shown in fig.1 (a) and Length of the specimen is 2000mm with constant moment span of 1000mm. As shown in fig. 1(b) end condition specified is simply supported. The spacing of screws was kept as 90 mm throughout the length. All the beams were designed to fail by distortional & local buckling. The specimens were analyzed for three different yield stresses 250, 350 & 450 MPa.

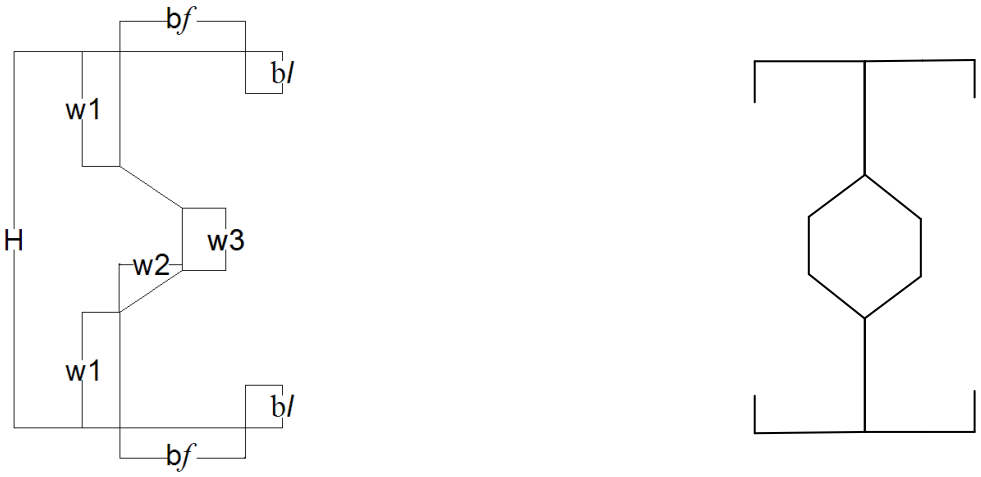

Figure1. (a) Specimen Details

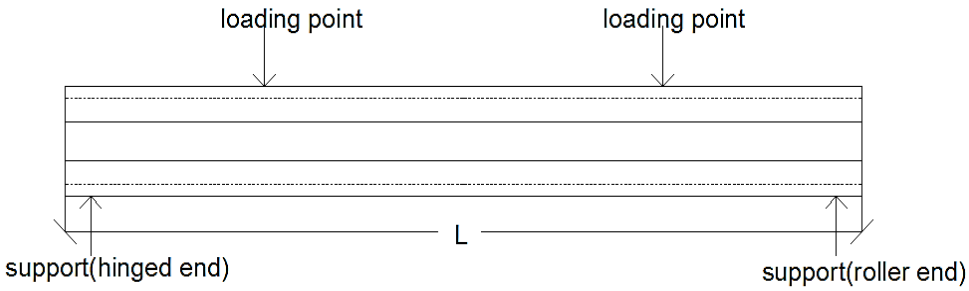

Figure1. (b) - Specimen side view

LABELLING OF SPECIMEN

The specimens considered were labelled based on height, breath of flange and thickness. Labelling indicating outside dimensions of section with all values in mm, For example, in specimen UU-80-160-1.5, the first term 80 indicates the outer width of the section, 160 indicates the overall height of the section and the last term 1.5 indicates thickness of plate in mm respectively. Various specimens shown Table.1

Table 1. Section Geometric Details

S. No.	Specimen	D/B	Lip	Flange	Web				Thickness
			b_l(mm)	b_f (mm)	h_w (mm)	w_1(mm)	w_2 (mm)	w_3 (mm)	T (mm)
1.	UU - 80X160X1.5	2.0	20	40	160	40	32	30	1.5
2.	UU - 80X160X2.0	2.0	20	40	160	40	32	30	2.0
3.	UU - 80X160X2.5	2.0	20	40	160	40	32	30	2.5
4.	UU - 120X180X1.5	1.5	20	60	180	50	32	30	1.5
5.	UU - 120X180X2.0	1.5	20	60	180	50	32	30	2.0

6.	UU - 120X180X2.5	1.5	20	60	180	50	32	30	2.5
7.	UU - 120X270X1.5	2.25	20	60	270	95	32	30	1.5
8.	UU - 120X270X2.0	2.25	20	60	270	95	32	30	2.0
9.	UU - 120X270X2.5	2.25	20	60	270	95	32	30	2.5

FINITE ELEMENT MODELLING AND VALIDATION

GENERAL

To verify the test results, numerical models were analyzed using the ABAQUS software and parametric analysis was conducted. This method of analysis has an advantages of that it can take care of any boundary and loading conditions. It establishes accurate FEM models for CFS built-up beam subjected to transverse load.

ELEMENT MODELLING

The finite element modeling was developed on the basis of four-point bending test. S4R shell elements are used to model the components specifying elastic modulus 210GPa and poisson ratio 0.3 for the cold-formed steel sections. All components were modelled elastic-perfectly plastic. The yield stress of the material is varied as 250, 350 and 450 MPa.

BOUNDARY AND LOADING CONDITIONS

The boundary conditions were defined at the end of the section based on the support conditions. The simply supported end condition of the beams was modelled as restricting rotation about the y and z-axis, and translations in x, y & z directions. A concentrated load was applied at the transverse loading reference point.

VALIDATION

Wang et al. (2015) studied the the distortional and local buckling behavior of simply supported beams with length 1310 mm. The built-up beams used were closed and open sections providing stiffeners. Based on the sectional configuration of the specimens, sufficient number of connectors were provided at flanges or webs which may barely affect distortional buckling. Modified design rules were adopted for those cold-formed steel doubly symmetric built-up sections under bending in the companion paper. The FEM analysis results observed are shown in Table 2 and it was found similar as given in the literature, thus validating the numerical model.

Table 2. Results for Four-Point Bending Tests

Specimens	Literature paper value (kN mm)	Results for ABAQUS Software (kN mm)	Failure mode
OI-1.0-B4-a	6,092	6,104	D & F

Note: D = distortional buckling; F = flexural buckling;



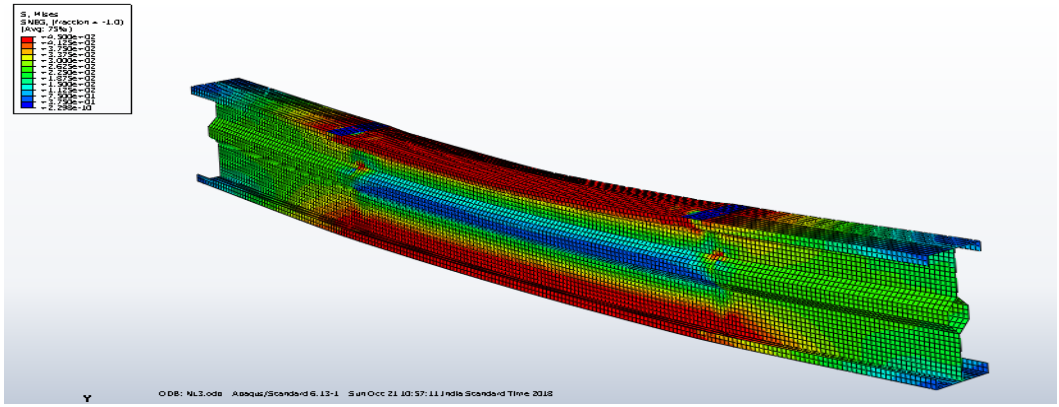

Figure2. Experimental and numerical observation comparisons

PARAMETRIC STUDY

Extensive parametric study was carried out using ABAQUS 6.13 for the verified FE model. Various cross section dimensions were selected by varying breadth to depth ratio. Different yield stress were considered for parametric study. The thickness of the specimens varied in the study are 1.5, 2.0 & 2.5 mm. All of the UU specimens were modelled with the length of 2000mm and constant moment span of 1000mm under four point bending. The numerical study has been conducted for 27 specimens which were selected to study local & distortional buckling. Fig.3 shows the non-linear analysis results.

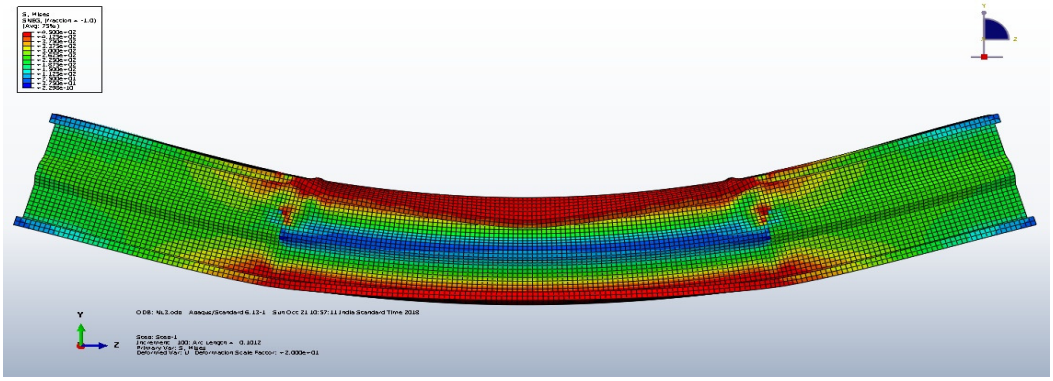

Figure3. Results from Non-Linear analysis

NUMERICAL ANALYSIS

The numerical studies have been carried out in the elastic as well as in the plastic ranges of loading. The specimens with constant moment span of 1000mm, were loaded under four point bending. Totally 27 specimens were analysed using ABAQUS 6.13. The numerical method mainly focused on linear & non-linear analysis. The specimens were observed to fail by distortional and local buckling.

THEORETICAL ANALYSIS

The properties of the sections were found out using GBTUL software to calculate the DSM values.The ABAQUS results predicted from DSM were compared with the theoretical results. The sections subjected to distortional & local buckling is evaluated.

COMPARISON OF NUMERICAL AND THEORETICAL RESULTS

Finally the obtained numerical value by using ABAQUS software, MFEA and theoretical value find out using DSM, MDSM were compared. The ratio of FEA-predicted strength to DSM predicted strength, MFEA / MDSM was found to be 1.135. Thus, for the adopted cross-section, the design predictions of DSM equation was found to be conservative and safe which are shown in Fig.4 & Fig.5

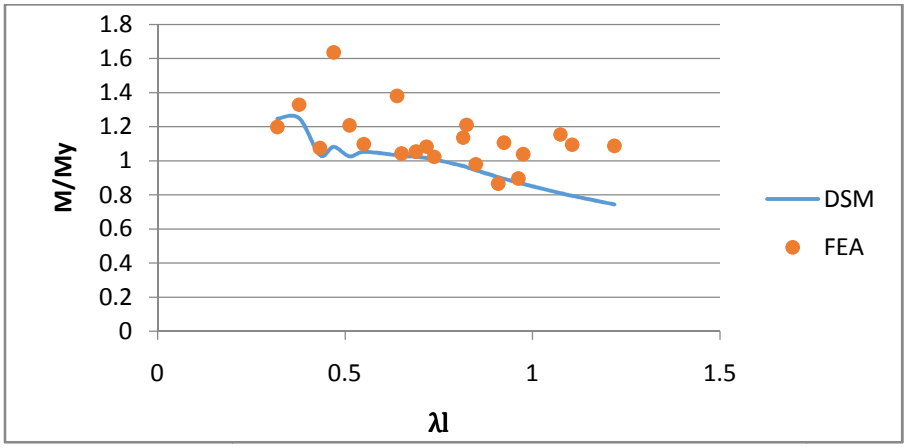

Figure4. Graph for Local buckling

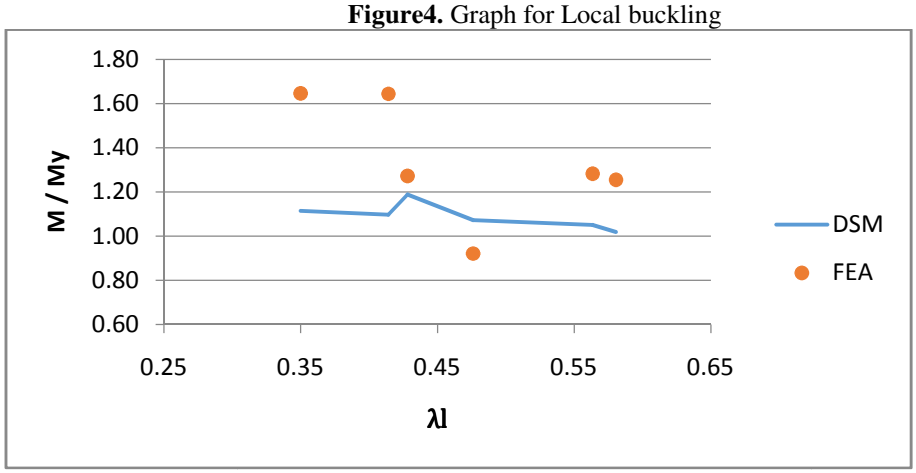

Figure5. Graph for Distortional buckling

CONCLUSION

This paper analyzed the moment capacities of cold formed steel section. Parametric study was done for various sections and it was inferred that the failure modes are local & distortional buckling. Based on the aspect ratios and yield stresses the strengths were predicted by both numerical analysis and theoretical analysis. DSM equation turned to be conservative and safe for most of the sections, hence can be adopted.

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Study on Structural Properties of Fibre Reinforced No Fine Concrete

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Abstract: No Fines Concrete (NFC) is an extremely sustainable, environmentally friendly material which creates an open cell structure due to the absence of fine aggregates which allows permeability in it. This kind of concrete is used for construction of parking lots, residential streets, sidewalks, and pathways in apartment, etc., where the load concentration is considerably low. Other than this it can also used for controlling landslide in hilly areas and used as non-structural wall panels in precast buildings. Generally the voids ratio in NFC varies between 10-30% with respect to the compressive strengths of 3.5 MPa to 28 MPa. This paper makes an attempt to put forth the study on Structural properties of Fibre Reinforced No Fines Concrete (FRNFC). It includes the comparison of structural properties of FRNFC with 5% of Polypropylene fibre, partially replaced with Surface Rubbed Ceramic Tile (SRCT) waste to the corresponding properties of FRNFC with 5% of Polypropylene fibre, partially replaced with Recycled Concrete Aggregates (RCA), in order to review the quality for replacement. It is observed that the mixes with 20% of SRCT & 50% of RCA perform better in the strength parameters for 7,14 and 28 days. And overall, 20% of surface rubbed ceramic tiles achieve a compressive strength of 16 MPa and a Flexural strength of 7.76 MPa at the end of 28 days result. From this it is inferred that the replacement of coarse aggregate with SRCT improves the structural properties of FRNFC without affecting its coefficient of permeability.

Keywords: No Fine concrete, Porosity, recycled concrete aggregate, surface rubbed ceramic tiles, Fibre Reinforcement, Compressive Strength.

INTRODUCTION

No Fine Concrete (NFC) is a key solution to address the storm water runoff that observed more in the coastal areas like Chennai due to the illegal construction of Residential and Commercial Buildings in the vast network of water bodies, as an effect of Continuous urbanization. Due to low compressive strength the applications of NFC is limited for light loading Conditions. This project includes the comparison study of Structural Properties of Fibre Reinforced No Fine Concrete (FRNFC) partially replaced with Surface Rubbed Ceramic Tiles (SRCT) and Recycled Concrete Aggregates (RCA), to study the quality for replacement. In this extension, 5% of Polypropylene fibre is taken for increase bonding between the coarse aggregates of varying proportion. It is expected that the partial replacement of coarse aggregate in NFC improves the structural properties like compressive strength, flexural strength, without affecting the porosity. So, this research projects objective is to attain porosity as well as high strength compared to conventional NFC.

In this present study experimental investigation was done on FRNFC using coarse aggregate of size 8–12 mm with partial replacement by 10%, 20%, and 30% of SRCT of 10mm and also by 0%, 50%, and 100% of RCA of 8–12 mm in the percentage of Coarse aggregate. The performance of above mixes was studied; under the ages of 7, 14 and 28 days in addition permeability property of the mixes was also studied. And the test result shows that FRNFC with 20 % SRCT perform very well under compression and flexural testing.

In case of Porosity FRNFC with 50 % of RCA has high permeability coefficient. But still the permeability coefficient of FRNFC with 20 % of SRCT is also acceptable.

BACKGROUND

As such NFC (Pervious Concrete) technology is not new. This technology was first used in United Kingdom in 1852 (Ghafoori and Dutta, 1995). It is said that Europeans first recognized the insulating properties in structural pervious concrete. They also used pervious concrete for paving.

In 1923 porous concrete begins to resurface as a viable construction material. And it was limited to the construction of 2 story structures in Scotland, Liverpool, London and Manchester, Mr VR Patil et al (2013).

As porous concrete requires lesser cement content than conventional concrete and at the same instance cement was scarcely available those days. The porous concrete was found to be popular material for construction in Venezuela, West Africa, Australia, Russia and the Middle East. (Wanielista et al 2007).

Utilization of razed concrete waste in receptive concrete by exchange some of coarse combination provides short term compressive strength And it'll decrease with increase in razed concrete waste content whereas it's effecting porousness. In receptive concrete DCW can't be use as full replacement of coarse combination. we should always use it as partial replacement of coarse combination and therefore the DCW content mustn't be over 5-10%.

The pervious concrete after World War II, it was initially seen using at Florida and other southern states. Ready mix producers started producing the pervious concrete product. The porous concrete was widely applied as cast-in-situ non-structural walls of single and multi-storied buildings. Now a days the porous concrete was used in high-rise buildings also, and at recent times it is being used in Strom Water Management for better control.

MATERIAL PROPERTIES

CEMENT

Cement is manufactured by burning a mixture of siliceous (silica), argillaceous (alumina) and calcareous (lime) material in a partial fusion taken in a definite proportion, at a temperature of 1400 to 1450°C. Ordinary Portland cement- 53 grade cement was used in the present investigation. The choice of Ordinary Portland cement for high strength concrete is extremely important. Different brands will have different strength development, Zuari cement was used in the test.

NATURAL AGGREGATE

8-12mm down size natural aggregate were used which met the grading requirement as per IS 2386.

SURFACE RUBBED CERAMIC TILES (SRCT)

10mm of surface rubbed Ceramic Tile pieces are collected from the demolition waste, these aggregates are subjected to laboratory tests and the test result was given in table 2.

RECYCLED CONCRETE AGGREGATE (RCA)

Recycled concrete aggregates were collected by breaking the waste tested specimens that were dumped near the laboratory. The aggregates obtained were properly washed and tests were carried out.

POLYPROPYLENE FIBRE

Polypropylene fibres are used to increase the bonding strength, it is made up of crystalline and non-crystalline regions. The diameter of the Polypropylene fibre chosen varies from fractions of a micrometer to centimeters in diameter.

Table 1. Fibre Properties

Tensile Strength (gf/den)	3.5 to 5.5
Abrasion resistance	Good
Elongation (%)	40 to 100
Moisture absorption (%)	0 to 0.05
Chemical resistance	Excellent
Relative density	0.97
Thermal conductivity	6.0 (with air as 1.0)
Softening point (ºC)	135
Melting point (ºC)	160
Electric insulation	Excellent
Resistance to mildew, moth	Excellent



Figure1. Polypropylene fiber

CHEMICAL ADMIXTURE

Chemical admixtures are the admixtures when added to green concrete enhance the properties of concrete. Type of admixture used in this research is type-F admixture (High range water reducer). Commercial Name: CONPLAST SP 430.

MATERIAL TEST RESULT

Table 2. Material Test Result for Coarse Aggregate

Material Property	Natural Aggregate	SRCT	RCA
Specific Gravity	2.78	2.22	2.73
Water Absorbtion	0.30	0.45	0.60
Fineness Modulus %	2.65	2.88	3.58
Impact Value %	17.39	28.14	37.51
Abrasion	3.58	2.68	6.26

CONCRETE MIX

The conventional concrete as is known is a mixture of aggregates, cement and water. Cement paste is composed of cement and water and whereas aggregates are of coarse and fine ones. The cement paste actually coats on the aggregates and forms a coherent mass known as Concrete. This concrete when freshly mixed can be molded into any shape. It is therefore called as plastic and it becomes strong and durable when it gains strength and is known as hardened concrete. In case of NFC, due to the absence of Fine aggregates, it requires careful proportioning and mixing of the ingredients to achieve desired workability and required durability for the fresh concrete and for the strength of hardened concrete respectively.

The concrete mix design has been made for various percentage replacement of natural aggregate by SRCT and RCA. IS 10262:2009 was followed for proportioning of concrete mix. Tests were conducted for 7, 14 and 28 days against Strength Parameters. Seven Mixes were prepared as given in the table.3

Table 3. Mix Proposition in Kg/m3

Materials	Conventional FRNFC	Surface Rubbed Ceramic Tiles			Recycled Coarse Aggregates		
		10%	20%	30%	25%	50%	100%
Mix Number	M1	M2	M3	M4	M5	M6	M7
Cement	390	390	390	390	390	390	390
Coarse Aggregate	1997	1798	1598	1398	1498	998	-
SRCT	-	199	399	599	-	-	-
RCA	-	-	-	-	499	999	1997
Polypropylene Fibre	19.5	19.5	19.5	19.5	19.5	19.5	19.5
Super Plasticizer	3	3	3	3	3	3	3
Water	156	156	156	156	156	156	156

PREPARATION, CONSERVATION & TESTING OF SAMPLE

The samples were prepared and cured for required period of time and the test results were taken. The samples can be either conserved in curing tanks or in a humid temperature (moist curing) for a period of 7, 14 and 28 days. In case of NFC moist curing is recommended. Generally aggregate to cement ratio for NFC is considered to be 5:1. The samples are tested for compressive strength, flexure strength and permeability coefficient.

I) COMPRESSIVE STRENGTH

It is a property that primarily meant to withstand compressive stress and can be used as an approximate qualitative measurement for other properties of concrete. Compressive strength test is carried out on cubes for various mixes T1, T2, T3,etc., on the 7,14 and 28 days. The test results were showed in table 4.

Table 4. Test Result for Compressive Strength

Compressive Strength (Age)\	Conventional NFC M30	Fibre Reinforced No Fine Concrete (FNFC) with 5% Polypropylene fibre					
		SRCT			RCA		
	T1	T2	T3	T4	T5	T6	T7
		10%	20%	30%	25%	50%	100%
7 days	2.55	4.87	5.47	4.81	3.95	4.96	3.44
	3.04	5.02	5.23	4.56	3.78	4.55	3.81
	2.96	5.11	5.89	4.75	4.17	4.67	3.58
Average	2.85	5.00	5.53	4.70	3.96	4.72	3.61
14 days	5.83	9.18	10.69	8.50	7.20	8.09	7.31
	5.51	9.54	10.71	8.44	6.89	8.02	7.07
	5.60	9.23	10.43	8.46	7.60	7.92	7.14
Average	5.64	9.31	10.61	8.46	7.23	8.01	7.17
28 days	8.92	14.53	15.84	13.07	13.20	13.37	12.33
	9.11	14.60	16.38	13.91	12.84	13.91	12.82
	8.69	14.43	15.91	13.87	12.51	13.53	12.47
Average	8.90	14.52	16.04	13.62	12.85	13.60	12.54

II) FLEXURAL STRENGTH

The flexural strength is a property of concrete measured with three-point load. The fulcrum with span of 240 mm is subjected to a load rate about 0.1–0.2 MPa/s. Three samples for each group are tested and the test results were showed in table 5.

Table 5. Test Result for Flexural Strength

Flexural Strength (Age)	Conventional NFC M30	Fibre Reinforced No Fine Concrete (FNFC) with 5% Polypropylene fibre					
		SRCT			RCA		
	T1	T2	T3	T4	T5	T6	T7
		10%	20%	30%	25%	50%	100%
7 days	2.13	3.42	3.88	3.21	2.76	3.73	3.14
	2.27	3.81	4.14	3.03	3.01	3.28	2.98
	2.05	4.04	3.71	3.64	2.69	3.57	3.10
Average	2.15	3.75	3.91	3.29	2.82	3.53	3.07
14 days	2.98	4.93	5.69	4.61	3.69	5.17	4.55
	3.12	5.38	6.34	4.57	4.71	5.34	4.17
	3.08	5.17	5.91	4.86	3.70	5.74	4.09
Average	3.06	5.16	5.98	4.68	4.03	5.41	4.27
28 days	3.78	6.86	7.83	5.98	5.34	6.02	6.23
	3.96	6.69	7.62	6.57	5.97	6.44	6.12
	3.85	7.03	7.85	6.42	5.64	6.35	6.06
Average	3.86	6.86	7.76	6.32	5.65	6.27	6.13

III) PERMEABILITY COEFFICIENT

The water permeability coefficient is the ratio of height of penetration with respect to the time interval. The test procedure for Coefficient of Permeability includes the experimental setup as shown in figure 2. The sample was covered with wax in the direction perpendicular to the water penetration. After sometime the wax will became cold and hard, and at once water was poured into the setup. When the water level reached 200 mm in the measuring jar, wait until the water level decreased to 180 mm, after that the timer was started. When the water level reached 160 mm, the timer was stopped. The water permeability coefficient (k) can be given by.

$$k = H/t$$

where k is the water permeability coefficient (mm/s), where H is the water level from 180 to 160 mm (20 mm), and t is the time (s) taken for water to penetrate from 180 to 160 mm.

Table 6. Coefficient of Permeability

Sl.No.	Mixture Name	Coefficient of Permeability mm/s
1	T1	5.1
2	T2	5.9
3	T3	8.2
4	T4	7.6
5	T5	6.2
6	T6	10.4
7	T7	6.6

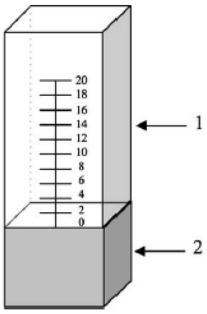

Figure 2. Permeability Meter

RESULT & DISCUSSION

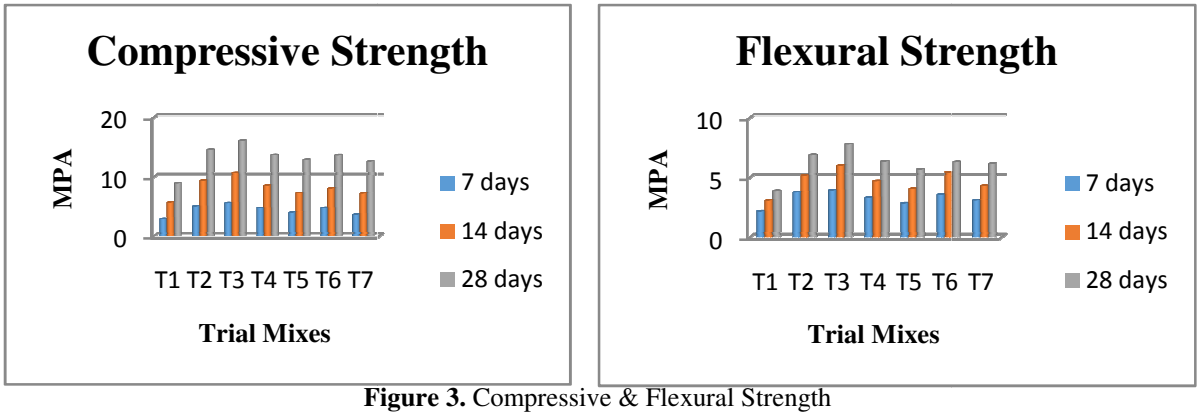

Figure 3. Compressive & Flexural Strength

The above results (Figure.3) shows that the compressive strength and flexural strength at 7, 14 and 28 days is highest for T3 (i.e., coarse aggregate is partially replaced by 20% of SRCT). The water Permeability test is carried out on cubes for various mixes T1, T2, T3,etc., and the results were showed in Figure 4.

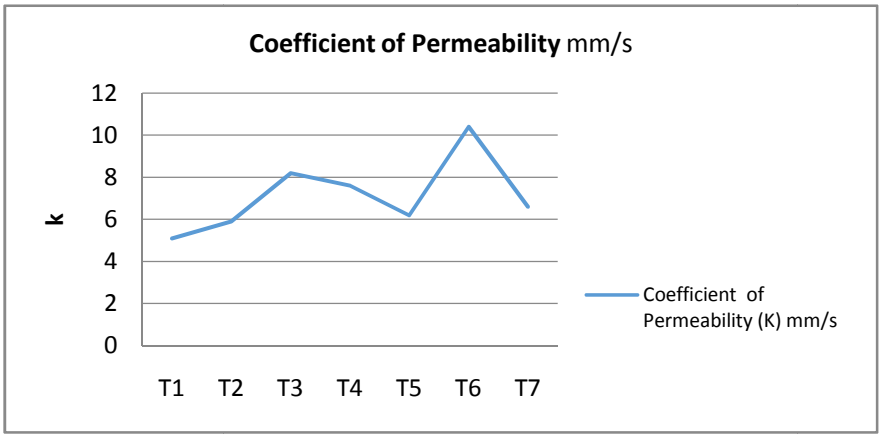

Figure 4. Coefficient of Permeability

1. Effect of the SRCT & RCA aggregate on the properties of FRNFC
2. The use of SRCT & RCA resulted in improvement of both compressive strength and Flexural strength of FRNFC but to a limited extent only.
3. Effect of Polypropylene Fibre on the properties of FRNFC
4. Using Polypropylene Fibre in the NFC enhances the strength greatly by creating a better bond in between the natural aggregate and replaced aggregate. However high dosage will result in poor workability.

CONCLUSION

Based on the obtained data the following conclusions were drawn, the use of SRCT & RCA resulted in improvement of both compressive strength and permeability of pervious concrete but to a limited extent only. Due to high voids content in NFC, it is not easy to get high percentage of compressive strength, by using the ordinary proportion of mixture. The use of small aggregates can increase the strength of this kind of concrete. At the same time, the quantity of cement must be adjusted with respect to the aggregate size. The RCA replacement level of 50% has achieved a considerable high strength than conventional Fibre Reinforced No Fine concrete, whereas the SRCT replacement level of 20% performed better than both FRNFC and FRNFC replaced with RCA. In case of Porosity FRNFC with 50 % of RCA has high permeability coefficient. But still the permeability coefficient of FRNFC with 20 % of SRCT is also acceptable. Using Polypropylene Fibre in the NFC can increase its strength. However, it is not easy to make sure the level of water penetration due to the fibre filling; it should be restricted to a level. Its cost is also high due to its high dosage. Further studies should be conducted on that FRNFC pavement blocks made with SRCT to meet conditions of increased strength due to high vehicular loading and traffic volume.

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Experimental Investigation on Workability and Mechanical Properties of Self-Compacting Geopolymer Concrete made with Eco Friendly Materials

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Abstract: The present paper exhibits an experimental investigations made with respect to the flow property and Compression Strength of SCGC made with ecofriendly industrial by products such as ground granulated blast furnace slag (GGBS) and Metakaolin (MK). The mix of self-compacting concrete was arrived by trial and error methods. The Self-Compacting Geopolymer Concrete were examined for slump flow as well as V-funnel, L-Box, T50cm slump flow as per EFNARC guidelines. The results show that workability parameters like slump flow, L-box ratios were decreased and V-funnel flow time and T50cm flow time were increased, and also with the increase in Metakaolin content and as well with increase in molarity. The results of Compressive Strength decreases with addition of Metakaolin content and however it increased in increase in Molarity (M) from 8M to 12M.

Keywords: Self-compacting Geopolymer concrete (SCGC), manufactured sand, Ground granulated blast furnace slag (GGBS), Metakaolin (MK), Molarity (M).

INTRODUCTION

The unique position that the conventional cement based concrete widely used construction material is understandable, given its wide spectrum favorable attributes. These include regional produce ability, versatility, wide ranging performance properties and cost effectiveness. The global usage of concrete is second to water. Annual Global production of concrete is calculable to be around 1 m3 for each person living on earth. The hyperbolic demand for concrete concerns hyperbolic production of cement, unarguably the foremost wide used single binder ingredient of ancient concrete. The annual rate of increase of cement production is concerning 3%.In view of this concern associated with minimizing the general carbon dioxide emissions related to OPC composites to the extent technically and economically feasible, and sustainability in concrete construction, blended cements are made by partially replacing the Ordinary Portland Cement by supplementary cementitious materials (SCM). Plenty of industrial by-products / pozzolans viz. fly ash, ground granulated blast furnace slag (GGBS), silica fume; Metakaolin, rice husk ash etc. are related to perform similar function as SCM. However, the concepts of blended cements have yielded limited results in mitigating the adverse impacts of heavy use of OPC. Sustaining the growth in construction industry, while maintaining the ecological balance, deserves high priority. Therefore, it is necessary to go beyond the current approach of the cement industry, that of increasing the replacement levels of OPC and maximizing the use of industrial unused products as SCMs to an approach based on complete elimination of OPC by synthesizing altogether alternate binders that are eco-friendly, sustainable and less energy intensive. In this direction, self-compacting Geopolymer concrete (SCGC) is a promising field for the synthesis of new generation, non-conventional, novel OPC free binders and self-compacts showing no segregation as well as blocking and may flow into places and around obstructions by it's self-weight to fill the formwork.

LITERATURE REVIEW

Daniel L.Y. Kong, et al., (2007), comparison of Metakaolin and fly-ash based mostly Geopolymer concrete exposed to high temperature. The SEM analysis over that the fly ash-based Geopolymer have giant numbers of little pores that facilitate the escape of wet once heated, so inflicting minute damage to the Geopolymer matrix

whereas Metakaolin Geopolymer don't possess such pore distribution structures and therefore the strength decreases.

Sashidhar C., et al., (2015), examined the potential of fly ash GGBS based SCGC. Here class "F" fly ash and GGBS were taken in 50:50 proportions with complete Substitution of river sand by manufactured sand to access the fresh properties and mechanical properties of SCGC for different molarities like 8M, 10M and 12M. Mechanically crushed coarse agg. (CA) of max size 14mm having relative density of 2.66 was used for all mixes. The base-forming alkaline solution-to binder quantitative relation or ratio (AS/B) was kept equal to 0.45. All mixes has water-to-Geopolymer solids ratio of zero.4 by mass and a constant total binder content of 450 kg/m3.

To obtain the expected fresh properties of SCGC, a WC of 25% and Super plasticizer dosage of 3% by mass of the binder was kept unchanged to all the mixes and all the specimens were ambient cured. The study revealed that the increase in NaOH molarity from 8M to 12M decreased slump flow value was decreased from 690 mm to 670 mm and the same trend was followed in L-box and due to increasing quantity of NaOH. The viscosity also increases and reduced the fluidity of concrete increased the T50cm value and with the increase in NaOH molarity, the filling ability was decreased and consequently V-funnel time was also increased. Coming to compressive strength increase in molarity increased the compressive strength up to 10% from 8M to 12M at the end of 56days and this is due to better Geopolymer synthesis and increase in NaOH molarity increases the dissolution of initial solid materials and will increase the Geopoly merization reaction which in turn improves the micro structure of the mix and increases the compressive strength of SCGC.

MATERIALS USED FOR PREPARING SCGC

GGBS AND METAKAOLIN

In this study GGBS in accordance to IS 12089- 1987 and Metakaolin were used. The following table 1 exhibits both chemical and physical properties GGBS and Metakaolin. And the displayed SEM micrographs shows that Ground Granulates Blast Slag particles are long, elongated, and flaky in shape as shown in 'figure 1' And Metakaolin particles are amorphous as shown in 'figure 2'.

AGGREGATES

M-Sand confirming Zone II, and 2.59 specific gravity, 2.2% water absorption and fineness modulus 2.68 and the mechanically crushed CA extracted from the local available mechanical crushing plant with 2.67 specific gravity 0.65% water absorption and fineness modulus 6.86 were used.

Table 1. physical and Chemical properties of GGBS and Metakaolin

Contents (% by weight)	Sio2	Al2O3	Fe2O3	Calcium oxide	Magnesium oxide	SO3	Na2O	K2o	LOI	Sp. Gravity	Specific surface (m2/Kg)
GGBS	33.77	13.24	0.65	33.77	10.13	0.23	…	…	0.19	2.9	416
Metakaolin	52	42.2	0.7	0.08	1.76	---	0.07	---	0.3	2.12	12000

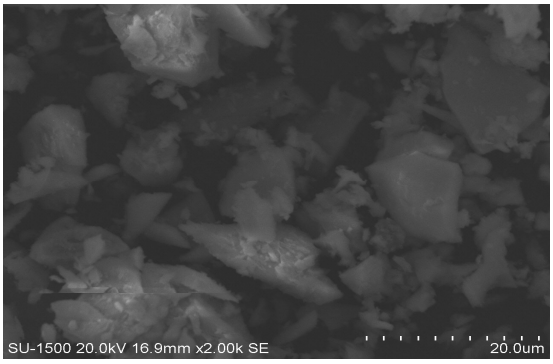

Figure 1. SEM image of GGBS

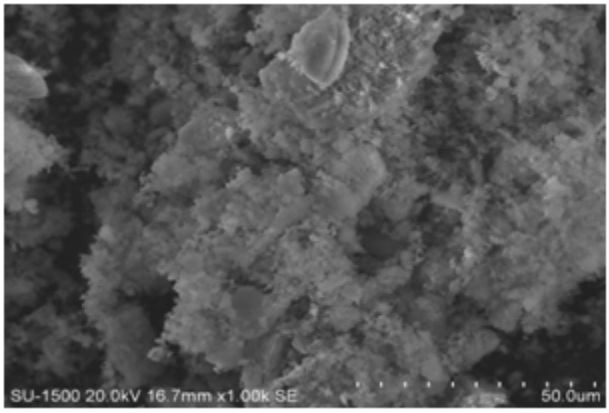

Figure 2. SEM image of Metakaolin

SUPER PLASTICIZER (S.P) AND WATER

Poly carboxylic ether based, Glenium SKY 8233 (S.P) was used in this study and with Sp. Gravity of 1.08 and chloride ion content < 0.2% and pH 6 is used for the study. Tap water was used for the entire study.

SODIUM HYDROXIDE

A commercial grade NaOH in the form of pellets with 99% pure and with Specific Gravity of 2.13 was used in this study. Sodium hydroxide is made to dissolve in the water at the varying rate of 8, 10, 12 molar concentration. It was prepared 24hours before use and also if it crosses 36 hr it will become a semi solid liquid state. And hence preparing the solution within this period of time is strictly monitored.

SODIUM SILICATE

Sodium silicate in a liquid gel form with a mixture of 55.52% of water, 29.75% Silicate dioxide and 14.73% sodium oxide was used in the present study.

ALKALINE SOLUTION PREPARATION

Alkaline solution is made by mixing NaOH and sodium silicate at the laboratory temperature in the ratio 1:2.5. And used as a binding agent.

MIX PROPORTIONS

For the present study, twelve mixes with GGBS was replaced by Metakaolin at 0%, 10%, 20%, and 30% by mass. M1, M2, M3, M4 respectively for 8 Molarity and M5, M6, M7, M8 respectively for 10 Molarity and M9, M10, M11, M12 respectively for 12 Molarity as show in Table II. The fluid to binder ratio (F/B) by mass for entire mixes kept constant at 0.37 and entire binder content kept constant at 512 kg/m3. To extract the desired workability characteristic of SCGC, extra water (E.W) of 12% was kept constant for all the Mix from M1-M12, and S.P dosage was varied according to the molarities by mass for the binder as shown in table 2.

CASTING AND CURING OF SPECIMENS

Initially a thoroughly stirred pre-mixed liquid combination having alkaline soln, superplasticizer, and extra water was prepared according to the required proportion and then a fine powdered materials like GGBS, Metakaolin and M-Sand were blended manually in a pan mixer and then the coarse agg., in saturated surface dry condition and mixed for about 2.5min. And at the finishing stage of dry mixing, this premixed liquid was added in the mixing compartment and mixed for another 2.5 to 3min. And this is used for workability test required for characterizing SCC. After testing SCGC in early state, this is again mixed by hand and drawn into the molds of cubes without any compaction and allowing it to fill all the corners of the mold by its self weight for testing compressive strength at the age of 3, 7, 28 and 56days. All the specimens was kept in oven for 24hours maintained at a temperature of 700C for curing and after 24hours the specimens were taken out of oven and it was demolded and it was kept for ambient curing till the respective test dates.

Table 2. Mix Proportion

Mix Notation	Binder Components (%)	GGBS (Kg/m3)	Metakaolin (Kg/m3)	M-Sand (Kg/m3)	Coarse Aggregate (Kg/m3)	(F/B) Ratio	Molarity (M)	S.P (%)	Extra Water (%)
M1	GGBS100% & MK0%	512	0	872	706	0.37	8M	6	12
M2	GGBS90% & MK10%	460.8	38.2	872	706	0.37	8M	8	12
M3	GGBS80% & MK20%	409.6	76.4	872	706	0.37	8M	10.5	12
M4	GGBS70% & MK30%	358.4	114.6	872	706	0.37	8M	12.5	12
M5	GGBS100% & MK0%	512	0	872	706	0.37	10M	6.5	12
M6	GGBS90% & MK10%	460.8	38.2	872	706	0.37	10M	9	12
M7	GGBS80% & MK20%	409.6	76.4	872	706	0.37	10M	11	12
M8	GGBS70% & MK30%	358.4	114.6	872	706	0.37	10M	13	12
M9	GGBS100% & MK0%	512	0	872	706	0.37	12M	7	12
M10	GGBS90% & MK10%	460.8	38.2	872	706	0.37	12M	10.5	12

FRESH PROPERTIES AND TEST RESULTS

As per EFNARC guidelines fresh properties of SCGC mixes were examined. Namely filling ability, passing ability, and resistance to segregation. In the present study, these characteristics were measured for all the molarities using following tests. Workability examined results are mentioned in table 3.

Table 3. Workability test results

Mix No	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12
Slump Flow (mm)	685	660	655	655	675	655	650	640	660	650	650	635
T50 slump flow (sec)	5	5	5.1	5.4	5	5	5.2	5.4	5.2	5	5.4	5.5
V-Funnel (sec)	10.9	11.5	12	13	11	12	12.5	13.5	12	12.21	13	14
L-Box (H2/H1)	0.89	0.85	0.84	0.82	0.87	0.83	0.83	0.82	0.85	0.82	0.8	0.79

SLUMP FLOW TEST

It is examined as per the guidelines given in EFNARC. The results of slump flow test obtained for various molarities are given in table 3 and the same as been plotted as shown in ‘figure. 3’. The test results point outs that as the Metakaolin content increases the slump flow decreases because Metakaolin particles are amorphous and has large surface area as displayed in fig 2 and table 1, and this in turn results in high water consumption and thus as a resulting in decreased workability and only for Mix (M12), all the parameters values were out of range. And as the molarity increases from 8M to 12M Sodium hydroxide concentration increases and hence it becomes more cohesive and results in reduction of workability of SCGC.

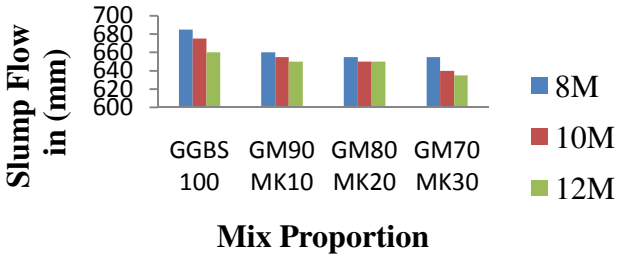

Figure 3. Slump flow test for various Molarities

T50 CM SLUMP FLOW TEST

The slump flow time for concrete is tested to reach 50 cm diameter is also recorded during the flow test and this is called as T50 cm slump flow test. Lower time indicates greater flow ability and as you can see in 'figure 4', as the Metakaolin content is increased the flow time is also increased this may be due to the increase in paste volume with GGBS and the molarity is increased due to high viscosity and hence the flow time is also increased.

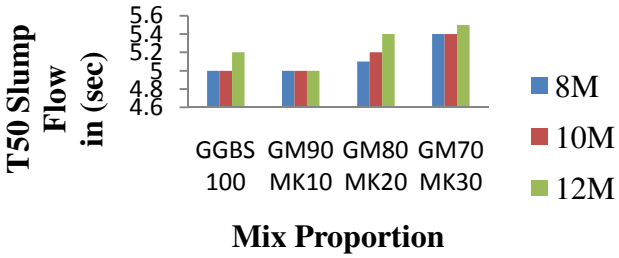

Figure 4. T50 cm slump test flow for various Molarities

V- FUNNEL TEST

It is utilized to assess SCC for the filling ability and additionally to examine the concrete to flow continuously without segregation and by reducing section and blocking the concrete. As you'll be able to see in 'figure 5', because the Metakaolin content accrued flow ability of concrete was leading to higher V-Funnel flow time

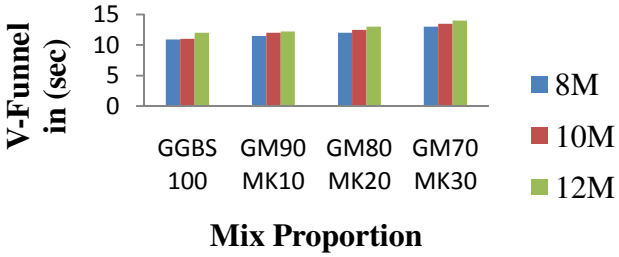

Figure 5. V-Funnel test for various Molarities

L-BOX TEST

It is employed to assess the filling and passing ability of SCC. From 'figure 6', the blocking ratio (H2/H1) decreases with increase in Metakaolin content and moreover with increase in NaOH concentration. Identical reason and mechanism for other test results also are commanding the reason for the results of L-Box Test.

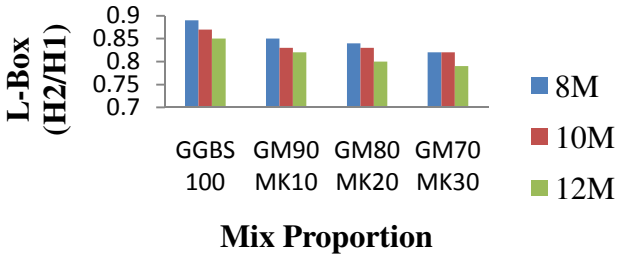

Figure 6. L-Box test for various Molarities

MECHANICAL PROPERTIES TEST RESULTS

Compressive strength test were conducted for all the molarities like 8M, 10M, and 12M at 3days, 7days, 28days and 56days as shown in table 4.

Table 4. Mechanical Properties

Mix Proportion	Molarities	Compressive strength (MPa)			
		3Days	7Days	28Days	56Days
M1	8M	41	42	45	46
M2		40.5	41.5	44	45
M3		39	40	42.5	44
M4		38	38.5	40	40.5
M5	10M	46	47.5	50	51.5
M6		43	44	47	47.5
M7		41.5	42	44.5	46
M8		40	41	43	44
M9	12M	49	50	56.5	59
M10		47.5	48	53.5	55
M11		45	46	52	53
M12		44	44.5	49	50

COMPRESSIVE STRENGTH TEST

The compression test was determined using cubical specimen of size 100mm. This was loaded in the uniaxial compression testing machine of capacity 3000kN tested as per IS 516-1999 and tested for maximum load. The three test cubes of all mix composition the mean compressive strength of is presented in Table 4, and the same is plotted as shown in 'figure 7'. As the percentage of Metakaolin was increased the compressive strength is decreased. Replacement of Metakaolin by 30% resulted in lowest compressive strength irrespective of any molarity.

And also you can see in 'figure 7', that as the molarity is increased the strength is also increased this is because as the sodium hydroxide concentration increases and hence the strength increases. The percentage increase in strength from 8M to 10M and from 10M to 12M at the end of 56days for M1 series is 11.9% and 14.5% and for M2 series is 5.5% and 15.7% and for M3 series is 4.5% and 15.2% and for M4 series is 8.6% and 13.6% respectively.

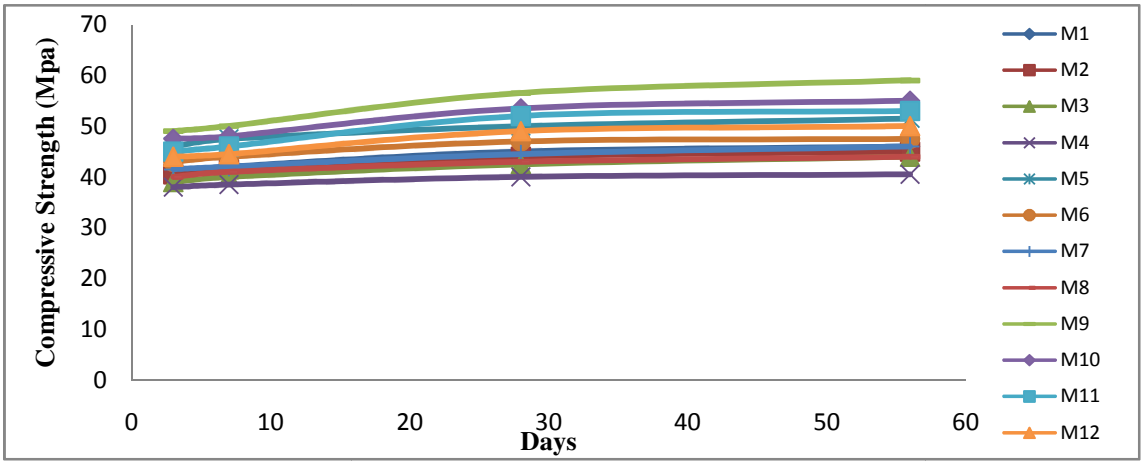

Figure 7. Effect of NaOH Molarity on Compressive Strength

CONCLUSION

As the Metakaolin content from 0 to 30% and NaOH concentration from 8M to12M increased, workability properties like slump flow and L-Box values decreased whereas the T50 cm slump flow and V-Funnel values increased. And only for Mix (M12), all the values were out of range for all the parameters as prescribed by EFNARC. As the addition of metakaolin increased from 0 to 30% with respect to GGBS, compressive strength decreased whereas it increased with increase in molarity content. The percentage increase in compressive strength from 8M to 12M at the end of 56days for GGBS100, GM90, GM80 and GM70 are 28.2%, 22.2%, 20.4% and 23.4% respectively.

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Alu - Form Construction Technology

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Abstract: The incorporation of modern construction technology these days are more often than not governed by several social indicators (like urbanization, resource utilization) that directly or indirectly influence the construction market. Therefore, in the wake of a seeming coalescence between these social phenomena and the exorbitant rise in demand for construction, the associated "boom" in the construction market calls for a research-based and calculated techniques for modern construction. Alu-Form (or Engineered Aluminium) Technology of formwork systems is one such form of modern technology that can be adopted for more versatile and efficient construction, which is highly ideal for the emergent methods of vertical dwelling construction. This paper aims to exhaustively review several aspects of this formwork technology and assess its premiere advantages and disadvantages, as compared to the conventional technique of using formworks made of timber, plywood etc. Also, in this paper, a construction cycle time analysis and a budget analysis is also done for effective usage of Alu-Form Technology to derive the limiting surface area for an aluminium formwork, considering economy and other extraneous factors that are required for construction.

Keywords: Formwork, Mivan, Monolithic Construction, Scrap Value, Sheathing Area, Shear Wall

INTRODUCTION

The excessive rise in demand for construction activities these days owes to several complex social phenomena affecting the economy- primary of them being, unprecedented population growth and urbanization. As planners and policy analysts often point out the repercussions ahead, enduring analyses on these duly inevitable social modificationslay the path for the foreseeable future. With many neo-liberal governments of the world easing up the reforms required for constructions through openness in the market, incentives etc., construction activities and infrastructure growth act as the catalyst to not just stimulate the economic growth of the country, but in turn emerge as a prospective solution for these social trends. Needless to say, engineers and developers are therefore, constantly challenged to find ways to offset the continuous requirements for new technologies in today's market scenario.

The boom in the construction sector, in the wake of several environmental and economic ramifications, calls for researched-based and calculated techniques of construction. These techniques are not just viable, but also deem to be progressive and satisfying. More often than not, researchers debate on several factors that revolve around them, like the challenges pertaining to real estate sector, a relatively inadequate FPA(Facility Planning Area) index etc. for a developing country like India, where the human population is forecasted to reach around 1.7 billion by 2050 ("India to surpass China by 2022 to become world's most populous nation", 2018). Further, the population survey also predicts that about 75 % of Indian population will migrate to the favourably situated fringes of the urban areas, as a result of several push-pull indicators. Economically, this sends out warning signals of imbalance and excessive land- rates in urban areas, which though can also be suggestive of large capital inflow for doing business. On the technical front, the model of vertical dwelling construction appears as the prospective way forward due to its ability to accommodate large occupants under a single roof.

Complementing this method of vertical dwelling construction, several other innovative construction techniques that are gradually gaining recognition these days include the Engineered Aluminium formwork systems (also known as Mivan Aluminium Formwork).This is because in 1990, the Mivan Company Ltd. from Malaysia pioneered the concept of manufacturing these Alu-form systems on a grand scale. Touted to save the construction time to a large extent by not compromising on the structural capabilities of the building, it is

promoted in the common-place both for its quality and economic aspects. The aluminium formwork system is an upcoming technology in the Indian construction market.

In this case study, the effectiveness of Alu-form construction technique over other conventional techniques is duly analyzed. Also, a technical comparison of this method in terms of the pre-planning of work system, construction time, level of accuracy in finishes, reusable values, strength comparison are subsequently done.

OVERVIEW

Traditionally, the mode of construction for houses and buildings involve the usage of bricks as an infill for Reinforced Concrete (RC) frames. Structural members like columns, beams and slabs involved during the construction process are cast-in situ, mainly using formworks made of timber and plywood. Such a system is often regarded as highlylabour-intensive and time consuming. Also, it is seen that a lot of on-site coordination is expected from the brick workers, carpenters, plasters to co-ordinate and monitor the pace of construction time and again. Therefore, it is implied that the processes involved, which include rebar, bending, formwork fabrication, concreting etc. are solely dependent on the very skill of the professional. Moreover, such a way of construction is often subjected to poor quality control or a general lack of precise detailing, despite the presence of experienced contractors on-site (Ramling& Ramesh, 2016).

On the other hand, the Alu-form technology of construction is recognized worldwide as the most advanced formwork system, with the ability to provide a durable, precise, sturdy and pre-engineered structural system to the building. Widely regarded for its several benefits over conventional methods, this technology works under the principle of casting the entire floor, consisting of walls, slab and other structural elements, in one continuous pour of the concrete. Interestingly, Aluminium formwork systems has in a way brought the much sought-after ‘assembly line’ technique of production to the construction site, with each floor carefully planned for construction, depending on the work cycle. Therefore, this is a versatile form of erecting the concrete structure, typically suited for high-rise construction (Ramling& Ramesh, 2016).

As far as the material aspects are concerned, the selection of aluminium as the base material for formwork is based on its light-weight properties and non-corrosiveness. The purpose of easy transport of formwork, especially for the targeted high-rise construction can be achieved through light-weight aluminium. The panels are specified to be made from high strength aluminium alloy with a 4 mm thick skin plate and 6mm thick ribbingin order to stiffen the panels and enhance its support.(Ramling& Ramesh, 2016)Further, the formwork is manufactured in size and shapes to best suit the requirements and maintain a great deal of precision for the engineering works.

The formwork is made with the aluminium sheet welded to the extruded rail segment. This angular segment acts as a firm support to the aluminium metal sheet, so as to withstand the load caused by the concrete, rebars, labours’ weight and resist deflection. This system is specifically designed to form multiple types of wall-design to suit all the architectural features within the structural integrity of the building design. Fixing and removal of the form-works is easy and simple due to the modular nature of it. Thus, the construction is fast and also doesn’t need highly skilled labour.

MOCK

Setting up a Mock of the building structure, that outlays a hands-on practice for usage of this formwork system is mandatory; especially if the market is aimed at involving workers engaging in the traditional modes of construction. It is often set out in the yard near the factory. By doing so, the builder would be in a position to monitor the failures that are likely to occur and evaluate the progress during the actual construction.

The practice of engaging workers in the site to a mock also emphasizes on the capacity-building required for the modern ways of engineered construction and exposes them to incorporate these improvements in their forthcoming projects.Taking a little time to get a fair idea of how these system works thus ensures a good check of quality control before the actual construction starts. Figure 1 shows the mockup assembly of Alu-form system.



Figure 1. Mock up Assembly

CONSTRUCTION PROCESS

SETTING UP THE FORMWORK

The construction process for the use of aluminium formwork on site is as follows:

Like any other conventional method of construction, the processes of ground leveling, co-ordinate marking of the building levels and foundation-casting are sequentially carried out. The formwork is received from the mockup yard and is assembled with provisions for reinforcement bars for walls and columns. The walls are connected with the help of flat wall ties which are secured by Pin and Wedge assembly. In addition to this, opening for windows and doors are provided which is started with the beam soffit panel and is supported by Bulk head and Prop head assembly. The beam and slab panels are centered using prop heads followed by its reinforcement. Cover plates are used to seal the doors and windows. Finally, the M&E cable containments are set up before concreting.

In order to avoid sticking of concrete on the sheathing area of panels, form-oil is applied. Formwork assembly is fixed either from the wall end or the corners, depending on the type of project undertaken. Once the Head site-engineer inspects the form-panels and the assembly, concreting is done in a single pour. Figure 2 shows the components of an aluminium formwork.

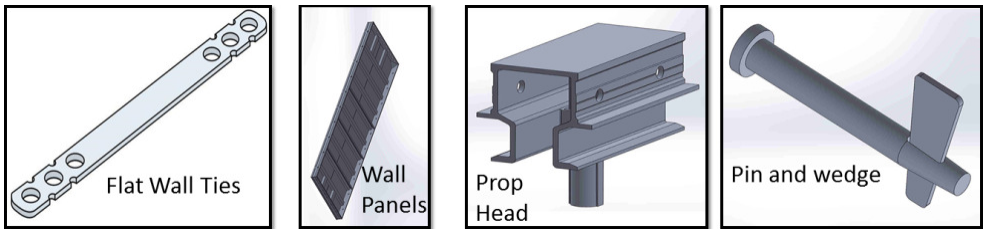

Figure 2. Alu-Form Components

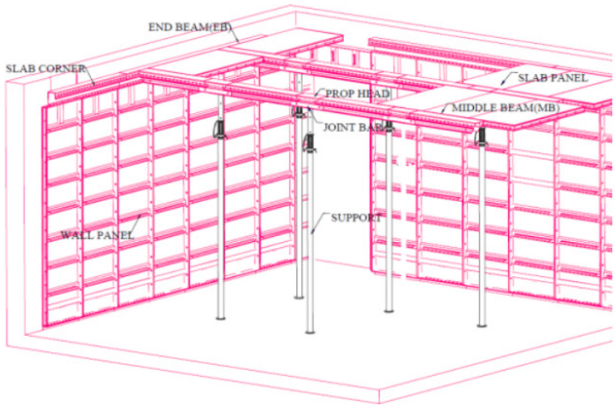

Figure 3. Alu-Form Panels and Components assembly (Jyoti et al., 2017)

Figure 3 shows the Alu-form assembly used in site. The ready mixed concrete is also considered for placing, especially in projects involving large carpet area or floor requirements. In commercial buildings like shopping malls, theatres etc. the usual practice is to initially construct the first 3 floors as a framed structure and then, all the remaining floors are constructed as load bearing structures.

DISMANTLING THE FORM-WORK

The wall, column panels are generally removed in 12 hours after the completion of concreting. Meanwhile, dismantling the slab and beam panel assembly is done only after 36 hours. Generally, the prop supports that are installed for the lower 2 floors are not removed till the current floor is concreted and its curing is completed, for safety reasons.

SELECTION OF TYPE OF CONCRETE

Choice of concrete, along with the proper mix proportion and reinforcements provided significantly influence the construction technology incorporated. The requirements of the structure vary with the nature of site, purpose of construction and other additional measures affecting it. The structural elements of the building, when built using Alu-Form Construction tend to have rebars spaced out very closely. Thus, concreting a 3m high wall with the conventional concrete does not seem like a satisfactory choice, as the vibration process will be more difficult and time-consuming. Essentially, this can also result in more air voids and honeycombs. Self-compacting concrete is generally adopted for the building built by Alu-Form technology.

SCC is generally a preferred material due to its filling and passing ability. In other words, its fluidity also facilitates the concrete to occupy even the corners of the structure (Okamura &Ouchi, 2003). As a result,it eliminates the presence of voids in the fresh concrete itself, thus leaving no honeycombs behind on the subsequent hardened concrete surface.

Some of the major advantages of using Self Compacting Concrete over Conventionally Vibrated Concrete (CVC) are:

- Easy and Faster Concreting,
- Requires lesser manpower,
- Smoother surface finish,
- Improved durability,
- Greater freedom in design,
- External compaction is avoided and
- Safer working environment by eliminating vibration and noises

An experiment conducted by the Structural Engineering Research Centre at Chennai, was aimed at comparing the structural behaviour of SCC over CVC of the same strength (70MPa). From this experimental study, it was observed that although both these concrete mixes have different composition and mode of compaction, the test results based on the tests like compressive strength test, split tensile test, flexural test and bond strength test were found to be almost similar to the concrete of the same age. Thus, SCC can be suitably adopted for any structural applications in practice, especially when there are complex reinforcements present (Shetty, 1994).

ANALYSIS

COMPARATIVE SEISMIC ANALYSIS OF ALU-FORM TECHNOLOGY OVER CONVENTIONAL TECHNOLOGY

It is a well-known fact in material engineering thatthe tensile properties of concrete are not so adequate. Therefore, it is reinforced with steel rods to enhance its tensile strength. Such a composite of concrete, known as Reinforced Concrete is aligned along the horizontal and vertical members to form a frame of the RC building. The brick masonry walls are constructed as planned in between the spaces of these RCC frame elements.

In the conventional RC building, the transfer of load is from slab to beam, then columns, and further to the lower columns, and finally to the foundation, which later transfers it to the soil. Therefore, as far as the dimensions involving the cross-sections go, the lowermost column is bound to take the maximum load.

During an earthquake, horizontal and vertical members are subjected to inertial forces due to which, the columns at the lower-most level fail due to lateral (or any other) sway, that in turn causes a lateral load on the brick masonry walls. In the cases where the intensity of the seismic load is very high, the bond strength in the infill brick masonry is not enough to resist this load and subsequentlythe structure begins to crack, which amplifies the chances for the whole building tocollapse (Murty, C.V.R)

However, in case of buildings constructed by Alu-Form technology, the entire structure can be visualized as a shear wall box structure without any brick masonry. During the case of an earthquake, the inertial forces acting gets properly distributed along the entire structure including the walls, as the structure is monolithically cast. By the effect of box action, the reinforcements present in these structures are supposed to resist these lateral forces and protect the structure from a possible collapse.

Thus, we can affirmatively conclude that the structure stability considered at the aftermath of a disastrous earthquake by this technology is lesser prone to damage as compared to the conventional masonry technique. It therefore appears to be more seismic resistant and contribute to the overall safety of the structure.

Few of the important results of a non-linear pushover analysisconducted by Pawan& Hemant (2017)give us an insight into the realistic behaviour of the structure and the shaking that occurs in the ground. In this,it can be observed that

- The Alu-Form structural system provides better lateral resistance to the overall displacement. The conventional structural system tends to displace upto 86% more than the former.
- Conventional structural system tends to have lower base shear as compared toAlu-Form structural system. The base shear of the latter is 40% more than conventional structural system. Therefore, the more-improved structural stiffness of Mivan structural system tends to take larger seismic loads.

TIME ANALYSIS

The construction cycle time for proper completion depends on a number of factors such as the structural complexity, repairsand maintenance of equipment and machines used, permissible striking times, skill level of the workmen, available working hours, bad weather and unfavorable site conditions, availability of floor space, location of site etc. Among these, type of formwork system used is a major deciding factor for the construction duration- thus a proper comparison of the time analysis can guide us with the proper selection of formwork.

It is found that Aluminium formwork is on par with any other type of formwork when it comes to delivering a competitive construction cycle time. In highly mechanized construction work, it is possible to achieve a 4-day, intensive-work cycle for a multi-storey building having identical floors. In a country like India where human power is available sparsely, 7-days per floor casting cycle can be practiced here, that corresponds to a time cycle almost 3 times quicker than the conventional formwork system.

Figure 4 illustrates the 96hours construction that can be adopted using the Aluminium formwork systems.

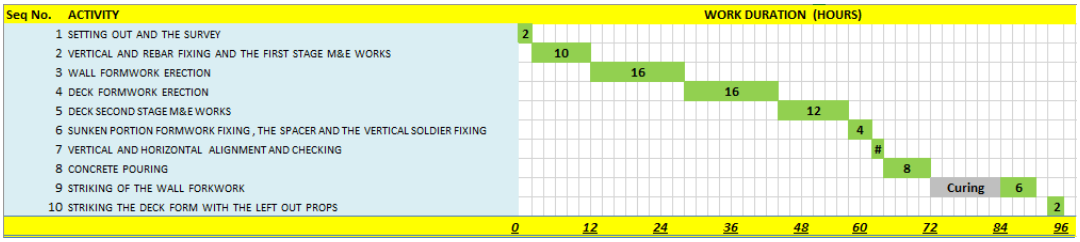

Figure 4. Work sequence and duration

COST ANALYSIS

In the present system of adopting conventional type of construction, the casting and curing of columns, beams, and slabs of a building are relatively time-consuming because the removal of timber formwork should be proceededwith, only after concrete attaining the sufficient strength. This overall work delay that affects the constructor will tend to cause a hike in the proposed project cost, and this burden is ultimately passed on to the end-customer also.

In case of Aluminium formwork systems;

- The concrete is done in one continuous pour, thus eliminating brickwork.
- Vertical (Wall) Formwork and Horizontal (Deck) Formwork can be dismantledin 12hours and 36 hours itself.
- The AluminiumFormwork casts walls and slabs of great accuracy and with smooth surface finish, thus eliminating the wall-plastering thereby saving enormous material cost.

Due to the above reasons, high speed of construction can be achieved by this system which also implies a faster completion of the project by as soon as 7 days per floor.

THE DEPRECIATION VALUE AND THE SCRAP VALUE

The other main reasons for maximum cost return are the depreciation value and the scrap value of the aluminium formwork material. As the form-panels are capable of being used over and over again for several work cycles, the depreciation cost can be calculated to be low.

Even after the formwork being used to its maximum efficiency, it can be considered and utilized as a scrap material. This scrap material is sold to the formwork manufactures for recycling. From Table 1 below, it is seen that, the rate of return of the Aluminium is high.

REPETITION DEPENDENCY ON COST OF PLYWOOD AND ALUMINIUM FORM-PANELS

Total Form-working Cost = (MC x RC) + (LC x SA)

Where,

MC = Material Cost of formwork and its assembling components.

RC = Repetition Cycle, is the ratio of the total shutter area to the number of repetition.

LC =Labour Charges per sqm. of shutter area.

SA = Total shutter area.

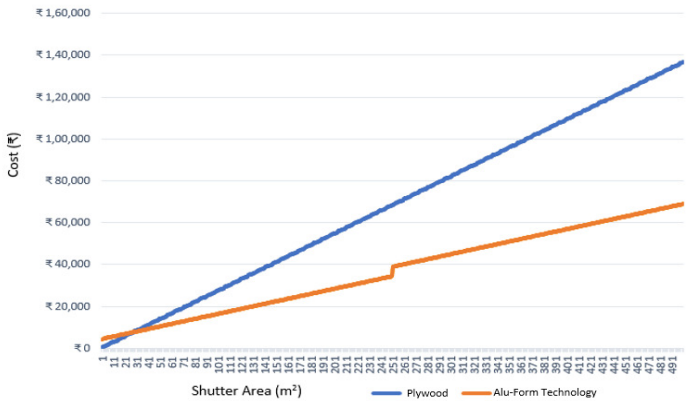

Figure 5. Work sequence and duration

It is seen that the cost of plywood-timber formwork per unit area in the Indian construction market amounts to around 600. It can generally be used to around 6 repetition cycle.The construction cost of 1m2 of aluminium formwork is around 9000 and has the capability to be used for 250 repetition cycle. The relatively high durability of aluminium formwork material can be also inferred in the fact in its scrap value which accounts to as much as 50% of its cost, whereas in timber, it is around 15%, as shown in Table 1.

Table 1. Scrap Value of formwork (Source: Avg. Indian Market Value).

Type of Formwork	Scrap Value	Remark
Plywood-Timber Formwork	15%	It breaks easily.
Alu-Form	50%	It doesn't corrode

The graph 5 plotted in Figure shows cost vs.shutter area explains the operational cost incurred when using the conventional and Alu-form system respectively during construction. The factors affecting the cost per metre area are based on the market cost of the material, average labour wages, repetition and its scrap value and accordingly a theoretical linear regression has been carried out. Equation 1 and 2 corresponds to cost incurred when using plywood-timber and aluminium formwork technology respectively, where y – cost incurred for x-shutter area in metres.

Equation	Regression Coeffecient	Equation No.
y = 272.86 X + 219.6	R2=1.0	……...(1)
y = 136.92 X + 2790.7	R2=0.9999	……...(2)

Here, the theoretical threshold shutter area for the formwork systems can be arrived at, as approximately 25 sq. metre. Aluminium formwork can be recommended for RC wall construction, theoretically involving shuttering area greater than the threshold value.

ADVANTAGES

The Aluminium formwork technology involves what is regarded as the 3S system of construction- encompassing speed, strength and safety. The Aluminium formwork panels used in this system involve fabrication with high precision, which can be specifically designed to allow rapid construction of all types of architectural layouts. This thereby results in the concrete structure having high dimension-precision, and one that can be maintained with perfect verticality and level. It also promises the surface with a smooth finish. Doing so, this method can eliminate the need for plasterwork and thereby save up to 50% of the construction time. Likewise, the resulting structure is expected to be more durable, keeping the expenditure on maintenance to a real minimum (Ramling& Ramesh, 2016).

The other striking feature of these formworks lies in its light weight panels (as compared to other formwork systems involving various other materials). Hence it becomes much easier for the laymen to conduct operations like fixing, dismantling, shifting panels form one place to another etc. The presence of pin and wedge system in these formwork panels adds to the above advantages by becoming more user-friendly. The Aluminium formwork panels can be used for around 250 work cycles as discussed above; while those conventional wood-shutter can be used only 6-10 work cycles. Once the aluminium formwork gets damaged, it can be recycled back and refabricated to a new formwork (Chotaliya & Rathod).

Considering the cost and the unsurpassed construction speed, Alu-Form technology can be regarded as one of the well-suited methods for high rise buildings and mass construction projects. The buildings constructed using formwork technologies are crack-free monolithic structures and hence more resistant to seismic attacks.

DISADVANTAGES

Although aluminium is discussed in this paper to be advantageous in several ways, this technology can be restricted only to construction companies that are capable of carrying out large projects and accommodating large value for the capital spent. Since the entire structure is considered to be a RCC structure, further modifications are generally not possible. Also, a fear of theft of valuable Aluminium Extrusions and sheets is always there and hence an incomplete kit can result in needless tension, especially during critical stages of construction (Ramling& Ramesh, 2016).

CONCLUSION

The Alu-Form technology of Aluminium formwork systems turns out to be a prospective alternative- now that we can witness several impedances to the existing techniques of construction to accommodate the future way of living in skyscrapers and high-rise construction. This pre-engineered form of formwork systems serves as a cost-effective and efficient tool to address the problems of mega housing project all over the world, especially in the booming market of developing countries like India.

To provide affordable housing to its exploding population of the country, quickness in construction by not compromising on durability and precision appear to be a few among the several unique-selling points of this technology. Despite few negatives that mainly provide the scope for rectification or future modification in

construction technique, it can be concluded that Alu-Form technology adheres to the universally conceived proposition of a business choice: that translates to the fact that quality and speed must always be given due consideration while undertaking small or large construction projects.

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High Gloss and Anti-Slippery with Laser Grip®– A Sustainable Technology

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Abstract: Public places are often elegantly paved with polished natural stones. While making a pleasant sight, glossy stone floors may become slippery when wet and dirt accumulated. To prevent people slipping and injuring themselves, the natural stone floors need to have a non-slip finish. States Of The Art anti slippery methods are 1.) Honing 2.) Flaming 3.) Sandblasted 4.) Chemical treatment (Hydrogen-fluoride). Lasergrip technology addressed all the negative points in the conventional ways of anti-slippery treatment and brings in saftey standards. The above methods can't retaining the elegance and still keeping anti-slippery character.Few are tough to clean and are optical disasters. Chemical treatment can retain glossiness but usage of high toxic chemicals makes it environmentally unfriendly. LaserGrip®.: The elegance and highgloss will be 80% retained.Its easy to clean at minimized costs Long holding of anti slipppery effect confirming to R9, BGR 181 (Institute of social Insurance & Occupational Accidents), DIN 51097, DIN 51130 certifications makes it a sustainable technology.

Key words:LaserGrip®, Anti-slippery, Chemical Free, Magna, DIN 51097, DIN 51130, R9,

INTRODUCTION

When we look at the modern-day public utility buildings, be they are Airports, Railway stations, Office complexes, Malls and Cinema Halls etc, we would have observed the elegant ambience and aesthetic looks due to their glossy, mirror image floorings. These floorings are beautifully paved with Granites, Marbles and Ceramic etc., stones in polished surface finish. When surfaces become wet and dirt was brought in from shoes, these elegant surfaces tend to become more slippery. If someone slips and gets injured on these surfaces who is going to take the responsibility of the accident and compensation, the Architect, Builder, Contractor, Owner or the Government? It's high time in India to bring standardization and regulations in this segment. To avoid people, especially children and elders, falling and getting injured due to high slippery nature of polished surfaces, to standardize the safety methods in flooring industry, all the public utility buildings ought to have a Non-slippery surface finish.

TECHNOLOGY

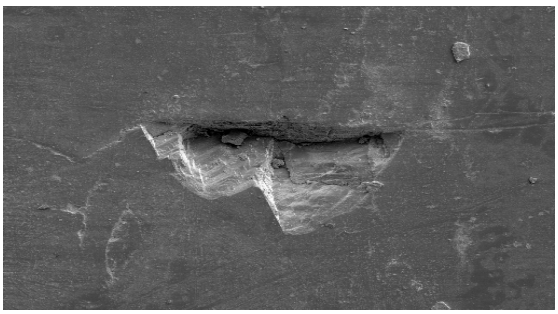

Figure 1. Public places with high volume traffic.Source:Author

The pulsed laser beam guided by three scanner mirrors, a special optical configuration, allowing the treatment to proceed at extremely high speed with exceptional precision. The machine carves 10,000 to 15,000 micro-craters / second on the surface. This gives a non-slip effect with varied dimensions and distance of the indentations with Dia 200 microns, Depth 30 micros and with 400 and 1,275 indentations / sqcm, each 0.3 to 0.5 millimeters apart.

REFERENCE PROJECTS

Used in Düsseldorf , Hamburg, Munich, Frankfurt and Budapest airports and in many more commercial places.



Figure 2. Public places with high volume traffic. Source:Author

CONVENTIONAL METHODS OF ANTI-SLIP

State of the art anti-slippery surface finish methods are 1.) Honed 2.) Flamed 3.) Sandblasted 4.) Chemical treated (Hydrogen-fluoride) etc. Even though these methods are cost effective, they are neither elagant nor long-lasting, sustainable practices. Let us look at these alternatives.

HONED SURFACE

One of the oldest ways for anti-slippery surface finish is honing. Honing is a process whereby the shining on the surface of a polished stone be mechanically removed. This makes the surface look unpolished, bit uneven and with no reelections of smooth finish. It is cheap comparing with other surface finishes but post-installation cleaning of this surface finish would be expensive, surface would be uneven in appearance and lacks glossy nature and elegance. This surface tend to get slippery when gets smoothened over a period of time.

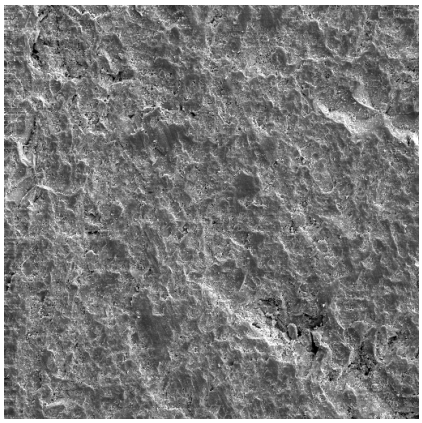

Figure 3. Honig Surface; Source:Author

FLAMED SURFACE

This surface finish can be attained either manually or mechanically by running an oxygen-propane flaming machine that produces intense flame on the surface of the stone. The intense flame burns the surface and makes it rough. Due to high degree of slip resistance this surface finished stones are mostly used in exteriors applications like pavements, pathways etc. This finish can normally be used on certain Granites and hard lime

stones only. Flaming surfaces are very anti-slippery, but costlier than honing finishes. Cleaning these surafaces will be very tough, also lacks glossy nature and elegance. It's an optical disaster for interiors.

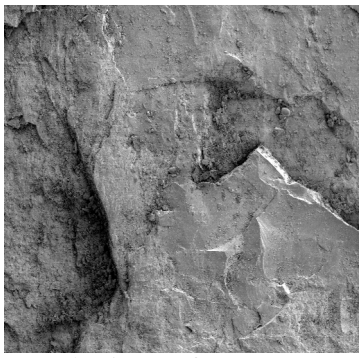

Figure 4. Flaming Surface; Source:Author

FLAMED AND BRUSHED SURFACE

The natural stone surface is either manually or mechanically flamed, as explained above and will further be brushed by metal and fiber brushes according to the end usage. Due to these brushings the surface will lose its coarseness. The resulting surface will look rough and anti-slippery, but will have a faded color and looks dull in appearance. Like flaming surfaces this too lacks glossy nature and elegance.



Figure 5. Flamed and Brushed; Source: Author

SANDBLASTED SURFACE

Sandblasting is a mechanical process of applying high pressure propelling of fine grained sand on the surface of the natural stone. Due to sand blasting process stone surface appears slightly scratched but appear even and smooth. The natural color of the stone reduces to a greater extent and appears dull. Sandblasted surfaces too are very anti-slippery. Like in the case of Flammed surfaces, cleaning sandblasted surfaces will be very difficult and expensive. This finish too lacks glossy nature and elegance. The visual brilliance for the aesthetic interiors is again a missing parameter here.



Figure 6. Sand Blasted; Source:Author

CHEMICAL TREATED SURFACE (HYDROGEN-FLUORIDE)

Comparing with other conventional methods chemical treatment could be less expensive and can more or less retain the glossiness of the surface.Usage of high toxic chemicals (HF) is environmentally unfriendly. The Risk of unwanted colorisation (rusty stones), only small micropores on surface due to chemical etching are few of the disadvanatges in this method. This treatment will make the surafce lose its anti-slippery effect faster caused by dirt and cleaning chemical. Dirt removing could be a herculean task.

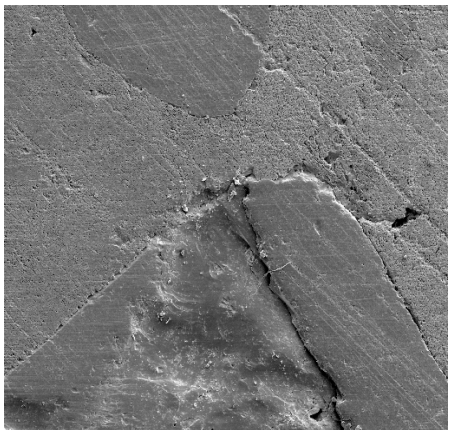

Figure 7. Chemically treated surface; Source:Author

LASERGRIP

The positives in LaserGrip® surface finish are, the elegance of the stone is not destroyed, 80% of the glossiness will be retained, long holding of the slippery effect and since it is chemical free both in processing and maintence, its absolutely environmental friendly. Added to these benefits it‘s maintenance is relatively easy. Hence it is aptly suitable for all commercial places. Only flipside could be the added cost. According to a project report by University of Reutlingen the escalated costs can be recovered in due course from the savings in maintenance. Due to these positive factors it‘s widely in use in Europe in commercial places.



Figure 8. LaserGrip®. Surface (from microscope) Source:Author

HOW IT WORKS

A German LaserGrip® team from Magna Naturstein GmbH addressed the twin objectives of retaining glossiness and still having the anti-slippery effect through this LaserGrip® technology. They developed a diode laser technology surface treatment process that retains the glossiness and intensity of the color of the stone surface on Gloss Meter to 80% and can still have the best anti-slippery effect. Magna’s LaserGrip® machined pads are externally monitored by scanners and a unique optical configuration. With each pulsed Laser beam, micro-craters are carved on the surface. The novel Diode lasers used by Magna Lasergrip team can carve 10,000 to 15,000 micr-craters / sec with an average diameter of about 200 microns and depth of 30 micros each. About 400 to 1,275 indentations can be carved per sq.cm with varied degree of dimentions, distance and non-slippery effect. These indentations that are in varied dimentions and seperated by 0.3 mm to 0.5 mm each can increase the slip resitsance by acting as suction pads between the shoe sole and stone surface. For a naked eye the

resultant surface appears uniform in color, as glossy as a polished surface even though it loses 20% of its glosiness in laser treatment while attaining the other objective of anti-slippery surface finish.

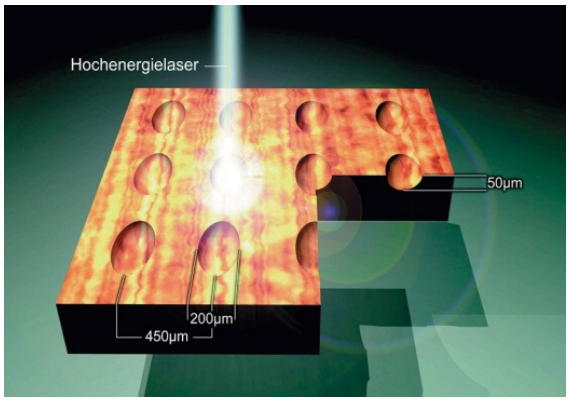

Figure 9. Pictorial Display of Indentations; Source:Author

The diode LaserGrip® technology guarantees chemical free process with slip resistance ramp-test certification R-9 is the only surface treatment adhering to the twin objectives of retaining glossy finish and keeping the anti-slippery nature. This technology with standard procedures and certifications can be applied on natural stones, porcelain tiles and engineered stones with polished and honed surfaces. After the pilot testing in 1997 this technology was commissioned commercially by Magna Naturstein GmbH factory, near Magdeburg, GERMANY from 1999 onwards. To bring standardization and safety practices of non-slippery properties of such floors, many governments across globe are contemplating special regulations. In Europe and US these regulations are helping all stake holders, like common man, industry, insurance companies equally. The data by insurance companies in Germany shows that there is a considerable decline in number of accidents and claims after the introduction of standardized and safety practices.

CERTIFICATIONS IN LASERGRIP

A research House, “Oxford Economics “ report on Global Economics, that was reported in TOI dated 07.12.2018, says that out of top 20 fastest growing cities in the world by 2035, 17 are Indian cities. This exponential urbanization of Indian cities giving more credence to this topic of “standardized safety regulations in commercial places. Some standards available in Europe are seen here.

DIN

In Germany slip resistance is evaluated in accordance with

DIN 51097

Is a German slip-resistance test on barefoot conditions in walking areas with moderate wetness They test the surface with soapy water as contaminant by varying the parameters and conditions of the nature of the stone, the surface finish and the degree of wetness,

DIN 51130

Is a German slip-resistance test to determine the slip-resistance characteristics at working areas and spaces with an elevated slip risk. They test the surface with oil as contaminant by varying the parameters and conditions of the nature of the stone, the surface finish and viscosity of the oils

R RATING

The majority of floor tiles these days are given an anti-slippery rating. This rating comes in the form of an 'R' value. The 'R' stands for 'ramp test'. This 'R' value ranges from R9, which has a small degree of slip resistance on dry and aft cleaned surfaces to right up to R13, which is the highest slip resistance on highly wet surfaces.For an inclined surface with less than10° angle R9 rating will be given. (Low friction) For an inclined surface with 10° to 19° angle R10 rating will be given. For an inclined surface with 19° to 27° angle R11 rating will be given. For an inclined surface with 27° to 35° angle R12 rating will be given (high Friction)

BGR 181

The slip-resistance properties of floor coverings are tested during type examination in accordance with BG Rule BGR 181 by walking on a ramp. In this method, which is standardized in DIN 51130, a test person walks forwards and backwards with an upright posture on the floor covering to be tested. Engine oil is applied to the floor covering. The test person wears safety footwear with a defined outsole. The inclination of the floor covering is then increased from the horizontal up to the angle at which the test person begins to lose their footing and to slip to the extent that they are no longer willing to continue walking. The angle of inclination of the ramp attained at this point is used as a measure of the slip resistance.

CLEANABILITY

'Anti-slippery' with LaserGrip means highest cleaning ability with required slip resistance and with more than 80% of the polished surface retention. A German government research (The German Federal Environmental Foundation) project with the University of Reutlingen, which tests the cleanability of non-slip surfaces, shows the best values for LaserGrip. The test was conducted in 3 different field trials spanned over 2 years 2 months from Dec 2012 to Jan 2015, where they developed methods of tests, optimized the processes & process of testing, developed stamp tests, optimized the stamp tests and developed quality assurances for LaserGrip surface tiles. They concluded that by using the optimally lasered tile surfaces, a minimum 20% reduction in the maintenance costs was achieved in the field trial. Thus, by reduction of chemical cleaning agents positive impact on environmental friendliness can be achieved. The economic efficiency is also ensured by the fact that no expensive special cleaning agents are needed, but only selected standard products from the building cleaning technology are enough. The escalated costs can be recovered in 2 years and project can save in maintenance costs, added to other benefits

CASE STUDY ON COST OF MAINTENANCE

LaserGrip® surface technology is not only environmental friendly, resource efficient and also very Economical.

SAMPLE COSTING

Porcelain flooring for 10 years in Euros (cleaning manually by pre-soaked micro-fiber covers)

SAMPLE BUILDING

Porcelain Unpolished : E 162,075

SAMPLE BUILDING

(Polished & light Sand blasted)Porcelain : E 144,985

SAMPLE BUILDING

Porcelain - LaserGrip : E 113,013

With other surface finishes from the evaluation group 'R9', no reduction in costs can be observed. The basic cleaning frequency generally depends on the subjective perception of dirt and the dirt holding capacity. LaserGrip® is therefore not only the ecological, but also the most economical solution for a visually brilliant floor covering made of natural stone or fine-grade products.

WHERE

Magna group, in the last 2 decades, did many public projects with LaserGrip® surfaces. The airport projects in Hamburg (10,000 m2), Munich (25,000 m2), Frankfort (10,000 m2 in honed surface) , Dusseldorf (15,000 m2) and in Budapest (under its old name SafeStep 15,000 m2) are a few to name.



Figure 10. Airport Dusseldorf; Source:Author

ECOLOGY

The risk of discoloration when exposed to chemicals depends on the mineral content of the stone. The Magna team has set itself the goal of using no chemicals. The LaserGrip® technology is consistently free of chemicals. The high laser power is sufficient to achieve the desired result. Chemical after-treatment is no longer necessary.

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Energy efficiency in buildings through effective cooling and lighting systems

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Abstract: Increasing need of energy for various activities in today's world is unaroused. Buildings are responsible for a considerable amount of worldwide energy use, and that too mainly in the form of electricity. The energy efficiency of buildings is highly affected by heating, ventilation, and air-conditioning (HVAC) systems being more energy – intensive, it is followed by electricity usage for lighting systems. The paper aims in the sustainability of buildings achieved through green measures incorporated with the efficient cooling and lighting system. The study focuses on the energy analysis of buildings, reduction of energy consumption of cooling and lighting systems. Software Design builder integrated with Energy plus simulation software is used to accomplish the energy simulation modelling. This modelling is used to analyse the requirements of the building's cooling load. A better lighting system and efficient cooling in building design will achieve energy efficiency and thermal comfort. The reduction in carbon dioxide emissions due to less electricity usage is also calculated.

Keywords: Cooling Load, Heating, Ventilation and Air-Conditioning (HVAC); Building, Energy Simulation Modelling, Lighting, Carbon Dioxide Emission.

INTRODUCTION

With the increase in population growth and demand for comfort needs, the energy usage has increased rapidly in the world. The energy usage of buildings is quite high, accounting to almost 40% of world's energy consumption. In buildings, more than 60% of energy consumption is by Heating, Ventilation and Air-conditioning systems (HVAC). And this is followed by lighting systems in the form of electricity, which accounts to almost 15-30% (K.J. Chua, 2013)..

The main aim of this paper is to lower the energy consumption of cooling and lighting systems in a building. Only by reducing the energy utilized for cooling and lighting, the overall building energy consumption can be reduced. For this, the cooling load required for a building needs to be modelled. Here, the modelling is done through Design builder software, which is integrated with Energy plus simulation software generated by U.S. Department of Energy's (DOE) Building Technologies Office (BTO) (Pan, Yin, & Huang, 2008). By obtaining the cooling load required, the cooling system can be designed accordingly to meet the optimum cooling requirements of the building. Utilization of efficient cooling systems such as variable air volume system, efficient water cooled chillers; variable refrigerant system, etc. can be done. For a specific building, the efficient cooling system can be selected based on the size of building, building type, etc. Such energy efficient systems help in reducing the kW/TR that leads to better cooling results with energy and cost savings.

The electricity utilized for lighting systems is lowered by analysing the energy utilized or energy spent for the lighting in the building. It is then compared with the case of optimum number of energy-efficient lights operated at less number of operating hours. Other than lighting, electricity consumption of equipment's like desktop computers, coffee machines, printers, etc. was also found to be high. However, in this paper, only electricity consumption due to lighting is considered and analysed.

Studies prove that with reduction in electricity, CO2 emissions can also be decreased. The reduction in CO2 emissions due to less electricity usage is also calculated. Reduction in CO2 emissions and lowering energy consumption acts as green measures leading to more energy efficient sustainable buildings.

METHODOLOGY

ENERGY-EFFICIENT COOLING SYSTEMS FOR REDUCTION IN ENERGY CONSUMPTION

1. To access the cooling load requirements, the heat load calculations has to be performed. This means that the factors contributing to heat generation in the building needs to be considered. These factors include:
2. Construction and orientation of the building,
3. U- value of the walls and windows exposed,
4. Number of people occupied in the building that contributes to sensible and latent heat load
   Other loads, i.e., load of equipment or components like computers, etc.

Generally, office buildings i.e. floor with large space, cooling is provided by means of Packaged Air conditioners in which all the components: compressor, condenser (which can be air cooled or water cooled), expansion valve and evaporator are housed in a single box. The cooled air is thrown by means of high capacity blower, and it flows through the ducts laid through various rooms. In the second arrangement, the compressor and condenser will be housed in one casing. The compressed gas passes through individual units, comprised of the expansion valve and cooling coil, located in various rooms. The efficiency of Packaged Air-conditioners is even more improved by means of VRF (Variable refrigerant flow) systems, in which the refrigerant flow is varied as according to the cooling demand.

In case of multi-storied Office buildings, the cooling can be achieved by means of Chillers and Variable air volume systems (VAV). Chillers can be air-cooled or water-cooled depending on the type of condenser. Water cooled Chillers being more efficient in terms of energy consumption than air-cooled chillers, the more energy-consuming air-cooled chillers can be replaced with the water-cooled chillers. VAV systems also proves to be better than the Constant air volume systems (CAV), since the volume of supply air can be controlled. VAV helps in demand based cooling, which means less energy is being consumed as compared to CAV systems. By usage of such energy efficient air-conditioning systems in a building, with low kW/TR, the energy consumed for cooling can be reduced.

COOLING ANALYSIS OF BUILDING AND ENERGY SAVINGS THROUGH EFFECTIVE COOLING

In this paper, an office building located in Bangalore, India with 1 floor and area of 150 m2 was taken for the study and analysis. Here, the building was modelled using design builder software, as shown in Fig.1. in which all the heat load factors were accounted for cooling analysis. This software uses the built-in templates, integrated with the Energy plus simulation software, generated by U.S. Department of Energy (Chowdhury, Rasul, & M. M.K. Khan, 2007).

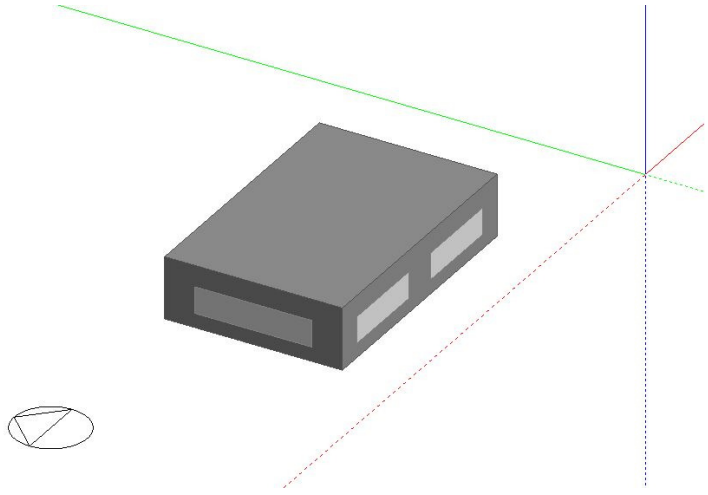

Figure1. Building model of office building by design builder software
Source:(Aaliya Azeem, 2018)

For the 150 m2 floor area office building with 1 floor of ceiling height 3.5m, the necessary considerations and factors were considered in the software (Saving energy in Commercial Buildings | Plug load assessment guidelines, 2002), for estimating the cooling load is listed in the following Table 1.

Table 1. Factors for accessing the cooling load requirement. Source (Aaliya Azeem, 2018)

Sl. No.	Description	Values
1	Area of the building (m2) =	150
2	No of people/ employees occupied =	80
3	Occupancy Density (people/m2) =	0.53
4	Computers Power density (W/m2) =	4.72
5	Power density of other Office Equipment (W/m2) =	11.72
6	Window to Wall % =	30%

With these factors, other factors like the construction of the building, its orientation, U-Value of windows, etc. were also considered for estimating the cooling load. By modelling, the cooling load required for the building obtained was 40 TR. The VRF template was used in simulation since the office under study was cooled by means of Packaged Air conditioner with VRF system. However, the Coefficient of Performance (COP) of the system was observed to be 3, which was less. Simulations were done by assuming COP to be high and the corresponding reduction in energy consumption is studied. Both present cooling system, which was comparatively less efficient with low COP and the recommended effective cooling system with higher COP were simulated.

By Simulation, energy consumption results were generated for the peak summer months: March, April and May. HVAC system with lower kW/TR and high COP gives more efficiency in terms of energy. An efficient VRF system with higher COP, COP = 6 was assumed and was simulated. When cooling system is designed with high COP (i.e. with low kW/TR) meeting the cooling requirements of the building, the cooling system is assumed to be designed at the optimum, by which, the energy consumption is significantly reduced. The reduction in energy consumption and CO2 emissions were simulated and graphically generated.

LIGHTING SYSTEMS OPTIMIZATION

For the energy analysis of the lighting system, the number of lights used in the building was taken into account. Also, the types of lights used were a major concern. The number of lights also needs to be optimized with daylight through windows being utilized. Studies prove that lights near the windows are ineffective and cause energy wastage. Instantaneous electricity demand or light power density (L.P.D) in W/m2 was taken into consideration as the major factor for the level of lighting required. The Lighting energy requirement mainly depends on: light power density, i.e. per W/m2 and office schedules.

The office schedule taken for study, starts from morning 8 a.m. to evening 8 p.m. Therefore, the light operating hours was 12 hours. It was observed that all the lights were 'ON' during all these office hours from morning to evening, irrespective of the time. The number of lights, its type and wattage was taken into account which is listed in Table.2.

Table 2. Observed lighting System in the Office building. Source (Aaliya Azeem, 2018)

Light Source	Fluorescent lights	CFL lamps
Wattage	32 W	15 W
No of lights	54	40

The present total wattage or power was obtained by multiplying the number of lights with wattage of those lights and summing it up, and was found to be 2.328 kW. Assuming 20 working days in a month with 12 operating hours in a day, the annual operating hours becomes 2880 hrs. Therefore, the annual electricity consumption determined by multiplying the total wattage (kW) and annual operating hours was 6704.64 kWh.

For reducing the energy consumption due to lighting, the most common practice is to replace the more energy consuming lights with the less energy consuming ones. Such energy saving lights include CFL lamps, LED lights, etc. which gives huge energy savings and cost savings. However, in the office building considered, the types of lights used were energy efficient ones. The energy efficient 32W T8 fluorescent lights generally used in office buildings, giving about 32000 lm are were used here. These consume less power as compared to normal 40W fluorescent lights that used in residential buildings. Also this office ceiling fluorescent light acts as linear source giving more angle of lighting than energy saving point sources of light. Therefore, here, number of fluorescent lights is varied only on the window basis. And then the remaining sizing of lighting is done based on light power allowance to give optimum light power density.

SIZING OF LIGHTS BY BUILDING AREA METHOD

Utilization of daylight through the windows can help in reducing the number of lights to an extent. Also, as we discussed, the lights positioned next to windows are nearly ineffective. So, out of 54 fluorescent lights, the rows of 9 lights next to windows were assumed to be removed. Therefore, we now consider only 45 nos. 32W fluorescent lights. After calculating its total wattage and comparing it with light power allowance (W) obtained from the optimum L.P.D. by building area method, the sizing of remaining CFL lights was done.

Building area method is generally used to calculate the total W/m2 for the entire building based on its type (Ministry of Power, India, 2017). First, the lighted gross floor area of the building has to be calculated. Then that area has to be multiplied with the allowed W/m2 as specified in ECBC for that building type, to determine the light power allowance. The building under case study was an enclosed office building, for which the allowed Light power density as per ECBC is 10.8 W/m2 (GreenTree Building Energy Pvt. Ltd, 2018). The calculations involved in sizing of lights for the respective office building under case study was done, as shown in the Table.2.

Table 3. Sizing of lighting by building area method. Source (Aaliya Azeem, 2018)

Sl. No.	Description and Calculations	Values
1	Area of the Office building =	150 m2
2	Optimum Light Power Density (as per ECBC) =	10.8 W/m2
3	Light Power allowance (Total Wattage required)= 150 m2 x 10.8 W/m2 =	1620 W
4	Of 54 lights , removing row of 9 Fluorescent lights near windows	
5	Proposed No of 32W Fluorescent lights =.	45 Nos
6	Total Wattage of Fluorescent lights = 45 Nos x 32 Watts =	1440W
7	Remaining Power/ Wattage required optimized by CFL lights = (1620 W - 1440 W)	180 W
8	No of 15W CFL lights therefore required =	12 Nos

With optimization of number of lights by building area method, the lighting power consumption can be reduced further by reducing the number of light operating hours. Though the lights were “ON” from morning 8 a.m., the employees mostly started their work only by 9 a.m. Also, it was observed that during noon time, from 12 p.m. to about 1p.m. or 2 p.m. the daylight was sufficient enough to work. In addition to that, during this time, the office schedule breaks for employees to have lunch. Therefore, within the office timing, all the lights can be turned off for 1 or 2 hours. By considering the operating hours to be less, i.e. 10 hours, with optimized number of lights, the reduction in lighting power consumption is achieved.

RESULTS AND DISCUSSIONS

ENERGY CONSUMPTION REDUCTION WITH EFFECTIVE COOLING SYSTEMS

The energy consumption of present system, the comparatively less effective one, with COP 3-3.5 was compared with the energy consumption of effective cooling system with COP 6. From the simulation results generated for peak months, a considerable reduction in energy consumption was obtained, as shown in graph Figure 2.

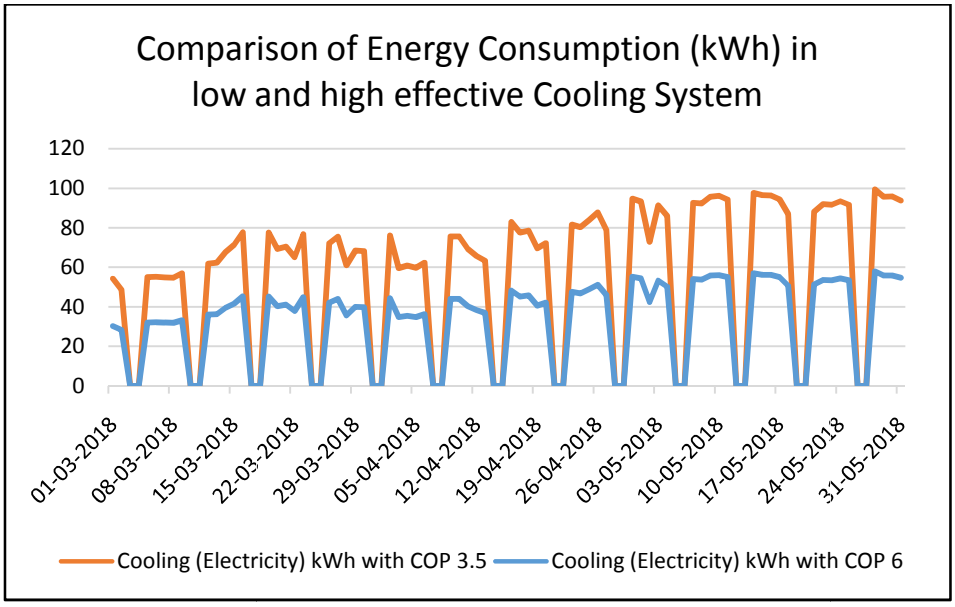

Figure 2. Comparison of Energy consumption in low and high effective cooling system
Source: (Aaliya Azeem, 2018)

REDUCTION OF CO2 EMISSIONS WITH EFFECTIVE COOLING

From studies, it is proven that CO_2 emissions have a linear relationship with the electricity consumption. This means that the CO_2 emissions increases and decreases linearly with the electricity consumption [kWh]. Approximately, 0.85 kg of CO_2 emissions are said to be released per unit electricity consumption. i.e., 0.85 kg CO_2 per kWh (GHG Inventory report for Electricity generation and consumption in India, 2009-2010). From electricity consumption results, CO_2 emissions were also calculated and is represented graphically as shown below, in Fig.3. By lowering the electricity consumption, the carbon emissions were also reduced, thus reducing the environmental impacts.

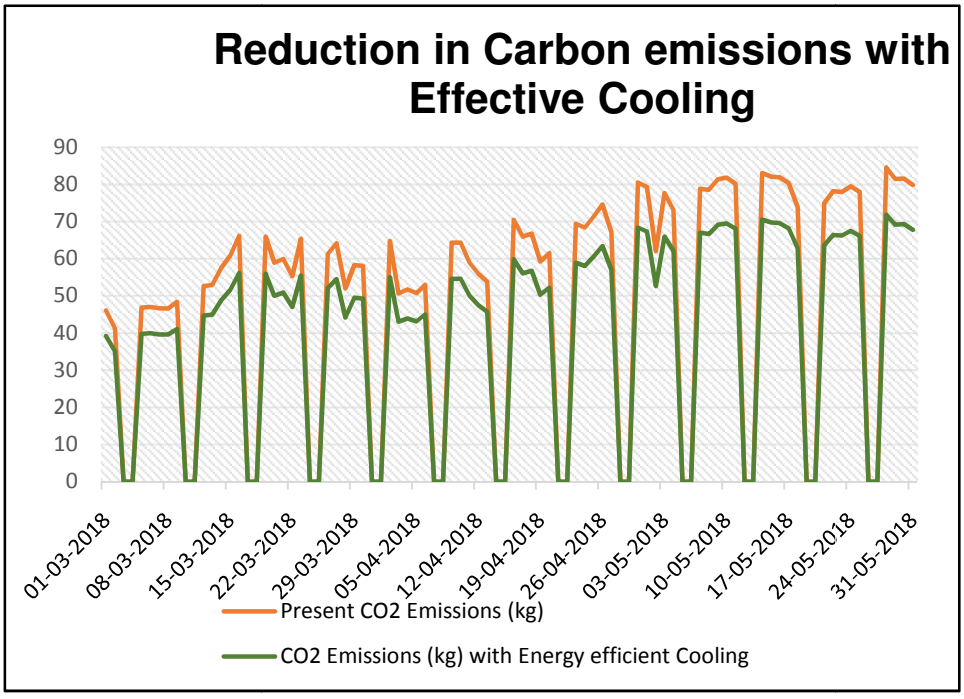

Figure 3. Reduction in CO_2 emissions with effective cooling.
Source: (Aaliya Azeem, 2018)

LIGHTING SIZING BY BUILDING AREA METHOD

After deducting the fluorescent lights near windows, assuming it to be ineffective, as daylight from the windows itself was sufficient enough, the number of CFL lamps was also calculated by building area method as per ECBC, to meet the light power allowance (in Watts) and optimum L.P.D. (W/m2). Then, the sizing of lights estimated is as shown in the table below Table 4.

Table 4. Lighting sizing by building area method. Source: (Aaliya Azeem, 2018)

Light Source	Fluorescent Lamps	CFL lamps
Wattage	32 W	15 W
No of lights	45	12

ANNUAL ELECTRICITY CONSUMPTION DUE TO LIGHTING AND ENERGY SAVINGS

With Sizing of lighting by building area method, the number of lights was calculated to meet the optimum light power density (W/m2). Also with optimum number of lights and less light operating hours considered, the annual electricity consumption (kWh) was calculated (Sugiura, Miwa, & Uno, 2013). By comparing the old lighting system with the proposed energy efficient lighting system, high energy savings were obtained, as shown in the below table.

Table5. Energy consumption due to lighting and Energy savings. Source (Aaliya Azeem, 2018)

Sl. No.	Description and Calculations	Values
1	Total Power / Wattage = (32W x 45 Nos + 15W x 12 Nos) =	1620 W
2	Total Power in kW =	1.62 kW
3	Operating hours =	10 hrs.
4	Operating days in a month =	20 days
5	Annual Operating hours =	2400 hrs.
6	Annual Electricity Consumption= (1.62 kW x 2880 hrs.) =	3888 kWh
7	Energy Savings obtained (in kWh) =	2816.64 kWh

REDUCTION IN ENERGY CONSUMPTION AND CARBON EMISSIONS WITH EFFECTIVE LIGHTING SYSTEM

With the effective lighting system, the annual electricity consumption in kWh was found to be lowered. Also, since the CO_2 emissions is assumed to vary linearly with the electricity consumption, i.e., 0.85 kg CO_2 per kWh. the carbon emissions were also calculated, to analyze the environmental impact reduction. From the analysis done, the carbon emissions were lowered from 5698.94 kg to 3304.80 kg. Thus, huge carbon savings of about 2394.14 kg was achieved. In the Figure 4., both the present and proposed effective lighting systems are being compared, representing the energy savings and carbon savings obtained.

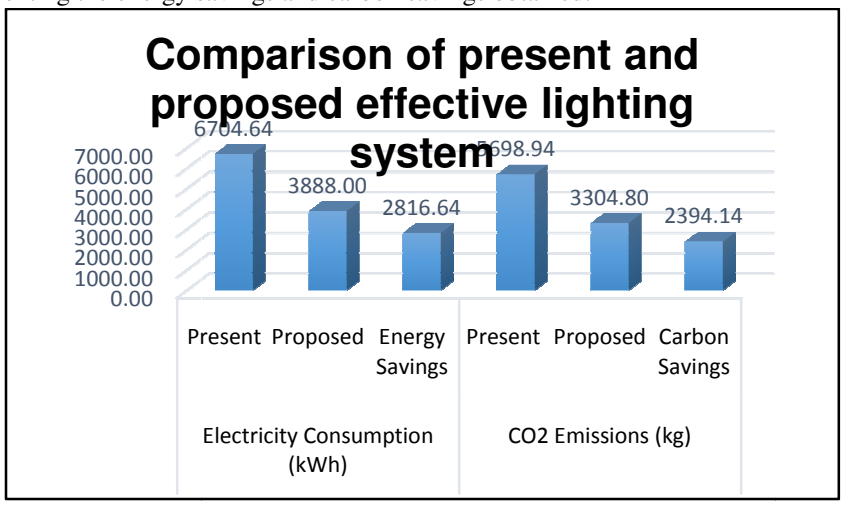

Figure4. Comparison of present and proposed effective lighting system
Source: (Aaliya Azeem, 2018)

CONCLUSION

Through cooling analysis of buildings, an appropriate effective cooling system can be adopted according to type of the building. The energy consumption of the cooling systems studied were simulated and it was observed that the cooling system with higher COP or low kW/TR was found to be energy efficient. The energy efficiency in lighting was brought by optimizing the number of lights by building area method and by reducing the light operating hours. Along with the effective cooling and lighting systems, the utilization of windows in building design acts as green measures for achieving good thermal comfort. Energy-efficient cooling systems and lighting systems lower the electricity consumption, thus CO_2 emissions and environmental impacts caused due to it, can be significantly reduced.

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Environmental Impact Assessment Of Rejuvenation Of Grand Canal Of Puducherry Under Surface Water Perspectives- A Smart City Mission Project

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Abstract: Grand Canal is a 3 km stretch in the heart of the town of Pondicherry and is crucial to the economy, health and welfare of a large part of the people of Puducherry and tourist as it is under ABD of Puducherry smart city development limited. It was constructed by the French in an around 1765 to drain the stormwater and to direct the rainwater towards the end into the uppar drain and toward the south into the sea close to the new light house. Over some undefined time frame, the canal has become a sewage line in the heart of the town, dump yard, parking space for vehicles and as a space for the local market. According to the survey which is recently done by the INTACH revealed that around 250 houses were letting their wastes into the drains. The average concentration of the physico-chemical and biological parameter were pH (8.13), EC (832.14 µS/cm), dissolved oxygen (1.9685 mg/l), total dissolved solid (540.89 mg/l), BOD (311.5 mg/l), COD (637.5 mg/l), chloride (911.3 mg/l) and total colliform (325.7 MPN/100 ml). The bad odour was also felt while collecting the sample at each station. The human excreta seem to be commonly found in almost every station where the samples were collected. The result of this project will help the authorities of the Puducherry smart city development limited to know the present status of the canal and then take the necessary steps for rejuvenation of the canal.

Keywords:Grand canal, Rejuvenation, Environmental impact assessment, wastewater, Pollution.

INTRODUCTION

The inherent development is brought up by economic, community and change in the environment (Dougherty et al., 1995). The development aims to bring about positive change but it can also lead to conflicts. The need to avoid adverse impacts and to ensure long term benefits led to the concept of sustainability (Dougherty et al., 1995).So as to foresee the natural effects of any advancement action and to give a chance to relieve against negative effects and upgrade positive effects, the environmental impact assessment (EIA) technique was created during the 1970s (Dougherty et al., 1995). EIA assesses the possible impact (positive or negative) that a proposed project may have on the environment; considering natural, social and economic aspects (Mondal et al., 2010). The aim of the evaluation is to assure that decision-makers consider the consequent environmental impacts to decide whether to proceed with the projects (Onishi et al., 2006). The International Association for Impact Assessment (IAIA) characterizes a natural effect appraisal as the way toward distinguishing, foreseeing, assessing and alleviating the biophysical, social, and other applicable impacts of advancement recommendations preceding significant choices being taken and duties made (Zamorano et al., 2005). Rejuvenation, retrofication, and modernization of any existing structures such as a canal, buildings, roads, etc. have become an important factor in this fast-growing and advancing technological era. Although it's an important factor, it is necessary to predict the environmental impact of it, ways to avoid and then come up with a positive solution. This is started primarily using EIA. The Grand Canal of Puducherry is a 3 km stretch in the heart of the town of Pondicherry. The canal will be taken up for beautification, will have pedestrian pathways (figure 1) on both the sides (Prasad, 2017), recreational use of water (figure 2) and hence requires proper environmental impact assessment as it is crucial to the economy, health and welfare of a large part of the people of Puducherry and tourist as it is under ABD of Puducherry smart city development limited. It was built as a storm water drain by the French around 1765 and to direct the rainwater towards the end into the upper drain and toward the south into the sea close to the new light house (Prasad, 2017).The canal was also extended beyond to the northern boulevard on 6 July 1827. Over some undefined time frame, the canal has become a sewage line in the heart of the Pondicherry town, dump yard, parking space for vehicles and as a space for the local market. According to the survey which is recently done by the INTACH revealed that around 250 houses were letting their wastes into the drains (Prasad, 2017).In this study (Kumwimba et al., 2017) and project work, it will carry out two things. Firstly, to locate and identify various households, shops, illegal activities, etc. in and around the canal that allows wastewater and other wastes to drain it. Secondly, to collect samples at each station at a distance of 300-500 m

and noting down the points of each station from which wastewater is being discharged and other wastes are dumped into it during the dry seasons (figure 3) and testing its physical, chemical and biological parameter.



Figure 1. Pedestrian pathways on both sides of the Grand Canal
(Source: https://pondicherrysmartcity.in/images/pdf/Puducherry%20Smart%20City%20Proposal%202017.pdf)



Figure 2. Recreational use of water in the Grand Canal
Source:https://pondicherrysmartcity.in/images/pdf/Puducherry%20Smart%20City%20Proposal%202017.pdf



Figure 3. The Grand Canal during the dry seasons
(Source : https://www.google.co.in/search?q=grand+canal+puducherry&hl=en-IN&authuser=0&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwj7j7HhioPfAhVGUZAKHccQDi8Q_AUIDygC&biw=1536&bih=724&dpr=1.25#imgrc=UYi6tanY6jap0M)

MATERIALS AND METHODS

STUDY AREA,ITS LOCATION AND SITE DESCRIPTION:

Under the smart city mission project, the rejuvenation of the Grand Canal will be done from Dubrayapet to Patel Salai to convert it into a tourism spot by beautifying, creating shopping opportunities, pedestrianizingon both the sides of the canal, improving the facade and mobility, and finally changing it into complete ecological lobby from the center of the city to the mangroves (Senthalir, 2017). The area of the study ((Islam et al., 2017) project is taken from Patel Salai ($11^0$56'27"N and $79^0$49'58"E) to Dubrayapet ($11^0$54'57.80"N and $79^0$48'44" E) and the end point of the canal (figure 4) where the wastewater are collected and treated at Dubrayapet sewage treatment plant and then finally discharged into the sea or used for irrigation purpose. The street of Patel Salai and Dubrayapet is quite busy with the traffic and quite closer to the rock beach of Puducherry. Screening has been done from Patel Salai to Dubrayapet. It is observed that many houses are discharging their wastewater using a small drain (figure 5) into the Grand Canal including the Government Hospital which is just opposite to the canal when it is walked through Patel Salai. Algal bloom was seen in some places of the canal. Besides the canal, the soil is seen to be losing its strength as it is being used for nature call by the people.



Figure 4. Small drain connected to Grand Canal
Source: Jamatia 2018

The surface water samples from the Grand Canal were collected at 7 sampling stations at a distance of 300-500 m each in the month of October 2018 before the rainy seasons in plastic bottles of 2L capacity each. The samples were transported to the laboratory within 3-4 hrs for analysis of physico-chemical parameters and bacteriological quality. The samples were protected from the sunlight by keeping them in a dark room.

PHYSICO-CHEMICAL PARAMETERS:

Portable thermometer, pH meter and conductivity meter were used for the determination of temperature, pH and electrical conductivity in its place of sample collection. The parameters like TDS, dissolved oxygen, BOD, COD and chloride were examined. The standard technique (APHA, 2017) was followed for collection, protection and examination of various characteristics of the sample collected at various stations. The summary of the measured parameters are given in the table 1

BIOLOGICAL PARAMETERS:

The Standard procedures were carried out for collection and bacteriological test of surface water samples of the canal. The samples were tested for TC using the MPN techniques. The presumptive coliform test was followed by confirmatory test using lactose broth and brilliant green lactose bile broth. The results are provided in the table 2.

RESULTS AND DISCUSSION

Physico-chemical characteristics of surface water sample:

The results of the Grand Canal are presented in table 1 an it reveals that it is highly polluted at almost every stations.

Table 1. Summary of the measured parameters

Station	Parameter							
	Temperature (^{0}C)	pH	EC (µS/cm)	DO (mg/l)	TDS (mg/l)	BOD (mg/l)	COD (mg/l)	Chloride (mg/l)
S-1	24.5	7.80	620	3.4	403	219.8	450.2	642.3
S-2	26.2	7.90	675	2.45	438.75	273.1	550.6	582.32
S-3	24.2	8.32	690	2.3	448.5	290.5	590.3	786.1
S-4	23.5	8.19	750	2.27	487.5	310	625.6	897.2
S-5	25	8.27	840	2.04	546	330.9	670.2	1123.3
S-6	24.5	8.17	1020	1.12	663	335.2	675.5	968.3
S-7	26.8	8.29	1230	0.2	799.5	420.9	900	1379.6

The pH seems to be moderately alkaline (7.80-8.39) in almost all 7 stations. The temperature range in all the stations does not very much. The discharge of the domestic wastes brings about thermal changes in the canal (Usharani et al., 2010). The increase in temperature of the sewage quicken chemical reactions, lower the solubility of gases, amplified taste and odour an elevates metabolic activity of organisms. Dissolved oxygen concentration (Ali et al., 2016) is low (table 1) in all the stations. The high content of TSS and TDS could be the possible reason, which utilized the significant amount of dissolved oxygen for biochemical degradation (Islam, 2017). The occupancy of phosphate in the canal also could increase the speed of the activities of some of the micro-organisms. The total dissolved solids (TDS) at some sampling stations shows quiet high. The cause of high and low TDS is due to proper and improper dilution of the domestic wastes discharged from household, shops and other sources. High BOD and COD (Ahmed et al., 2010) at all stations especially in the last stations indicates that the canal is severely polluted and the reason could be due to the coming together of domestic sewage, solid waste, etc. The possibility of quiet high BOD and COD in the canal might be due to the discharge of sewage which is not being treated. At some sampling stations (table 1) the concentration of the chloride seems to be very high which is due to the sewage.

BACTERIOLOGICAL CHARACTERISTICS OF THE SURFACE WATER:

The table 2shows the result of the TC from all the sampling stations of the Grand Canal. The bacterial population in the surface water had totally deteriorated the canal. From the result (table 2), it reveals that the canal is extremely contaminated which is hazardous to the public health and the animals. Escherichiacoli which acts a biological indicator plays a vital role for the determination of bacterial population and surface water quality of the aquatic ecosystem. Domestic sewage and human excreta are the main reasons behind the bacterial contamination in the canal. Some of the genera of bacteria like Bacillus sp, Escherichia coli, , streptococci sp, Enterrobacter sp, etc. could be present in the canal and the reason behind might be due to the excreta of human and the domestic sewage. The last sampling stations was found to be with more of bacterial density compared to other stations and the reason could be the excreta of human and the domestic waste and also as this is the place where the Grand Canal meets the Upper Canal.

Table 2. Bacteriological characteristic of the sample

Station	Total Coliforms (MPN/100) ml
S-1	130
S-2	140
S-3	180
S-4	280
S-5	280
S-6	350
S-7	920

CONCLUSION

Environmental impact assessment checks the expected effects on the natural environment, human health and considered to be a very essential tool to integrate environmental, political, economic and socio-economic conditions. They protect society from an adverse impact, which could result from the rejuvenation of such projects as Grand Canal. Hence, EIA procedures are considered as a useful tool for the sound management of the environment but it is not only restricted to the impact on the seawater, soil, aquifer and sewage system. The

physico-chemical and biological parameters like BOD, COD, chloride, TDS, TC, etc. shows that the Grand canal is experiencing severe pollution from various sources like from more than 250 houses, shops and also by other illegal activities in and around the canal. The surrounding areas of the canal was also seen very polluted besides the surface water and could be very harmful to the plants that are besides the canal. The inflow of the domestic waste water and solid wastes into the canal can increase in a span of time due to the rapid growth of residential and commercial activities. It is observed that more houses are being constructed even though the space is limited in the area between the Patel Salai and Dubrayapet and so chances of letting the domestic wastewater may increase more in the days to come. The authorities should make or provide an alternative arrangement to avoid flow of wastewater into the canal. The canal requires an urgent restoration for the well being of the human welfare and the surrounding environment along with rejuvenation as it is under smart city mission project which will be a boom to the economy of the state and the nation. The rejuvenation of Grand Canal should be one of the top priorities taken by the Puducherry Smart City Development Limited as it is in the heart of the town of Pondicherry.

Acknowledgement

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Estimation of carbon dioxide reduction through recognition of energy wastage in buildings

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Abstract: Exhaustion of energy resources and the increase in energy usage affects the sustainability directly. Excess usage of energy leading to higher emissions has several environmental impacts like air pollution, ocean acidification, polluted vegetation, etc. Carbon dioxide (CO_2) equivalent is a measure of study for assessing the impact of higher energy use. Real-time activity recognition is a tool to estimate the energy wastage in buildings. Application and benefits of real-time activity recognition technique in various types of buildings such as boarding houses, study halls, eateries, lavatory buildings, and workrooms are analyzed. CO_2 reduction potential is used to assess the benefit of real-time activity recognition technique with different sources of electric power generation. For a boarding house type building with average power consumption of 100kWh per month, with weighted sum model, reduction up to 24.6kg equivalent CO_2 emission is observed. The equivalent CO_2 emission rate can be reduced up to an average of 25%. Thus energy efficiency with real-time activity recognition technique focuses at reducing the energy consumption with the same level of serviceability and providing the same quality of life.

Keywords: Energy Efficiency, Real-Time Activity Recognition, Weighted Sum Model, Buildings, CO_2 Reduction Potential.

INTRODUCTION

Industrialization and urbanization across the world along with the development of technology in recent years have led to a drastic increase in the use of energy resources. The energy source for humans reconditioned from biofuels to fossil fuels through ages. Development of technology paved the way for the renewable, non-conventional sources of energy. The renewable sources reduced the depletion of available resources and also had much-reduced emissions. Immense reduction of impact on the environment is possible with increasing the usage of non-conventional sources of energy. Efficient use of renewable energy further decreases the load on the environment and reserves energy for future consumptions leading to sustainability. One of the key outcomes of the 2015 Paris climate conference was to decrease the global CO_2emission and bring down the temperature, most of the parties including India have their own nationally determined contribution for its accomplishment. All these show the importance of attaining maximum possible efficiency in the energy usage activities. Earning it at the cost of people's comfort will not give positive results. Social acceptance and affordability are two sides of the same coin which restrains many innovations to the limelight.

During few decades CO_2 emissions are increasing at alarming rate and CO_2 is a major contributor of global warming. As per the European Commission's–JRC Science for Policy Report there has been an average increase of 59% global CO_2 emission from 1990 to 2016, and when it comes to India it shows a drastic increase of 286% for the same time period (Janssens-Maenhout, et al., 2017). This increasing emission is a potential threat to sustainable development. Table 1 gives the data of CO_2 emission in kton CO_2 for the world and India, this data is used to show a graphical representation of the problem (Figure 1).

Table 1. CO_2 emission (in kton CO_2) for the World and India.Source: (Janssens-Maenhout, et al., 2017)

Year	CO_2 emission-World (kton CO_2)	CO_2 emission–India (kton CO_2)
1990	22452432	655461.6
2000	25595733	1064431
2005	29771013	1262994
2010	33589795	1843399
2012	34792575	2086788
2014	35688794	2328013
2015	35633093	2419637
2016	35755322	2533638
% increase for 16 years	59.249216	286.5425

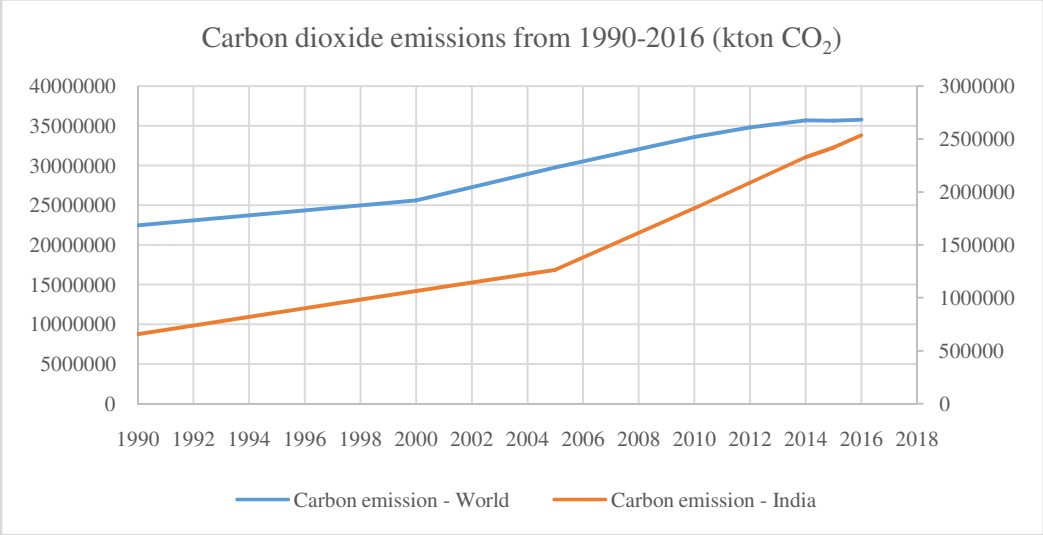

Figure 1. Carbon dioxide emission for the World and India for period from 1990 to 2016. (Source: (Janssens-Maenhout, et al., 2017))

An energy outlook report shows that 29% of world energy consumption is by the buildings and it is increasing year by year (2018 Energy Outlook, 2018). From the interpretation of sector wise energy consumption report by BP Energy Outlook 2018 reveals that building energy consumption have almost doubled from 1970 to 2010 and still increasing. Source of energy for building systems and applications is delivered and consumed in the form of electricity. Electricity is generated from different sources like coal, oil, natural gas, solar energy, and nuclear sources and further developments are under research stage (example; electricity generation by pumping the water to underground and raising the temperature and tapping the energy). All of these sources have different levels of impacts on environmental. Increase in energy consumption leads to higher emissions, so decreasing the energy consumption in a building sector can reduce the global CO_2 emissions and also other impacts. The impact potential of energy consumption is calculated using CO_2 equivalence.

Real-time activity recognition technique, developed by researchers from the University of Southern California, is a method to estimate wastages by human activities in buildings. The study provides details of accuracy achieved and average wastages for different human activities like entering a room, preparing food, switching on a monitor, etc. Savings in energy consumption is calculated using the values of average activity wastages in different types of buildings of study. The wastage calculated is useful to make aware of energy savings plus decrease the energy consumption.

Carbon dioxide equivalence is a versatile functional unit that can evaluate the impacts, convert it to various factors according to the boundary and scope of the study. Further, weighted sum model is used to select the best alternative of energy wastage percentage from the two different assumptions for a given type of building. The alternatives, assigned based on the scores for energy consumption as detailed in methodologies, are used to estimate the energy wastages in each type of building and this is further calculated in terms of CO2 reduction amounts. Thus the novelty of this study is to estimate CO2 reduction through recognition of energy wastage in buildings using activity recognition technique and weighted sum model.

METHODOLOGIES ADOPTED

REAL TIME ACTIVITY RECOGNITION TECHNIQUE

Real time activity recognition is a method to assess the wastages in buildings. The technique was developed by the researchers from University of Southern California. Wearable and environmental sensors were used to detect the activities and the environment inside a building. Wearable sensors used to detect actions like walking movements, standing etc. Environmental sensors are more complex which detects the environment where it is placed, it might be like detecting the light intensity, smoke/gases etc. Three algorithms action detection, activity recognition and waste estimation were developed using the sensors for the waste estimation from each activity. Average accuracies for each activity recognition was calculated based on ground reality and statistics (Simin

Ahmadi-Karvigh, Ali Ghahramani, Burcin Becerik-Gerber, & Lucio Soibelman, 2018). Table 2 details the activities and the average accuracy for each activity recognition.

Table 2. Accuracy for different activities in activity recognition. (Source: (Simin Ahmadi-Karvigh, Ali Ghahramani, Burcin Becerik-Gerber, & Lucio Soibelman, 2018))

Activity	Average Accuracy
Entering to room/building	100.00%
Leaving room/building	100.00%
Sleeping	95.00%
Washing utensils	100.00%
Washing clothes	100.00%
Using television	98.02%
Working on computer	95.05%
Cooking	91.09%
Eating	90.10%

The accuracies obtained in table 2 is used to analyze the applicability and benefits of real time activity recognition technique in different types of buildings.

TYPES OF BUILDINGS AND ACTIVITIES

Five types of buildings under consideration are: 1. Boarding houses, 2. Study halls, 3. Eateries, 4. Lavatory buildings, 5. Work rooms. Based on the type of building the activities varies, it is not necessary all the activities mentioned in Table 2 needs to be happening in all the building. Certain activities are general to all buildings like entering or leaving a building etc. and some are specific too. In Table 3 activities are mapped according to their occurrence or non-occurrence for the type of building. The activity mapping is used for developing a model that estimates the energy wastage condition in a building.

Table 3. Mapping of activities to the type of building; (Y: Yes, N: No). (Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018)

	Activity Number	Boarding Houses	Study Halls	Eateries	Lavatory Buildings	Work Rooms
Entering room/building	A1	Y	Y	Y	Y	Y
Leaving room/building	A2	Y	Y	Y	Y	Y
Working with computer	A3	Y	Y	N	N	Y
Sleeping	A4	Y	N	N	N	N
Using television	A5	Y	N	N	N	N
Washing utensils	A6	Y	N	Y	N	N
Washing clothes	A7	Y	N	N	N	N
Cooking	A8	N	N	Y	N	N
Eating	A9	Y	N	Y	N	N

CARBON DIOXIDE EMISSIONS

Carbon dioxide emissions are calculated in terms of carbon footprint. It is the CO_2 consumed or emitted during a products life. Carbon foot print is used nowadays to define sustainability of a product. Carbon foot print value gives the opportunity for decision makers to choose from the alternatives that have less CO_2 footprint. CO_2 emissions are present for all types of power (electricity) generation sources. Some people might think non-conventional sources like solar wind etc. are having zero emissions. That is not true, at some point of its life it has CO_2 marks. Different life cycle and other studies have been occurring around the world in this regard to assess the carbon foot print of non-conventional energy sources. Per unit CO_2 emissions will be useful to determine carbon emissions at different levels in a study boundary. Table 4 lists CO_2 emissions as per the

carbon foot print report submitted for European parliament (The Parliamentary Office of Science and Technology, 2011). Table 4 details maximum CO_2 emission in grams(g) of CO_2 for one kilowatt hour(kWh) generation of power from different sources such as coal, oil, gas, solar, wind, geothermal, wave and tidal and nuclear. Due to uncertainties in carbon foot print value for hydroelectric because of dependency on locations and other factors like flooding of bio-environment etc., hydroelectric source is not considered in this study.

Table 4. CO_2 emission for different sources of electricity generation.(Source: (The Parliamentary Office of Science and Technology, 2011))

Source	gCO_2/kWh (g:gram; kWh: kilowatt hour)
Coal	990
Natural Gas	488
Solar	116
Wind	96
Geothermal	53
Wave and Tidal	39
Nuclear	26

WEIGHTED SUM MODEL

Weighted sum model is a statistical technique to find out the best viable alternative for different conditions. Here energy wastage percentage, in a type of building with a specific set of activities, is calculated using the weighted sum model. Activities in a building are considered as the criteria. Energy consumption for each activity is not the same, it depends on the type of activity. Considering two activities like working on computer and washing utensils, washing utensils needs less energy than the other and it will be having less energy wastage. Based on this thought that activities with more energy consumption more weighted energy wastage and thus weighted energy wastage for activities are consigned. Table 5 specifies the assigned weighted energy wastage (WA).

Two alternatives (i=1,2) are considered for all five types of buildings. Score out 100 (scoreiA) is fixed based on the energy consumption by each activity. Table 6 details the score and corresponding description of that score, this score is used in the two different alternative assumptions. The two alternative assumptions are:

Alternative 1: all activities are having same score of energy consumption (30 out of 100), moderate energy consumption is marked with score 30.

Alternative 2: prime activities of a type of building will have more energy consumption.

Maximum weighted sum is adopted to find the viable alternative that should be considered for wastage estimation. For the nine activity criteria with two alternatives, the best alternative is the one that satisfies the following expression:

$$Alternative = \max \sum_{A=1}^{9} (W_A * score_{iA}) \, , for \; i = 1,2 \, ;$$

where WA-Weighted energy wastage of an activity; scoreiA-Score of activity A in ith alternative.

Table 5. Assigned percentage of energy consumption for each activity. (Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018)

Activities Considered	Activity Number	Weighted energy wastage (WA)
Entering room/building	A1	5%
Leaving room/building	A2	10%
Working with computer	A3	20%
Sleeping	A4	10%
Using television	A5	15%

Washing utensils	A6	5%
Washing clothes	A7	15%
Cooking	A8	15%
Eating	A9	5%

Table 6. Score and corresponding energy consumption range.
(Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018)

Score(out of 100)	Energy consumption range(Watt(W))	Description of energy consumption
5	below 10W	Nominal energy consumption.
10	10.0-60.0	Very less energy consumption.
20	60.0-110.0	Less energy consumption.
30	110.0-150.0	Moderate energy consumption.
40	150.0-190.0	High energy consumption.
50	190W and above	Significant energy consumption.

CALCULATIONS

As per the score descriptions score for each activity is assigned as per the two assumptions and the weighted sum is calculated in below Table 7. Score for the Alternative 1 and Alternative 2 is assigned based on the energy consumption range (fixed in Table 6) and assumptions made in weighted sum model.

Table 7. Weighted sum calculation for two alternative assumptions of energy wastages in building.(Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018)

	Activity Number	A1	A2	A3	A4	A5	A6	A7	A8	A9	Weighted sum
	Weighted energy consumption-WA	5	10	20	10	15	5	15	15	5	100
Boarding Houses	Alternative 1	30	30	30	30	30	30	30	X	30	25.5
	Alternative 2	20	10	30	30	30	10	50	X	5	23.75
Study Halls	Alternative 1	30	30	30	X	X	X	X	X	X	10.5
	Alternative 2	20	10	30	X	X	X	X	X	X	8
Eateries	Alternative 1	30	30	X	X	X	30	X	30	30	12
	Alternative 2	20	10	X	X	X	40	X	50	20	12.5
Lavatory Buildings	Alternative 1	30	30	X	X	X	X	X	X	X	4.5
	Alternative 2	30	20	X	X	X	X	X	X	X	3.5
Work room	Alternative 1	30	30	30	X	X	X	X	X	X	10.5
	Alternative 2	30	20	40	X	X	X	X	X	X	11.5

The highlighted row, with max weighted sum, represents the alternative that needs to be chosen (among the two alternatives). This alternative is used to calculate the average waste elimination percentage in a building. Accuracy of activity recognition is used with the workable alternative to estimate the minimum energy wastage

percentage that can be eliminated from a building. The following formula is used to calculate the waste elimination percentage (%) is:

$$Average \text{ elimination } \% \text{ of energy } wastage = \sum_{A=1}^{9} (W_A * score_A * accuracy_A)$$

Wastage in energy consumption is calculated based on the maximum weighted sum alternative selected among the two assumed alternative of activities happening in a building. To calculate CO_2 emission reduction building is considered with a monthly consumption of 100kWh. Many developed countries have an average per month household consumption far more than 100kWh even though it is used for emission calculation due to its ease of referencing. Amount of CO_2 emission reduction for different sources of electric power generation is computed using the percentage energy wastage and the kg CO_2 value detailed in Table 4.

RESULTS AND DISCUSSIONS

The average elimination percentage of energy wastage from each type of building and the amount of reduction in CO_2 (in kg CO_2) is listed in Table 8.

Table 8. Average energy wastage elimination in a particular type of building. (Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018)

	Boarding Houses	Study Halls	Eateries	Lavatory Buildings	Work Rooms
Elimination % of energy wastage	25%	10%	12%	5%	11%
	Emission reduction in kg CO_2				
Coal	24.6	10.1	11.6	4.5	11.0
Natural Gas	12.1	5.0	5.7	2.2	5.4
Solar	2.9	1.2	1.4	0.5	1.3
Wind	2.4	1.0	1.1	0.4	1.1
Geothermal	1.3	0.5	0.6	0.2	0.6
Wave and Tidal	1.0	0.4	0.5	0.2	0.4
Nuclear	0.6	0.3	0.3	0.1	0.3

The average reduction in energy that can be achieved as recorded in Table 8 is minimum for lavatory buildings (5%) and maximum for boarding houses (25%). The results show that the technique is effective in detecting the energy wastages even for buildings with multiple activities as in the case of boarding houses. Also it can be established that energy wastage is more in buildings with numerous activities.

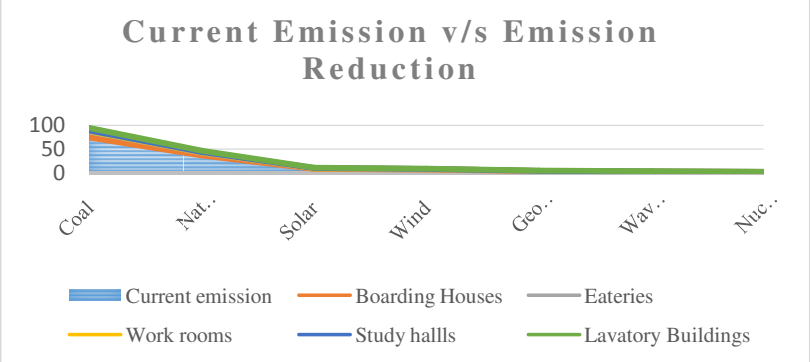

Figure 2. Plot between current emission and reduced emission of CO_2 (in kg CO_2) for five building types and different sources of electric power generation.
Source: Mohammed Bin Zacharia K and Dr. P Sridhar, 2018

Apart from the type of activity scores perhaps the wastage calculated is a minimal one, it can be still higher based on the usage and behavior of individuals. The energy needed for the operation of activity detection or recognition sensors and microprocessors have been neglected in the study as it is very nominal. Figure 2 represents a plot between the current emission (blue area) and the reduced emission in kg CO_2.

From the above plot (Figure 2), it is visible that impact of CO_2 reduction is more if the power generation source is coal or natural gas. Solar and wind generation of electricity also marks some evident CO_2. While coming to the remaining sources of power generation due to its less carbon footprint, even though more than twenty percentage wastage is eliminated CO_2 reduction is in very less quantity. The plot area thus reveals that if power generation is from high carbon footprint sources the activity recognition technique to reduce the energy wastage can reduce large quantity of CO_2 emission. The wastage elimination is responsible for the reduction of CO_2 emissions. Reduction of 24.6kg of CO_2 per month can be achieved in boarding house type buildings with coal as the power generation source. So with large amount wastage elimination subsequent CO_2 emissions can also be reduced. Amount of emission reduction estimated revels that activity recognition technique is a very powerful tool to reduce the emission through energy efficient usages in buildings.

CONCLUSION

Considerable quantity of CO_2 emissions can be reduced by attaining energy wastage elimination in buildings. The energy wastage elimination in buildings can be achieved by adopting activity recognition technique. Three key points deduced from the study are:

- Energy wastage is more in buildings with numerous activities.
- Any percentage of energy wastage reduction can have successive CO_2 emission reduction.
- Positive impact of CO_2 emission reduction is largely visible if the source of power is coal or natural.

CO_2 emission reduction values shown in this study are for a single building if it is implementable in large numbers even for a small wastage percentage can give constructive impact. Social acceptance and accuracy of sensors in a complex environment and activities inside a building are still barriers for expanding activity recognition technique as a major energy reducer. This paper recommends further research into more complex building environment and activities that influence the reduction of energy usage and also technological solutions that may facilitate the reduction of energy consumption.

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Bamboo as a Building Material

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Abstract: Recent construction and development activities have been causing adverse impacts on the environment due to unsustainable practices. This has led to research on sustainable building materials and technology. This study is an attempt to understand the sustainable use of bamboo in building industry. Literature is reviewed to know more on the biological characteristics & global distribution, relevant codes and organizations actively involved in working with bamboo and the applications of the material. A literature case study is done on different pole structures and engineered bamboo structures. A live case study of the bamboo-made architecture firm Inspiration in Cochin is done. It is inferred that steel, although used as dowels, contribute significantly to the energy consumption than what the main structural element bamboo consumes. The findings from the study so as to why bamboo is still not in the forefront of construction are a) the perception that bamboo is "Poor man's timber", b) lack of building codes, c) irregularity in structure, d) flammability and e)durability.

Keywords: Sustainability, Bamboo Structures

INTRODUCTION

Bamboo usage has been under research as a viable construction material suiting the modern requirements since 1990s. India, being the second largest producer of bamboo, has a huge opportunity in research and development of bamboo. It is found that bamboo is an excellent substitute for wood and steel. Life Cycle Analysis conducted on bamboo structures in New Zealand and China has inferred bamboo to be environment friendly, cost effective and strong construction material (Escamilla and Habert 2014; Yu et al. 2011). Bamboo is yet to come to the forefront in construction industry. This study is an attempt to analyze the versatility of bamboo in construction and scope for further improvement.

REVIEW OF LITERATURE

EVOLUTION OF BAMBOO AS AN IMPORTANT RESOURCE

Bamboo was an important resource in its natives like India and China. In India, bamboo was used as a building material, source of food & medicines and other daily requirements like furniture, decorative purposes etc. Bamboo structures were temporary with excellent disaster resilient properties. Bamboo mats, bamboo poles and bamboo leaves were the major structural members. In China, bamboo has been a part of their culture and is regarded as a symbol of virtue and morality. Chinese bamboo culture has been inherited and carried along its 5000 years of history (Zhu Zhaohua 2018). With the onset of industrialization and production of well defined ready to use materials, the significance of bamboo declined. Lack of knowledge regarding all its properties prevented its use when compared to concrete and steel whose properties were established(Modern Bamboo Structures 2008). Deforestation to meet timber demand led to search of a renewable non wooden substitute. This resulted in resuming the use and development of bamboo. Over the years, research has showed that bamboo can substitute steel(Atanda 2015)(Modern Bamboo Structures 2008). To create awareness about bamboo various organizations were established across the world starting from the World Bamboo Organization (WBO) in 1984 and International Network of Bamboo and Rattan (INBAR) in 1997 and many others (Zhu Zhaohua 2018). In India, Manasaram Architects in Bangalore, IPIRTI-TRADA research, Auroville Bamboo Centre in Pondicherry, KFRI in Peechi are involved in bamboo construction and research. IIT Delhi has been working on the areas of bamboo reinforcement and bamboo mass housing.

BIOLOGICAL CHARACTERISTICS OF BAMBOO

Bamboo belongs to subfamily Bambusoideae of the grass family Poaceae. It is fast growing (at the rate of 30-120 cm everyday) and can be harvested in 3-5 years. Although it is native to warm and tropical region, it can be grown anywhere, even on sloping terrain where other foresting is not possible. Bamboo has a rhizome dependent growth which may be clumping (slowly spreading) or running (fast spreading). (Takano et al. 2017).The stems are hollow and columnar with vascular bundles in the cross section. The fibers are scattered

such that bamboo forms a functionally gradient material. Its physical properties depend on the fiber distribution which further affects mechanical and other properties(Modern Bamboo Structures 2008) . The culms grow to their full height and diameter in three to four months. The branches form when majority of them mature. By the end of the third year the culm hardens and shoot becomes fully matured. After 5-8 years the culm collapses due to fungal growth. Thus bamboo lives for 5-8 years. The best time to use bamboo is during 3-7 years of its life.

BAMBOO DISTRIBUTION AROUND THE GLOBE

Bamboo is native to Latin American countries, Africa and Asian countries. There are 75 general and 1250 species of bamboo. As per National Bamboo Mission, India has 136 bamboo species covering an area of 13.96 million hectare. A majority of these are cultivated through agro forestry. Various models have been proposed for agro forestry of bamboo (Kumar et al. 2014). The village bamboos in North East India are found to mitigate the global climatic change (Nath and Das 2012).

USES OF BAMBOO

The major areas where bamboo is used are Construction, Paper pulp industry, Furniture and souvenir, Textile industry, Food and beverages, Pharmaceuticals, Bio fuel and Musical Instruments

APPLICATION OF BAMBOO IN CONSTRUCTION

BAMBOO POLES

Earlier bamboo poles were used for houses. Today pole structures are limited to temporary and small civil works.

Table 1. Properties of bamboo poles

Mechanical Properties	Thermal Properties	Acoustic Properties	Durability	Fire Resistance
Similar to hardwood. Hardness of bamboo is found to be 1450 in the Janka Hardness Scale(National Bamboo Mission Data).	Thermal properties vary with density, porosity, microstructure, fibre angle, temperature, volume fraction. (Kiran et al. 2012; Mounika et al. 2012)(Loebus et al. 2014).	Sound absorption coefficient varies with length, thickness, air gap, diameter, density of the fibre. (Farid et al. 2017; Putra et al. 2015; Yahya and Sheng Chin 2017)	Untreated bamboo has a lifetime of 2 years. If not exposed to elements like UV rays and moisture, this is up to 7 years (Shah et al. 2018). The presence of starch leads to pest attack. Treatment methods like drying under the sun and soaking in sea water as well as water treatment can ensure a life upto 50 years. (Xiao et al.2008).	Better than other natural materials due to the presence of silicate acid but less than other building materials. Hence treatments like boron treatment are done

Table 2. Research on mechanical properties of bamboo across world

Sl no	Papers	Tensile Strength	Compressive strength	Shear strength	Bending Strength	Split strength	Breaking Strength
1	(Awalluddin et al. 2017)	✓	✓				
2	(Jakovljević et al. 2017)	✓	✓		✓		
3	(Moses et al. 2015)	✓					✓
4	(Chen et al. 2018)	✓					

ENGINEERED BAMBOO

Engineered bamboo structures may be residential, commercial, disaster management or public utilities. IPIRTI in Bangalore has developed Bamboo Mat Board (BMB), Bamboo Mat Corrugated Sheets (BMCS) and Bamboo Mat Wood Veneer Composites (BMVC). GluBam or Glue Laminated Bamboo is developed in China, Nigeria,

Netherlands and North America. Strand Woven Bamboo (SWB), Bamboo scrimbers and Plybamboo are the other engineered bamboo.

The mechanical properties of manufactured bamboo is similar to timber and timber products (Sharma et al. 2015). The durability depends on species of bamboo, manufacturing processes and thermal and moisture stresses it undergoes (Li et al. 2012). Engineered bamboo composites are better thermal insulators in buildings (Shah et al. 2016). Below is a brief description on the major engineered bamboo.

1. Bamboo Mat Board (BMB): The manufacturing of BMB involves weaving of silvers and bamboo fibers. IS: 13958 has provisions for paneling, ceiling, doors, furniture etc. Thermal properties vary with density and prophylactic treatment is used for durability (Kiran et al. 2012)
2. Bamboo Mat Corrugated Sheets (BMCS): This is mainly used as roof covering due to low thermal conductivity. It can also be used as structural elements. Manufacturing involves weaving of fibers to mats.
3. Bamboo Mat Wood Veneer Composites (BMVC): This is preferred as a panel material than BMB due to better mechanical properties. Melocanna bamboos are used for its manufacture. Thermal properties depend on density, volumetric fraction and microstructure(Shah et al. 2016). It is water proof and resistant to decay and fire(Modern Bamboo Structures 2008).
4. GluBam: GluBam is Glue Laminated Bamboo. This is inspired by the timber product Glue laminated timer, Glulam. The major application of GluBam is in the girders for pedestrian and vehicular bridges. It is also used as structural member in prefabricated houses. Aging and degradation have a linear relationship and is also prone to fire hazard (Shan et al. 2012) (Xiao and Ma 2012).

SCAFFOLDING

Bamboo is used in scaffolds due to its lightness and less cost. Various models like modular scaffold system and tube and fitting models have been developed (Beale 2014). The collapse of scaffolding is attributed to elastic instability (Beale 2014). Since scaffold is exposed to external environment, phenomenon like rain can affect their mechanical properties. It is found that increase in moisture content can degrade the mechanical properties. This is particularly important in the bottom part of the scaffold as it supports the entire structure (Xu et al. 2014)

CASE STUDIES: LITERATURE STUDY:

POLE STRUCTURES

TRADITIONAL HOUSES IN NORTH EAST INDIA

The major types of houses built were Ikra house, Chang house and Bamboo house. As per topography, the house construction differed(Das et al. 2014, 2012).Ikra house (‘Assam Type house’) is a single storey building. Chang house is meant for larger family. They are built on raised stilts in areas of thick vegetation and banks of rivers. In bamboo house, bamboo is used as the main structural elements with brick wall. These are designed to combat heavy monsoons.

OTHER STRUCTURES

Guadua Bamboo Car Park in Amsterdam, Biomimetic bamboo tree house in Columbia, Bamboo Vacation Home in Costa Rica, Wind and Water Bar in Vietnam, The Great Hall in Java, Mandala Agung in Bali(Revian Nathanael Wirabuana 2017) and a play area in Indonesia (D Susanto, Widyarko and Department 2018) were studied. It is inferred that bamboo is used due to its flexibility, easiness to assemble and dissemble, hardness, sound producing properties and disaster resilience. The closed structures can ensure more lifetime for the bamboo as well as natural lighting and ventilation.

ENGINEERED BAMBOO STRUCTURES

BRIDGES IN CHINA AND AMSTERDAM

Bridges in China are constructed with GluBam girders. The first modern pedestrian bamboo bridge was built in November 2006 followed by a 10m long single lane roadway bridge Hunan Province in China in 2007 (Xiao et al. 2009). The bridge in Hunan is first of its kind in the world. The bridge is designed to carry 90 ton and has a

life time of 20-30 years. Concrete slabs are placed above GluBam girders with Carbon Fibre Reinforced Polymer enhancement. A pedestrian bridge is made with Guadua augustifolia in Amsterdam woods with GluBam for pathway and poles for columns, beams and rails. Boron preservatives, which is fire repellent and non-hazardous, are used.(van der Lugt et al. 2006)

DISASTER MANAGEMENT AND REHABILITATION STRUCTURES & RESIDENTIAL BUILDINGS

FLOOD RESILIENT STRUCTURE, ASSAM, INDIA:

Assam is susceptible to cyclones, earthquakes as well as flooding. A hybrid building of traditional Assam houses and amphibious structure using bamboo is tested and found to be effective flood resilient. These structures would be on the ground during normal time. When there is a flood, they start floating due to vertical poles (Das and Mukhopadhyay 2018).

MANGROVE REHABILITATION STRUCTURE, MUMBAI, MAHARASHTRA, INDIA

A Mangrove Rehabilitation Project in Mumbai, India proposes to use the locally available Bambusa balcooa for confinement piles. The bamboo culms and reel panels act as drainage pipes. Bamboo is untreated since it is considered as a temporary structure(Harihar and Verhagen 2017).

HOUSES DEVELOPED BY IPIRTI-TRADA

IPIRTI-TRADA has developed protocols for building bamboo prefabricated houses. The major features include use of light foundation, bamboo mat board or bamboo veneer board for wall panels, bamboo corrugated sheets for roof covering, bamboo trusses and purlins. A 2.7m2 building was tested and found that it could resist an earthquake of almost 7 in the Richter Scale(Modern Bamboo Structures 2008).

LIVE CASE STUDY

INSPIRATION OFFICE, COCHIN, INDIA

'Inspiration' is an architecture firm whose head office is at Cochin. This office is a bamboo structure which was erected in the year 2002. The building was envisaged by its director, Mr. Jaigopal. G as a modern building. Bamboo was chosen with the aim of preserving the ecological system on site. This building won the category prize in the International Bamboo Building Design competition held at Hawaii in 2007.



Figure 1. Inspiration office
Source: Mahadevan, 2018

The main species of bamboo used is Dendrocalamus giganteous (Kallan), (column and beam reinforcements) sourced from Wandoor in Palakkad district of Kerala (170 km from the site). Konkan (Dendrocalamus strictus) (wall panels) and Lathi (Thrysostachys oliveri) (columns and beam reinforcement) is brought from Kudal in Maharashtra and Palakkad respectively. For the maintenance or repair work, if any, bamboo is from Mangalore. Rest is cut from the immediate premises of the building or residue from other sites. The building has an area of 2750 sqft and cost of Rs18, 16,000.




Figure 2. Bamboos in fences are from residue in other sites
Figure 3. Entrance with bamboo ("Padippura") Source: Mahadevan, 2018

Pre Construction requirements: The bamboo used for construction is harvested when the starch content is lowest to resist pest attack thus increasing the durability. The culms for construction must be as straight as possible with minimum tapering and end to end change in diameter and no split. Approximate dimensions for main structural members (columns and frames) are 80-100mm diameter and 10-12mm wall thickness. For purlins, with 25-35 mm diameter & 10-12mm wall thickness and for grid members 18-20mm wide strips with 10-12mm thickness are used. Durability and preservation: Protection treatment starts immediately after harvesting. Hot dip treatment, cold dip treatment and pressure treatment are done. The building is raised on a concrete stilt to prevent dampness from seeping in and safeguard the bamboo from termite, insect and rodent attacks.

FIRE RESISTANCE

Treatment with ammonium diphosphate, sodium arsenate and sodium tetraborate makes bamboo fire resistant.

CONSTRUCTION

3 feet deep isolated footing is provided for columns for a maximum load of 30kN. Floor slab in ground floor, elevated on concrete stilts, is designed for a load of 400kg/m2. Half cut bamboos are placed at a gap of 1-1.2m. Reinforced plaster and red oxide is applied. Bamboo culms of 80-100mm diameter act as structural columns. 300mm long mild steel dowels of 8 or 10 mm diameter are inserted through holes drilled at 150mm spacing all along the length which act as anchors in columns and wall panel. Wall plates of plantation timber of 100 x 38 mm are placed on the columns to provide the roof level tie. Pre cast ferro cement beams are fixed into grooves.




Figure 4. Slabs **Figure 5.** Roof with tie beams
Source : Mahadevan, 2018

Bamboo panels comprising of bamboo strips and chicken mesh are used for the walls through lath and plaster method. The half cut bamboo is fixed with the smooth surface facing the exterior. The framework is plastered on interior with cement coarse sand mortar mix of 1:3. Finished wall panel has a thickness of 50-60mm. Bamboo trusses and purlins are used as roofs with Bamboo Mat Corrugated Sheet as covering. Prefabricated trusses are placed over each grid at 1200 mm spacing and fixed to the wall panels using mild steel brackets.




Figure 6. Cracks developed in the roof are difficult to repair as the entire panel will have to be replaced.
Source : Mahadevan, 2018

Problems with the building: The fences and gates are to be replaced every 5-6 years despite the treatment. Maintenance and coating are to be done every 2-3 years. In spite of treatments and fire extinguishers, fire hazard is a threat for the building. The architect of the firm points out the following difficulties in using bamboo:

- Cost of good quality bamboo is high due to fierce competition from paper pulp industry
- Concept that bamboo is poor man's building material
- Deterioration of bamboo due to pests and water exposure
- Cannot be used in open space due to exposure to weather
- Less availability of skilled labor to deal with irregularity of bamboo

DISCUSSION

The case studies reveal that bamboo is a versatile construction material. Despite certain drawbacks bamboo has a high potential to become a prominent building material. Since it is natural and renewable, the energy consumed in production processes is found to be less when compared to common building materials (around 50 times less than that of steel for unit volume production). A comparison between a bamboo house and conventional house designed by the Manasram Architects in Bangalore with the same plan in terms of embodied energy shows a conventional house requires almost 5 times the energy as that for a bamboo house. A similar energy calculation is done for the Live Case study – Inspiration with a column as the functional unit. The bamboo and steel used in it is considered. Since the bamboo does not require much processing, only production and transportation parameters of both the materials are considered.

PRODUCTION AND TRANSPORTATION ENERGY FOR BAMBOO AND STEEL IN A COLUMN

SCOPE

Kallan (Dendrocalamus giganteous) is sourced from Wandoor in Palakkad, 170km from the site. 100 bamboos are carried in a diesel truck. The production and transportation energy for 1 load of bamboo and equivalent volume of concrete, steel and wood is compared here. The steel is sourced from Edappally which is 9.2km from the site.

DATABASE

Dimensions of bamboo:-

Length – 12 m
Diameter- 0.1 m
Wall thickness - 0 (almost solid)
Volume of 1 culm- 0.0942 m3
Total volume per load - 9.42 m3

Table 3. Energy database (Source:Neelam and Manjunath 2008)

Material	Energy for production(MJ/kg)	Weight per volume(kg/m3)
Concrete	0.8	2400
Steel	30	7800
Wood	1	600
Bamboo	0.5	600

Energy use (MJ/ton) for transportation in diesel truck= 2.14/ km(Yu et al. 2011)

The column in the building consists of 4 bamboos attached with mild steel washers.

Volume of 4 bamboos (assuming height of 1 column to be 3m) = 0.0942 m3

Steel dowels of 300mm length and 10mm diameter are placed at a spacing of 150mm.

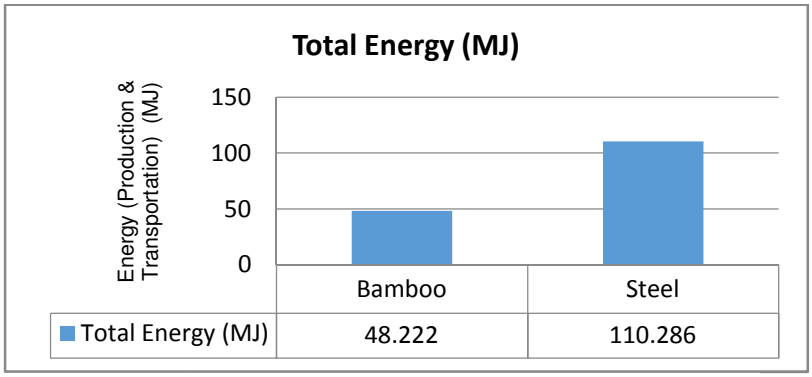
Total number of dowels = 3/0.15 = 20

Volume of 1 dowel = 0.00002355 m3

Total volume = 0.000471 m3

Table 4. Comparison of production and transportation energy		
	Bamboo	**Steel**
Total weight (kg)	56.52	3.6738
Energy for production(MJ)	28.26	110.214
Energy for transportation(MJ)	20.562	0.072
Total energy (MJ)	48.822	110.286

Although steel is used as dowels, it contributes almost twice energy of the main structural component bamboo.



Graph I. Comparison of Total Energy in MJ (production and transportation energy) for bamboo culms and steel dowels used in the column

CONCLUSION

SUSTAINABILITY OF BAMBOO

Bamboo sector provides employment opportunities to local communities in its manufacturing stages. (Modern Bamboo Structures 2008).Home gardened and bamboo in agro forestry are becoming popular than the natural ones. The overall cost of bamboo structures is less than equivalent conventional structures.

Bamboo is an environment friendly material with high carbon sequestration potential. Bamboo cultivation helps in greening of wetlands (around 160 million hectares in India itself) (Flander and Rovers 2009). Due to the rapid growth and extensive root network bamboo controls erosion and preserves the water table (Lugt and Brezet 2009).

ISSUES WITH SUSTAINABILITY OF BAMBOO

Use of phenol formaldehyde in gluing process and preservative treatments like hygrothermal caramelisation and chemical bleaching are environmentally harmful(Shah et al. 2018). Labour cost is high due to lack of skilled labour and irregularity of bamboo. The water absorption and attack from environmental agents reduces its lifetime. The social stigma that bamboo is a “Poor man’s timber” and lack of building codes are social issues related to sustainability.

SCOPE FOR DEVELOPMENT OF BAMBOO SECTOR

As mentioned, in spite of its advantages, people still hesitate to use bamboo due to lack of knowledge regarding its properties. Researchers are incorporating BIM and AI to study bamboo through 3D scanning, digitalization and robotic fabrication (Lorenzo et al. 2017). Bamboo standards and building codes are being developed and improvised (Sharma et al. 2014). Section 3B – Part 6 of National Building Code of India has norms for bamboo.

Engineered bamboo is solving issues associated with bamboo’s natural properties. Bio based preservative treatments are studied. A joint venture of chemical industries and civil engineers can bring a big boost in sustainable preservative treatments. Scientists are also working on improving fire resistance of bamboo.

Irregularity in bamboo is one major problem to tackle with. Currently freeform structure designing have been able to demonstrate how systematically and algorithmically parametric modeling can be used to tackle this.

Planning, policy making and market are important for the development of the bamboo sector. Exploration of local species and development of traditional products ensures opening and expansion of markets. Capacity building must be concentrated through awareness, expert consultancy, innovations and multi-participation. The bamboo product and sector life-cycle has to be analyzed regularly through specific strategies and financial tools (Zhu Zhaohua 2018).

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Biological hydrogen production utilizing starch waste water using mixed anaerobic sludge and SEM Assessment

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Abstract: The fermentation methodevaluated forbio-hydrogen production and wastewater treatment from starch wastewater with (CSTR) Continuous Stirred Tank Reactor using a working volume of 16.34 L using mixed anaerobic sludge. Subsequently inoculating with anaerobic digested sludge and the reactor primarily runs with Organic Loading Rate of 2.47, 3.33, and 2.6 kg COD/m3.d with an HRT of 24h, 16h, 12h, and 8h. The temperature varied from 35°C, 55°C, and 70°C with constant 60 rpm, the CSTR reactor attained stable fermentation after 20 days of operations. When OLR was further increased to maximum 25.09, 29.115, and 29.87 kg COD/m3.d on the 60th day, fermentation dominant micro flora was enhanced. The results revealed that the maximum hydrogen production, Effluent pH, VFA/Alkalinity ratio, COD removal percentage, and VSS are (4161, 2608, and 1577 ml/d), (5.9, 5.8, and 5.9), (0.3, 0.4, and 1.0), (83%, 67%, and 50%) and (7.5, 6.28, and 5.64 g/l) were achieved at HRT 8h for temperature 35°C, 55°C and 12h HRT for 70oC. The SEM analysis of the Anaerobic Sludge Granules was examined for Microbial Biomass population in the CSTR. The experimental results illustrated to facilitate the CSTR reactor had better microbial activity and operation stability, which show the way to high substrate utilization rateandhydrogen production capability.

Key words:Sago wastewater, Mixed anaerobic sludge, Fermentation, Biological hydrogen Production.

INTRODUCTION

Environmental pollution contravention is a reason for the developing interest in the production of eco-friendly fuel to substitute fossil fuels. Fossil fuels provide energy and convenience in home appliances, transport and industry. However, the unfettered use of fossil fuels makes climate change with possibly disastrous effects such as global warming, acid rain, etc., the source of this also getting exhausted to non-reformable levels Kapdan IK and Kargi F 2006.Hence the journey on the way to sustainable energy production of which one of the replacement is renewable energy. Hydrogen will found to be the pre-eminent for worlds 'clean energy' by driving sustainable path using the global energy Vatsala TM et al., 2008.Singh et al., 1994 addressed that hydrogen act as a substitute to fossil fuels and then prominent to be naturally safe. Hydrogen has threefold the energy yield when it is compared with unit mass of conventional fuels. During the combustion of hydrogen it yields only water and lacking of any adversere leases such asCO2, CO and hydrocarbons Liu 2008.Hydrogen production consists of mainly four basic biological processes namely: photo fermentation and dark fermentation, direct in addition indirect bio photolysis. As associated with photosynthetic processes, Dark Fermentative hydrogen process affords higher hydrogen production rates Vatsala TM et al., 2008. Photo fermentation needs light energy; hence dark fermentation was known to be enhancing hydrogen production, which consumes various carbon sources, containing wastewater as feed (industrial wastewater, agricultural residues, food wastes, etc.). Nowadays, different industries are developing in quantity to meet the increasing needs of the world's population, while simultaneously increasing the release of industrial effluents introduce into the environment Lin et al., 2012.Biological hydrogen production through Dark fermentation using these effluents rich in nutrients carbon source. Especially lots of water consumed for starch processing industry, causing enormous volume of industrial wastewater. Improperly, the wastewater mostly released into the sewerage systems in the absence of proper treatment, which creates an unadorned environmental pollution problem. Starch wastewater holds high chemical oxygen demand (COD) having 10000 to 30000mg/l, and executes a substantial pollution to environment, generating great costs in disposal Jinet al., 2002. Starch wastewater retains high temperature 35 to 40oC due to rich in biodegradable organic matter. Additionally, it comprises a rich in protein fraction, celluloses, nutrients and carbohydrates signifying a vital available of carbon rich energy source and possibly changed to an extensive useful product. Jamuna and Ramakrishna 1989recover valuable resources from starch wastewater; bioconversion is a privileged process specifically to yield microbial biomass protein and bio-pesticide Lu et al., 2007.Microbial biomass protein having high nucleic acid content which leads to unpleasant

taste and slow digestion rate, therefore end users hesitate to use it. As a result, the application of microbial protein was used for defining a capable method for simultaneously renewable energy, hydrogen production using starch wastewater and treatment.

So many earlier experiments were performed on continuous operation using glucose and sucrose hydrolysates for continuous bio-hydrogen production however less information available on continuous bio-hydrogen synthesis out of starch waste Hussy et al., 2003studied biological H2 production using starch substrate with CSTR towards the start-up, the maximum of 21 days period data only available in which the first 12 days lasted forstart-up and remaining period of days accounted for hydrogen yields from two different hydraulic retention time (HRTs).Biological hydrogen production utilizing starch wastewater through dark fermentation was broadly studied for their valuable low operational cost and efficiency. The hydrogen production rate defined by some parameters like HRT, OLR and pH by an aerobic fermentation process Wu et al., 2006Kumar and Das 2001,.Biological hydrogen production using different strategies enhancement are under great interest to achieve the target production. The possible stepping up conditions are effects of pH, temperature, inocula Wan, Wand Wang, JL 2008 partial pressure, HRT, OLR, reduction for removal of head space Lin et al., 2012.

The aim of this investigation was to examine continue continuous bio-hydrogen production in a CSTR operated for 180 days using starch wastewater as a substrate with varying temperature (35oC, 55oC, and 70oC), HRT (24h, 16h, 12h and 8h), and OLR with the significance on the percentage of COD removal then variables influencing biological hydrogen production rate.

MATERIALS AND METHODS

SEED SLUDGE

Anaerobic seed inoculums acquired in Wastewater treatment unit Attur, Tamilnadu, India and heat treated at 100oC for 2 h was surrendered out to yield the hydrogen-creating microscopic organisms, for example, Clostridium species and also to hinder the action of methanogens, homoacetogenes. The heat pre-treatment was favoured since it is quick, profoundly effective and simple process Bakonyi P et al., 2014. The seed sludge was sifted through a screen. VSS and TSS of seedinoculums7832 and 9871 mg/l were existed, determined by the standard method.

SUBSTRATE

Starch wastewater was obtained from cassava processing industry, Attur, Tamilnadu, India. The substrate concentration of starch wastewater was 42800mg/L (COD) starch wastewater was diluted to reduce COD concentration without nutrient supplementation was being added to the reactor.

EXPERIMENTAL SETUP

Fig.1 represents the CSTR lab scale reactor having 16.34L of effective volume. The constant pH maintained at 5.5-6.0 and the mixing rate was 60rpm Sivagurunathan P et al., 2015and the temperature was maintained at 35oC, 55oC, and 70oC. The primary chemical oxygen demand (COD) was 2.47, 3.33, 2.6 kg COD/m3.d which relate to HRT of 24h. The loading rate was improved stepwise by diminishing24h to 16h, 12h and 8hHRT. To attain steady state conditions, the reactor runs over adequate period at each HRT.

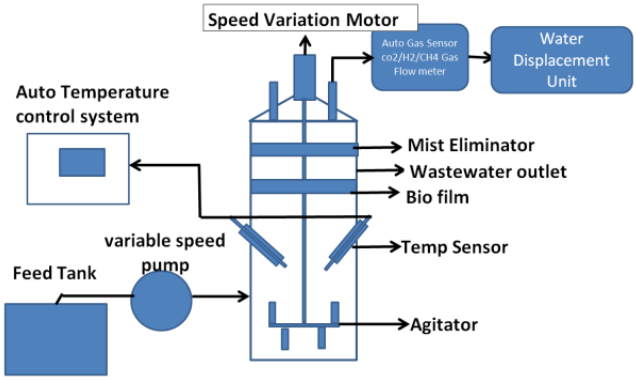

Figure1. Schematic representation of Continuous Stirred Tank Reactor

ANALYSIS METHOD

Auto Gas measuring sensor unit and Gas Chromatograph (GC-7610) outfitted by a (TCD) thermal conductivity Detector with two columns have been used for the Biogas composition analysis.

RESULTS AND DISCUSSION

CSTR PERFORMANCE AND EFFECT OF TEMPERATURE

Initially the reactor began with 35oC with pH kept at 5.5-6.0 using OLR 2.47 kg.COD/m3.d then start-up stage 24h HRT was followed, it takes 20 days to stabilize after the acclimatization stage reactor keeps running with 16h, 12h, and 8h to decide the ideal OLR that amplify hydrogen yield. The OLR was additionally expanded from 2.47 to 30.87 kg.COD/m3.d and the greatest VHP rate of 1040.25ml-H2/L.d was attained at 30.87 kg.COD/m3.d at 8h HRT which is lower than Guoet al., 2008 who acquired VHPR of 1.64L-H2/L.d. bio-hydrogen production rate of 138.7ml-H2/g.biomass.d was accomplished in this study, which is higher when contrasted with 74ml H2/g.biomass.d acquired by Nasr et al., 2013 yet lower than the 388ml H2/g.biomass.d accomplished by Sreethawong et al., 2010 with OLR of 30kg.COD/m3.d from cassava starch wastewater.

After the reactor keeps running with 35oC, the CSTR again begins with 55oC and 70oC with an organic loading rate ranges from 3.33 to 29.115kg.COD/m3.d for 55oC and 2.6 to 29.84 kg.COD/m3.d for 70oC with the HRT of 16h, 12h and 8h. For the two cases VFA/Alk proportion lies between 0.3-1.0 which shows that the reactor persistently keeps running in a steady state. In this two temperature cases it takes about almost 20 days to get stabilize, after the stabilization the reactor keeps running with the HRT 16h, 12h, and 8h as like the reactor keeps running with temperature 35oC. At 55oC the greatest VHPR of 652 ml-H2/L.d firmly close to the Nasr et al., 2013 having 720ml H2/g.biomass.d yet under 883ml-H2/L.d acquired by Thanwisedet al., 2012 and the most extreme explicit hydrogen generation rate of 103.82 ml H2/g.biomass.d was accomplished at HRT of 8h with an OLR of 29.115 kg.COD/m3.d is lower than outcomes achieved in temperature 35oC and Guoet al., 2008, anyway the SHPR was lower than the 365ml H2/g.biomass.d uncovered by Zhang et al., 2003 and 146ml H2/g.biomass.d gotten by Liu et al.,2004. At last the reactor keeps running in hyper thermophilic states of 70oC with an OLR ranges from 2.6 to 29.84 kg.COD/m3.d with shifting HRT from start-up 24h to 16, 12, and 8h HRT. The greatest volumetric hydrogen creation rate and explicit hydrogen generation rate of 358.75ml-H2/L.d and 106.77 ml-H2/g.biomass.d which is lower than the volumetric hydrogen generation when the reactor worked at 35oC, the explicit hydrogen generation rate was marginally higher than the SHPR of reactor worked by 55oC. The outcomes uncovered that the reactor worked at 35oC has achieved the most extreme volumetric hydrogen production and also the most noteworthy explicit hydrogen generation rate at 8h HRT.

As appeared in figure 3 and 4 the most extreme hydrogen production of 4161ml achieved at 35oC with HRT of 8h at OLR 30.87 kg.COD/m3.d with greatest VSS concentration of 7.8g/l. The reactor keeps running with 55oC and yield greatest hydrogen generation of 2608ml observed at 8h HRT usingOLR29.115 kg.COD/m3.d through most extreme VSS 6.28g/l which is not exactly the hydrogen production of 1577ml at 70oC at OLR of 29.84 kg.COD/m3.d with maximum VSS 5.64g/l.

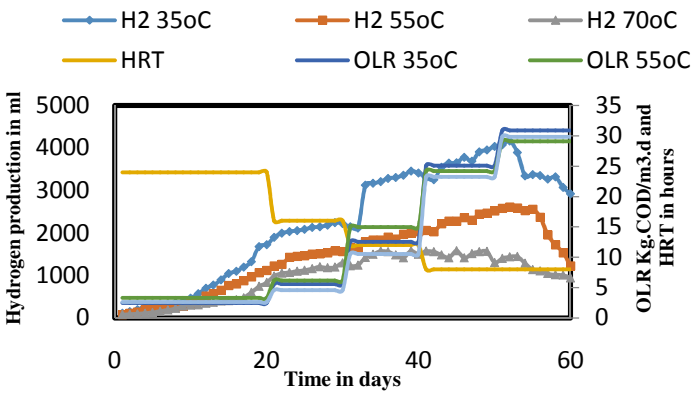

Figure 2. Hydrogen production vs. Organic Loading Rate and Hydraulic Retention Time

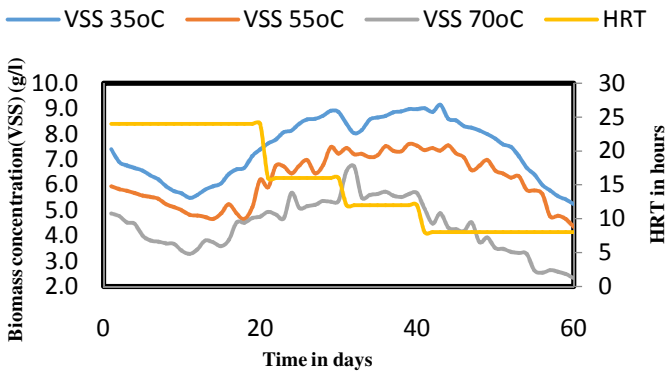

Figure 3. VSS concentrations at various Temperatures

EFFECT OF PH AND INOCULUMPRE-TREATMENT

pH involves a crucial role in bacterial consortium for hydrogen production, as pH affects the bacterial structure in the mixed culture and leads to metabolic movement impacts on hydrogen producer (skhanal et al., 2004; Zhang T et., al 2003, Ginkelet al., 2001, Liu H and Fang HHP, 2002). During all temperature cases investigations previously mentioned the pH kept 5.5-6.0, no methane generation was detected, meaning that just acidogenesis was active, anyway a portion of the embraced pH conditions (higher than pH 7.0) have been proper for methanogenesis. As indicated by Lin et al., 2003, Zhang et al., 2012underlying pH estimations of 5.0– 5.5 were better than higher pH levels (> 5.5) for hydrogen generation from the starch wastewater through mixed digested sludge, and at low pH (< 5.0) with low substrate concentration for fermentation process, showing that Hydrogen production is hindered at low pH. In another examination, Steven van Ginkel and Shihwu Sung additionally determined that the most extreme hydrogen production occurred at pH 5.5 consuming sucrose manufactured wastewater as substrate Ginkel SV et al., 2001. Abijit Gadhe et al., 2014 also kept pH of 5.5 for his tests utilizing refinery spent wash as substrate and anaerobic sludge as inoculum.

The most regularly utilized method for hydrogen producing bacteria enrichment, identified as Heat pre-treatment method Wang JL and Wan W 2009.Heat shock pre-treatment considered to be leading pre-treatment method for inoculum while utilizing substrate waste as complex in nature Bakonyi et al.,2014, Cossu and Alibardi and, 2016, Liu et al., 2006, Kumar et al., 2015. The fundamental parameters during heat pre-treatment were heat pre-treatment duration and temperatures associated with this have to be improved. Pre-treatment at Short period or minimum temperatures cannot powerful towards constrain greater part of Hydrogen producers, however long term pre-treatment or high temperatures could prompt reducing Hydrogen producers activities. As indicated by the literature, the range of the heating duration and temperature are15 min to 2 h and 65– 100oC individually Bakonyi et al., 2014, Sivagurunathan p et al., 2016. Hence in this examination was likewise directed with preheat treated anaerobic sludge heated at 100oC Bakonyi P et al., 2014 for 2h to improve the hydrogen generation and restrain the methanogens is activities.

MICROSCOPIC OBSERVATION

The anaerobic sludgeScanning electron micrographs in the CSTR show smooth and locales on the surface of the sludge Figure.4 microbial cells in the acidogenic maturation were spread thickly in the aggregates with little openings Nanqi Ren et al., 2006 (anaerobic fermentation utilizing molasses using bioreactor runs in a pilot scalefor biological hydrogen production) were seen through which the developed biogas may be discharged. The point by point micrographs coordinated to facilitate the bacterial cells were connected to one another with stringy materials from metabolic by-products Rachmanet al., 1998.

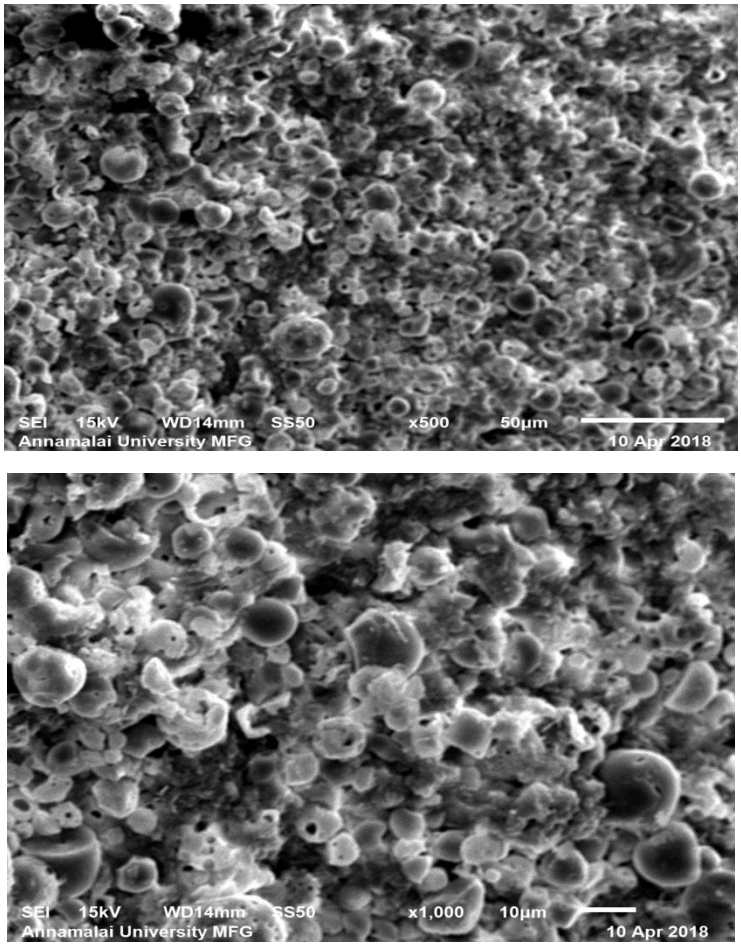

Figure 4. Scanning Electron microscopy of sphere-shaped flocs (a) and openings in which the biogas discharged using acidogens (b) of anaerobic sludge in the CSTR keeps running at 35°C

CONCLUSION

In light of the exploratory outcomes, it tends to be presumed that starch wastewater with anaerobic acidogenesis in a CSTR revealed at the same time hydrogen production and treat wastewater capability at 35°C. A high biomass concentration of 7500 mg/L acquired at HRT of 8h, bringing about maximum hydrogen production capacity and COD removal. The greatest VHPR 1040.25 ml-H2/l.d and the most extreme explicit hydrogen generation rate of 138.7ml-H2/g.biomass.d were achieved. The acidogenic CSTR framework was worked steadily with a COD removal of 81-86% and bio-hydrogen production effectively on pH 5.5-6.0.The outcomes additionally demonstrated that the CSTR is the predominant of suspended method so far utilizing starch wastewater to produce hydrogen.

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Experimental Study of Eco Friendly Inhibitor for Corrosion for Mild Steel in Reinforced Concrete

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Abstract: In present years, because of the emerging activeness and recognition of the world regarding the conservation of the environmental and dangerous consequences of utilizing chemicals on the ecological stability, the standard proceeding towards the corrosion inhibitors has slowly varied. For any natural inhibitor to be a powerful defender opposed to corrosion of metal, it should have superior rconnection with the metal to be safeguarded. Environmental friendly products have examined highly as corrosion inhibitor together in resultant blends taken out from natural origin such as parts of plants like leaves or vital unalloyed products acquired from natural plants. Owing to the fact of their availability and biodegradability plant extracts are supreme choice as inhibitors. These extracts can be procured in effortlessly with economical solvents that are broadly accessed with little toxicity and at cheap cost. For this study, as Environmental Friendly Corrosion Inhibitor (EFCI) the extracts from Calotropis Gigantea plant leaf were used. The efficiency of the Calotropis Gigantea leaf extract which is applied on the mild steel of Reinforced Concrete (RC) specimen was determined experimentally. The results are then compared with the specimens of uncoated mild steel in reinforced concrete.

Keywords: Corrosion Inhibitor, Environmental Friendly Corrosion Inhibitor, Calotropis Gigantea, Reinforced Concrete

INTRODUCTION

The building construction is the sole, which uses steel to a notable range. The conflict about the corrosion in steel is becoming noteworthy. The corrosion in the reinforced bars is the major distress for the RC structure, so in present years the application of these inhibitors in making non-corroded steel in concrete has escalated. Abdulrahman et al. explained clearly that inhibitors are annexed with concrete to upgrade its worth and probity. Marko Chigondo and Fidelis Chigondo had made clear that conventionally, depletion of corrosion has been controlled by different ways counting cathodic conservation, process control, lowering of the metal contamination content, and requisition of surface treatment techniques, and also as addition of appropriate alloys. These inhibitors will minimize the corrosion rate and thus overcome the budgetary fall on industrial equipment's and also surfaces.

In the latest research the central point has been resolved to spread environmentally friendly ways for corrosion reduction down using inorganic and organic inhibitors since they are risky and expensive. Desai 2015 has studied that the extract obtained from leaves of Ankado for corrosive nature of mild steel with the help of weight reduction measurements and techniques of electrochemical. Sudesh Kumar and Suraj Prakash Mathur 2013 had investigated that the attrition reluctance of aluminium in the solution of sulfuric acid in the existence of dissimilar segment of plants was investigated by corrosion rate and temperature method. The ethanolic extricates of C. procera and C. Gigantea acts as a defender in the acidic domain. The dependency power will escalate with shoot up in defender application.

Ambrish Singh et al 2011 investigated about evolution of “green” substitute to diminish corrosion. Amid the considered leaves, extracts of Andrographispaniculata exhibited superior inhibitory discharge than other extract of the leaves. Strychnos-nuxvomica revealed finer inhibition than any other pull out of the seeds. Moringaoleifera showed fine rcorrosive inhibitory efficiency for mild steel of 98% inhibition capacity among the examined extracts from fruits. Bacopamonnieri reflected its most corrosion inhibition up to 95% from the studied extracts of stems. Hence is it concluded that in acid medium the extracts of plant were determined as the good corrosion inhibition of mild steel.

GREEN CORROSION INHIBITOR- CALOTROPIS GIGANTEA

Green corrosion inhibitors are naturally available eco friendly products which do notholdany metals toxic compounds and it is very cost effective. The influence of Calotropis gigantea leaves extract on mild steel for corrosion resistivity has been studied.

Experimental Studies

Materials

The OPC grade 53 cement confirming to IS 12269-2013 is used in this study. The fine aggregate physical properties were determined and are described in Table 1. Coarse aggregate physical properties are described in Table 2. For reinforcement in RC Beams 16mm diameter bars of Fe250 Mild steel are used.

Table 1. Physical Properties of Fine-aggregate

Properties	Test Results
Specific Gravity	2.97
Bulk Density	1705 kg/cm^3
Fineness Modulus	3.98
Water absorption	1%
Grading	Zone II

Table 2. Physical Properties of Coarse-aggregate

Properties	Test Results
Specific Gravity	2.73
Bulk Density	1602 kg/cm^3
Fineness Modulus	7.17
Water absorption	0.60%
Impact Strength	25.19%
Crushing Value	27%

Mix Proportions

The mix proportions for M30 Grade concrete were arrived by IS methods conforming to IS 10262-2009 and is presented in Table 3.

Table 3. Design Mix Proportion of M30 Grade concrete

Cement	380kg/m^3
Fine aggregate	711kg/m^3
Coarse aggregate	1283kg/m^3
Water	180kg/m^3
Admixture	1.90kg/m^3

Tensile Strength of Mild Steel

For the mild steel of Fe250 and 10mm diameter, the tensile strength was determined as per IS432 for uncoated steel bar and bar coated with CG extract and their stress- strain graph is shown in Figure 1.

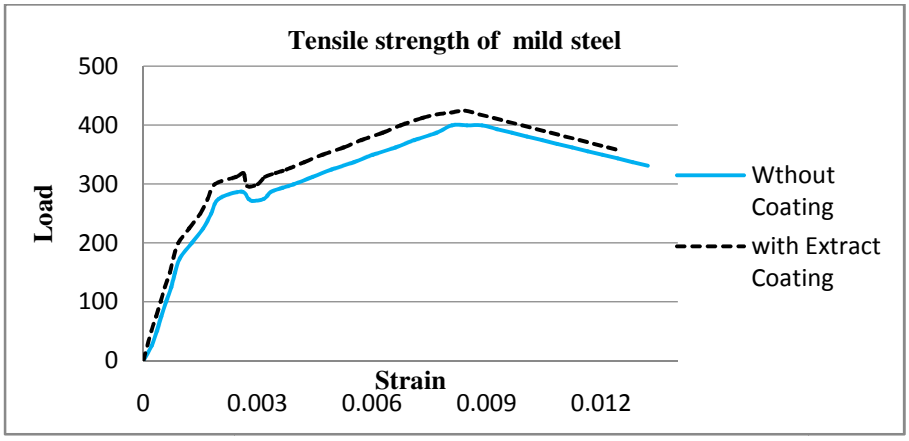

Figure 1. Stress and Strain Relationship graph of mild steel bars.

TESTING OF SPECIMENS

Compressive Strength of Concrete

For designed concrete mix grade, the compressive strength were determined using the 150mm cube size as per IS 516-1959 (reaffirmed 2013).

Flexural Strength of Concrete

Details of Specimen

The specimen of size 1500mm x 250mm x 250mm was casted to study the flexural character of M30 Grade concrete. The beam was reinforced with 16mm diameter mild steel bars of Fe250 with two bars on both top and bottom and stirrups were provided at their ends. The specimen was supported with two steel rollers of 38 mm in diameter. The load is applied axially through a two rollers mounted at top of the specimen. The comparison graph of flexural strength of reinforced concrete with and without CG extract coating is shown in Figure 2.

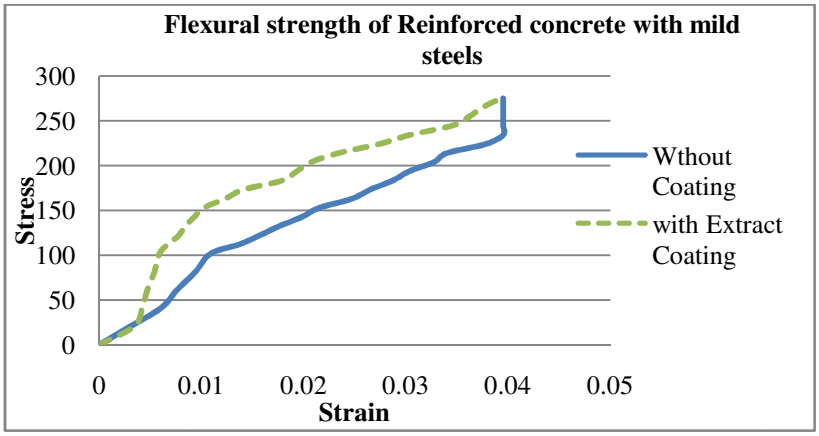

Figure 2. Flexural strength graph of mild steel bars.

Corrosion Test

Visual Inspection

For monitoring corrosion visual inspection will be the one of the oldest inspection method. This technique is very simple, speedy and economical one. However this holds certain limitations since this will provide the qualitative results and not the quantitative one. Rather than all the time the corrosion can also be identified with human eyes but this is the initial scrutiny in monitoring corrosion. By this study, the specimens will be examined precedent and succeeding the immersion time for the surface emergence.

PROPOSED WORK

Weight-Loss Measurement

The efficiency of steel corrosive resistance with extract of Calotropis gigantea will be investigated at room temperature by weight loss measurement method. The test samples will be completely immersed in the beaker filled with the solutions of 1M of HCl and 3% of NaCl about 45 days and the measurement for loss in weigh of steel will be determined at the interval of 3 days.

Accelerated Corrosion Test

The impressed current of specified current density (1-4mA/cm2) will be induced over the mild steel rod which was coated with CG Extract. The reinforced concrete beam specimens of size 100 x100 x 500 mm will be used in this study about the corrosion resistance of CG extract. As longitudinal reinforcement 8mm bars with 15mm clear cover will be used and as vertical stirrups uncoated 6mm bars spaced with 100mm center will be provided.

Microstructural Analyses of the Samples

In order to understand what happened in the surface of mild steel during corrosion, microstructural SEM analyses will be done for CG extract coated and uncoated mild steel bars. The morphological changes in mild steel in accordance with heat treatment of about 800℃ temperatures will be inferred. So this will significantly change the grains arrangement and the corrosive behaviour of steel when immersed in CG extract.

RESULTS AND DISCUSSION

The outcome of extracts from the leaf of Calotropis Gigantea (CG), in reinforced concrete mild steels, for sustainable non-toxic corrosion inhibitors has been studied for Tensile strength of mild steels, compression and flexural properties of M30 Grade Concrete.

- Focusing on minimizing the usage of more toxic product as corrosion inhibitors, Calotropis Gigantea (CG) leaf extract can be consider as a natural low toxicity corrosion inhibition compound.
- The mild steel when coated with the CG extract shows slightly higher tensile strength when compared to uncoated mild steel.
- Flexural strength graph shows, that the load deflection curve is quite comparable at initial and final stage of deflection in both coated and uncoated mild steel specimens. But in between stages it is noted that the specimen reinforced by mild steel coated with CG extract tends to take higher load to deflect with compared to uncoated mild steel bars.

CONCLUSION

The review aims at understanding the research work done on Calotropis Gigantea leaf extract so far in order to provide sufficient information for further research works. As per our approach, an effective bondage between Calotropis Gigantea (CG), mild steel bars and concrete is been showcased. So this CG plant extract has proved its worth in the flexural strength and tensile strength by providing a better deflection and cracking rate compared to the uncoated mild steel. So CG is highly unfortunate in being used only for research purposes. The corrosion inhibitory efficiency of this CG extract on mild steel concrete is also visualized more efficient.

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Extraction of bio oil through E- Waste

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Abstract: Now-a-days E-waste has increased rapidly in the world .CPCB (Central Pollution Control Board) in 2005 made a survey in India in which they found 1,03,047 lakh ton of E-waste all over India. This E waste is thrown to atmosphere and dumped to the environment and it was considered as the solid waste. This solid waste may not be recyclable one. In recent years this has been increased more rapidly. This E-waste is very harmful to the environment, such as Lead, Cadmium, Barium, Chromium etc, these are some of the harmful chemicals emitted from E-waste. In this study by implementing the technique of pyrolysis process which converts this E waste into oil that is called pyrolysis oil. In this pyrolysis oil can be served as low grade oil and used for heating purposes in chemical and boiler heating purposes. For our work, E- waste collected from the local scrap store and this waste can be consider as no more usage. This e- waste was converted into powder with the help of ball milling process and it contains low carbon content and maximum of volatile content. From this investigation by using fixed bed pyrolysis process, E- waste powder converted into oil, char and synthesis gas. Pyrolysis oil is used for heating process and char may be used as fertilizer process.

Keywords: E-waste powder, Bio oil, pyrolysis.

INTRODUCTION

Due to fossil fuel depletion and increasing the environmental pollution, researchers are motivated to find the fuel. The maximum use of non renewable source leads to cause of global warming. The temperature increased around 1° C in the global that could causes of human diseases and sea level also rises from 7 to 23 inches. Increase in CO2 emissions are the important factors for searching new fuel, price of fossil fuel increasing day by day and increasing population. Pyrolysis oil is a one kind of fuel that derived from pyrolysis process which made from biomass such as agriculture waste, vegetable waste. In this paper reviewed that pyrolysis oil production from E- Waste. E waste increasing rapidly over the global, due to vast usage of computers, laptops, television, tablets and smart phones. Electronic products can be discarded and thrown to environment after the usage. E- Waste is one among the sources for bio production and it consists of carbon content. The E- waste was collected from the local scrap shop, particularly this waste is thrown to atmosphere and dumped to the environment and it was considered as the solid waste. This solid waste can be recyclable one and cost of recycling is too high. In global e waste reaches nearly 41.8 million ton of waste was generated in 2014, it reaches 45 million ton of e waste in 2016 and it will reaches 50 million ton in 2018. CPCB (Central Pollution Control Board) in 2005 made a survey in India in which they found 1,03,047 lakh ton of E-waste all over India. In recent years this has been increased more rapidly. These E-wastes are very harmful to the environment. Lead, Cadmium, Barium, Chromium etc, these are some of the harmful chemicals emitted from E waste. In this work, to reduce environment pollution, and maintain the e waste management our proposed work is to convert the e waste into useful fuel into engines. E waste consist of metals mainly Fe, Al, Cu, Waste Electrical and Electronic Equipment (WEEE) and it contains different plastics namely acrylonitrile-butadiene-styrene, polystyrene, polycarbonate- polyethylene, polyvinyl chloride, styrene acrylonitrile and WEEE consist of brittle metal also. Bakas et al. (2014) reported that the mobile phones, laptops and computer spare parts which contain maximum of critical metals.

P. Madhu et al. studied and reviewed the increase of global urbanization, energy demand and sustainable environment are required to search new kind of fuel. For global urbanization the population is increasing day by day which needs the energy for various purposes and depletion of fossil fuel is motivate to find the alternate fuel and main thing of searching new source of fuel is environmental pollution for using this fossil fuel. Now a day renewable energy resources are one of the promising source of fuel for using partially or totally for replacing the fossil fuel. Biomass is the hopeful renewable source for replacing the fossil fuel which having high rich quantity of carbon. Bio oil can be produced from the lemongrass with the help of fixed bed pyrolysis process. Temperature, particle size and heat rate are important factors that affect the production of bio oil. The maximum of oil production from the reaction was temperature reaches 450º C, particle size 0.71-1.00 mm and heating rate of 45º C/ min.

Pravakar Mohanty et al. reviewed bio oil obtained from different species are characterized by hydropyrolysis process; in this process consist of two steps. First step raw biomass (agro and forest waste) are converted into low calorific bio oil with the help of different pyrolysis Again this low calorific value of oil is upgraded into high calorific value by using hydrotreating and reforming process.

Yusuf Makarfi Isa et al. studied biomass was the promising technique to resolve the fossil fuel depletion and global warming. Algae and palm oil based oil was the most promising fuel to alter the petroleum fuels. Bio oil obtained from pyrolysis process gives low heating value, incomplete volatility, acidity and instability are not suitable properties do not match with their diesel properties, with the help of transesterification, thermal cracking, hydrocracking and catalytic cracking process the properties of bio oil can be improved. Finally concluded this study to avoid the petroleum range hydrocarbon, need more number of attentions and more number of techniques to convert the biomass into useful oil.

Venkateswarlu Chintala has described the use of solar assisted thermochemical process (pyrolysis), the biomass was converted into bio oil. Energy reduction process, without use of conventional heating process, the biomass was upgraded and utilized in IC engine with the help of solar driven pyrolysis process. Due to high viscosity and water content present in the pyrolised oil poor atomization can occurred results in decreased thermal efficiencies in IC engine. This kind of bio oil can be used to industries and power application.

Siu Hua Chang has studied bio oil obtained from the Empty Fruit Bunch (EFB) from palm oil by using pyrolsis and solvolysis process. In non catalytic fast, catalytic fast pyrolysis process and solvolysis process achieved with lower operating temperature and high pressure. Final conclusion from this work was bio oil obtained from the Empty Fruit Bunch (EFB) properties are does not match with diesel properties but it's coincide with light oil.

Bo Zhang et al. studied with the aid of ultrasonic pretreated method the bio crude oil from the micro algae. The maximum yield derived from this process was 32% and optimum operating conditions are 260º C and 300 W powers at 2 min, if increasing the pre prolonged time also gives maximum yield of 50% shows that negative effect of this process.

Koray Alper et al. described two valuable products are obtained from the Cornelian cherry stone and Grape seeds by using pyrolysis process. The products was bio oil and bio char. The maximum production of bio oil obtained from the Cornelian cherry stone and grape seeds are 47.5% wt and 41.04% wt at 500º C and 700º C. They also reviewed promising that both bio char and bio oil are one of the fuels for environmental concern.

Hyeon Su Heo et al. analyzed the bio oil yield from waste furniture saw dust, in this analysis bio oil production was depend on the temperature, particle size, feed rate and heat flow rate. Finally they concluded, the maximum condition of bio oil yield from the fast pyrolsis process were temperature of 450 º C with a small particle size of 0.7 mm and maximum gas flow rates and maximum feed rate.

Many researchers are used bio oil production with the use of pyrolysis process. So the author can choose this method for bio oil preparation purpose. In the present work, bio oil yield from E waste was carried out by using fixed bed pyrolysis process. E waste is one of the sources for bio oil production and it consists of carbon content also. From the literature collection the main important factor which affects the bio oil yielding was pyrolysis temperature, small particle size and heating rate also investigated in this study.

PROBLEM DEFINITION

Diesel cost is higher than petrol, diesel is very high efficient than petrol and also diesel engine is used for heavy vehicles. Using of diesel engine is slower but it is stronger and enduring. The next biggest competitor of diesel is petrol, when compared to diesel engine petrol engine is more efficient, but the price of petrol is much greater than diesel. Due to usage of petrol and diesel in SI and CI engines, the pollution is also increased in the practice leads to global warming and produce to green house effect. Another reason for moving alternate fuel is fossil fuel depletion for rectifying the above problem we discover the biodiesel and bio oil from the E-waste powder, moved to first step of separate the bio oil from E-waste powder by using fixed bed pyrolysis process.

METHODOLOGY

E-waste is collected from the waste electrical storage shop. Reduce the size of the specimen by using of ball milling. Then the powder is converted into bio oil by the pyrolysis set up. This pyrolysis set up consists of condenser, fixed bed reactor, temperature indicator and collecting tank. From this pyrolysis set up there are three important factors that affect the bio oil and bio char production like pyrolysis temperature, heating rate and small particle size. In this study temperature was increasing from 300-600 ºC at constant small particle size of 0.6 mm and heating rate of 30 ºC/ min to 60 ºC/ min

Pyroloysis Set Up

Pyrolysis oil obtained from the sample E-waste powder was studied by using fixed bed reactor. Main parts of this pyrolysis system contains reactor, heater, condenser and oil collector. The reactor which consists of a stainless tube and it has 100 mm diameter and 150 mm height. This stainless flange has 170 mm diameter and 10 mm thickness. A small opening between in the reactor opening for exiting gas out, a 2kW power of electric heater was provided with ammeter and voltmeter set up for heating the biomass. A two identical k type thermocouple was inserted in between the heater for measuring the temperature of the heater. With the help of autotransformer, the rate of heat input was varied. Under the atmospheric pressure, the temperature was varied about 400-700 ºC.

Water cooled condenser was used to cool the condensable gas. The water circulate continuously at a temperature of 5 ºC around the condenser set up which recovers or converts volatile/ condensable gas into liquid type fuel which was called pyrolysis oil and it was collected in the conical flasks. Under the atmospheric pressure, the temperature was varied about 400-700 ºC. 100g of sample was carried out for investigation with varying temperature, rate of heat input and different particle size. From this reaction, fine charcoal, gas and volatile compounds are main outputs. A small opening between in the reactor opening for exiting gas out, a 2kW power of electric heater was provided with ammeter and voltmeter set up for heating the biomass. A two identical k type thermocouple was inserted in between the heater for measuring the temperature of the heater. With the help of autotransformer, the rate of heat input was varied. Under the atmospheric pressure, the temperature was varied about 400-700 ºC. 1kg of sample was carried out for investigation with varying temperature, rate of heat input and different particle size. From this reaction, fine charcoal, gas and volatile compounds are main outputs. The non condensable gas from the pyrolysis reactor collected in the condenser and char can be collected at the bottom of the reactor set up.

Fixed Bed Reactor

A mild steel (ms) reactor is used for pyrolysis of rubber shells. The reactor chamber has a capacity of about 2Kg and a Nichrome coil is used to heat the reactor. Glass wool is wrapped around the heating coil to avoid heat loss; it is again covered with an aluminum sheet for safety of the user. The reactor chamber is cylindrical in shape. The reactor lid consists of two thermocouples one for obtaining the material temperature and the other for obtaining the gas temperature. The top of the reactor enables the movement of gas out to the condenser. A gasket is employed between the lid and top of the reactor to avoid gas leak during pyrolysis and six lock nuts are used to fix the lid

Experimental Procedure

The PCB boards were collected from various computer accessories that were sold from various scrap shops in the locality. Those boards were grinded using a grinding machine to remove the unwanted projections like integrated circuits and light emitting diodes.then the completely grinded PCB board was hammered into small pieces using a small hammer.It took nearly two complete hours to grind 5 kgs of PCB board. The board obtained after the grinding process was about 3 kgs ie, 2 kgs of unwanted projections were there in the obtained PCB boards.The pieces that were broken was of the size of one inch approximately. These hammered pieces were subjected to further processing. The hammered PCB board was further processed by make it into powder. The process that was used in powdering is known as milling process. The hammered pieces were subjected to a ball miller for powdering. It completely took 8 hrs for powdering. as the miller could not be run for more than 4 hrs continuously we ran it into two partition like 4 hrs a day and another 4 hrs another day. The powder obtained was of very minute configuration and we could not find the dimension so we thought of sieving it into different configuration, the sieving process was carried out with the help of a sieve shaker. The configuration that was

sieved into three categories like 300nm,150nm and 90nm.The different configuration were differently subjected to pyrolysis process and oil yield was observed with various temperatures.

From the fixed bed reactor heating the bio mass (E waste powder) at a particular temperature, the temperature yields to attain the gaseous state, the gaseous products are allowed to condenser, the condenser condense the gaseous product and pass the liquid to collecting tank, balancing of obtaining the biomass from the reactor is called char.

RESULTS AND DISCUSSION

The Table 1 represents the amount of solid, liquid and gaseous materials obtained after completion of the pyrolytic process. The powdered PCB powder was subjected to the pyrolytic reactor with different temperatures, the temperature variations gave different results as represented in the tabular column.

When the powder was subjected to the reactor at 500º C the solid char output was about 79.2%,the gaseous output was upto 13.1%and the liquid output was 9.2%.Secondly when the powder was subjected to reactor at 550º C the solid char output was about 69.8%,the gaseous output was upto 5.05% and the liquid output was 22.7%.And finally at 600º C the gaseous output was 8.07% the solid output was 75.8% and the liquid output reduced to 12.7%,the total input. Fig. 1a and Fig. 1b shows the bio oil and bio char obtained from the pyrolysis process.

Table 1. Amount of solid, liquid and gaseous materials obtained after completion of the pyrolytic process

Input Material Pcb	**Pyroysis Temperature & Heating Flow Rate**	**Product Yield Wt%**	
From Computers	500º C (30℃/ min heating rate)	S	79.2%
		G	13.1%
		L	9.2%
From Computers	550 º C (45 º C / min heating rate)	S	69.8%
		G	5.05%
		L	22.7%
From Television	600 º C (60 º C / min heating rate)	S	75.8%
		G	8.07%
		L	12.7%



Figure 1. Left: bio oil yield from the pyrolysis process; Right: bio char yield from the pyrolysis process



(a) (b) (c) (d) (e)

Figure 2. (a) Broken PCB waste; (b) Powdered PCB waste with the help of grinding Machine; (c) Fixed bed pyrolysis reactor; (d) Bio oil yield; (e) Bio char yield

CONCLUSION

In this study pyrolysis oil obtained from the E waste was taken from the pyrolysis reactor in the effects of pyrolysis temperature, heating rate and heating flow rate was analyzed. The experimental results shows that the maximum yield of pyrolysis oil was in the range of 550 ° C and heat flow rate of 45 ° C/ min at constant particle size of 0.6 mm. The bio char production dependent on the pyrolysis conditions like pyrolysis temperature and heating flow rate. Further improvements are needed to convert this kind of bio oil into useful oil in IC engine. In this reason, biooil transesterification can be suggested and they need to separate ester from this oil.

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Thermal Comfort in Indian Buildings: A Review Article

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Abstract: The main focus of this paper is to provide the literature study on improvising options for the thermal comfort in the buildings without the consumption of electrical energy. Thermal comfort is the salient factor for good physical condition and yield good output. If there is any lack in thermal comfort, it will cause depression among the people who are residing in buildings. During summer season, due to more heat in the buildings, the people were fatigued and during winter season due to coldness the people are unable to get relaxation. When they are too warm, the people may feel tired; when too cold, they will tend to become agitated and diverted. According to ASHRAE Standard 55 (2017), thermal comfort is expressed the status of our mind that has to be satisfied with the environment and is evaluated by subjective evaluation. The salient factors which affecting the thermal comfort are ventilation, phase change material in buildings, clothing insulation and relative humidity, loss and gain of heat. In the modern society thermal comfort in structures are playing vital role in appreciating the sustainability in environment .In order to avail thermal comfort for human beings there was a huge investment in artificial cooling. The present paper focuses the numbers of possible solutions to avail thermal comfort without using electrical energy consumption. The paper is concentrated on the review of the important methods which are proper natural ventilation to the building, integration of phase change material in the construction, the relative humidity and number of occupants in a building, temperature of the surrounding which significantly trims down the electrical energy consumption.

Keywords: Thermal comfort, Air ventilation, PCM, Relative humidity, Sustainability

INTRODUCTION

According to GHG emissions India occupies fourth position in the world i.e. (77.58 tons of total global emissions of 1293 million metric tons) (PayamNejat et al.,2015) India gave assurance that it would lessen carbon emissions content to 35% by 2030 relating to 2005 levels at the UN CCC Summit 2015, Paris (Bangzhu Zhu et al.,2018) .In order to ensure safety in the future for ourselves and future generations to follow, it is widely acknowledged that we must be more active now to diminish energy consumption and substantially cut greenhouse gases, such as CO2, NOx and Hydro fluorocarbons. EIA's International Energy Outlook 2017 (IEO2017) reveals that Indian buildings energy consumption growth rate increases by 2.7% every year and it is very high compared to other countries in the world.

India's modern structures are passive energy absorbers. Commercial and Residential constructions are consuming approximately 32% of the total country power consumption in 2016. The Ministry of Statistics Planning and implementation mentioned in latest annual energy statistics has found that there as a huge demand in electricity when the city becomes more popular The energy policy agency declared by government calculates approximately that energy demand from Indian building will shoot up to 800% in 2047 when compared with 2012 (Riya Rachel 2018), under the current scenario; India is looking for higher energy cost and missile rocket energy consumption for the past decades. Considering the energy consumption at higher level will impact on high level air pollution which makes negative impact in global warming and climate change. By considering the above fact India needs better energy efficient programmes and policies now on an emergent measure.

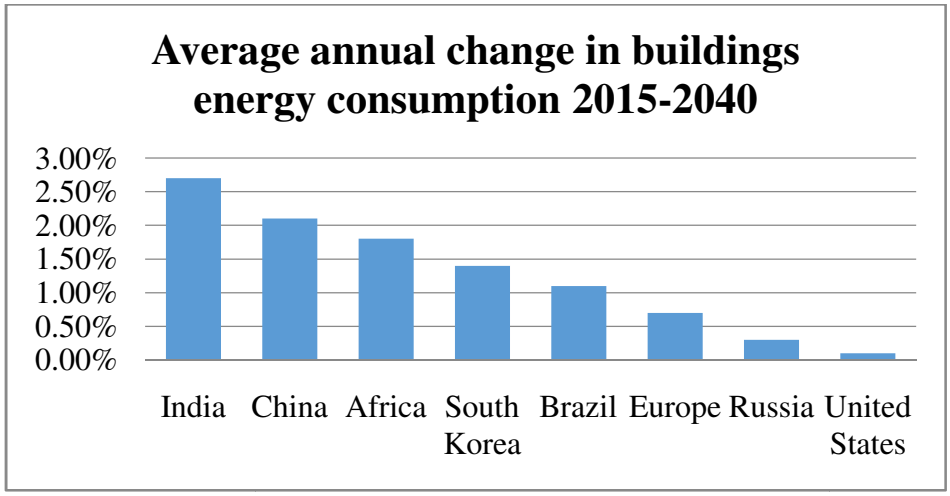

Figure 1. Average Annual Change in Buildings Energy Consumption for different countries

Efficient buildings have been elevated as a powerful factor to India's climate change mitigation strategy and weather commitments. India is having plenty of ways to reduce the energy consumption in buildings and thereby building efficiency will be improved. After nearly four years of research, analyse and stake holder dialogues it can be asserted that, if the national building code 2017 is implemented in future building there may be savings/ reduction by 35% in cooling of building for attaining thermal comfort.

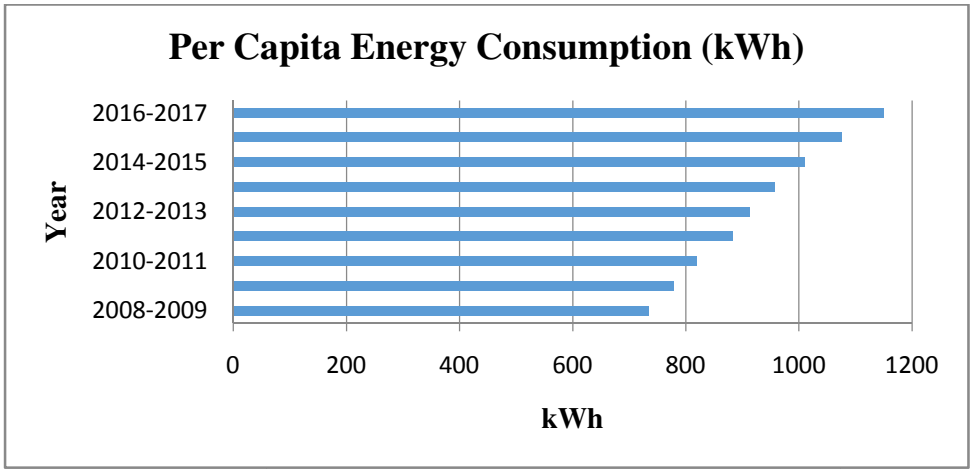

Figure 2. Per Capita Energy Consumption (kWh)

The per capita electricity consumption in India has been sharply escalating continuously over the last 10 years because of the significant improvement in distribution of electricity in villages. By combining all the reasons we are in dire need of energy conservation in buildings. The present paper presents the recent trends in reduction of energy consumption for the provision of thermal comfort in edifice.

THERMAL COMFORT USING VENTILATION

Now-a-days Thermal comfort is becoming a perennial issue to the tenants of many housing buildings and commercial buildings without air-conditioning system in hot climates. Natural ventilation is the only viable option for those buildings to improve their thermal comfort. According to previous Indian author's investigation, there was a mismatch of data in thermal comfort between ASHRAE and our consolidated report. By adopting the different analyses and methods by the recent researchers, now our finding data has been accepted by ASHRAE and updated in ASHRAE standard also. Cooling techniques are classified into two types.

1. Passive cooling techniques and
2. Adaptive cooling Technique

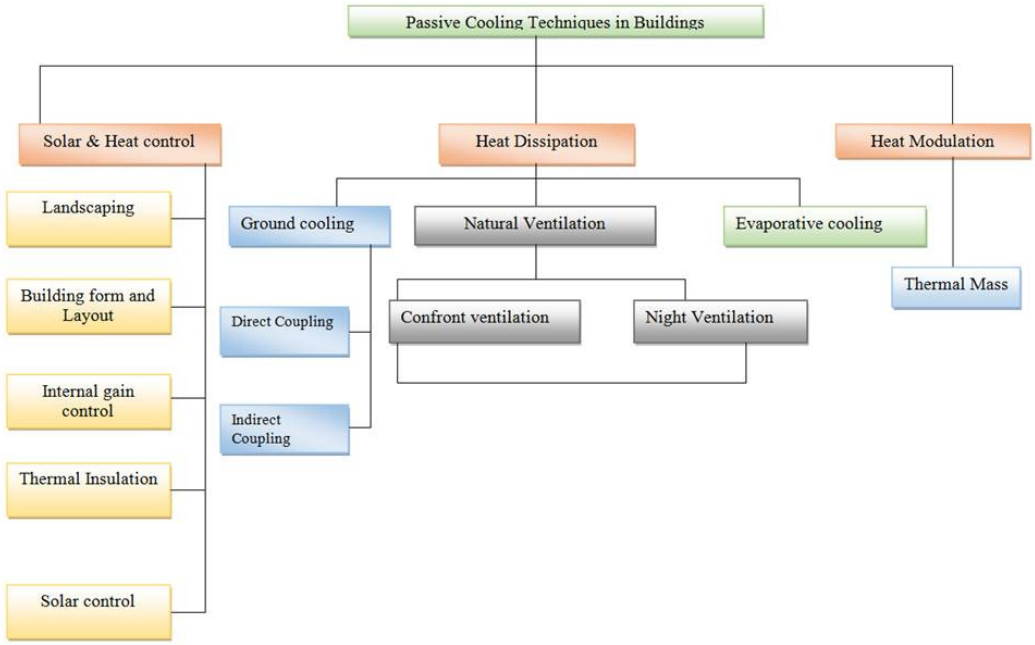

Figure 3. Passive Cooling Techniques in Buildings

Adaptive Thermal Comfort is the hypothesis which hints that the convenience inside the buildings will be affected by outdoor environment and aspect which are related to connections over the adjacent surroundings which permit resident themselves to get a thirst for to a broad range of thermal conditions.

Jindal et al (Aradhana Jindal 2018) revealed that the neutral temperature is determined at 27.1°C which is higher than anticipated for adults under the same thermal environmental conditions based on NBC 2016 (Indian model of adaptive thermal comfort). He added that thermal comfort temperature for both seasons is 15.3–33.7°C.

Pellegrino et al (Pellegrino et al 2012) conducted a thermal comfort study on naturally ventilated class rooms in different universities which are situated in kolkatta. The study reported that the calculation of neutral temperature is 30.9°C which seems to be high.

A thermal comfort zone study was carried out in hostel buildings at Jaipur city which was ventilated naturally. The study report stated that the neutral temperature is established as 30.2°C by using regression analysis with mean value of clothing which is 0.41. It is added that the 0.51 m/s velocity and Relative Humidity of 36% are acceptable (Sanjay Kumar et al 2018).

A detailed thermal comfort study report which contains 1147 datasets was conducted in two different zones of same zone divided by elevation. The study disclosed that the thermal neutrality and insulation in clothing are the important two functions of elevation and outer ecological conditions. The detailed study report proposed an adaptive model which is applicable for chilly and hazy regions in India.

Mishra and Ramgopal (AK Mishra, M Ramgopal 2014) conducted the thermal comfort study and occupants mental health in class rooms and lab in composite climate of India. Neutral temperature of 29°C is finalized using regression analysis in different classroom, even though the desired temperature for comfort is established as 26.8°C. The study forced that the students aggressively used adaptive chances like changing clothes, posture and moving into airy places

D. Prakash and P. Ravikumar (D. Prakash and P. Ravikumar 2015) performed numerical study and identified that change of inlet air flow occurs by providing additional vent in roof and location of vent in roof.

Plabita Baruah et al (Plabita Baruah 2014) conducted a questionnaire study in Tezppur University. This study reported that the suitable temperature range varies from 22 to 23.5 °C in cold seasons and 27.3 to 30.7 °C in hot

seasons. It also finalized that nearly all the objects recorded cool thermal sensation and preferred a warmer climate in winter and warm thermal sensation and preferred a cooler environment in summer.

Madhavi Indraganti et al arrived a conclusion which states that young people, women, and lean people feel better comfort in high temperature than men, elderly people and fat people and it is added that Females accepted the environments better than their counterparts (Madhavi Indraganti et al 2010).

Leo Samuel et al (Leo Samuel et al 2017) proved that incorporation of ventilated air gaps in the top roof will have appreciable influence of reduction in average temperature by 1.2°C.The study revealed that discomfort to the occupants of building would occur in late night and morning hours. Subhashini and Thirumaran confirmed that the shading device execution is the method which will control the heat absorption from the walls and windows of the buildings. (Subhashini and Thirumaran 2018)

PCM Application in Buildings

Thermal energy storage is considered as the emerging method for energy efficient buildings for sustainable development. By applying PCM in the building there may be a drastic reduction in electrical energy consumption, thereby reducing GHG emissions. The incorporation of building materials along with the PCM is the best way to increase the thermal energy storage capacity in building materials.

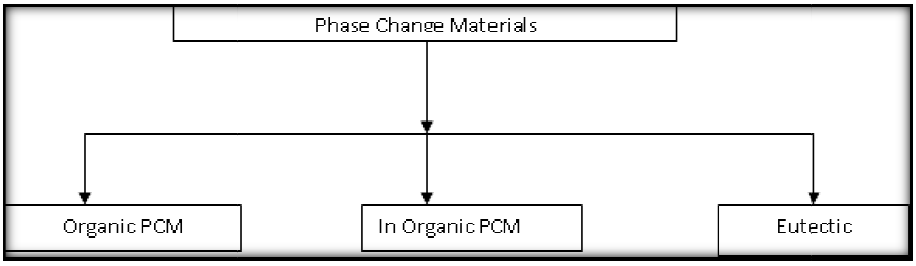

Figure 4. Classification of Phase Change Materials

From the previous studies (Kośny et al. 2010a, 2010b, 2013, Sharma 2013,Liu Zhengxuan et al2018), it is inferred that microencapsulate or macro-encapsulate PCM are polymeric materials which is mostly used in constructions by avoiding the leakage of PCM in buildings. PCM can be used in preparation of thermally insulated window.

Ismail et.al [Ismail et al 2001, 2002] identified a new concept for the uses of PCM in buildings. Windows are covered by double sheet with a gap in between them. The gap is being filled with air. All the sides of the window are sealed with the use of sealer. The window consists of two holes at bottom and the holes are joined through the plastic tube to a PCM tank and pump. The energy absorbing device is joined with the tank which will be surrounded by the Phase Change Material that is in liquid phase. Temperature sensor is provided to control the pump operation. The pump will make an immediate start, if the temperature difference reached the pre determined value the liquid PCM is melted and come outside to fill up the gap between the planes of the glass. When lower temperature is accomplished at the external surface, the liquid PCM will be converted in to solid, projecting appearance in a solid layer that increases in thickness of the air gap with respect to time and prevents the temperature of the internal ambient from decreasing. This process is continued till the PCM is converted to solid phase

Ramakrishnan et al (Ramakrishnan et al 2016) numerically investigated the thermal function of the Phase Change Materials endorsed in buildings. By incorporating the Bio-PCM in the building there may be deduction of temperature 32%&65% corresponding to discomfort and heat wave period. Lotfi Derradji et al (Lotfi Derradji et al 2016) numerically simulated the behavior of PCM when it is implemented in buildings. During the warmest season there was a drop of 7°C air temperature and in winter season there may be an increase in temperature by 4°C

Baetens et al , Al-Saadi and Zhai , Khudhair and Farid, Cabeza et al., Kuznik et al and others, (Simen Edsj Kalnæsa and Bjørn Petter Jelle 2015) have done experiments which are in relation to PCM in buildings for storage of thermal energy and indoor environment console function, obviously indicated that the attention to the PCM is emerging worldwide. Many authors have confirmed that PCM helps saving electricity in the summer season and in the counterpart season (winter) there were only limited benefits.

Clothing Effect

Clothing is a significant factor for attaining and achieving thermal comfort for different temperatures. In a steady-state heat transfer, that energy lost by heat produced by our body equivalent to loss of heat by three mode of heat transfer like conduction, convection , radiation ,respiration and evaporation. Weiwei Liu et al confirmed that the IC-RM model which is having R2 value more than 0.9 implied that the projected model provides an efficient way to measure the change of clothing insulation inside the buildings based on the thermal history effect (Weiwei Liu et al 2009). Paul Gregory and Durkesh Karthik numerically investigated the incorporation of phase change materials in clothing which will be highly beneficial to Rajasthan & Kashmir jawans (Paul Gregory and Durkesh2017). Dakuri and Hayavadana had done research with the PCM on Textiles. It is informed that adoption of PCM in textiles will increase the weight and decrease the strength and causes elongation of the textiles (Dakuri and Hayavadana 2014).

Relative Humidity

Relative humidity is defined as the ratio between the water vapor content present in the air and the maximum content of water vapour to be accumulated in the air which could hold at the specific temperature and pressure. The human frame is having sensors which will detect heat, coldness and relative humidity (RH) indirectly. Our heat in the body will be lost when we are having sweating in the body, during high RH. Due to high water vapour in the air content the heat loss also decreases air. Considering the reverse effect, the RH value will be varying from 20% to 30% in the dry environments On the other hand; Relative Humidity varying from 20-30% in every dry environment is felt as uncomfortable because of their effect on the mucous membranes. The ASHRAE is recommending that the RH be varied from 30%-60% for comfortable atmosphere. But it will be varied according to the countries.

CONCLUSION

Of late pancity, of guidelines for thermal comfort in mechanically ventilated and naturally ventilated office buildings in India has led to uncertainty when planning and designing such buildings. The scenario of occupants in an office and their comfort conditions and requirements in India is not the same as compared to their counterparts in the west. These need to be investigated and explored in detail in order to develop custom made comfort standard. Field studies and survey of actual thermal conditions and gathering occupant response (post occupancy evaluation), computer aided simulation etc would provide vital guidance for both the design and operation of buildings or retrofit of old structures. Various design parameters and ways to improve the thermal comfort and thermal performance can also be implemented like, consciousness and awareness to environment and climate responsive design, energy efficient design including passive deign etc, to enhance and improve the occupants thermal comfort inside. It is also essential to understand that since thermal comfort is a person's cognitive state and condition of mind, it is not of concern how effective and efficient the equipment or technology is, if the heating and cooling systems along with the building enclosure does not create a comfortable condition adaptable to the maximum of the residents in the space, if not the whole purpose of creating a thermally comfortable environment will remains defeated.

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Study on Structural Behaviour of Cold-Formed Steel Built-Up Beams

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Abstract: A detailed parametric study is conducted on the local buckling behaviour of cold-formed steel built-up beam composed of four channel sections. Due to its superior quality, good design flexibility and inherent green benefits cold-formed steel is a sustainable solution for construction industry. A numerical model was developed by using ABAQUS software and was validated by using the test results reported in literature, where a satisfactory agreement has been observed in sectional capacity and modes of failure. The parametric study was conducted by using the validated numerical model for the selected cross sections. All the numerical models were analyzed under four-point bending test configuration in simply supported end condition. A total of 18 analyses in two series were done incorporating different depth to breadth ratios and by varying yield stresses. The results from finite element analysis were compared with the strength predictions obtained using Direct Strength method (DSM) provided in the North American Specification (AISI-S100:2012). Based on the acquired results, conclusions were driven and summarized.

Keywords: yield stress, design strength, local buckling, local slenderness.

INTRODUCTION

Cold formed steel (CFS) had come into the lime light due to the growing demands for materials with high strength to weight ratio in construction industry. Cold-formed Steel members are made of thin sheets that can be formed with no heat into desired shapes by roll forming the structural quality steel through a series of dies. The use of CFS sections in structures has become popular due to the ability of achieving sections with close tolerances. With superior quality, good design flexibility and inherent green benefits cold-formed steel is a sustainable solution for construction industry. Built-up steel sections with CFS members can provide great flexibility, improved strength to meet design requirements. Due to elements of small thickness, CFS members are observed to have peculiar failure modes such as local buckling of component elements before yielding with which this study is concerned. In this investigation, four channel sections were assembled into a single unit forming a CFS built-up beam. The beam was analyzed under four-point bending configuration with simply supported end condition using finite element software. The theoretical study was done using Direct Strength method (DSM).

RESEARCH BACKGROUND

Numerous studies are being carried on the structural behaviour and sectional capacity of CFS members. Few literatures of relevance were taken as references for conducting this investigation and are listed below.

T Anapayan et al. (2011) after comparing the sectional capacity of both Lite steel and CFS sections with the design predictions, concluded that the current design doesn't include the effects of inelastic bending capacity. Thus, to avoid more conservative results, few modifications are suggested to be adopted for compact and non-compact sections as present in hot rolled section. Luís Laím et al. (2013) found modest agreement between the experimental and ABAQUS results, confirming the reliability of the software. They concluded that for spans greater than 4.5m the Eurocode provisions may return unsafe predictions for lateral-torsional buckling. Wang et al. (2015) observed that the numerical (ABAQUS version 6.12-1) and experimental results were similar for the open and closed sections under bending considered in the study. In their subsequent paper, they performed a numerical parametric study on several open and closed built-up beams. Due to the shortcomings of DSM predictions for their section, modifications were made and these equations were recommended. Barichello et al. (2016) conducted study on behaviour and DSM design of CFS "S" type beams undergoing distortional buckling. They covered vast range of yield stresses to study their effect on distortional slenderness. On comparison with the existing codified DSM, they found DSM to be incapable of safely predicting the ultimate bending moments for their sections taken for investigation. Meza et al. (2016) conducted experimental investigation on built-up

CFS beams of constant length but different connector spacing. With reduced spacing in moment span, ultimate capacity of the beam was found to be increased.

From the studies discussed above, it can be observed that more studies are needed to predict the behaviour of CFS sections and adaptability of the existing design provisions. This study investigates the local buckling of short span CFS built-up beams assembled with four channel sections using numerical methods. A non-linear finite element analysis (FEA) was done using ABAQUS FEA software, based on the justified numerical model against the experimental results produced by Meza et al. (2016). The theoretical study was done using equations given in Direct Strength method (DSM) in accordance with North American Specification (AISI-S100:2012) and its adaptability was assessed.

SPECIMEN GEOMETRY AND LABELLING

The built-up beams were designed by assembling four channel sections of thickness 1.5 mm fastened with self-driven screws at flanges. Two channel sections were placed as web portion of the beam spaced at one-third of base dimension and two channel sections making the flanges of the beam as shown in figure 1. The distance between the simply supported end supports was maintained constant of length 2000mm.

The numerical simulations were subjected to two-point loading at a distance of 668 mm apart. The spacing between the screws shown in figure 2 throughout the span was maintained a constant of 100 mm to prevent failure in the shear span.

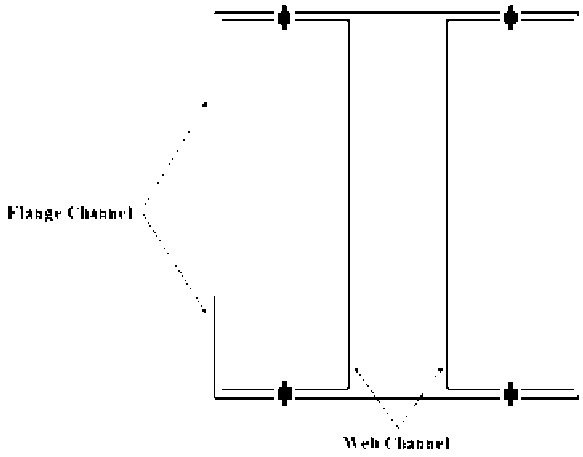

Figure 1. Geometry of Built-up beam

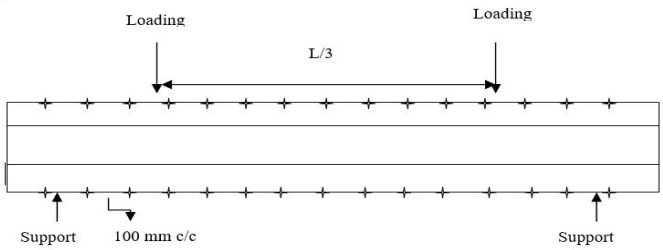

Figure 2. Specimen loading and boundary condition

The specimens considered were labelled based on height, breath of flange and thickness. The labelling of the specimens was done in such a way to self-describe about the specimen. For example, in specimen FC-100-150-1.5, the first term 100 indicates the outer width of the section (B), 150 indicates the overall height (D) of the section and the last term 1.5 indicates thickness (t) of plate in mm respectively.

Table 1 shows the geometric details of selected six FC sections displayed with outer-outer dimensions and they were analyzed for three different yield stresses: 250,350 and 450 MPa. Under four-point bending, the models were assessed to find the failure modes and their ultimate sectional capacity.

Table 1. Dimensions of the specimen

Type	D/B	Section	Web channel		Flange Channel	
			Web (mm)	Flange (mm)	Web (mm)	Flange (mm)
1	1.5	FC-100-150-1.5	148.3	33.4	100	25
2		FC-120-180-1.5	178.3	38.4	120	25
3		FC-150-225-1.5	223.3	48.4	150	25
4	1.75	FC-100-175-1.5	173.3	33.4	100	25
5		FC-120-210-1.5	208.3	38.4	120	25
6		FC-150-262.5-1.5	260.8	48.4	150	25

PARAMETRIC STUDY

The Finite element software ABAQUS serves as a simulation tool for thin-walled elements incorporating the non-linear behaviour. ABAQUS version 6.13 was used in this study for simulating the behaviour of CFS sections under transverse loading to replicate test conditions. Initially a numerical model was developed and the results were compared with reported test results.

Later a numerical analysis was performed using the validated FEA model with eighteen numerical simulations by varying the yield stresses of the material of the specimen. Finally, the analysis results were compared with the strength predicted by DSM equations.

FINITE ELEMENT MODELLING AND VALIDATION

Element Type

The CFS specimens were modelled using thin shell S4R element available in the ABAQUS elements library. It is linear doubly curved, 4-node shell element designed (Luís Laím et al.,2013) to decrease the computational time with reduced integration.

Material Modelling and Imperfections

The stress-strain curve of CFS sections was observed to have a brief yielding prior (Luís Laím et al.,2013) to a period of strain hardening. All components were modelled elastic-perfectly plastic adopting the Young's modulus of elasticity as 210 GPa and Poisson ratio as 0.3. The yield stress of material was varied as 250,350 and 450 MPa. The material non-linearities were included in the models by incorporating von-mises yield criterion and isotropic hardening. Geometric local imperfections were provided as 0.34 x thickness, Schafer and Pekoz (1998) on the critical buckling modes.

FE Mesh

Effect of meshing on the behaviour of CFS sections were studied to arrive at the optimum mesh size and finite element meshes of size 10 x 10 mm was adopted on all cold-formed profiles to save computational time. Since the residual stresses possess meagre effects on the strength as observed by Schafer and Pekoz (1998), they were ignored.

Boundary Condition and Load Application

A three-dimensional model was created by adapting the desired cross-section and material properties to simulate the buckling modes under test conditions. In ABAQUS, modelling was done by extruding the beam along z-axis and cross-section along xy axis. The simply supported end conditions were provided by restraining lateral, longitudinal and vertical displacements along with torsion at pinned end whereas lateral and vertical displacements along with torsion at roller end (Wang et al., 2018). The loading plates were also simulated so as to replicate the test conditions. Loads were applied along y-direction at the center of these plates each at a distance of 666 mm from the nearby support. Self-contact was used in contact interactions due to its simplicity, between surfaces. Contact behaviour was assumed to be frictionless and hard in all simulations.

FE Analysis

Finite element analysis of all the specimens was done in two phases. Initially, a linear perturbation analysis was performed and critical eigen modes were identified to lie in first two eigen buckling modes for all the specimens. The effects of local geometric imperfections were induced on the critical nodes. Material imperfections were added and a non-linear static analysis was performed with NLGEOM=ON to include large deflection effects.

VALIDATING THE MODEL

The results recorded by Meza et al. (2016) from experimental study were used to validate the developed numerical model. The dimensions of the specimen and material properties obtained from coupon test provided in their research study was adapted for individual elements. The boundary and loading conditions were provided with precision to simulate the experimental test set-up.

Table 2. Comparison of results- FEA and experiment

Section	Failure Mode	Ultimate Moment Capacity (FEA) (kN m)	Ultimate Moment capacity from experiment (literature) (kN m)	MEXP/MFEA
B-0b	LB	11.45	11.84	1.034
B-2b	LB	12.85	13.14	1.022
B-3b	LB	13.22	13.01	0.984
Mean				1.013

Note: LB=Local Buckling

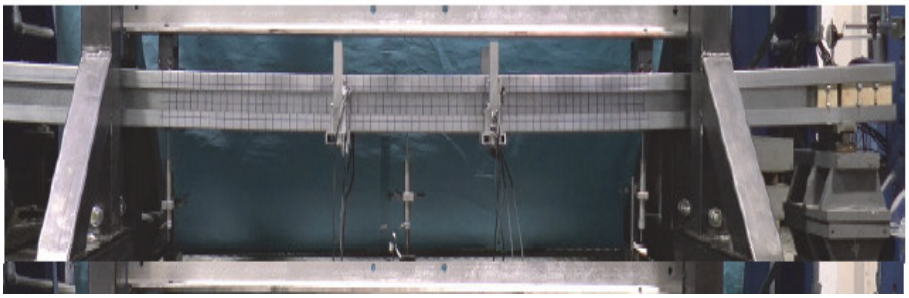

Figure 3 (a). Experimental Deformation of B-0b specimen

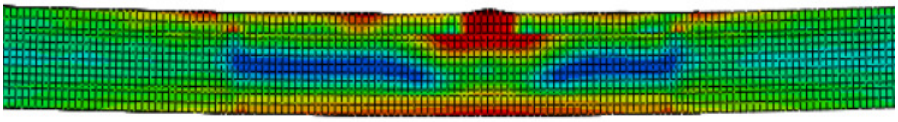

Figure 3 (b). FEA Deformation of B-0b specimen

Eigen buckling analysis followed by non-linear static analysis was performed and the results were compared with the experimental results observed in the paper as in table 2. The buckling mode was also found as in figure 3 to be similar with the results observed through experiment.

The mean value of the ratio MEXP/MFEA was found to be 1.013 with a standard deviation of 0.026 showing good accuracy and also the specimens failed by local buckling of top channels in constant moment region, the same as observed by the authors. From the table 3 and figure 3, it can be observed that the results from FEA showed good agreement with the experimental results, confirming the adaptability of the developed numerical model.

NUMERICAL ANALYSIS

The purpose of the parametric study was to understand buckling behaviour of the built-up CFS sections. A total of eighteen analyses in two series were performed using six specimens and varying the yield stress of the material by 250,350 and 450 MPa respectively. The specimens were loaded under four-point bending configuration with a constant moment span of 668mm.The finite element models were created using the justified numerical model and non-linear static analysis was carried out. All the specimens were observed to fail by local buckling of top flange of the built-up beam as displayed in figure 4 in the constant moment span.

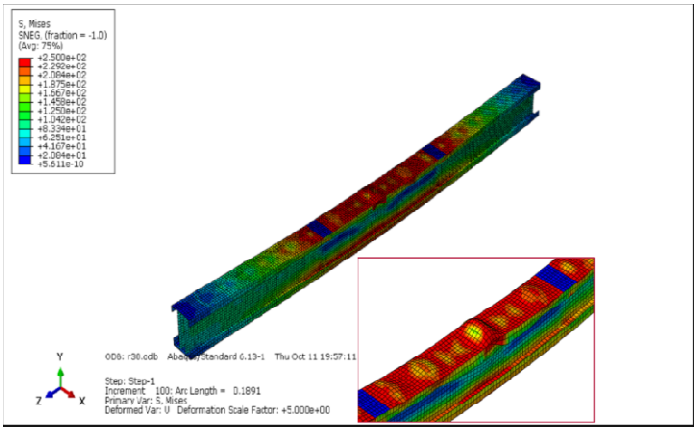

Figure 4. Local buckling failure of specimen-FC-100-175-1.5 of yield stress 350 MPa

THEORETICAL ANALYSIS

The theoretical study was done using DSM equation for the sections considered in the study and the sectional capacity was evaluated under the local buckling criterion. To obtain the properties of the section, analysis was done using GBTUL software and the values were incorporated in DSM calculations. The yield moment My and local buckling moment, Mnl as per DSM in accordance with North American Specification (AISI-S100:2012) were calculated for all the FC sections considered in numerical analysis.

COMPARISON OF NUMERICAL AND THEORETICAL RESULTS

The results from the finite element analysis obtained by using ABAQUS software, MFEA and theoretical analysis using DSM, MDSM were compared for all the sections. A comparison graph was plotted, figure 5 with the FEA, DSM results against the local slenderness, λl of the sections. The ratio of FEA-predicted strength to DSM predicted strength, MFEA / MDSM was found to be 0.85 with a standard deviation of 0.068. This implies that the FEA results fall below the results arrived using existing DSM provisions for local buckling. Thus, for the FC sections, the predictions of DSM equation were found to be un conservative and unsafe under local buckling criterion.

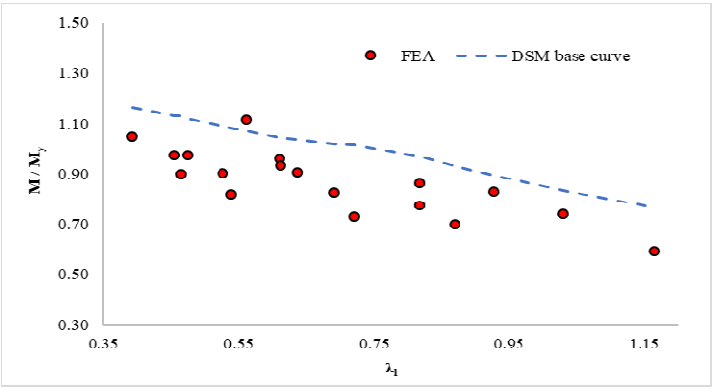

Figure 5. Comparison of FEA and DSM results - local buckling

CONCLUSION

A numerical model was developed and it was justified by comparing with experimental results recorded in the literature. A numerical analysis on eighteen simulations of CFS sections was conducted and all the simulations were observed to fail by local buckling of flanges. Eigen buckling analysis was done to arrive at the critical moments required in direct strength equations. The results from finite element analysis were compared with the predicted theoretical results. The average of ratio MFEA / MDSM was found to be 0.85 which shows that the results calculated using existing DSM equation for local buckling are un conservative for the sections considered in the study. On this aspect, a detailed parametric study is recommended and is under progress by the authors.

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Marine Ship Pollution (Causes, Effects and Solutions)

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Abstract: Marine pollution is defined as the dumping of oil and other wastes from ships into oceans. The cruise ships can cause Marine pollution in eight ways, namely- Ballast water pollution, Air and Noise pollution, Grey and black water pollution and so on. The effects of Marine Ship Pollution are oxygen depletion, higher acidity, choking marine life, blocking sunlight and affecting human health. MARPOL 73/78 provides six Annexes to control and prevent Marine Ship Pollution. The preventive measures are Ballast water Management, Oily water separation and Ship's waste water treatment.This technical paper discusses all these important matters related to causes, effects and solutions of Marine Ship Pollution.

Keywords: Cruise ships, Maine ship pollution, MARPOL 73/78, Water Management and Biological Sewage Treatment.

INTRODUCTION

Marine ship pollution refers to deliberate dumping of oil and others wastes from ships in the oceans. Diesel engines in the cruise ships produce air pollution. A cruise ship can pollute both the water and the air. A large cruise carries 1000s of passengers. Each passenger produces a personal waste which ends up in ocean water. Ships do pollute the ocean waters.

SEVEN WAYS IN WHICH CRUISE SHIPS CAN CAUSE IN MARINE ENVIRONMENT

Cruise ships discharge waste streams to the marine environment. This waste includes grey water, ballast water, sewage, solid waste, waste oil, air pollutants.

(I) Air Pollution

We are all aware of the concept of air pollution. A large cruise ship emits NOX and ultra fine particles in large amount. The emissions are CO2, NOX and particle emissions.

(II) Ballast Water Pollution

Ballast water in a ship increases its stability. Ballast water is discharged during loading and unloading. It sometimes contains sediments and plants and living organisms. Ballast water discharge into the ocean can have negative impact.

(III) Noise Pollution

Because of entertainment in the Cruise Ships like dancing, music programmes, unpleasant noises are produced. It affects sensitivity of marine animals and mammals. Their hearing gets harmed. This leads to unwanted death and loss to the ecosystem. Human beings are also affected inside the ship,who love peace of mind inside the ship, while travelling through the ocean water.

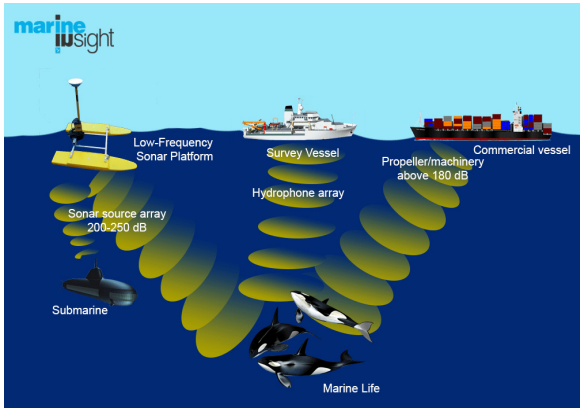

Figure 1. Noise Pollution and Marine life, Source: Marine Pollutions from ships on Marine Life: Smita 2016

(IV) Grey Water Pollution

It means bath, and shower water and waste water from lavatory sinks and dish washers. It harms the marine environment. Untreated grey water impacts water quality and public health.

(V) Black Water Pollution

Cruise ships release millions of gallons of sewage into the ocean. This is classified as black water. Sewage is waste from toilets and health facilities. Cruise ships should dump only treated waste water. This is the requirement of Federal law.

(VI) Solid Waste

The solid wastes generated by cruise ships are food waste, plastics, wood etc. A 3000- passenger cruise ship generates 50 tonnes of garbage and solid waste. Dumping of garbage at sea is prohibited within 3 to 25 miles from shore. This solid waste dumping affects oceanic living creatures.

(VII) Oily Bilge Water

Last but not the leas- oily bilge water pollution. The average cruise ship produces 7000 gallons oily bilge water. Most of the marine pollution is due to oil spill from cruise ships. Oil leaks through faulty engines. Oil is heavier than water and oil does not degrade quickly. Intake of polluted marine water due to oil spill by the sea creatures affects their health. We must take care of marine life forms.

EFFECTS OF MARINE SHIP POLLUTION

The following are the effects of Marine Ship Pollution:

(i) Noise Pollution, (ii) Oxygen concentration reduction, (iii) Ocean acidification, (iv) Sunlight block out, (v) Flying becomes difficult for Marine birds.

(I) Noise Pollution

Shipping causes noise pollution. This noise can travel long distances. Some of the species living in the ocean may be harmed by these types of pollution. These species rely on sound propagated by them for their direction, communication and food. Sound pollution affects their survival in ocean.

(II) Oxygen Concentration Reduction

Oxygen is life for all living beings, especially marine organisms. Seawater contains dissolved oxygen(DO, Oxygen molecules dissolved in sea water).When oxygen concentration is reduced, the living organisms in sea water struggle to get oxygen and their survival becomes difficult. Plants in seawater, fishes love oxygen and take it to survive and live abundantly in ocean. Oxygen depletion occurs when bio degradable material is dumped to sea water.

(III) Ocean Acidification

Sulphor dioxide (SO_2) emissions from ships result in ocean acidification. The acidification of sea water is very dangerous. CO_2 emissions are eight times more than acid water released from ships.

(IV) Flying Becomes Difficult for Birds

Air that we breathe is important for survival. It is also true for birds flying in the marine environment. The birds in our planet are in crisis. Water birds are affected by oil Pollution. Approximately, 5,00,000 water birds are killed every year due to oil spills in ocean.

(V) Sunlight Block Out

Plants living in the ocean need sunlight to do the function of photo- synthesis. Light is good and reveals things to visibility. Pollutants from ships block out sunlight.

MONITORING, CONTROL PREVENTIVE MEASURES OF MARINE POLLUTION

We need to take preventive measures to protect the seas. Act to prevent pollution from ships/ MARPOL are the ways by which, we can control and prevent marine ship pollution. MARPOL 73/78 Convention2: MARPOL1 stands for Marine Pollution. The Convention was conducted in the years 1973 and 1978 to prevent Marine ship pollution.

Marpol Regulations about Marine Ship Pollution

Annex I is about Regulations regarding Oil Pollution prevention. Annex II prohibits effluent containing substances discharged into the ocean. Substances are divided into X,Y and Z categories. X category causes greatest threat and Z category causes smallest threat. Annex III is about Regulations concerning substances which are harmful in the form of packages. These are dangerous goods. Annex IV explains the Regulations to prevent sewage pollution by ships. Sewage means any form of toilets and urinals, drainage from living animals. Annex V is about Regulations to prevent Garbage Pollution by ships. The categories are plastics, food wastes, domestic wastes, cooking oil, incinerator ashes etc. Annex VI Regulates Prevention of Air Pollution from ships. The dangerous emissions are NOX emissions, Ozone depleting substances, Sulphor oxide emissions.

Solutions to Marine Ship Pollution

(I) ***Oil Water Separator4:*** OWS is equipment which separates water and oil. There are different types. It is mandatory for oil tankers should have double hull. The following sketch illustrates O.W.S. Stokes law states that heavier oils require more retention time.

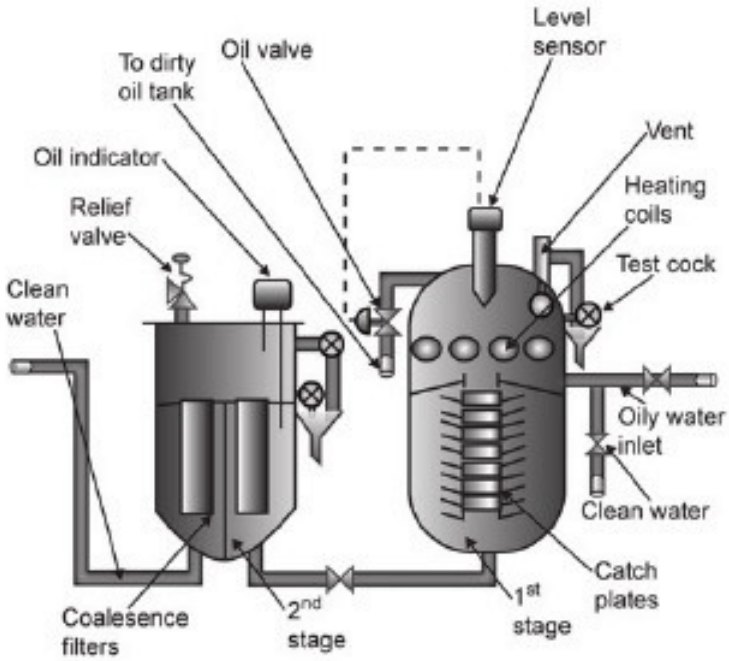

Figure 2. Oily Water Separator
Source: Oil Water Separators- Working Principles/generalcargoship.com

(II) Ballast Water Management

BWM stands for Ballast Water Management. Fresh water or sea water sometimes contains sediments. B.W.M. controls harmful invasive species. BWM aims to protect the Marine Environment from the transfer of harmful organisms.

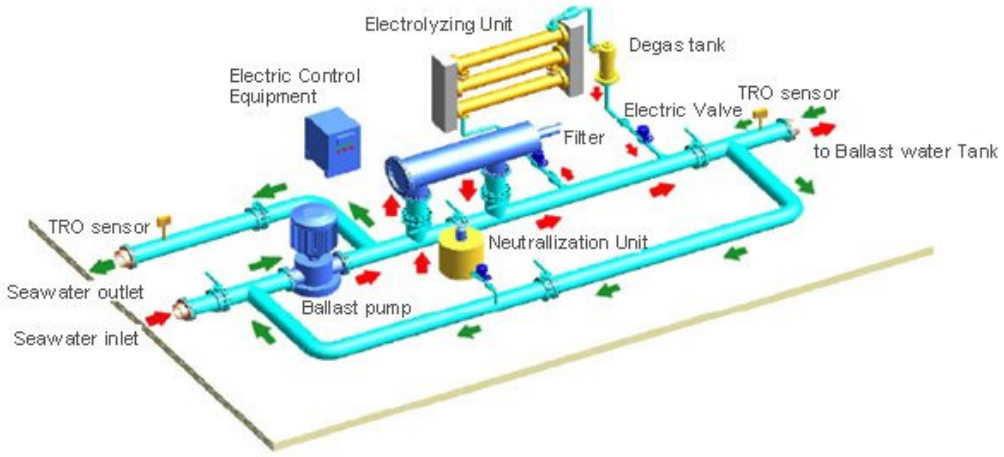

Figure 3. Ballast water treatment system
Source: How Ballast Water Treatment System Works By Raunek: 2017

(III) Ships Waste Water Management

Modern Cruise liners produce waste water. Waste water treatment technologies are used on cruise vessels. When suspended solids are removed from waste water, the remaining water is called effluent. Waste water must be treated before discharging into the marine environment. The ship should have an accepted sewage treatment Plant. The following sketch shows a Biological Sewage Treatment Plant.

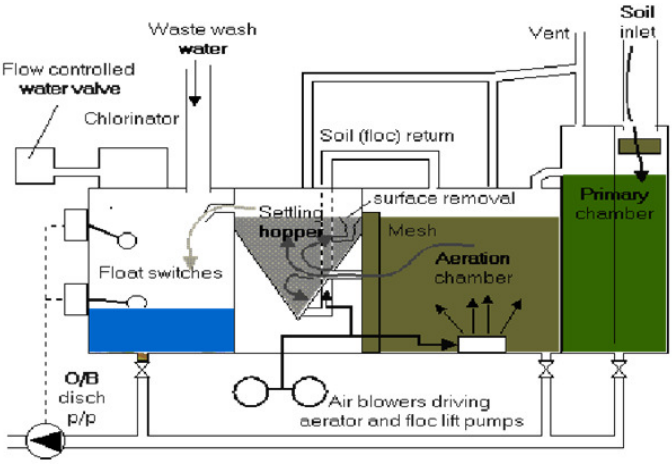

Figure 4. Waste Water Treatment Plant
Source: marineengineering.org.uk

CONCLUSION AND RECOMMENDATION

(i) Sources of Marine Pollution from ships have been established, which includes discharge of oily water, invasive organisms from ballast, Grey water and black water pollution, air, noise and solid waste pollution. (ii) Pollutants damage the ecosystem. Systems life and human health. (iii) Control and Preventive measures have been established including adherence and enforcement of standard operations as contained in Annex I- VI of IMO Conventions.

The following are some of the recommendations: (i) Control marine pollutions by introducing penalties to ships found polluting the Marine Environment. (ii) Exchange technical information, technology, and experience between countries all over the world. (iii) Protect aquatic environment and practice IMO Standards. (iv) Cleanup the marine environment and create awareness by educating Citizen and Ship owners, respect and protect Marine Environment.



Figure 5. Seven Seas Explorer: Most Luxurious Ship
Source:bocadolobo.com/blog/lifestyle/regent-seven-seas-explorer

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Development of a new Blended Polyether Sulfone membrane for dye removal from synthetic wastewater

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Abstract: The wastewater produced from various industries like textile, paper, rubber, leather, plastics, cosmetics, pharmaceuticals contain many dyes. Most commonly found dyes in these effluents are Orange G and Methylene Blue. These dyes are toxic and are harmful to the environment as well as humans. Hence they need to be removed from the wastewater. Polyether sulfone (PES) membranes are most widely used in ultrafiltration separation processes. Enhancement in membrane permeability and improving the rejection capabilities of the membrane is a key challenge faced by membrane researchers. The current works represents the effect of Barium chloride blending on separation performance of PES membranes. Through systematic experimental studies, this research work aims to fabricate polyethersulfone (PES) based membranes and to investigate their efficiency in removing Orange G and Methylene blue from synthetic wastewater. Five different membranes, one of which is a pristine PES membrane and four others made of PES blended with different wt % of barium chloride were synthesized in our lab by phase inversion method.. The characterization was carried for these fabricated membranes for various properties like membrane morphology, porosity, surface hydrophilicity, and pure water flux. It was evident from the experimental results that PES blended with Bacl2 membranes showed better dye separation efficiency in comparison with the primal PES membrane. Also, out of the four blended membranes, the one with 2 wt % Bacl2 showed the highest pure water flux; permeate flux, dye rejection, lowest contact angle and the best porosity. The above experimental observations indicate that the UF PES membranes blended with 2 wt % Bacl2 can be a viable alternative membrane for the separation of dyes from industrial water.

Keywords: Phase inversion, Barium Chloride, Contact angle, Porosity, and UV-Vis spectrophotometer

INTRODUCTION

Water contamination due to effluents from various industries is a matter of serious concern since a large quantity of effluent is discharged into the water bodies. Most industrial wastewater contains various synthetic dyes that cause environmental issues (Lei Yao et al., 2015). Dyes are used as a coloring material in industries like textile, printing, paper, plastic, leather and food industries (Lei Yao et al., 2015; M. EL Alouani et al., 2018). Approximately, more than seven lakh tons of dyes are consumed every year by industries (Lei Yao et al., 2015; Narjess Zaghbani et al., 2007). These dyes have complex molecular structure and are aromatic in nature imparting a stable colour to the other material. The non–biodegradability of dyes also reduces the BOD/COD ratio to a larger extent. When the dye effluent is mixed with water bodies, they cause a reduction in the penetration of sunlight, decreases photosynthesis of aquatic plants, and promote the occurrence of eutrophication (M.H. Ehrampoush et al., 2010; S. Foorginezhad et al., 2017). Among the various dyes, the commonly found dyes are Orange G and Methylene blue. These are thiazine cationic dye used for dying and coloring purposes. (M. EL Alouani et al., 2018; Jin-Hui Huang et al., 2010; Narjess Zaghbani et al., 2007). These dyes cause severe health problem such as vomiting, breathing problem, diarrhea, cyanosis, jaundice etc., (M. EL Alouani et al., 2018; P.V. Nidheesh et al., 2012; N.M. Mubarak et al., 2015). Therefore, these dyes need to be eliminated from water bodies.

There are many methods available for removal of dyes such as adsorption (G.Z. Kyzas et al., 2015;G. Mezohegyi et al., 2012; V. Panic et al., 2013), coagulation-flocculation (A.K. Verma et al., 2012; C.S. Lee et al., 2014), membrane separation (A. Cassano et al., 2001; C. Fersi et al., 2005; S. Yu et al., 2010; C. Zhou et al., 2014; C.-Z. Liang et al., 2014), catalytic oxidation (N. Muhd Julkapli et al., 2014; P.V. Nidheesh et al., 2012), ion-exchanger, biodegradation. These methods are found to be effective but the capital and working costs are high and are very difficult to maintain (M. EL Alouani et al., 2018; Jin-Hui Huang et al., 2010). Among these methods, membrane separation of dye effluent offers higher rejection and is considered to be highly effective

since the capital investment and maintenance cost are less. The membranes are also highly stable and long lasting (S. Foorginezhad et al., 2017). These types of membrane have good film forming property and are easy to fabricate. Some of the widely used polymers are Polyether Sulfone (PES), polyethylene glycol (PEG) and poly vinyl pyrrolidone (PVP) (S. Velu et al., 2011). PES is ranked the best among these polymers due to its excellent physical and mechanical properties, good chemical resistance, and thermal stability (S. Velu et al., 2011; Rambabu K et al., 2017). Membranes from these types of polymers are prepared by the phase inversion method where interactions of the polymer with the solvent as well as with the non solvent play a critical role. At times PES polymeric ultrafiltration membranes are blended with an additive to enhance its porosity, surface hydrophilicity and pure water flux (Rambabu K et al., 2017).

The aim of this research work is to fabricate regular poly ether sulfone membranes and to modify their surface by adding BaCl2 salt as an additive of varying composition and to investigate their potential applications for the separation of dyes from contaminated water bodies.

In this study, five sets of PES based primal and blended ultra filtration membranes were developed by changing the composition of PES, DMF and Barium Chloride as shown in Table 1. The synthesized membranes were then tested for their hydrophilic nature, surface characteristics, porosity and water permeability. The membranes were then tested for their rejection capabilities for methylene blue and orange G of 100 ppm concentration with the aid of batch filtration equipment. The results obtained are presented and discussed in detail.

MATERIALS AND METHODS

Materials Used

Polyethersulfone of molecular weight 58000 were procured from BASF, India. Orange-G and Methylene Blue dyes powders purchased from Sigma-Aldrich were used as a model dye. Analytical grade N, N-dimethylformamide (DMF) and formalin were purchased from Spectrum reagents and Chemical Pvt. Ltd, Cochin, Kerala. Barium chloride was purchased from Sigma-Aldrich Limited, India. Distilled water was used throughout the experiment.

Membrane Synthesis

Here in this study, five different sets of membranes tagged as M1, M2, M3, M4 and M5 were prepared by varying the amount of barium chloride in the dope solution. The required quantities of chemicals were added and mixed together to make a homogenous dope solution. The homogenous dope solution was poured on a glass plate and air dried on the glass plate for 60-sec to achieve dry phase inversion before immersing in the water bath for 2 hrs maintained at a temperature of 20˚C. The membrane prepared by the above method is shown in Fig 1.



Figure 1. Synthesized blended PES membrane

Table 1. Different Compositions of membranes synthesized			
Membrane ID	**Membrane Composition (by weight %)**		
	PES	BaCl2	DMF
Pristine (M1)	80	20	0
PES- BaCl2-1 (M2)	79	20	1
PES- BaCl2-2 (M3)	78	20	2
PES- BaCl2-3 (M4)	77	20	3
PES- BaCl2-4 (M5)	76	20	4

MEMBRANES CHARACTERIZATION

Scanning Electron Microscope (Sem)

The Scanning Electron Microscope gives information on the top surface morphology of a surface. Here, the membranes samples (1 cm x 1 cm) were initially frozen by soaking it in liquid nitrogen for 20 s and then dried. (Hitachi, Model: S-3400N, USA). The dried membrane samples were subjected to gold sputtering with 20mA current for 3 minutes.

Measurement Of Contact Angle

The affinity of the membranes towards water can be quantified by Contact angle measurement which was done with the help of a goniometer (DSA20B, Kruss Germany). Measurements were made at three different regions on the membrane surface and the mean value was calculated.

Porosity

The porosity (ε) was determined by finding out the water absorbing capacity of the membrane sample by immersing it in water for 24 hrs and then drying it in an oven at 65 C. The mass of the wet (m1) and dried membrane (m2) was noted and the porosity (P) calculations were made using the following equation

$$P = \frac{m_1 - m_2}{\rho_W A l} \tag{1}$$

Here, A is the surface area of the membrane in m2, l is the thickness of the membrane in m, and ρ_W is the density of water in kg m-3. (R. Krishnamoorthy et al., 2015).

Separation Performance Test of the Fabricated Pure and Blend Pes Membrane



Figure 2. Photograph of Dead-end stirred cell filtration setup

The experimental set up used to measure the water permeation rate and rejection performance is shown in Figure 2. The set up has a housing made of stainless steel for holding the feed solution, a collection tank for

permeate, membrane housing unit and a high pressure compressor. A feed solution of known concentration (100 ppm) was taken in the feed tank and was forced through the membrane unit by the high pressure developed by the compressor. Both permeate and retentate solutions were collected in separate stainless steel containers. A needle valve located at the feed housing was used to adjust the pressure in the membrane housing. A constant pressure of 4 atm was maintained throughout the experimental runs and the membranes used in the housing had an effective cross sectional area of 6.4 x 10 -3 m2.

Equation used to calculate the water permeation flux is given below

$$J_W = \frac{Q}{A \times t} \quad (2)$$

Here JW is the water permeation flux in L/m2.hr, Q is the permeate measured in litres, A is the cross sectional area of the membrane measured in m2, t is the time interval in hr for which the permeate is collected (R. Krishnamoorthy et al., 2015)

Extensive experimental studies were then carried out to establish the suitability of blended membranes for the rejection of the selected dyes namely orange G and methylene blue. Aqueous feed solution containing a solute of specified concentration (100 ppm) is prepared by adding measured quantity of solute with raw water and taken in the feed tank. The operating pressure of the unit was fixed at 4 atm by adjusting the needle manual valve. Permeate and retentate samples were collected and analyzed using UV –visible spectro photometer. For each one of the two solutes, the experiments were repeated with different membranes for same feed concentrations and inlet pressures. The values of feed concentration, feed pressure and Permeate concentrations for each of these experimental studies were recorded and presented in graphical form.

The membrane rejection efficiency is calculated by the following relation.

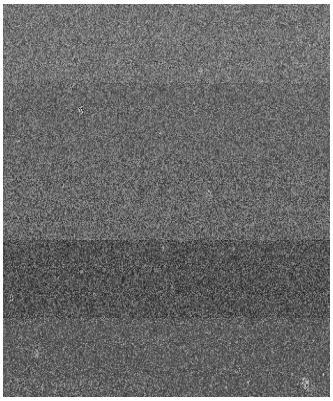
$$\text{Rejection efficiency } (\%) = \left(1 - \frac{C_p}{C_f}\right) \quad (3)$$

where Cp and Cf are the concentration (ppm) of dyes in the permeate stream and feed stream respectively.

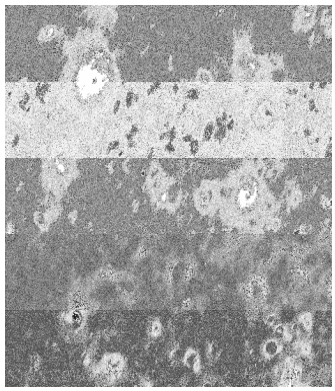
RESULTS AND DISCUSSIONS

Scanning Electron Microscopy (SEM)

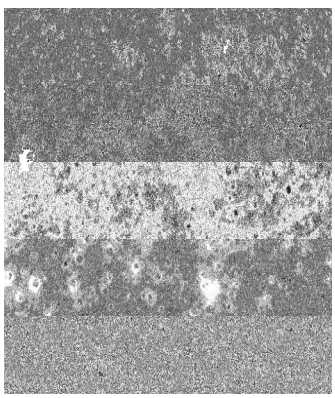
SEM analysis was carried out to determine the changes on the top surface of the pristine PES and blended PES membranes. The formation of dense top layer happened at the PES and DMF interface. The top surface of the blended PES membranes shows clear distribution of pores on the top surface of 1 & 2 wt % BaCl2 membranes as shown in fig 3. (b) & (c). The 2 wt % BaCl2 blended membranes have large number of pores on the surface and the size of the pore was found to be bigger. It happens because of the hydrophilic nature of the BaCl2. However, with the increase in BaCl2 content above 2 wt % in the PES matrix, it was noticed that the dope solution blend was not miscible and the resultant blend membranes showed some irregularities in the cross section and were not stable.



(a)

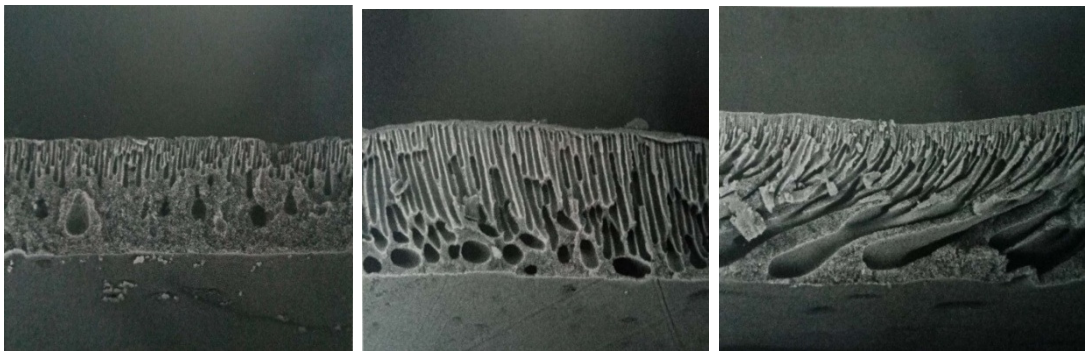


(b)



(c)

Figure 3. Images captured by SEM showing the membrane top surface (a) Primal PES membrane (b) 1 wt% BaCl2 (c) 2 wt% BaCl2



(a) (b) (c)

Figure 3. Images captured by SEM showing the membrane cross sections (a) Primal PES membrane (b) 1 wt% BaCl2 (c) 2 wt% BaCl2

Fig 3.1 shows the cross-section views of the primal PES and blend BaCl2 membranes. It is easy to visualize from the image that the membrane formed has an asymmetric structure with a densely populated top layer and a sublayer with pores. Long elongated cavity like projections as well as larger void containing structures are more clearly present in the blended membranes and is more predominantly seen in higher BaCl2 concentration in the dope solution.

CONTACT ANGLE AND POROSITY MEASUREMENTS

The contact angle and porosity results are presented in Table 2. The blended PES membranes have lower contact angle than that of primal PES membrane. Usually, PES membranes have good chemical resistance, thermal stability and excellent mechanical strength (Nasrul Arahman et al., 2012; A. Rahimpour et al., 2007; A. M. Sakinah et al., 2007; A. V. R. Reddy et al., 2008), but are more hydrophobic in nature, which is the main disadvantage in practical applications. In this research work, hydrophilic additive BaCl2 was added to the PES polymer solution in order to increase the hydrophilic property of blended PES membranes. As evident from table 2, pristine PES membrane showed higher water contact angle which means the membrane is hydrophobic. The addition of BaCl2 in the membranes M2 to M5 has made the membranes more hydrophilic as indicated by the contact angle values.

Table 2. Contact angle and Porosity values of the prepared membranes

Membrane ID	Composition (by weight %)			Contact angle (degree)	Porosity (P)
	PES	BaCl2	DMF		
Pristine (M1)	20	0	80	67.3	0.49
PES- BaCl2-1 (M2)	20	1	79	59.9	0.59
PES- BaCl2-2 (M3)	20	2	78	54.8	0.73
PES- BaCl2-3 (M4)	20	3	77	50	0.75
PES- BaCl2-4 (M5)	20	4	76	43.7	0.77

With regard to Porosity, it is a known fact that the water permeation rate will be higher for highly porous membranes. Based on Table 2, the primal PES membrane has the lowest porosity due to its higher polymer concentration in the membrane solution. On addition of BaCl2 upto 2% over the PES surface, the porosity of the membrane structure got enhanced by 50%. However, with the further increase in concentration of BaCl2 (3 & 4%) the dope solution because more and more viscous and membrane became partially miscible. In general, all the BaCl2 blended membranes (M2 to M5) possessed higher porosity than the primal PES membrane.

PURE WATER FLUX

Information on flux of the membrane in industrial applications is important because of its direct inflence on the productivity of the process. Here, an attempt is made to develop a membrane with higher water flux by manipulating the BaCl2 concentration. A dead end filtration set up was used to measure the permeation rate of the primal and blended membranes .The effect of BaCl2 addition over the primal membrane on the pure water flux was shown in figure 4. It can be observed that the pristine membrane without Bacl2 additive had recorded the lowest pure water flux of 47 L/m2.hr. However, as the addition of BaCl2 was increased up to 2 wt % in the PES matrix, the water flux was found to increase by 3 times more than the primal membrane due to the enhanced hydrophilicity. The increase in pure water permeability was comparatively higher at higher BaCl2 concentration (> 2 wt %), but the resultant membranes were not stable. Thus we can conclude that the membrane became more hydrophilic on account of barium chloride addition upto 2 wt %, but for higher concentration of BaCl2, the hydrophilic properties could not account as the membrane became more unstable.

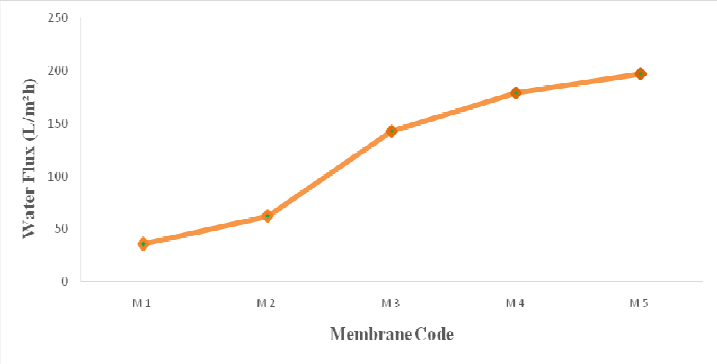


Figure 4. Water flux recorded for different membranes

SEPARATION PERFORMANCE OF THE PURE PES AND BLENDED BACL2 MEMBRANE

The separation capabilities of the prepared membranes for Orange G and methylene blue were presented in terms of rejection efficiency as shown in Fig 5. For the inlet feed concentration of 100 ppm and for a transmembrane pressure of 4 atm, the rejection efficiency of orange G by the prepared membranes are observed to vary between 65% and 85 %. Whereas for Methylene blue, the rejection efficiency values vary between 85% to 91%. Out of the five membranes, the one with 2 wt% BaCl2 shows highest rejection of 85% for orange G and 91% for Methylene blue. These results clearly show that blend membranes have higher pure water flux and higher dye rejection than pure membranes. This is due to the increasing porosity and hydrophilicity of the blended membranes due to BaCl2 addition.

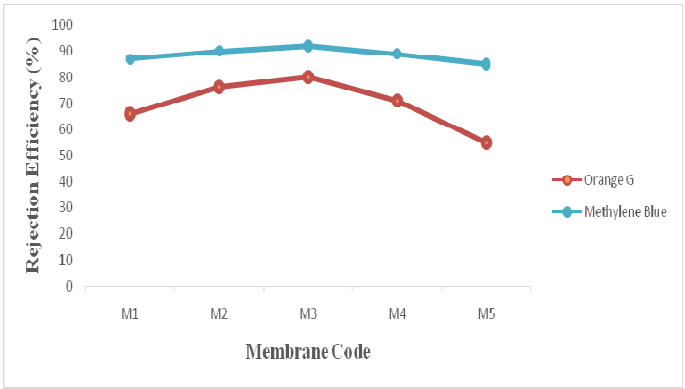


Figure 5. Dye rejection efficiency recorded for the various membranes

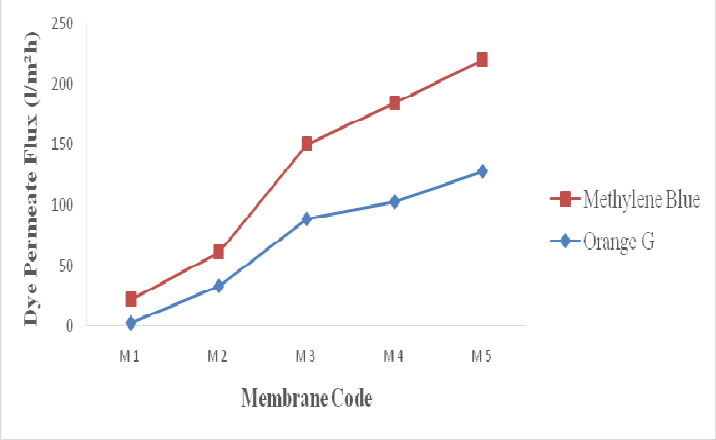


Figure 6. Permeate flux recorded for various membranes



(a) (b)

Figure 7. (a) Feed and Permeate samples of Orange G solution (b) Feed and permeate samples of Methylene blue solution

CONCLUSION

Thus the 2 wt% blended BaCl2 membrane offers an exciting opportunity to be considered as an alternative treatment technique for dye polluted water bodies because of its better flux and high rejection efficiency. The primal and blended PES novel ultrafiltration membranes were synthesized in-situ by phase inversion technique. The blending of BaCl2 with PES matrix resulted in the alteration of membrane morphology and enhanced the porosity and hydrophilicity of the membrane. This is evident from the results of contact angle and permeation results. Of all the blended membranes , the membrane with 2 Wt% BaCl2 showed a porosity of 0.73 and the pure water flux values were 3 times higher than the pure membrane. Taking all the tested performance into consideration, when the concentration of BaCl2 was 2 wt%, the blend PES/ BaCl2 membrane M3, had the best performance in terms of rejection efficiency which were found to be 85% and 91% for Orange G and Methylene blue respectively. Thus the 2 wt % BaCl2 (M3) membrane promises to provide an alternative treatment technique for the separation of the dyes from waste water.

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Adaptive Neuro-Fuzzy Based Model for Performance Evaluation of Hybrid Fibre Reinforced Concrete

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Abstract: Hybrid fiber reinforced concrete (HFRC) has found applications for concrete members requiring high performance. Incorporation of higher modulus rigid and lower modulus flexible fibers in conventional concrete has been found to possess comparatively higher performance. Therefore, an effort is made in this study to develop a mathematical model for compressive strength, modulus of rupture, service load and deflection and ultimate load and deflection of HFRC specimens using Adaptive Neuro-Fuzzy Inference systems (ANFIS) and compared the predicted results with experimental results. All the ANFIS take total fiber volume fraction (Vf), a percentage of steel and polyolefin fiber as input variables. Input and output membership function type assigned as 'trimf' (triangular membership function) and linear respectively. From the study, it was observed that the ANFIS successfully applied for predicting the properties of HFRC and the predictions were very closely agreed with experimental results.

Keywords: HFRC, Matlab, Fuzzy Logic, ANFIS

INTRODUCTION

Fundamental properties of a cement-based material have been needed to a Civil Engineer for estimation of the strength, ductility, and durability, for the purpose of proper utilization into different structural applications. For an instance, Young's modulus of concrete is directly proportional to the compressive strength (IS 456 – 2000), and hence, if the concrete having high strength would be high Young's modulus. However, Young's modulus can be calculated by testing of standard specimens under compressive load (IS 516 – 2004), whereas, this is quite difficult in the case of execution and the experimental results would also vary with respect to materials used, climatic condition, testing procedure and etc. For this reason, a correct/more accurate method of finding of Young's modulus becomes vital for calculation of deflection of various structural members. Hence, a mathematical model that has to be a more accurate prediction capacity of concrete properties is required, either by theoretically or empirically.

However, the use of numerical modeling together with statistical ones to predict the properties of hybrid fiber reinforced concrete (HFRC) could lead to more difficult. Moreover, various soft computing methods have been available like artificial neural networks (ANN), fuzzy logic (FL), and adaptive neuro-fuzzy inference systems (ANFIS), that gives a positive loom for prediction of different properties (Flood & Kartam, 1994; Flood et al., 2001; Fuat, 2005; Sedat et al., 2004). In the present study, the ANFIS models were developed using the fuzzy toolbox which is available in Matlab software (MATLAB, 2004). The paper brings out such an attempt by using ANFIS for predicting the properties of HFRC such as compressive strength, modulus of rupture, service load, service load deflection, ultimate load, and ultimate deflection. Training, as well as testing, was performed for the generation of the ANFIS model, by using the existing literature (Eswari et al., 2008; Eswari et al., 2011). Input variables considered for the prediction of each property of HFRC were of total volume fraction (Vf), a percentage of steel and polyolefin fibers and comparison of both experimental and predicted are also furnished.

TRAINING OF FUZZY CONTROLLER

Fuzzy inference system (FIS) initially discovered scientifically by Takagi and Sugeno (1985), had been found several realistic uses in prediction and inference (Takagi & Sugeno, 1985). Taking into account the first-order Takagi-Sugeno-Kang fuzzy logic system, a fuzzy model have the following rules (Zadeh & Berkeley, 1995; Kukolj, 2002; Li et al., 2018).

$$Rule\ 1: If\ x\ is\ A_1\ and\ y\ is\ B_1, then\ f_1 = p_1x + q_1y + r_1$$

$$Rule\ 2: If\ x\ is\ A_2\ and\ y\ is\ B_2, then\ f_2 = p_2x + q_2y + r_2$$

If f1 and f2 are constants instead of linear equations, then it has a zero-order fuzzy model.

The fuzzy-reasoning mechanism and corresponding ANFIS architecture is shown in Figure 1. Node functions in the same layer are of the same function family, explained as under.

Layer 1: Each node i in this layer generates membership grades of a linguistic label, for instance, the node function of the ith node is given in Eqn. 1. Oji indicates the output of the ith node in layer j.

$$O_{i}^{1} = \mu A_i(x) = \frac{1}{1 + [((x - c_i)/a_i)^2]^{bi}} \quad \ldots (1)$$

where x is the input to node i and Ai is the linguistic label (small, large, etc.) associated with this node; and ai, bi, ci (or ai, ci in the latter case) is the parameter set that changes the shapes of the membership function.

Layer 2: Each node in this layer calculates the 'firing strength' of each rule via multiplication as given in Eqn. 2.

$$O_{i}^{2} = \omega_i = \mu A_i(x)\, x \mu B_i(y), \qquad i = 1, 2. \quad \ldots (2)$$

Layer 3: The ith node of this layer calculates the ratio of the ith rule's firing strength to the sum of all rules' firing strengths give in Eqn. 3. Outputs of this layer can be known as 'normalized firing' strengths.

$$O_{i}^{3} = \underline{\omega}_i = \omega_i/(\omega_1 + \omega_2), \qquad i = 1, 2. \quad \ldots (3)$$

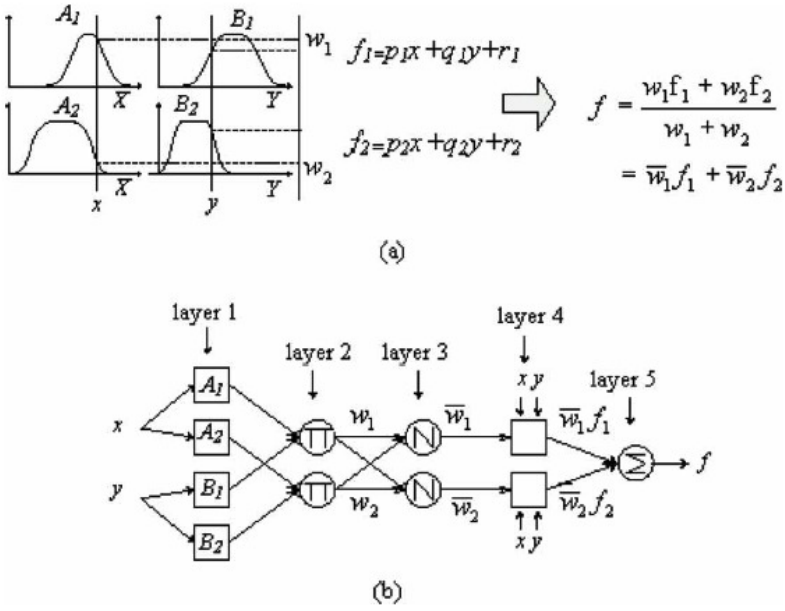

Figure 1. (a) First-order of TSK Fuzzy Model; (b) ANFIS Architecture
Source: Zadeh & Berkeley, 1995

Layer 4: Every node (i) in this layer is a square node with a node function given in Eqn. 4.

$$O_{i}^{4} = \underline{\omega}_i f_i = \underline{\omega}_i(p_i x + q_i y + r_i), \quad \ldots (4)$$

where i is the output of layer 3 and is the parameter set and parameters in this layer will be referred to as 'consequent parameters'.

$$O_{i}^{5} = overall\ output = \sum_i \underline{\omega}_i f_i = \sum_i \omega_i f_i / \sum_i \omega_i \quad \ldots (5)$$

Layer 5: The single node in this layer is a circle node labeled as ∑ that computes the 'overall output' as a summation of all incoming signals, is given in Eqn. 5.

DEVELOPMENT OF ANFIS MODEL

The ANFIS is a type of hybrid system which consisted of both the advantages of ANN and FL techniques. The purpose of using the ANN and FL techniques are different. The ANN has computation ability and the FL has decision-making ability. Before going for the prediction process, the ANFIS has to indulge in training and testing processes with a set of data for each and every property. After the ANFIS get trained with the given set of date, then it can be able to get the prediction capability for the respective property. Table 1 was used as training data sets obtained from the literature for each prediction properties.

Table 1. Training data for HFRC specimens.

Property	Specimen								
	V0-S0P0	**V0.5-S100P0**	**V0.5-S70P30**	**V1.0-S100P0**	**V1.0-S70P30**	**V1.5-S100P0**	**V1.5-S70P30**	**V2.0-S100P0**	**V2.0-S70P30**
Compressive strength (MPa)	26.65	27.96	27.86	28.18	28.98	31.10	31.16	30.74	30.34
Modulus of rupture (MPa)	7.06	7.16	9.60	10.18	11.50	10.52	11.84	11.21	12.18
Service load (kN)	11.77	11.93	16.01	16.97	19.17	17.53	19.73	18.68	20.30
Service load deflection (mm)	0.37	0.55	0.68	0.70	0.74	0.72	0.81	0.83	1.06
Ultimate load (kN)	17.66	17.89	24.01	25.45	28.75	26.30	29.60	28.02	30.45
Ultimate deflection (mm)	0.56	0.94	0.96	1.01	1.08	1.10	1.21	1.24	1.33

ANFIS along with a 'grid partition' type has used for prediction of each property prediction. In this method input and output membership function (MF) type assigned as 'trimf' (triangular membership function) and linear, respectively. Experimental results are preferred for training of ANFIS methodology which is given in Table 1. Matlab package was used for creating the required models for this study by adopting a command 'anfisedit' which is presented in the fuzzy toolbox, and individual FIS objects were generated for every prediction property. Figure 2 shows ANFIS architectures for all HFRC specimens. It involves series of functional activities such as getting of input variable(s), assigning of the number of input MF(s), the formation of a rule(s), assigning of the number of output MF(s), and prediction of output. In this study, there are three input variables those are total volume fraction (Vf), a percentage of steel and polyolefin fibers, were considered for the prediction of properties of HFRC. Each input variables (which are appeared in black colour circles) developed two inputs MFs (inputmf) which are appeared in white colour circles, in order to form a triangle shape (between input & inputmf) as shown in Figure 2, since, the input MF assigned as triangular. Based on the input MFs, the fuzzy rules were automatically generated using logical operations such as 'and', 'or', & 'not', within the ANFIS model (between inputmf & rule) which is appeared in blue colour circles (rule) as shown in the above Figure.

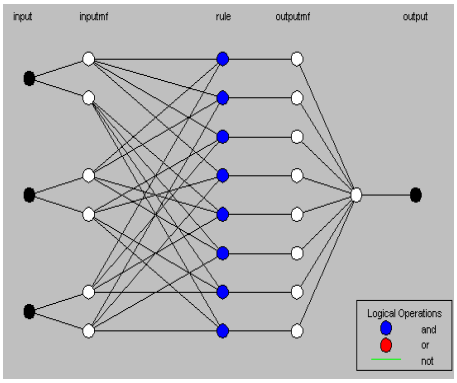

Figure 2. Graphical Representation of ANFIS Structure for HFRC Data

Further, the each generated rules were directly/linearly converted into different output MFs (between rule & output mf) which are again appeared in white colour circles (output mf), just because of the output MF initially assigned as linear ones. Then all the different output MFs was processed into a single MF as appeared as a single white colour circle (between output mf & output) in the same Figure. Finally, the ANFIS transformed this single output MF (appeared as a single white colour circle between the output mf & output columns) into an output (appeared as a single black colour circle at the end) that is known to be the required result. Likewise, the ANFIS model predicts the output results of all the properties of HFRC.

The system discovers most excellent function mapping the input variables, i.e. total volume fraction (Vf), percentage steel fibre and percentage polyolefin fibre, to the output variable, i.e. for example, compressive strength. Figure 3 shows one of the MF plots of the inputs for HFRC namely, total volume fraction (input1). It works under FIS variables (i.e. input1, input2, and input3), and predict the output i.e. f (u). The plots were drawn between 'in1mf1' & 'in1mf2' (input 1 – MF 1 & input 1 – MF 2, considered both in the vertical direction) versus 'input1' (total volume fraction, considered alone in the horizontal direction). In the horizontal direction, the input variable was taken in the range between 0 – 2% of the total volume fraction (Vf). It is understood that the prediction performance of the ANFIS model would be more realistic if the 'input1' (total volume fraction) within the above range, and the corresponding error percentage will be minimum. Whereas, if the 'input1' (total volume fraction) out of the above range, ultimately, the results would be vice versa, and the corresponding error percentage will also be more. The model considered total plot points equal to 181, for the generation of the above MF. Similarly, the MF plots were parallelly generated for the rest of the input variables (i.e. for the percentage of steel and polyolefin fibres).

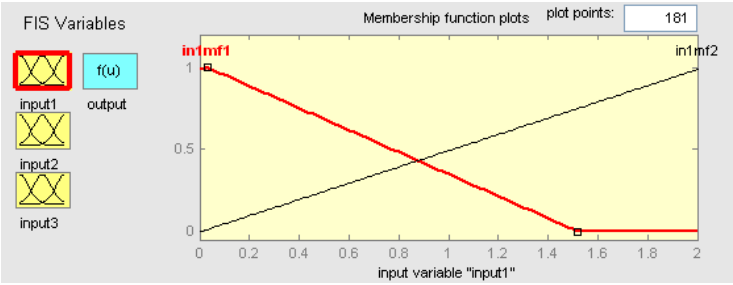

Figure 3. Membership Function Plots for Total Volume Fraction (Vf)

MODEL PREDICTION

The ANFIS editor GUI used is shown in Figure 4, which is available in the MATLAB environment, for modeling. The main purpose of using this GUI is initially to train and test a given set of respective data. It involves various sequences of operations like 'Load data', 'Generate FIS', 'Train FIS', and 'Test FIS', as shown in Figure 4. It has a facility to see the results of the trained data and the corresponding FIS output, visually, and other information like number of inputs, number of outputs, and number of input MFs, physically, in the ANFIS Information box. ANFIS start training the data set up to 25th Epochs. It shows the following 'editor' box after training as in Figure 4. After training the data, saved the ANFIS object in the workspace as 'scs' for testing. Selecting Testing data button for the prediction of compressive strength which appears as a red colour star, in the 'editor' box with a testing error of 0.087128. At the ending of the training cycle, error of root mean square (RMS) of the each prediction properties was found to be 0.002472, 0.015763, 0.026373, 1.5523x10-5, 0.039379, and 4.279x10-6, for the compressive strength, modulus of rupture, service load, service load deflection, ultimate load, and ultimate deflection, respectively.

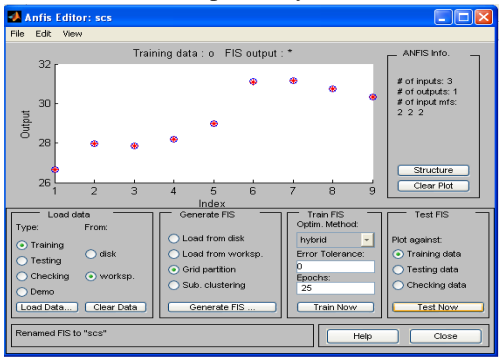

Figure 4. ANFIS Training

RESULTS AND DISCUSSIONS

Prediction of results using the ANFIS was carried out in two different aspects. First one is to compare the predicted results with the experimental results available in literature with respect to the testing and training of the ANFIS model. The next is to predict the property of HFRC based on the required input parameters.

Model Consideration

All the parameters were generated with 'trimf' (triangular membership function) and linear membership functions for input and output, respectively. Influences of above, ANFIS performance for the HFRC specimens are as follows.

The ANFIS models were also employed for examining the prediction performance of HFRC specimens with the total volume fraction (Vf) = 0.5, the percentage of steel fibre = 80, and percentage of polyolefin fibre = 20. Comparisons of experimental results versus predicted results are displayed in Table 2. It is observed from the above Table 2, that the experimental results are slightly lesser than the ANFIS predicted results, which may be attributed to the various material constitution presented in the experimental investigation. It is found that the predicted compressive strength of the HFRC specimen is equal to 28.43 MPa, whereas, the corresponding experimental result is given as 28.34 MPa. The percentage difference between the above results is found to be 0.31%, which shows quite more accurate prediction capacity of the model. Similarly, for the modulus of rupture of the HFRC specimen, predicted by the model is equal to 9.40 MPa, and the corresponding experimental result is given as 9.20 MPa. The percentage difference between the above results also found to be 2.12%, which shows a more accurate prediction capacity of the model. The percentage difference between the above two strength properties of HFRC is found well within the limit.

Table 2. Comparison of experimental and predicted results for HFRC Specimens.

Property	Input parameter			Result		% difference
	V_f	% of steel fibre	% of polyolefin fibre	Experiment*	ANFIS	
Compressive strength (MPa)	0.5	80	20	28.34	28.43	0.31
Modulus of rupture (MPa)	0.5	80	20	9.20	9.40	2.12
Compressive strength (MPa)	2.0	75	25	--	29.98	--

* Experimental results are arrived from the literature Eswari et al., (2011).

GUI for HFRC Specimens

Present work is mainly consisting of creating the ANFIS model for the various properties of HFRC. GUI was also created to have a visual input and output for a client in Matlab called HFRC_Specimen_Properties for HFRC specimens. This script can be run from Matlab environment by loading it on the Matlab script editor and pressing F5 to run the programme. The ANFIS object called 'scs', 'smr', 'ssl', 'ssd', 'sul', and 'sud', was generated for predicting the compressive strength, modulus of rupture, service load, service load deflection, ultimate load, and ultimate deflection, respectively. The following menu appears in the Matlab environment.

1 - Compressive Strength
2 - Modulus of Rupture
3 - Service Load
4 - Service Load Deflection
5 - Ultimate Load
6 - Ultimate Deflection
Enter your choice (1 - 6): 1
Input:

Enter fibre volume ratio: 2
Enter percentage steel: 75
Enter percentage polyolefin: 25
Output:
Compressive Strength: 29.9831 MPa
Do you want to continue (y/n): n

Further, prediction of compressive strength with another input variables, for which the experimental investigation was not carried out, i.e. the total volume fraction (Vf) = 2, the fibre percentage (steel = 75 & polyolefin = 25), was done using the GUI, and the predicted result seems to be 29.98 MPa. Another option was created for the purpose of exit/continue with the network. Similarly, depending upon the required choice, ANFIS predict the corresponding output values.

CONCLUSIONS

Based on the prediction performance of the ANFIS, the following conclusions are made:

- ANFIS has been successfully applied for predicting properties of HFRC, and the predictions are very closely agreed with the experimental results.
- Using the ANFIS for Civil Engineering problems requires proper choice for the number and type of membership function.
- All the ANFIS objects generated for HFRC specimen performed well with two membership functions. Triangular and linear MF for input and output, respectively, were produced the ANFIS object with prediction levels much closer to the training as well as testing points.
- The percentage difference between the predicted and experimental results for the compressive strength of the HFRC is found to be 0.31%. The percentage difference between the predicted and experimental results for the modulus of rupture of the HFRC is found to be 2.12%. The percentage difference between the two strength properties is found well within the limit.
- GUI for accessing the ANFIS object and displaying their predictions was also developed. This would make more convenient for those are not much experienced with them once.

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Aggregates from Wastes: An Overview

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Abstract: *Construction industry is focusing on creation of infrastructure like laying of roads, bridges, port development, various types of commercial and residential buildings and other development activities and this has resulted in increasing the demand for aggregates. Aggregates are used for concrete and other construction activities and its demand has always been on the rise resulting in the search for alternative materials in view of limited availability of natural resources. Most of the wastes generated from agricultural process and industrial process like: copper slag, steel, bottom slag, fly ash, discarded rubber tyres and marble pieces have already been considered for use as non-conventional aggregates. The Light weight aggregates produced from marine clay, either by using chemical process or heat treatment process, exhibit comparable mechanical properties and better thermal insulation. However, there is a definite need to assess the available and usable natural resources for aggregates and to arrive at a dynamic balance between the naturally available aggregates and manufactured aggregates for construction purposes so as to achieve sustainable resource utilization. Use of manufactured aggregates from waste materials and dredged materials need to be strengthened, as it would help in better environment management and waste handling. Finally, there is need for sustained research, development of specifications and implementation in real -life in the area of "aggregates from wastes", so as to attain sustainability in practice which is the need of the hour in the Indian Context.*

Keywords: Aggregates, Agricultural waste, Industrial waste, Marine clay, Resource management.

INTRODUCTION

The thrust on development and the consequent need for infrastructure facilities has given a major fillip to the construction industry. There is an in escapable pressure on resource identification and recycling options so as to meet the growing demand of the present and future. In the 12th five year plan, the Government of India (GOI) has envisaged growth of infrastructure facilities like: construction of roads, highways, railways, ports, power plants and various communication facilities with a projected investment of US$ 1trillion. The government has also planned to provide housing for all, by 2022.All these have contributed to a sustained increase in growth in the construction industry. At present the existing quarries, which are the primary source of coarse aggregates in India, are being exploited extensively for producing natural aggregates. However, the consequential impact due to the above actions on the environment like: air pollution and ecological imbalances, need a closer study. Further, a comprehensive geological survey of usable resources for aggregates considering the fact of 'sustainability' needs to be carried out.

In this context, a detailed study on the available resources which was carried out in the United Kingdom is available as the British Geological Report. (Maneklow J.M. et al 2008) is worth mentioning and emulating .As estimated demand of aggregates in the order of 10-12Mt/y has been projected, in the UK. Out of this, the share of recycled aggregates account for 7mt/y. The contribution of marine clay - based aggregates is around 9%, in meeting the requirements of aggregates.

A similar comprehensive study by the various States in India can be advantageous not only in better management of available aggregates, but also in improving the environment, by addressing the current and larger issue of 'sustainability of environment'. Thus, the use of alternative materials derived from wastes and recycled materials, will automatically lead to establish a 'sustainable built environment ' not only globally, but also in India, where it is the need of the hour. In this context, an attempt has been made to survey the earlier studies aimed at unraveling an all-embracing perspective on the production of aggregates from various sources of wastes like: agro wastes, industrial wastes, recycled waste materials and light weight aggregates from marine clay. Further, the course of action to be carried out in the Indian context is also highlighted.

Use of Manufactured Sand as Aggregates

Fine aggregates in the form of river sand, which is generally one of the important ingredients of concrete, has become very scarce in recent times, due to the legal restrictions imposed on its exploitation, by the legal system in India. This has almost jeopardized the constructing industry in India, economically and also impacting the sustenance of millions of poor/common people India who are dependent on the construction industry. One of the alternatives/solution explored is the use of 'manufactured sand ' in short referred as M-sand. Even though the use of M-sand has been recognised in Indian codes , there are practical issues like: identification, leasing and production of M-sand, Uniform / assured quality of M-sand obtained from various sources, costs of production and affordability to all sections /stake holders; ease of use in concrete and mortar and in finishing works in construction. There are no clear answers to the above, as on date; there is lack of comprehensive and scientific studies by qualified personnel in the field. However, a brief of review of studies carried out on M-sand are reviewed here, highlighting the salient progress/contributions made. M-sand has been used as fine aggregates either partially or in full in concrete and investigated using the samples collected from Karur, Pudukottai and Padalur in Tamilnadu, India. (Vaishali.P. et. al., 2018).It has been reported that the sieve analysis carried out on the samples from three places comply with the relevant BIS codal provisions. Further, the test results reported on strength measure such as in compression and flexure tests; also indicate the suitability of use of M-sand as an alternative, for conventional river sand.

AGGREGATES FROM AGRO WASTE

An exhaustive study of discarded agro refuse as an effective stand-in as aggregate is available. (Jnyanendra Kumar Prusty et, al., 2016).The agro wastes studied include, but not limited to: rice husk, jute fibre, groundnut shell, saw dust, sugarcane bagasse ash and cork. Further, studies on the use of: coal combustion residue, construction waste, blast furnace slag, iron tailing have also been carried out. These additives are reported to gain comparable strength and exhibit physical properties that render them as a viable alternative for replacement of fine aggregates to the extent of 20% of the requirement, when the mix contained bagasse waste, saw dust ash and oyster shell. The agro - based waste generated and its share in the solid wastes generated in India has also been brought out in the Figure 1.

In France, wastes generated from agricultural process and industrial process have been converted as additive materials and used for making bricks.(Cecile Bories et., al., 2014).A host of agricultural wastes is reported to have been tried for use as a medium for formation of pores in the process. The quantity of additives used are varied, for studying the behavior of modified clay bricks, with the main aim of converting polluting agents into useful material so as to improve the environmental quality.

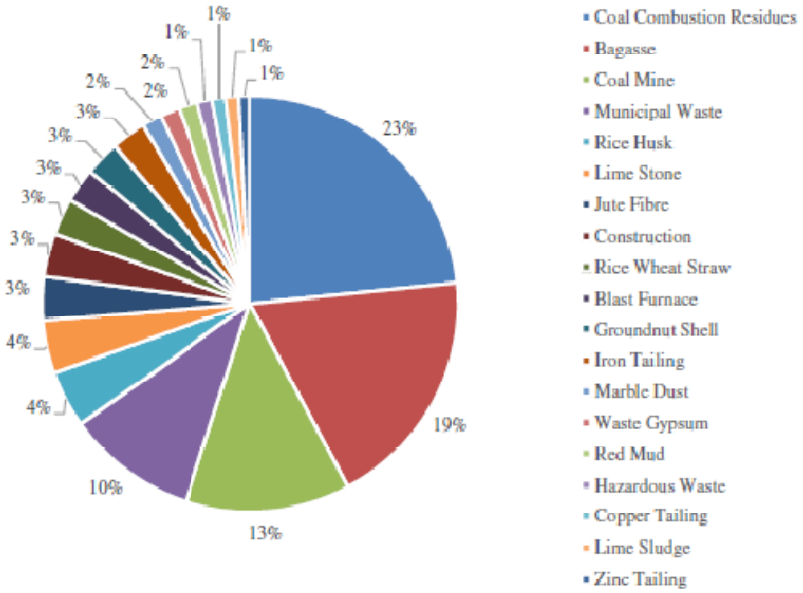

Fig. 1. Status of solid waste generated in India (Madurwar et al., 2013).

Aggregates from Recycled Materials

Waste material such as: fly ash, furnace slag, discarded marble, rice husk and palm oil could be recycled, to be used as an alternative to natural aggregates in concrete, particularly for withstanding higher temperatures .(N S Ghadzali et., al., 2018). From the analysis of the observation of the physical behaviour and thermal analysis, it has been reported these recycled materials could be used as an alternative to conventional sand used in concrete. The mechanical behaviour of various studies conducted has shown that recycled glass can be a potential replacement for fine aggregate, when subjected to higher temperatures. Recycled glass when added to on architectural mortar ranging from 25% to 100%, is found to produce very desirable strength and appearance on the self compacting architectural mortar (SCAM).(Ming -zhi guo et., al., 2015). The above mortar has also retained the aesthetical appearance, when subjected to above high elevated temperatures.

Aggregates from Marble and Other Construction Wastes

Marble waste when used as a partial replacement of 75% of natural coarse aggregates, for the production of concrete, exhibits satisfactory performance in thermal properties up to a temperature of 4000 C, with pozzolona cement . However, the compressive strength reduced by about 5% when subjected to 200o C and exhibited a strength equivalent to that of M 25 grade of concrete at about 350o C. (Kore Sudarshan et.al.2017).

The scope for using construction demolition waste such as: crushed spent fire bricks, sheet glass powder, and quarry dust have been investigated and it has been reported that all these waste materials generated can be considered as a stand- in for use as fine aggregate based on the strength behaviour observed. (Anzar Hamid Mir., 2015).

AGGREGATES FROM MARINE CLAY

Marine clay which is traditionally recognized as the most problematic soil, turn out to be a useful construction material when mixed with cement. Light weight aggregates can be produced by mixing marine clay and semiconductor industry sludge rich in CaF2, and produced in a bench scale rotary. The light weight aggregates thus produced has good thermal and sound insulation properties. Further, it has been proved that, 'fluorine' contained in the sludge, does not pose any hazard. It is a classic example of not only extracting wealth from waste, but also, how a toxic material can be easily immobilised and pollution of environment saved, by a simple process. (K.Laursen et. al., 2006). Dredging of channels and marine constructions leads to a huge accumulation of 'dredged soil', posing disposal and environmental problems, worldwide. However, efforts have been made to use them ingeniously with other forms of industrial waste material such as: steel slag. Marine clay/dredged materials , when treated with 'steel slag 'and heated up to 1150 o C in a rotary kiln , produces a light weight aggregate , with potential for commercial exploitation. (Chee-Ming et., al, 2011).

CODAL PROVISIONS FOR USE OF NON -CONVENTIONAL AGGREGATES

Bureau of Indian Standards (BIS), India, has codified the use of alternative to natural sand from other sources. Use of steel slag, fly ash, crushed over burnt bricks and tiles are permitted to be used as additives. The recommended replacement is of the order of 35% to 50% .Further, it has upgraded the standards for mix design in IS:10262.Similar provision has also been made in the preparation of concrete in a centralized plant in IS:4926.The Use of artificial light weight materials for aggregates has been codified by the BIS, in IS:9142.The Indian Standard specification for masonry cement has also codified and defined specification for use of waste materials that includes but not limited fly ash, sludge having carbonate content and slag up to 5% as performance improvers in ordinary portland cement.

CONCLUDING REMARKS

There is a constant growth in construction activity all over the world, more so, in the Indian context in the recent decades. However, the natural resources that can be economically used are limited and are reported to be fast depleting. This has created a need to look at the waste materials and recycled materials as viable source for production of non - conventional aggregates across the world. While there is scope for modifying the waste generated for replacement of aggregates either partially or in full, the use of marine clay and soft clay for production of light weight aggregates has to be addressed. The Bureau of Indian Standards (BIS), even though have codified and published relevant specifications, still there is a definite need to tackle the resource

management with a scientific approach so as to establish a dynamic equilibrium between the needs of the construction industry and the quantum of available resources, and sustainability in the Indian context .This opens out new vistas in the search for use of non - conventional materials in construction industry, based on sustainable and comprehensive research focusing on meeting the specific requirements for various materials of the construction industry. A loud and unbiased thinking and a plan of action (POA), is the need of the hour, which is lacking in the Indian context. It is the duty of all Civil Engineers and Material Scientists, to make an earnest attempt, immediately, without losing sight of the 'stark reality' that is staring on us.

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Experimental study on the behaviour of cold formed ferritic stainless steel stub column

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Abstract: The property of stainless steel section of high strength, corrosion resistance, fire resistance, ease of maintenance, reuse and recycle is suitable forwide range of structural and architectural application in sustainable construction. Experimental study of cold formed ferritic stainless steel stub column is presented here. The specimen was fabricated from ferritic stainless steel 409M grade. Six specimens of square, rectangular hollow section (SHS, RHS) subjected to axially loaded were tested under pinned end condition. Tensile coupon test was conducted to obtain property of selected material. Experimental results were compared with various existing design rule of Australian/New Zealand (AS/NZS 4673) standard, European code (EN 1993-1-4) and direct strength method (DSM). Discussion and conclusion were arrived based on comparison of result.

Keywords: Stub column, DSM, Stainless steel 40M grade.

INTRODUCTION

Due to the presence of the chromium content in stainless steel, it creates a passive layer that prevents corrosion. To meet the strength, stiffness and fabrication requirement in structural applications the other alloying elements was helpful which was added during the manufacturing stage. Ferritic stainless steel contains less nickel content with the main alloying element of chromium. Hence, price is stable and also initial material cost is low. So stainless steel is an alternative material for structural application. Strength of hollow column is mainly influenced by coupled instabilities. Local, flexural buckling failure mode may develop separately based on shape.

Young and Hartono conducted experiment and compared test result with available design rule and found that the current specification is unconservative. Finite element investigation for LDSS lipped channel column were recently reported by Anbarasu and Ashraf and also proposed DSM formulations for LDSS lipped channel columns. Cold formed stainless steel sections widely adopted in construction industry. Hence investigation is required to find out structural characteristics for this type of material.

Lateral dimensions and length equal to three times its maximum of lateral dimension of the hollow sections have been chosen with the help of existing literature. The SHS and RHS columns are subjected axial compression were tested under pinned end condition. The ultimate strength from test results was compared with AS/NZS 4673standard, EN 1993-1-4 and DSM. It was observed that the current specification predict conservative results with respect to ultimate strength.

EXPERIMENTAL INVESTIGATION

A test was performed by three type of stub column in laboratory. Concentric compressive load was applied to get accurate result two sections were tested in each type.

MATERIAL PROPERTIES

A tensile coupon test was conducted to obtain stress strain values of ferritic stainless steel specimen. Coupon obtained from flat face of the specimen in longitudinal direction and tested as per IS1608 - 2005. The coupon thickness is less than 2mm, coupon width is 12.5 mm. The gauge length (L0) is 50 mm. The coupon has enlarged end, in which case there is a transition radius of not less than 20 mm between gripped end and parallel portion. The minimum width of enlarged end is 20 mm. The maximum width of enlarged end is not more than 40 mm. The longitudinal axis of the coupon was coincided with the loading axis (pull) of the testing machine. The parallel length is kept between L0 + 0.5b& L0 + 2b.

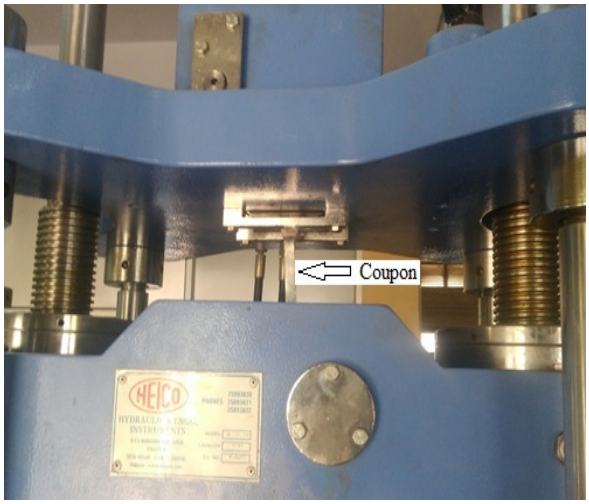

Figure 1. Test setup of coupon

The material propertyvalues, young's modulus of elasticity (E), 0.2% proof stress (σ0.2) andultimate stress (σu) were shown in table 1.

Table 1. Material property in N/mm2				
Description	**E**	**σ0.2**	**σu**	**Percentage of elongation**
Flat coupon	210500	390	495	38

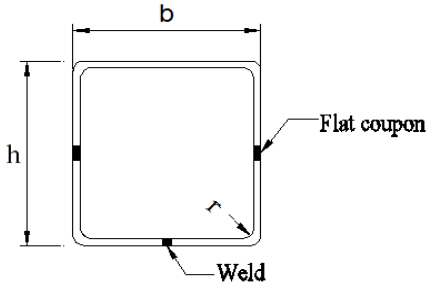

Figure 2. Cross section and coupon location

SPECIMEN LABELING

The test specimens were labeled as, RHS-100-80-1 denotes a Rectangular hollow section, member depth and width are 100mmand 80mm respectively and the last terms 1 indicate repeatability of specimens. The thickness of the specimen is 1.2mm. The nominal and measured dimension for the tested specimen was shown in table 2.

Table 2. Nominal and Measured dimension for the tested specimen in mm										
S. No.	**Specimen ID**	**Nominal dimension**				**Measured dimension**				**Δ**
		b	**h**	**t**	**l**	**b**	**h**	**t**	**l**	
1.	SHS-60-60-1	60	60	1.2	180	59	62	1.2	180	0.1
2.	SHS-60-60-2	60	60	1.2	180	56	63	1.2	180	0.2
3.	SHS-80-80-1	80	80	1.2	240	83	77	1.2	240	0.2
4.	SHS-80-80-2	80	80	1.2	240	82	78	1.2	240	0.2
5.	RHS-100-80-1	100	80	1.2	300	104	78	1.2	300	0.1
6.	RHS-100-80-2	100	80	1.2	300	103	79	1.2	300	0.1

GEOMETRIC IMPERFECTION

The initial local geometric imperfection is measure using linear variable differential transformer (LVDT). For equal interval at mid-length of the specimen, geometric imperfection measured with an accuracy of 0.01mm.

Local geometric imperfection was assumed as zero at both end of the specimen. Maximum local geometric imperfection (Δ) at mid length over the specimen length is shown in table 2.

TEST SETUP AND RESULTS

The both end of the stub column specimen was prepared by mill finish. The load is applied gradually and uniformly by using servo controlled actuator of 250kN. To ensure the even compression over the entire cross sectional area, thick rigid plate was placed at end of the column. The load was applied at the centroid (CG) of the section. The axial deformation of the column was recorded for every increment of load. The load is applied till the specimen attains complete failure.



Figure 1. Experimental setup

The local buckling occurs in side face of rectangular hollow section. The failure observed at base like elephant foot in both of the square hollow sections. The failure mode of the specimen at final stage during test is shown in figure 4.The axial compressive strength (PEXP), axial shortening and failure mode from test were presented in table 3.

Table 3. Load and Axial shortening of the specimen

S. No.	Specimen ID	Ultimate load PEXP (kN)	Axial shortening (mm)	Failure mode
1	SHS-60-60-1	58	0.77	E
2	SHS-60-60-2	65	0.73	E
3	SHS-80-80-1	79	0.62	E
4	SHS-80-80-2	82	0.59	E
5	RHS-100-80-1	91	0.59	L
6	RHS-100-80-2	88	0.57	L
Elephant foot (E) and Local (L) buckling.				



Figure 4. Failure mode of the specimen

THEORETICAL CALCULATIONS

DIRECT STRENGTH METHOD

DSM does not require effective width calculation to obtain load carrying capacity of structural steel member. Load at elastic buckling stage is necessary to find out member strength. Elastic buckling load may calculated by numerical analysis (or) FEM. Cross section slenderness ratio is arrived instead of individual element slenderness. The design equation of DSM for cold formed steel columnis shown in equations(1.1) – (1.3).

$$P_{DSM} = \min\left(P_{ne,} P_{nl}\right) \quad ----(1.1)$$

Where

$$P_{ne} = \begin{cases} \left(0.658\lambda_c^2\right)P_y \text{ for } \lambda_c \leq 1.5. \\ \left(\frac{0.877}{\lambda_c^2}\right)P_y \text{ for } \lambda_c \leq 1.5. \end{cases} \quad ----(1.2)$$

$$P_{nl} = \begin{cases} P_{ne} & \text{for } \lambda_l \leq 0.77. \\ \left[1 - 0.15\left(\frac{P_{crl}}{P_{ne}}\right)^{0.4}\right]\left(\frac{P_{crl}}{P_{ne}}\right)^{0.4} P_{ne} & \text{for } \lambda_l > 0.77. \end{cases} \quad ----(1.3)$$

Where, $P_y = f_y A$; $\lambda_c = \sqrt{P_y/P_{crl}}$; $\lambda_l = \sqrt{P_{ne}/P_{crl}}$,

where, $P_{cre} = \pi^2 EA \,/\left(l_e/r_y\right)^2$.

EUROPEAN CODE

The design strength (PEC3) of column was calculated based on clause 5.4.1 of EC3 Part1.4 [4]. Member is subjected to uniform compression, so factor for reduction (χ) is obtained from clause 5.4.2.1. Imperfection factor (α) is 0.49, limiting slenderness (λo) is 0.4 was considered to calculate reduction factor.

As per EN1993-1-4, effective width (le) is arrived based onreduction factor (ρ) given by equation (1.4).

$$\rho = \frac{0.772}{\bar{\lambda}_p} - \frac{0.125}{\bar{\lambda}_p^2}; where\ \bar{\lambda}_p = \frac{\frac{l}{t}}{28.4\varepsilon\sqrt{k}} \quad ----(1.4)$$

Australian/NewZealand (AS/NZS) standard

From clause 3.4.2 of AS/NZS standard [5] provides detailed procedure to find the strength of column. The direct approach does not require iterative process. The existing AS/NZS provisions does not include ferritic stainless steel. To calculate buckling stress the parameters α, β, λ0 and λ1 for ferritic steel 1.16, 0.13, 0.65 and 0.42 were used. The effective area was calculated as per clause 2.2.1.2.

DISCUSSION ON RESULT

The ultimate load values of experimental and theoretical analysis are presented in table 4. The variation of ultimate load in chosen specimen was observed from experimental results. The load versus axial shortening of tested specimen is shown in figure 5. The axial shortening was gradually increase till the ultimate load reaches and also noted that there is not much more variation of the increment in all specimens. The failure of stub column was observed as local and elephant foot buckling so it based on the specimen size. Local plate buckling is a key aspect to determine strength of thin walled structures in compression. The design strength predicted by the specification is conservative for cold formed ferritic stainless steel stub column.

Table 4. Comparison of ultimate load with experimental and theoretical analysis

S. No.	Specimen ID	PEXP (kN)	PEXP/ PDSM	PEXP/ PEC3	PEXP/ PAS/NZS
1	SHS-60-60-1	58	0.83	0.84	0.82

2	SHS-60-60-2	65	0.93	0.94	0.92
3	SHS-80-80-1	79	0.82	1.01	0.87
4	SHS-80-80-2	82	0.85	1.05	0.90
5	RHS-100-80-1	91	0.89	1.06	0.95
6	RHS-100-80-2	88	0.86	1.02	0.92
Mean			0.86	0.98	0.89
Standard deviation			0.056	0.182	0.098

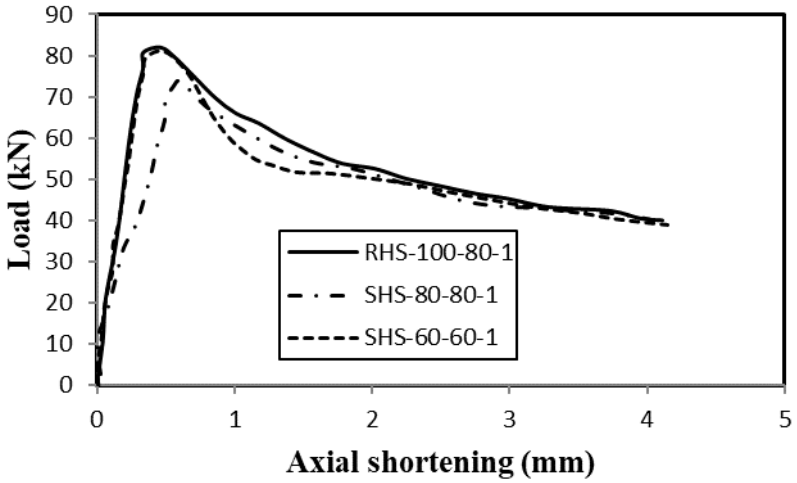

Figure 5. Load vsaxial shortening of the tested specimen

CONCLUSION

The ultimate resistance and axial shortening of cold formed ferritic stainless hollow stub column was reported. Initial local geometric imperfection measured by LVDT at side face of specimen and mentioned maximum value of each specimen. The material properties of young's modulus, 0.2% proof stress, ultimate stress and percentage of elongation were obtained from coupon test.SHS stub column was failed by elephant foot buckling. RHS stub column failed by local buckling. The stub column test strength was compared with design strength calculated by direct strength method, Australian/New Zealand standard and European specification. It is observed that strength predictions by the specification were conservative for SHS of coldformed ferritic stub column.

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An Approach to reduce the Adverse Outcome of Urban Heat Island: an Overview

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Abstract: - Cities reside in usually 2% area of earth global and it's resident consumes 75% energy resources of total world's energy. Now-a-days the population of urban are increasing tremendously because of migration from rural areas depends upon several dynamic reasons such as environmental, geographical, demographic, social, economical and other phenomenon so that the temperature of urban areas are growing day by day which is very alarming condition for human life as well as environment. Heat islands usually are described as urban areas that create higher than background surface temperatures allied with rural surroundings. The occurrence of heat island has led to the climatic variation of some urban areas due to discharge of heat due to originating through human beings, reserve solar radiation in city environment, excessive lack of vegetation and plants and green roofs. The heat is consequently backed to the atmosphere and increase ambient temperature at night. So, it becomes a burning problem for the researchers to overcome such issues like to reduce the adverse effect of urban heat island. The main goal of this review paper is to find out the right steps which is useful to reduce the bad effect of urban heat island (UHI) which includes green roofs, vegetation and plants, , highway road surface, green parks and green spaces as well as building type and material which may be fruitful for sustainable urban design and planning.

Keywords: - Urban Heat; Heat Island; Temperature, Planning; Green development

INTRODUCTION

The temperature difference between urban and it's rural environment was firstly demonstrated by the Horward in 1833. Manley (1985) gave the term "Urban Heat Island" in place of urban rural temperature and further it is described by many researchers. The dynamic impact of urban heat island in many areas of developing country was demonstrated by many scholars now-a-days. Usually the urban heat island is a result of climatic change due to the rapid urbanization and industrialization. (Santamouris, 2001) found that the temperature of urban area is more than that of its rural areas and sub-urban areas. Due to excess of reserve of solar radiation in the city and excessive release of anthropogenic gas which is generated due to human activity results higher urban temperature. Rapid urbanization and industrialization, growing population, minimum area of vegetation and plantation and maximum use of non-renewable energy resources is the main cause of increased urban heat. The absorption of solar heat by various elements such as road pavement, structures of buildings and other source consume heat in daylight in the presence of sunlight and emit it night so the temperature increases very large known as ambient temperature.

Various climatic changes like decrease in rainfall, smog, wind pattern, changes in duration of winter and summer season are only due to the urban heat. The increased urban temperatures affect the growth life of human beings as well as vegetation and surrounding environment. Excessive radiated radiation posses many threat to human being as well as animal. The cooling effect of green areas like parks and field in cities has been established by the above studies. It is almost certainly that the UHI effect is exasperated mainly due to the lost of green areas in the urban surroundings than rural areas. It also affect the air quality of the urban area. The dynamic influence of vegetation and greenery on the thermal environment of urban was introduced by Avissar (1996). With the help of numerical analysis Honjo and Takakura (1990/1991) find out the cooling effect of greenery on their surrounding environment.

The problem of global warming and green houses gases become alarming and challenging now-a-days due to increased temperature of urban area due change in modern culture, excessive industrialization, constructions, vehicles etc. between the developed countries. Feng and Petzold (1988), Karl et al. (1988), Karl and Jones

(1989) demonstrate the effect of UHI on the earth surface records about 0.06 degree Celsius annually and 0.13 degree Celsius minimum.

This review paper generally focuses recent work on characteristics, causes and effects of urban heat island which is alarming day by day. It is a burning problem for researchers and scholars. It also covers the strategies to mitigate the effect of UHI in urban areas so that a sustainable life can be created.

UHI key characteristics

In 1833, Luke Horward first of all describes the concept of urban heat island. Due to UHI the temperature of urban area is more than that of UHI surrounding rural areas by means of positive ambient temperatures. Such temperature becomes more at night-time as comparison to day-time and affects the pattern of wind in cities and urban areas. So, the difference in temperature is found different place to place in day as well as in night which is also known as spatial-temporal contest. It was found that the temperature around the city is more than 10 degree Celsius than surrounding rural areas under light wind and clear skies condition (Ohashi and Kida, 2002). According to Soch and Grimmand UHI comprises following properties:-

- It is a night-time phenomenon.
- It generally happened throughout the year.
- Mostly it is depend upon the seasonal variation condition of wind
- It posses maximum temperature in urban areas and minimum in rural areas.

Causes and effects of UHI

Poor building design as well as unmannered and haphazard urbanization is the main cause of UH. Now-a-days it becomes a burning issue for metropolitan cities especially in developing country. In, modern age, the cities is designed by effective manner so that the consequences of UHI can be minimized. The construction of road pavement is constructed with the high temperature and non-permeable surface so that it absorbs the maximum sunlight and not re-radiate. The effect of UHI summarised by the geological and geometry of urban areas like regular arrangement of buildings, height, shape and sizes, loss of plantation and vegetation in urban areas, urban surface thermal characteristics, excessive use of vehicles and automobile engines and machines, factories, extensive use of A.C. in summer season and construction of urban areas. Various commercial and residential buildings in the city and loss of vegetation and plantation absorbs less amount of moisture. In the other hand the excess UHI affects the air quality as well as air quality and air quantity. So it results more panic for human and other living things because it trigger the death rate and illness of people in cities is more than rural areas.

Planning strategies for the mitigation

Researchers has concluded that many factors supply to the increasing of urban heat island (e.g., changes in land such as rapid urbanization, lack of water body and day by day fall in green spaces, etc.) Rapid urbanization is the main factor of UHI. Impervious surfaces have least albedo and absorb much to the incoming solar radiation. First, the higher temperature in a city brought about by UHI has an adverse impact on air quality. If we compare to rural areas, cities experience higher rates of heat related to illness and death. High summer warm in the UHI amplify energy use for cooling and speed up the development of smog. An study to investigate the temperature pattern being the last 100 years in more cities in the united state shows that since 1940. The temperature in urban areas had raised 0.5-3°C. So, the electricity demand increases about 2 - 4%.

The excessive use of vegetation like green places as well as more number of trees can mitigate or prevent the effect of heat island. There are several parameters by which we can minimize the effect of UHI:

- Green places and vegetation
- By green roofs
- Highway pavement
- Albedo
- Urban design

Green Spaces and vegetation

The main source or urban heat island is the large amount of heat produced from urban structures, as they absorbs and re-radiated solar radiation. Vegetation mainly in occurrence of high moistures, even more than may

non-reflective or low albedo surfaces. Growing urban green areas is measured as one of the efficient steps to moderate urban heat island. It has been cleared that increasing urban green areas such as green parks and spaces could diminish air temperature. Wong et al. replicated the effects of the greenery systems like parks and plantation on the temperature and energy consumption of buildings. The marks obtained showed that 100% greenery treatment from greenery systems was successful in minimizing the mean radiant temperature of glass cover-up buildings. However, it was not clear accurately how green spaces like park etc. affected the formation of the heat island through three processes:

- Evapotranspiration
- Enhance of direct shading on urban surface
- Pressure on air movement and heat exchange

Green Roofs

Green roof are an additional means of mitigating urban heat island effects. Green roofs, mitigate UHI through removing heat by evapotranspiration, decreasing heat absorption and also reducing the need for air conditioning. The result shows that the roofing material can absorbs energy from the sun and convert into sensible heat, contributes to the urban heat island effects. The extensive use of green roofs is to keep the buildings warmer in winter seasons and cool in summer season.

Albedo

Albedo is a measure of reflectivity on earth's surface. Albedo increase in the area of interest might thus represent a probability to diminish the UHI effect and its consequences. In order to reduce the UHI effect, the effect of the urban albedo amplifies has been investigated. The average albedo of the whole urban area has been increased from 0.2 to 0.8 for roofs, walls and roads. The increase of the albedo leads to a decrease of the urban temperature by up to 2.5 ^{0}C at day time and also at night time.

Pavement:

Some scientific data indicating that reflecting of paving materials is the only determinant for the UHI effect. There is various scholar efforts under way looking at the influence of pavement material on urban heat islands. Generally, government funded research should be conducted to analyse the impact of pavement characteristics on their potential to moderate the UHI effects. Porous asphalt pavements and open-graded friction course are known to be efficient at dropping pavement surface temperature. It in unfamiliar whether or how pavement surface temperature impacts urban air temperature and building cooling or heating loads. The reflectivity standards applied to roads should not apply to pavement materials because of their different functions and locations in the urban landscape.

Impact of UHI

- Increased air pollution
- Negative health impact
- Increased stress on ecosystem health
- Increased water consumption
- Negative economic impacts

CONCLUSION

Therefore, it is clear that with the help of green parks, vegetation, plantation, green roofs and effective design of urban structures it is possible to mitigate the effects of urban heat island because if we not take action against this then it becomes alarming and challenging for all human beings and other living things. Excessive use of greenery makes the environment clear and clean and also helpful in air quality so that a sustainable can be developed for future generation.

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