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DESIGN OF AN ENERGY EFFICIENT BUILDING : A SUSTAINABLE APPROACH

Aswathy Mohan[1], Arjun R Nair[1], Jibin Mathew Saji[1], Aiswarya V Aji[1]

[1]Department of Civil Engineering, St. Joseph's College of Engineering & Technology, Palai , Kerala Technology University-686009, India

aswathymohan960@gmail.com, Tel. :+917736862560

ABSTRACT
The project aims at the design of an energy efficient building taking into consideration of various criteria's. The preliminary objective of this paper is to reduce the energy consumption of an existing building with minimum cost, wastage and environmental impacts. Passive Energy Management principles are adopted to achieve the sustainable design of the building. Steps to be undertaken are as follows – choice of appropriate software, incorporating the concept of building orientation, building envelop design, passive solar design and energy performance analysis with various factors like climate, site conditions, building use and space allotted.

Keywords:- Cost Effective, Energy Efficiency, Global Warming, Minimum Wastage, Sustainability

1. INTRODUCTION

Energy efficiency in buildings refers to designing and constructing buildings in a way that minimizes energy consumption while maximizing comfort and productivity for the occupants. Buildings plays a vital role in global energy consumption and greenhouse gas emission which results in a greater environmental impacts. Improving energy efficiency leads to reduction in energy consumption ,lesser greenhouse gas and saves money for building owners and occupants.

There are two main principles of energy management i.e active and passive energy management principles. Passive energy management refers to the design and construction of buildings and other structures that minimize the need for active energy consumption. The goal of passive energy management is to reduce the amount of energy required to heat, cool, and light buildings, thereby decreasing their carbon footprint and energy costs. Passive energy management design typically involves strategies such as proper orientation of the building, maximizing natural daylight, proper insulation, natural ventilation, and shading. This design strategy takes advantage of natural resources and processes to regulate a building's temperature, lighting, and ventilation

2. PASSIVE MANAGEMENT PRINCIPLES

2.1 Orientation: A building's orientation can have a big impact on how much energy it uses. To maximise natural lighting and ventilation, building design should take into account the direction of the sun and the predominant winds.

2.2 Insulation: Minimising heat absorption or loss through walls, roofs, and floors requires sufficient insulation. Fibreglass and cellulose are examples of insulation materials,foam can assist cut down on energy use by blocking heat transmission.

2.3 Windows: Windows can have an effect on how much energy a building uses depending on their kind, size, and placement. Better insulation can be achieved with double or triple-pane windows coated with low emissivity materials, while south-facing windows shaded appropriately can let in natural light and warmth.

2.4 Natural ventilation: By allowing air to flow through windows and other openings, natural ventilation can be employed to cool buildings during the summer. By preventing the accumulation of contaminants and moisture, proper ventilation can also enhance the quality of indoor air.

2.5 Thermal mass: By gently absorbing and dissipating heat, thermal mass materials like brick, stone, or concrete can help control indoor temperatures. To maintain a more consistent indoor environment, thermal mass can be used in floors, walls, and ceilings.

2.6 Sustainable

3. PASSIVE DESIGN

3.1 Form and orientation:

By utilizing the sun and prevailing winds to our advantage, design and orientation have a huge impact on a building's energy efficiency as we go towards net zero energy goals. Thermal and visual comfort are largely influenced by the building's shape and space orientation. In comparison to a building that is improperly oriented, an appropriate building orientation can reduce cooling demand and energy use.

3.1.1 Recommendations

- Sites with several structures must be ordered in ascending height order.
- For optimal ventilation, buildings should be oriented at 45° or 30° to the wind.
- Taller structures positioned in the path of the wind.
- Staggered design

3.2 Shading:

Building facade solar benefits can be lowered by shading. External shading devices and internal shading devices are the two primary categories of shading devices. Devices for external shading are an efficient approach to lower energy use, increase comfort, and improve the building's appearance. Fixed shading, retractable shading, solar screens, exterior blinds, and vegetation shading are a few popular forms of exterior shading equipment. The sort of shade device chosen will depend on the intended level of shading, energy efficiency, building orientation, climate, and design, among other things. Internal shading devices, on the other hand, are used to regulate the quantity of light and heat entering the area, enhancing the inhabitants' thermal and visual comfort.

3.2.1 Recommendations

- North-South orientation of the building's longer side
- Install fixed horizontal overhangs on windows facing south.
- Keep the amount of glass facing east and west to a minimum (window space)
- Roof extensions, internal blinds, well-placed deciduous trees on the East and West for lower buildings, semi-outdoor places like balconies, and reduced solar heat gain coefficients are required if external shading is not an option.

3.3 Cool Roofs:

In contrast to conventional roofs, cool roofs are constructed to reflect sunlight and absorb less heat. These roofs, especially in hot and sunny climates, can aid in lowering energy consumption, enhancing thermal comfort, and reducing the impact of urban island heat. White roofs, green roofs, metal roofs, and tile roofs are a few common examples of cool roofs. Climate, building type, roof design, and budget all influence the type of roof that is chosen.

3.3.1 Recommendations

- Proper design techniques must be used to avoid condensation
- Use of materials such as well-graded broken pieces of glossy glazed tiles, modified bitumen
- With plastic and a layer of reinforced material, RCC roof topped with elastomeric cool
- Consideration of climate as cool roof installation increases energy cost in colder climates whereas increases greater savings in hot climates
- Special chemicals to be included in roof coating to prevent mould or algae growth

3.4 Fenestration:

Fenestrations are openings in buildings that, when necessary, let light and the prevailing breeze inside. These fenestrations, especially windows, may allow solar radiation to enter and cause significant heat gain. Windows with glazing keep the heat inside the room. Lighting and cooling loads can be significantly impacted by a building's fenestration. Changes in window size, orientation, glazing, and internal and external shading devices can somewhat limit heat gain. Without sacrificing the visual and thermal comfort of building inhabitants, it lowers lighting loads. South-facing facades receive the most solar radiation, both in terms of quantity and duration, whereas north-facing apertures or walls receive the least. Openings (or walls) facing east and west receive a lot of sun radiation all year long.

3.4.1 Recommendations

- Reducing the glazing area as necessary
- Lowering the Solar Heat Gain Coefficient (SHGC), the U-Value of glazing, and the SHGC overall, with the exception of cold climates
- When describing the performance of windows, be sure to mention "whole product performance values" or the entire window unit for SHGC and U-factor
- The use of "glass-only" U-factors should be avoided because they can be 10% to 40% better than the whole product value. South-facing windows with high SHGC values and low U-factors should be suggested for buildings in cold locations

3.5 Insulation:

Thermal insulation in roofs and walls prevents heat from transferring from inside to outside and contributes to the maintenance of a comfortable interior temperature. The environment is made healthier, sound is controlled, and most importantly, the electricity costs are reduced. Insulation keeps indoor spaces warm in the winter and cool in the summer.

3.5.1 Recommendations

- Insulation should be installed on the surface that receives more heat
- When selecting an insulation material, factors such as thermal performance, lifetime performance, fire safety, moisture and condensation, air infiltration, and environmental benefits should be taken into account.
- Damp-proof materials should always be used on the warm side of the insulation

- Condensation factor should also be taken into consideration; • Insulation should be utilised with a heat-storing substance, and this storage mass should be put inside a passively cooled building.
- It is advised that architects speak with the designers of air-conditioning systems to investigate the savings offered by an insulated wall.
- Adding insulation with a thickness greater than 100 mm does not significantly improve energy efficiency.
- Installing the initial 25mm of insulation results in the biggest cumulative energy savings.

3.6 Daylighting:

A building design technique to make use of sunlight is daylighting. Natural light enhances wellbeing, heightens environmental awareness, and increases energy-saving potential by reducing reliance on artificial lighting in occupied spaces. The building's windows, skylights, clerestories, and other openings can all be used effectively to capture natural light. While integrating daylighting with artificial lighting can significantly cut energy usage, it can also increase air conditioning loads because of heat gain. Therefore, design advisors and decision-makers must carefully balance daylighting features and reduce solar heat gains.

3.6.1 Recommendations

- Larger buildings can bring sunshine into more places by having central courtyards or atria.
- Longer on their east-west axis buildings are better for daylighting and visual comfort
- . Larger and taller buildings should have thinner profiles to maximize daylighting possibilities.
- Maximum daylight factor, increased uniformity of light dispersion, decreased glare, and minimal solar gains should all be prioritized. It also aids in bringing in more light to increase the height of each level to allow for higher windows.

3.7 Natural Ventilation:

Fresh air in a building improves its occupants' health and degree of comfort; it is seen as an effective and healthful solution because it lessens the need for mechanical ventilation systems. By strategically introducing fresh air into a built space, passive design strategies can lessen, and in some cases totally do away with, the need for mechanical ventilation systems.

3.7.1 Recommendations

- The building can be oriented 0° to 30° with respect to the direction of the predominant wind. Maximum air movement is achieved by keeping the sill height at 85% of the critical height. Building openings should be in the opposite pressure zone for good natural ventilation.
- The window-to-wall ratio (WWR) shouldn't exceed 60%

3.8 Thermal Mass:

Thermal mass serves to store heat inside the framework of the building and to control temperature swings inside. By allowing for a delay, the building material's propensity to store heat aids in providing thermal comfort for inhabitants. This capacity for storing heat in buildings is influenced by the mass and density of a building material. Materials with high thermal mass include concrete, bricks, and stone, while low thermal mass materials include wood or plastic.

3.8.1 Recommendations

4 Thermal mass in climates with large diurnal temperature ranges

5 Choose appropriate mass color with low reflectivity

6 Do not substitute thermal mass for insulation

3.9 Evaporative Cooling:

Most Indian homes employ systems like desert coolers, which primarily use evaporative cooling. Evaporative cooling reduces the temperature of the air inside buildings, which minimizes the energy costs associated with air conditioning. Meeting the NZEB design objectives is made possible by a reduced energy demand. Evaporative cooling, however, works best in hot, dry climates with little humidity.

3.9.1 Recommendations

- Water in pools and fountains can be employed as a cooling factor combined with cross-ventilating arrangements of openings
- Pools, ponds, and water features right outside windows or in courtyards can pre-cool air entering the house
- The benefits of evaporative cooling include Wet grass helps in evapotranspiration, which lowers the temperature of the ground, Siliceous shale roof materials can lower the temperature of the roof
- Evaporative cooling is most effective in hot, dry climates

3.10 Thermal Comfort:

An evaluation of the thermal state of the environment is known as thermal comfort. Thermal comfort is described by ISO 7730 as "That state of mind that expresses satisfaction with the thermal environment." Physiological and psychological elements are just as significant as the environment's thermal condition in determining whether a person feels warm, chilly, or just comfortable.

3.10.1 Recommendations

- For naturally ventilated or hybrid ventilated buildings, the thermal comfort model should be used.
- The time of year when mechanical cooling or heating systems can be disregarded to keep spaces at a comfortable temperature for greater energy conservation
- Assessing the percentage of people who are dissatisfied with the thermal environment is above a given threshold is a straightforward method of assessing the amount of thermal in a space or environment.
- In hot conditions, thermal comfort promotes body heat loss via radiation, convection, evaporation, and ventilation

3.11 Vegetation:

A versatile solar and wind penetration controller for buildings is vegetation. It lessens the amount of direct sunlight that strikes and heats up building surfaces. It also lowers the temperature of the outside air, which affects how much heat is transferred from the outside to the building exterior and inside. For as long as structures have been constructed, vegetation has been employed to control the microclimate of a place. A building's heat load can be reduced by using green roofs or roof gardens. These further cool the roof surface by retaining moisture from the rain.

3.11.1 Recommendations

- Local species for vegetation are highly recommended as they are accustomed to the variations in temperature, rainfall patterns, and soil conditions for that region
- Exotic species should cover no more than 25% of the landscaped area of a building
- Reduce lawn area in the garden to a minimum to reduce the amount of water that is needed for irrigation

5. PLAN

The AutoCAD drawing of the building we considered is given below in Fig 1. A 3D model was developed from this 2D on Autodesk Revit. That is then used for the energy analysis of the building.

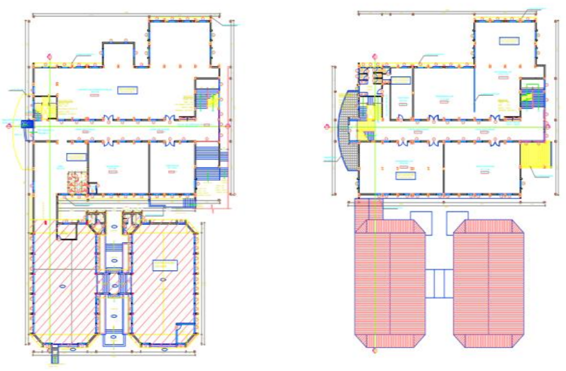

Fig 1: 2D PLAN

6. ANALYSIS RESULT

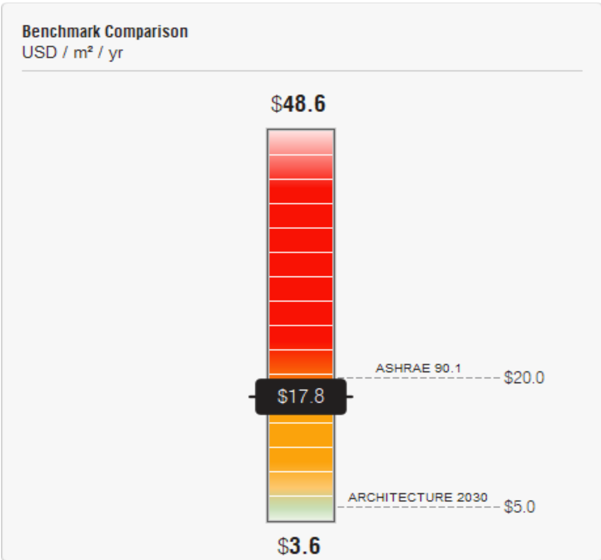

Fig 2: BENCHMARK COMPARISON

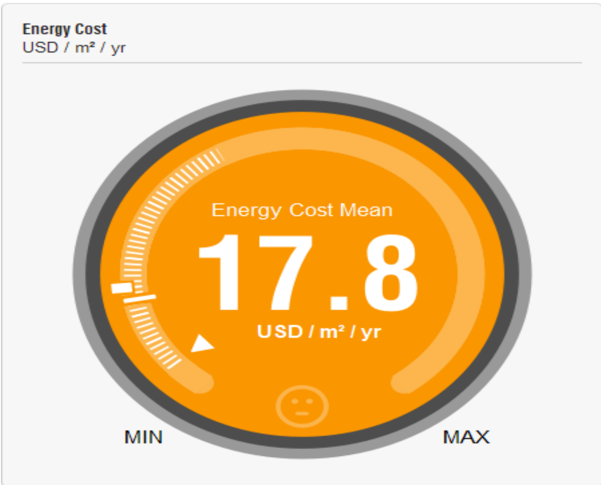

Fig 3 : ENERGY COST

7. CONCLUSION

Designing energy-efficient structures is crucial in the current climate change context. Buildings utilize a large quantity of energy and produce a large amount of greenhouse gas emissions. Building information modelling (BIM) software, like Revit, has become a crucial component of the design process of energy-efficient buildings in order to reduce these emissions. With the help of the effective program Revit, architects and designers may generate a 3D model of a building and evaluate how different design choices affect its energy efficiency.

Techniques for managing passive energy are attractive in a variety of scenarios due to their many benefits. Here are a few significant benefits: Efficiency in Energy, Cost savings, Durability and Reliability, Comfort and indoor environmental quality, Reduced Environmental effect, Adaptability and resilience.

Some of the few limitations of Passive Energy Management Principles are limited control, dependency on climate and location, lack of flexibility etc.

Utilizing Revit for the design of energy-efficient structures is essential for achieving sustainability objectives and lowering the carbon footprint of buildings. To create energy-efficient buildings that satisfy inhabitant needs while reducing their environmental impact, designers must collaborate with architects, engineers, and constructors. Revit streamlines the design process, lowering errors and reducing construction time and expense. Energy-efficient buildings have numerous long-term advantages, such as lower energy costs, greater occupant comfort, and a more sustainable future.

To meet the goal of Architecture 2030, we intend to convert the current structure into a more energy-efficient one using passive energy management methods. The "2030 Challenge," which establishes goals for the design and construction of buildings and developments to minimize their greenhouse gas emissions, is promoted by Architecture 2030. To meet the challenge's objectives, all new construction must be carbon-neutral by 2030, and existing structures must be retrofitted to increase their energy efficiency and lower their emissions.

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