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ENERGY ANALYSIS IN RETROFITTED RESIDENTIAL BUILDINGS WITH SUSTAINABLE DESIGN STRATEGIES

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Abstract : The purpose of this study is to compare the energy efficiency of buildings that have been retrofitted with sustainable design principles. In order to achieve goals related to sustainability and energy efficiency in the built environment, retrofitting existing structures is essential. The main goal of the study is to evaluate how well different sustainable design techniques—like day lighting, natural ventilation, insulation, passive solar design, and energy-efficient systems—achieve their goals of lowering energy use and enhancing interior environmental quality. The methodology examines the energy efficiency of buildings with sustainable design features that have been retrofitted in comparison to traditional retrofit methods through energy modelling and simulation with software tools. To help building owners, designers, and legislators make well-informed judgments about sustainable retrofitting strategies for existing buildings, the study will offer insightful information.

I. INTRODUCTION

Green technologies are defined as any technology (or collection of measures) that can improve building performance in terms of sustainability in this study (energy, water, health, and human well-being). Energy retrofit technologies can include energy conservation methods like building fabric insulation, increased glazing, and window shading, as well as energy efficiency strategies including control system installation, lighting upgrades, thermal storage, and heat recovery. Green roofs, water efficiency systems, and daylight optimization are among the technologies that can increase building sustainability in different ways.

In light of India's ongoing industrialization and building sector boom. Many cities are being converted to smart cities, with the major goal of the transformation being sustainability. There has been a large demand for retrofits. This smart city movement focuses on the city's public and recreational areas.

Despite the economic and environmental benefits of green technology for building retrofits, these technologies have been reluctant to catch on in real-world applications. Researchers discovered that decision-makers confront substantial obstacles when it comes to selecting green technologies.

- Because of the rapid advancement of technology, there is a scarcity of complete understanding about it. This could make it difficult for decision-makers to make aninformed conclusion.
- Existing building has their own unique characteristic and has their own operational characters which makes it a tedious process in order to come up with a prototype that can be adopted as standard in smart cities.
- With so many technical viable options, a comparison may be necessary. The comparison can be made based on a variety of energy-related criteria. These factors might be quantitative or qualitative, with diverse qualities, which can make decision-making difficult.
- Multiple stakeholders may be involved in the technology selection process,including but not limited to the owner, tenants, and the design team, which consists of designers and consultants from various disciplines.

A residential building is taken as a case study in this process to evaluate the energy performance with existing design and material and its being retrofitted with sustainable techniques made two to three different approaches towards design of the retrofit and energy analysis of every model is taken into account. Final observation received from the analysis are being observed to find out the best impact of those particular design. The software used in this analysis is green building studio which is a plugin in Revit is used to carry the life cycle assessment. Knowing how to use appropriate building materials is both a benefit and a drawback in terms of energy efficiency.

Retrofitting technique in order to reduce Energy Consumption

- Solar Panel
- Bio Wall
- Reflective/Cooling Paint
- Double Glazed Windows

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II. METHODOLOGY

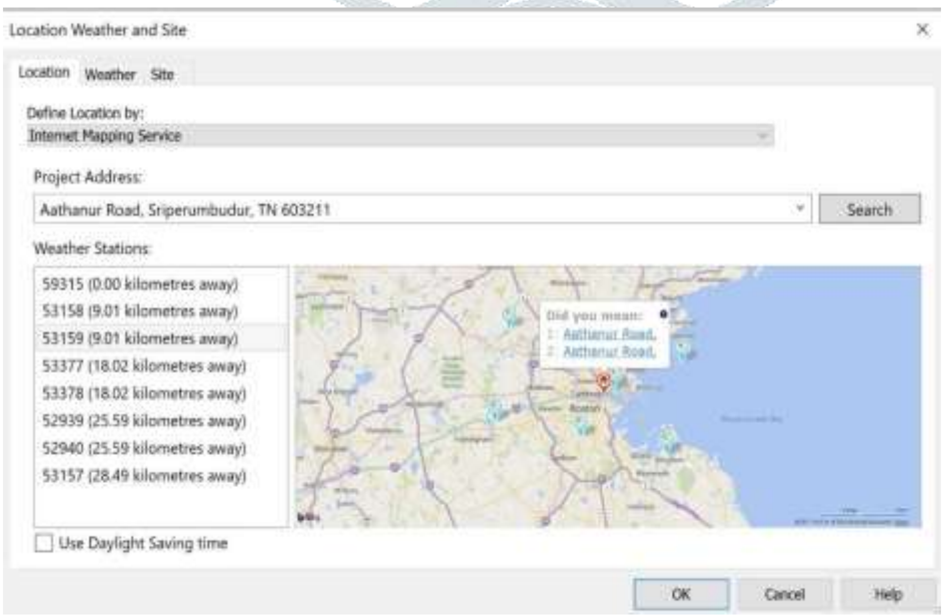
We have taken a case study of a residential building, one of the projects of Chennai slum clearance board near Adhanur Road, Adhanur, Tamil Nadu. It is a G+3 building which has been constructed around 20 years back with single bedroom unit with 2 units at each floor having a total of 8 units with a terrace and head room on the top floor. The flow of methodology will continue as the model of this case study is created in the software with all the input parameters as specified in the case study. The model is then analyzed in software, and it is retrofitted with sustainable techniques, for which the model is analyzed again, and a report is generated for which the comparison is made.

- Structure - Ground + 3, Residential Building
- Total Building Area - 268.33 m2
- Number of flats - 8 (2 flats on each floor)
- Location: Adhanur Road, Adhanur, Tamil Nadu - 614707

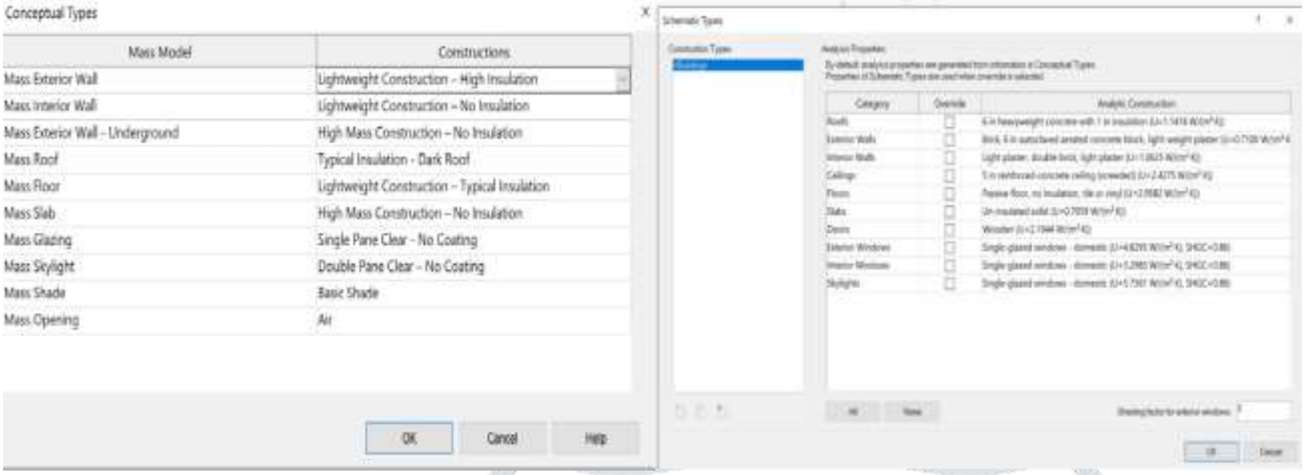
Auto desk was used to simulate the base model, which was created in Revit.

3D Model of the Building

Input Parameter



Location



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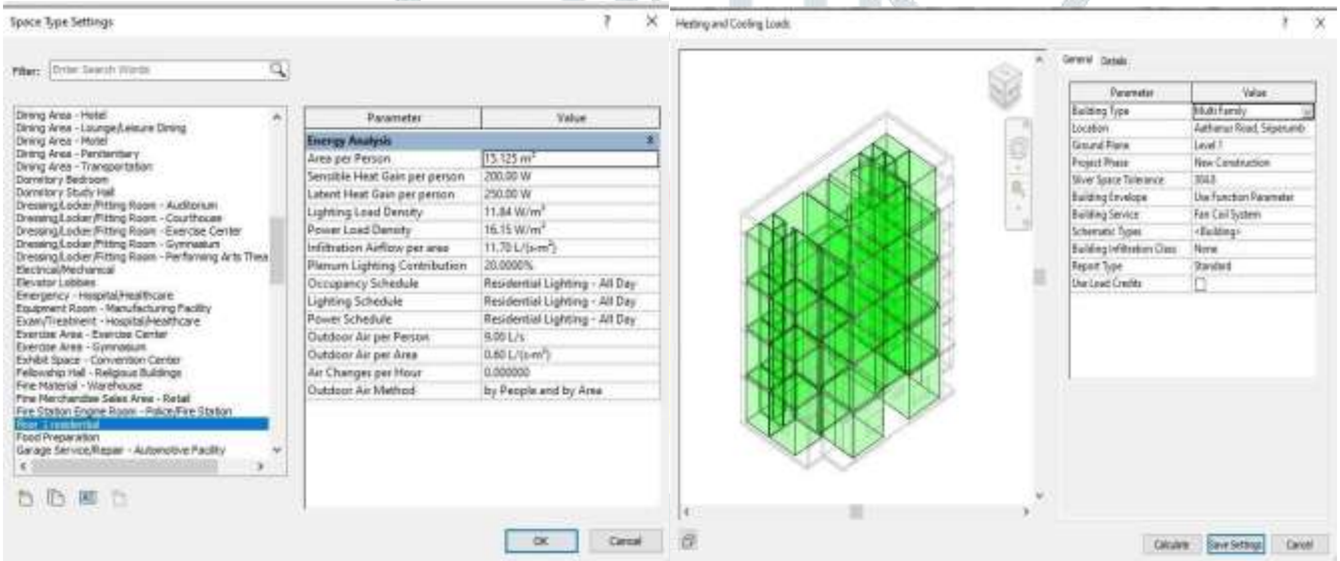
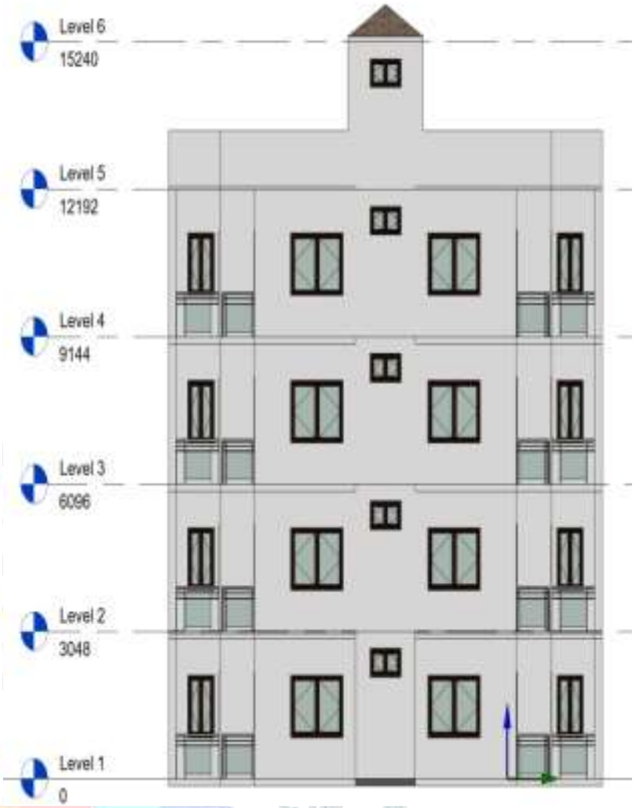


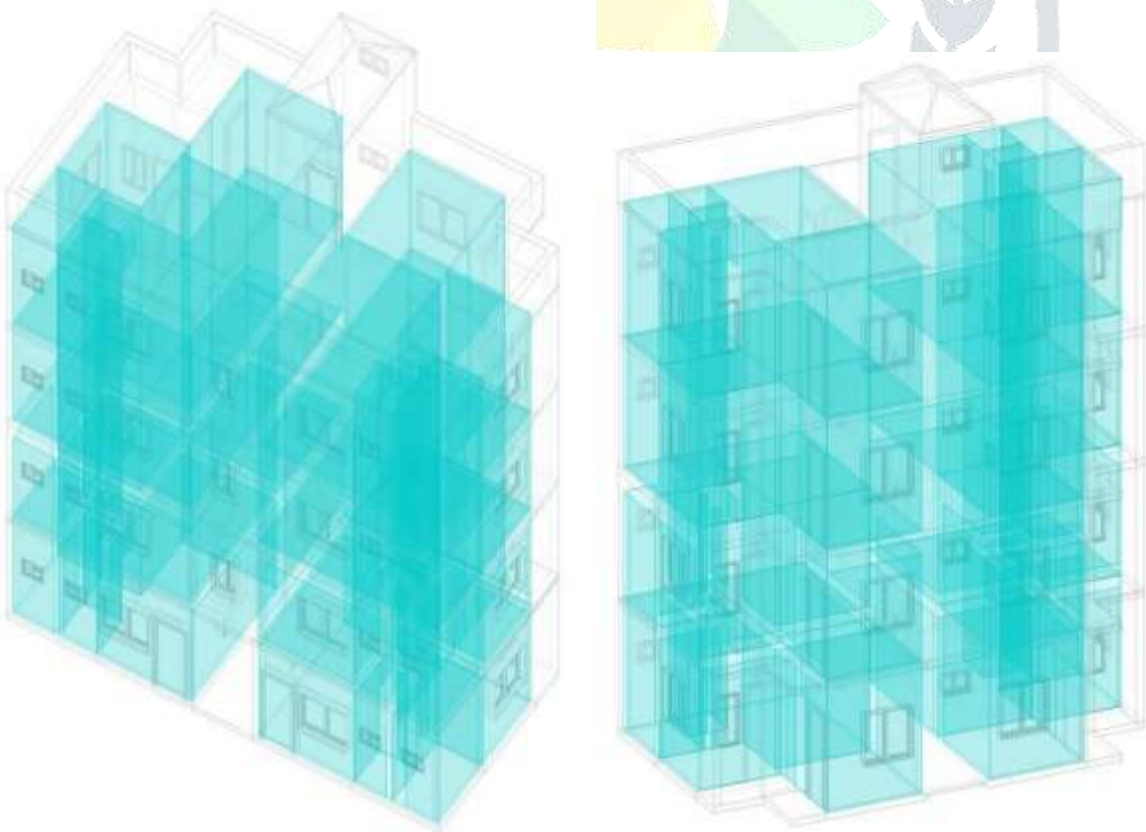
Space Settings

Building Plan

Section of the Building



Elevation of the Building



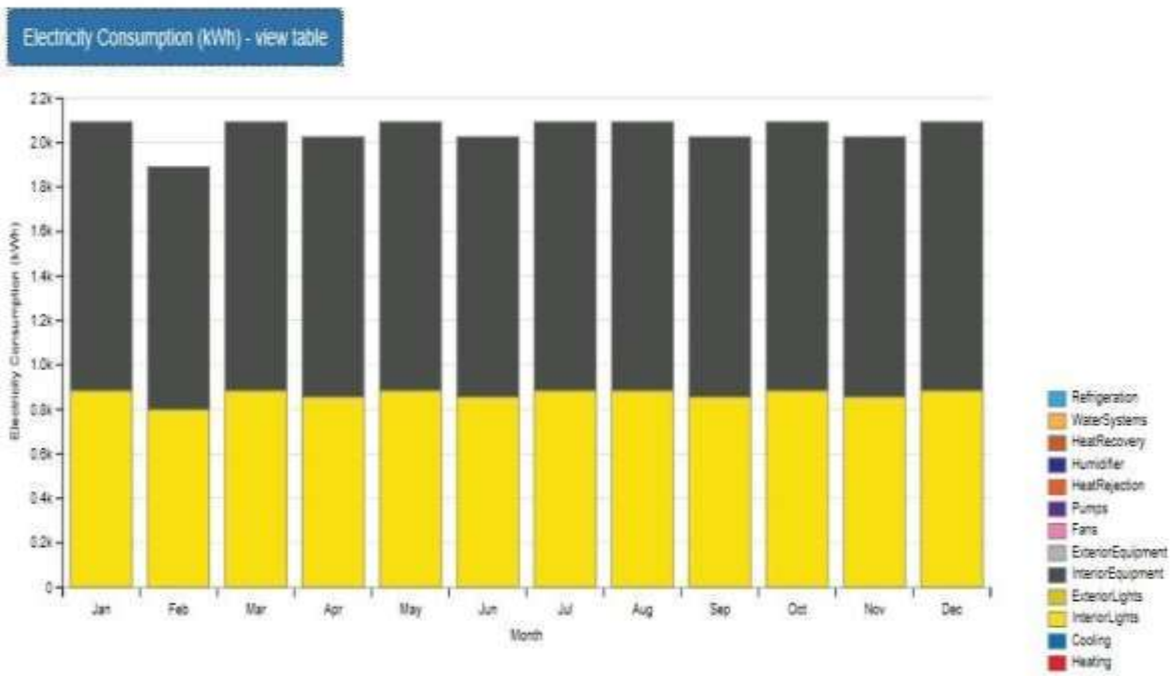
Energy Analysis Area

III. RESULTS

The analysis report obtained from software before and after retrofitting is considered, and these analyses are compared with the results obtained from the reference study where the sustainable techniques were implemented under the same climatic conditions. Aside from these observations and analyses, there is a cost benefit analysis done for each technique with a break-even period as well as considering the maintenance cost as well. These techniques have also been explained in detail on its different items that are a part of its installation and its rates as well. The findings of these observations and analyses are also considered in terms of economic feasibility in the Indian market.

Building Summary

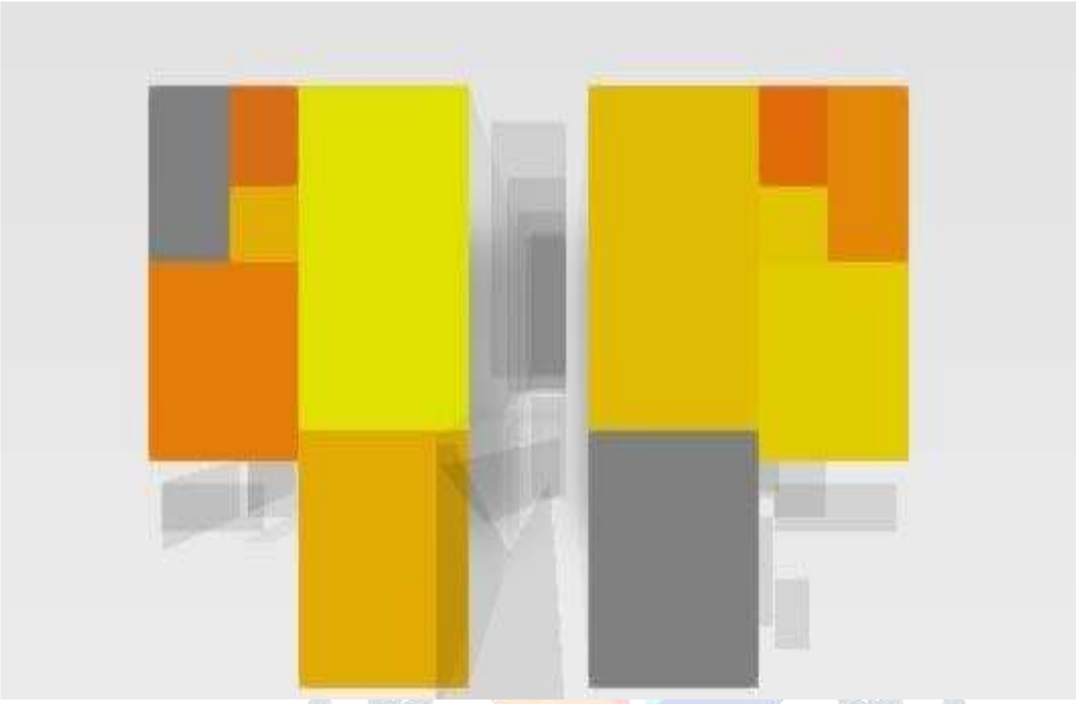
Inputs	
Building Type	Multi Family
Area (m²)	284
Volume (m³)	854.77
Calculated Results	
Peak Cooling Total Load (W)	**69,996**
Peak Cooling Month and Hour	July 16:00
Peak Cooling Sensible Load (W)	67,895
Peak Cooling Latent Load (W)	2,101
Maximum Cooling Capacity (W)	69,996
Peak Cooling Airflow (L/s)	3,636.8
Peak Heating Load (W)	**112,403**
Peak Heating Airflow (L/s)	5,708.0
Checksums	
Cooling Load Density (W/m²)	246.76
Cooling Flow Density (L/(s·m²))	12.82
Cooling Flow / Load (L/(s·kW))	51.96
Cooling Area / Load (m²/kW)	4.05
Heating Load Density (W/m²)	396.26
Heating Flow Density (L/(s·m²))	20.12



Electricity Consumption Analysis

RETROFITTING TECHNIQUES

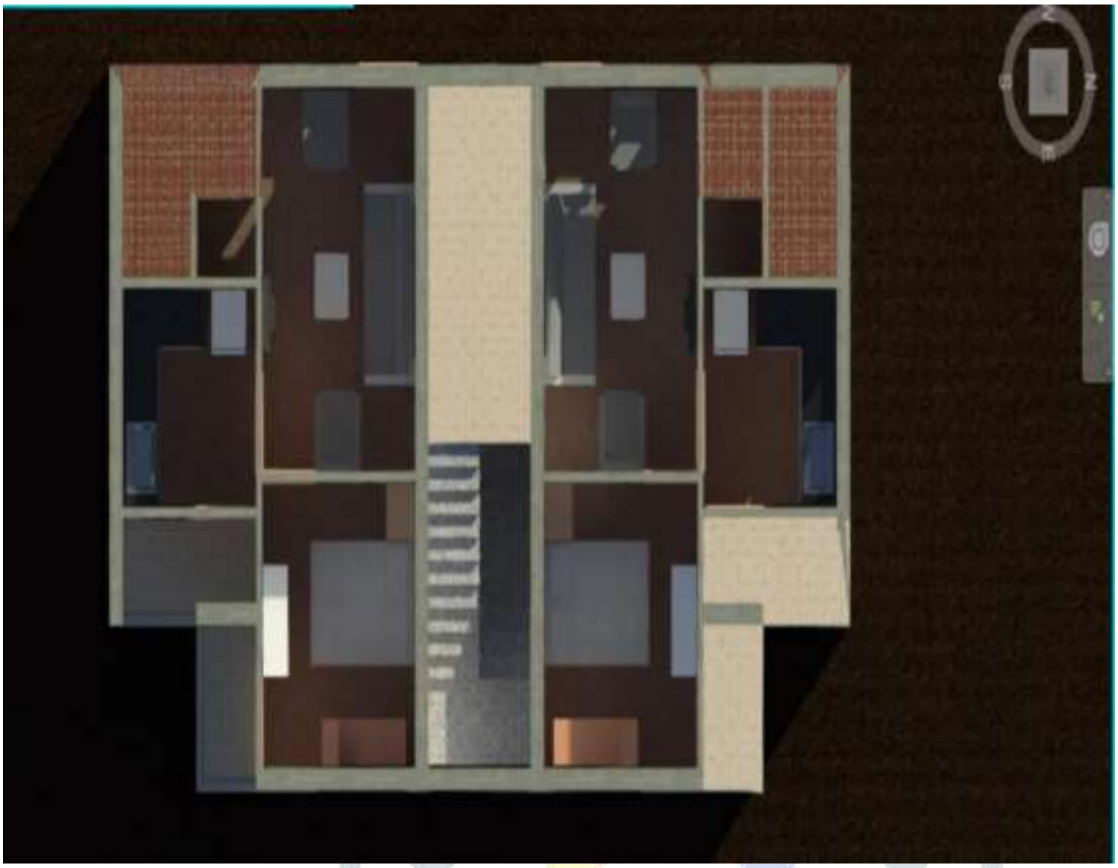
- **Solar Analysis**
  Based the following simulation result, it has been observed that, “Light Yellow” to “Dark Orange” coloured areas get high solar gain.



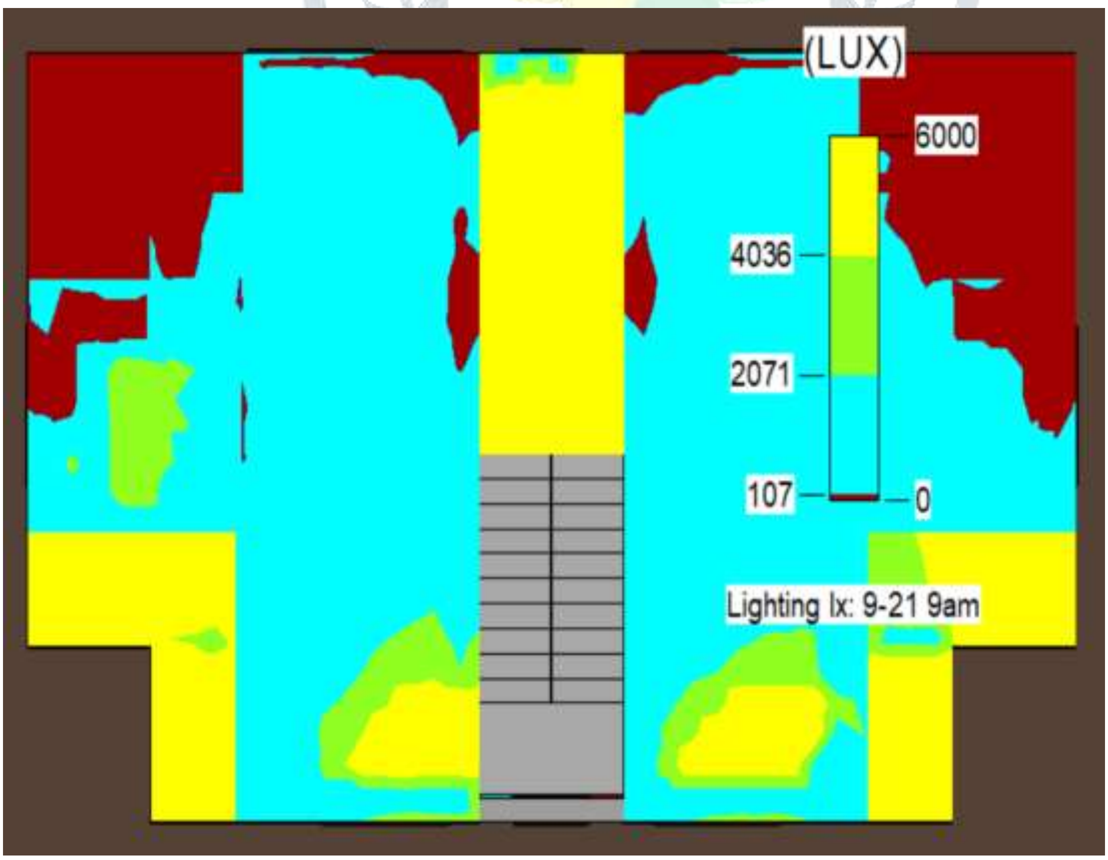
Solar Coverage in Roof

Placement of Solar Panel (Top View)

- **Window Light Fall Analysis**



Shadow-Light Display



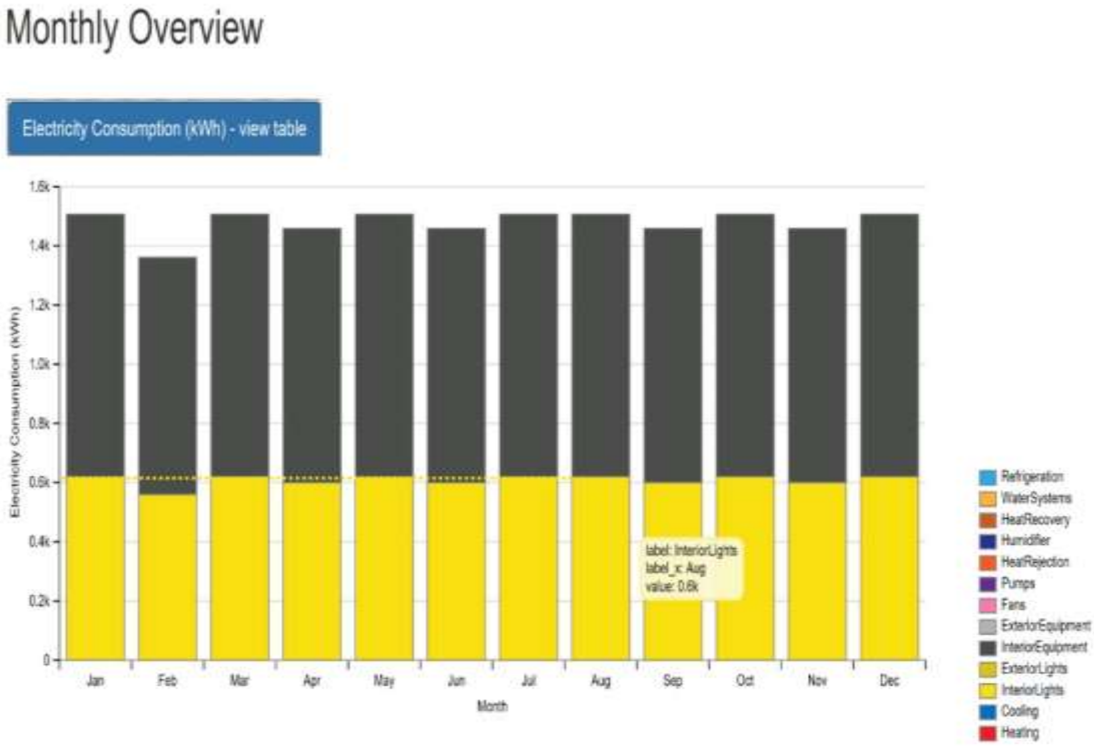
Impact of opening and its light fall

- **Bio Wall Analysis**

Result after Retrofitting - impact on cooling load

Calculated Results	
Peak Cooling Load (W)	**32,144**
Peak Cooling Month and Hour	July 16:00
Peak Cooling Sensible Load (W)	25,956
Peak Cooling Latent Load (W)	6,188
Peak Cooling Airflow (L/s)	1,261.9
Peak Heating Load (W)	**38,962**
Peak Heating Airflow (L/s)	1,239.0
Peak Ventilation Airflow (L/s)	367.0

After Retrofitting



Electricity Consumption Analysis (After Retrofitting)

COMPARISON OF ENERGY ANALYSIS AFTER RETROFITTING:

1. ELECTRICITY CONSUMPTION:

The above analysis simulation is taken from the case study building for individual unit where there is an average of 68 kwh consumption per day (for 1 building, with 8 flats, including the common area) which is considered for interior lighting and interior equipment only this does not include motor and other common amenities.

We conclude that an individual flat will have an average of 8.25 unit / day (i.e., 8.25 kwh/day) electricity consumption. Solar panel above mentioned is available in the market which on average produces electricity of 4 units /day for an area of 1 KWh. 6 sq.m area is required to setup 1 KWh panel.

Total area of installation - 105 sq.m (terrace area, head room, parapet wall area minus the pipelines distribution area) Total production of energy - 4 * 17KWh = 68 unit per day

On the previous implementation of solar panel, we are saving a 68 unit out of 68 unit of electricity consumption in the total building.

As per the case study it is has been observed that users in the house are frequently using cooling device since they are able to bear the heat in the region which leads to higher electricity consumption.

On an average there are four people using single flat from the observation made from the case study.

The above analysis simulation is taken from the case study building for individual unit where there is an average of 50 kwh consumption per day (for 1 building, with 8 flats, including the shared area) which is considered for interior lighting and interior equipment only this does not include motor and other common amenities.

We conclude that an individual flat will have an average of 6.25 unit / day (i.e., 6.25 kwh/day) electricity consumption. Variation of about 14 unit per day is seen on average in electricity consumption after the model is being retrofitted.

Hence on a conclusion the above techniques rather than solar panel, other techniques have significantly reduced the effect of cooling load which in turn directly affected the electricity consumption which is been used.

2. WINDOW GLAZING:

A building's and its windows' principal objective is to provide thermal and visual comfort to the people who reside inside. The findings suggest that suitable glazing systems can decrease solar heat gain, reduce cooling demand, and improve thermal comfort. A layer of air or argon gas is trapped between two glasses when you install double glazing windows.

If we consider the best glass among the above for double glazing, i.e., One layer of Low E glass coating and an insulating cover, it is observed that only 63% of the total heat will pass through the window glass. Remaining 37% of the heat will be reflected into the atmosphere, which will reduce the cooling load of the rooms.

According to the results of the above reference study, 37% of the total heat gained by the rooms may be lowered, which can be incorporated in our model. The entire outer wall surface area of the structure is 5864 sq. ft, of which 640 sq. ft is covered by windows, based on the room size.

3. BIO WALL

The residential wall and the inexperienced facade, internal temperatures were reduced by 4.0°C and 3.0°C, respectively. The living wall reduces both inside and outside air and floor temperatures due to the direct relationship between surface temperature and air temperature. In our plan, a total of 815 square feet is allotted for the construction of bio or living walls, which will help to keep the entire family cool.

Although an inexperienced facade can allow air to pass through the greenery, ventilating the air cavity, the shade provided by the living wall reduces temperatures more effectively. The downside of both of the vertical greenery systems investigated in this study was that they increased humidity. The humidity in the green facade cavity is better than the humidity in the housing wall.

4. HEAT REFLECTIVE PAINT

Roofs, ceilings, and walls with Heat Reflective Paint reflect 98 percent of heat. And it lowers the building's internal temperature by up to 15°C. Evaporation losses, pollutants, smog, the urban heat island effect, and global warming are all reduced.

Heat Reflective Paint more cost than ordinary paint and are recommended only in areas with high amount of sunshine and less effective in winters. But they contribute to the reduction of roof heat by reflecting ultraviolet and infrared rays back to the atmosphere and have more lasting and less maintenance than ordinary paints. They
are simple to clean with water because they do not contain any solvents. This paint has no hazardous ingredients.

We are applying heat reflective paint at the walls of our building on all the four sides which is having an area of 545-meter square. By applying the reflective paint for this much area we will be able to reduce the temperature by 3-to-5°C on our building.

IV. CONCLUSION

On the whole retrofitting of these techniques have shown a 30-40% I.e. (bio wall –20-30%, heat reflective paint – 35-40%, glazing –10-15%) difference in the Energy consumption of the building which has significant impact on cost and as well lively hood of the residents. On observation of all the retrofitted techniques with respect to objectives of the paper were lack knowledge of technologies available in the market and the cost of these applications are taken into considerations with respect to the Indian Market, this could be able to provide an information about the existing market with so many technical options available, a comparison may be necessary. This case study has been taken is supposed to be an TN slum clearance board building, retrofitting to these old buildings without much of cost addition and strengthening the old structure with modern technology and getting to build towards sustainable future approach could be used as a prototype of all these related projects.

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