Energy Efficient Building

Dr. Praseeda E[1], Nisha[2]
[1]*Associate Professor, R R Institute of Technology*
[2]*Student, R R Institute of Technology*

Abstract— **Energy efficient buildings are superior in every aspect than the ordinary building. From the strategy making outlook, it is necessary to know up to what point our understanding of energy efficiency of building reaches and the perspective and practice beyond estimation. It includes the supportable and economic studies with recommendation to the non-renewable natural resources that are essential for continuous growth. This work aims about the energy and the environment, material, economic condition with acquiring the techniques like designing, analysis, model making using energy efficient materials, actual cover with magnifying the use of renewable resource and goals to save energy and eco friendly. By taking the conventional building, we adopt some passive strategies such as earth air tunnel, solar energy, and replacement of materials like brick with FAL-G block and window glass with Low-e-glass. These strategies are put in the model and help to save energy.**

Index Terms: **Energy efficient materials, Earth air tunnel, Solar access analysis.**

INTRODUCTION

Energy efficient building (EEB) is a plan provided for the reduction of the energy for heating and cooling of a structure, on its own energy and the materials selected to heat or cool the structure. Now a days, the building sector uses 35% to 40% of energy in India, which contribute to significant environmental and economical issues which arises due to more demands for the cooling, ventilation, heating and lighting. By understanding this situation and requirement of energy adopting, the energy efficient building is a sustainable approach, which provides the best solution to lessen the energy demand. This leads to the reduction of the environmental issues and also the cost.

Energy efficient building is an effective method, as it provides higher durability, comfort and also healthy indoor environment. Energy efficiency of the structure is the extension of the energy utilization per square measure of ground region of the structure measuring up to established energy consumption under the defined weather state for the standard mark of the specific type of structure (Neogi and Patel, 2015). Energy Efficient Building is environmentally friendly, the carbon dioxide emission can be reduced as it conserves energy, moreover it lowers the waste production. The building energy codes are observed to be more economical and successful in enhancing the energy efficiency of buildings (Awawdeh and Tweed, 2011). The automation and surveillance simultaneously develop sustainable environment on achieving simple, easy and cost effective system (Gurav et al., 2018).

Adoption of fly ash brick, low-e-glass used for the construction plays a foremost part in the energy efficiency of the building. Conventional masonry block can be replaced with FAL-G masonry block (Jayasudha et al., 2013). The study of Koshti et al., (2019), aims in reducing and replacing materials like bricks with low priced substitute like fly ash bricks. Total embodied energy of FAL-G block including transportation is 3.92MJ (Tanuj et al., 2016). On point of view of acquiring minimum heat, low-e glass windows are found to be energy efficient out of all buildings that are considered in three regions of India (Kiran Kumar et al., 2017).

Energy efficient building can be analyzed and designed using the Design Builder software (Ajeet Kumar et al., 2017; Pawar and Karade, 2018). Ismail et al., (2015), compared outcomes of energy consumption by studying electricity meters and through Design Builder software.

A new wide-ranging automation of the Earth Air Tunnel (EAT) system that lowers the buildings thermic load are in the earlier period in India. It is necessary to know the energy efficiency of the building by dehumidification process. Researchers like Prasad et al., (2016), conducted studies, for planning, how to install EAT for energy efficient building. When compared to simple EAT heat exchanger, less space is required for the installation of EAT heat exchanger in series connection (Jakhar et al., 2017). If Earth Air Heat Exchanger is used instead of AC for summer cooling, the amount of electrical power consumption can be saved (Bisoniya et al., 2014).

Solar panels are made of solar cells. Solar cells are the essential component by which light is converted into electrical energy and they are usually made of crystalline silicon. Each solar panel normally contains 32 to 96 solar cells. The solar cells produce electricity by converting enormous solar energy that the earth receives every day in the form of sunlight (Shaikh et al., 2017). Solar panels help to produce power that can lower the building's dependents also where aided to generate hot water and replace the electric geyser in building (Munde and Thakre 2017). Researchers like Chaudhari et al., (2013), suggests that the solution for the use of energy in a effective way, is using latest technologies in advanced buildings. Sahu (2017) explained about emerging solar energy technologies in the business sectors by the aim of cost effective and efficiency of solar power generation in the market.

METHODOLOGY

A. *Site investigation*

The project site is located at the Guttebasaveshwara nagar, Chikkabanavara bridge road, Bengaluru urban-560090. The building located in the South- West corner of the site. Building consists of ground floor, first floor and second floor. The building is spread over an area of 98.477 square meters. Site investigation is organized to obtain the possible information about the electricity consumption of the building, window orientation and also placement. The most important orientation aspect to consider is the direction of the house, windows face and their solar access.

Details of each floor: -

- Ground floor has 3 Shops and parking (West face) is provided and there is no window. 28.8 units of electricity is consumed in the ground floor per month.
- First floor consists of living room, kitchen, 2 bedrooms, 2 bath and wc, puja room. The electricity consumption is 90 units per month.

Kitchen - window dimensions of 3'0"x 2'6" at south
Dinning - window dimensions of 3'0"x 4'0" at east
Master bed room - window dimensions of 5'0" x 4'0" at south
Master bed room, Bath & WC - window dimensions of 2'6" x 2'6" at west
Living room - window dimensions of 1'6" x 4'0"- 2 windows at west
Living room – window dimensions of 4' 0" x 6'0" at east
Bath and WC - window dimensions of 2'6" x 2'6" at west
Bed room – window dimensions of 5'0" x 4'0" at north
Courtyard provided above the puja room at east side

- Second floor has 2 individual house each consisting of 1 bedroom, living, kitchen and dinning, bath and wc, puja room. This consumes 87 units of electricity per month.

House 1 and House 2
Living room – window dimensions of 3'0" x 4'0" at east
Kitchen – window dimensions of 3'0" x 2'6" at south
Bed room – window dimensions of 5'0" x 4'0" at south
Bath & WC – 2'6" x 2'6" at west

B. *Plan and Analysis of EEB*

- For designing the EEB existing plan of the building is taken and dimensions of the windows are replaced.

Fig. 1 Plan of Replaced Window Dimensions

- By using Design builder software, the data of energy consumption of the building with and without adopting strategies can be collected. This collected data is used to analyze the energy consumption in the building.

➢ Data of energy consumption of building, with adopting strategies using design builder software:-

TABLE I ENERGY EFFICIENCY OF BUILDING DATA

Construction	U-value(w/m^2-k)	R-value(m^2-k/w)
Main Wall	0.097	0.3
Flat roof	0.045	0.15
Ground flooring	0.045	0.4
Wood	2.823	0.354
Glazing	1.96	-

TABLE II TOTAL ENERGY CONSUMPTION

Total energy (kbtu)	Energy per total building area (kbtu/ft^2)
2513399.91	41.76

TABLE III ENERGY CONSUMPTION ON DAILY USE

.	User Design Load (Btu)	User Design Load per Area (Btu/ft^2)
Electricity	0	-
Natural gas	0	-
Cooling	268576.8	13.39
Heating	103167.44	5.14
Water	110.12	-

➢ Data of energy consumption of building, without adopting strategies using design builder software:-

TABLE IV ENERGY EFFICIENCY OF BUILDING DATA

Construction	U-value(w/m^2-k)	R-value(m^2-k/w)
Main wall	0.345	1.673
Flat roof	0.15	3.999
Ground flooring	0.4	4.001
Wood	2.823	0.354
Glazing	1.96	-

TABLE V TOTAL ENERGY CONSUMPTION

Total energy (kbtu)	Energy per total building area (kbtu/ft^2)
10201336.17	169.97

TABLE VI ENERGY CONSUMPTION ON DAILY USE

End-use	User Design Load (Btu)	User Design Load per Area (Btu/ft^2)
Electricity	2017551.96	33.62
Natural gas	0	-
Cooling	1140965.61	57.03
Heating	314015.85	15.69
Water	327.41	-

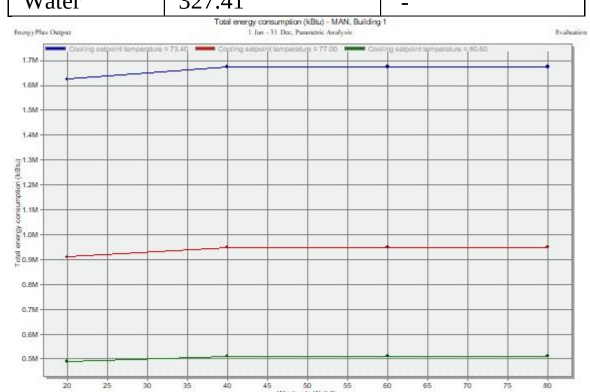

Fig. 2 Total energy consumption of the building

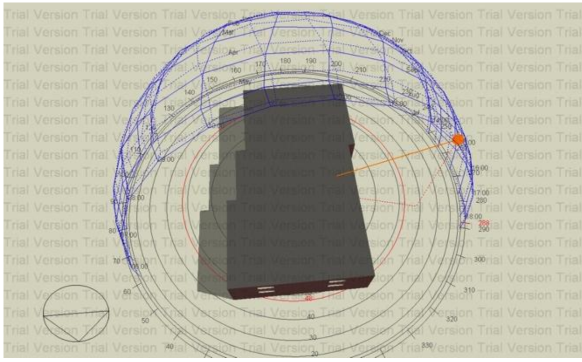

Fig. 3 Solar path throughout the year around the building

C. *Passive strategy adaption*

1) *Materials:* Material like conventional block is replaced with FAL-G block. Mix proportions and strength of FAL-G block are shown (table VII and table VIII). Normal window glass is replaced with Low e-glass. It manages the sun's heat by filtering 80 percent of the sun's radiation and remaining heat is allowed to transfer inside along with the Light.

TABLE VII MIX PROPORTION OF FAL-G BLOCK

Materials	Weight	Percentage
Fly ash	11.6 kg	60%
M-Sand	3.2 kg	18%
Lime	2.8 kg	15%
Gypsum	0.9 kg	5%
6mm Coarse aggregates	0.3 kg	2%

Fig. 4 Compression test for FAL-G block

2) *Solar*: From the collected data of the building, 256kw of electricity is consumed per month, by installing solar panels energy consumption can be reduced. An inverter having 24V is installed to convert DC to AC. Excess electricity is stored in the battery having a capacity of 200Ah.

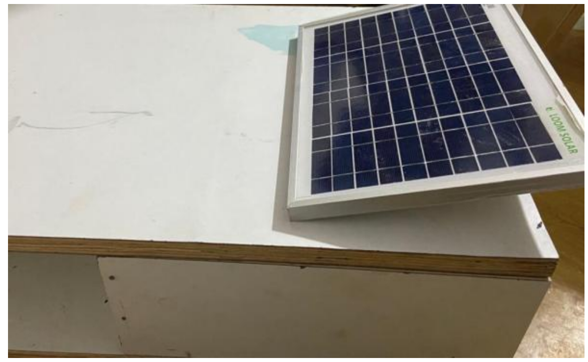

Fig. 5 Solar installation in the model

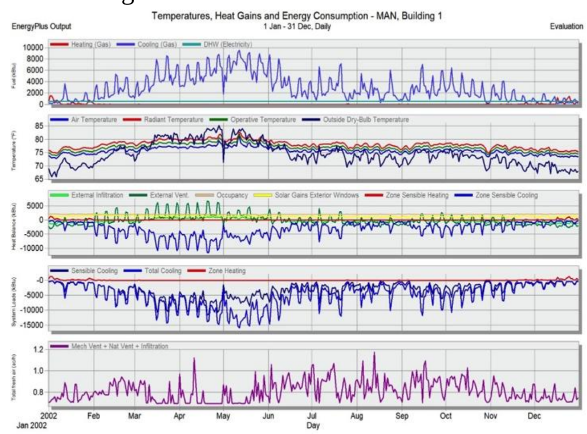

Fig. 6 Temperature, Heat Gains of the building

3) *Earth Air Tunnel (EAT):* EAT is a pre-cooling and preheating system that consists of a network of pipes buried at depth of 5m and PVC pipes of 150mm diameter are placed inside these tunnels and earth is filled in. One tunnel with two pipes inside is required to serve 4 normal sized rooms. One end of the pipe system is exposed to atmosphere and the other end is connected to the Air Handling Unit (AHU), which in order distributes air to rooms after humidifying or dehumidifying. Hot air from rooms is sent out through the normal draft achieved by installing heat stack in each room.

Fig. 7 Installing PVC pipes for EAT in the model

D. Comparison between Energy Efficient Building and Conventional Building

1) *FAL-G block and conventional block:* As comparing does the observation of energy consumption of FAL-G block is 0.95-1.7MJ where as conventional block is 4.75MJ. Weight of FAL-G block is 17.4kg and conventional block is 23.78kg. Density and strength obtained from FAL-G block is 1478kg/m^3 and 6.008N/mm^2 while conventional block has 1961kg/m^3 and 7.85N/mm^2. It is also noticed that FAL-G blocks are cost effective where each block is 18.16rupees and conventional block is 32rupees.
2) *Low-e-glass and Plain glass:* Low-e-glass filters 80% of the heat from the sun and transfers remaining heat inside the room along with the light where as plain glass fails to filter the heat. Breakage wont be easier when compared also the initial cost is high and maintenance is less in low-e-glass where it is opposite in plain glass.
3) *Earth Air Tunnel (EAT) and Air Conditioner (AC):* Energy consumption is less in EAT and is environmental friendly, moreover heating and cooling takes place in one system itself but in AC, consumption of energy is more and it is non-eco-friendly, on the other hand it requires two different system for heating and cooling. The initial cost is 25% more and maintenance is less in EAT when compared with AC.
4) *Solar and Electricity:* Solar is a renewable energy resource. In addition, the initial cost is more and maintenance cost is less. However, electricity is a non renewable energy resource, where initial cost is less but maintenance cost is more.

FUTURE SCOPE

Energy efficient building reduces wasted energy usages, greenhouse gas emissions, and its demand for non-renewable energy resources. It also offer healthier, cleaner living conditions. A financial saving may also occur in energy efficient buildings.

CONCLUSION

The following conclusions may be drawn from the present study;

- The experimental result shows the reduction in the energy consumption with the use of FAL-G block. Therefore with the use of FAL-G block as a replacement of conventional block, the energy can be reduced and also being to be cost effective.
- Use of Low-e-glass can reduce the heat by filtering it outside and then transfer it inside the room. It keeps the home cooler and saves the furniture's or interiors from the UV rays.
- The method of adopting earth air tunnel aids to reduce the surrounding temperature during both summer and winter.
- As a renewable energy resource, solar is used for the building where energy consumption is observed in every aspect.

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