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"COMPARATIVE STUDY OF GREEN AND CONVENTIONAL BUILDING MATERIAL AND THEIR LIFE CYCLE COST ASSESSMENT"

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Abstract: A green building uses less energy, water, and natural resources, creates less waste and is healthier for the people living inside compared to a standard building. There is a rapidly expanding market for green building materials. Green buildings provide a suitable environment by controlling solar radiation temperature, energy efficiency, water conservation using domestic treatment plant and indoor air quality. The main aim of green buildings is to reduce the environmental impact of new buildings. Sustainability in the environment can be well achieved by reducing the energy emission and consumption by the buildings. Sustainability means using energy efficiently. Green Building refers to a structure that is environmentally responsible and resource-efficient throughout a building's life cycle. The aim of this project is to conduct a comparative study on conventional and green residential buildings. Data regarding temperature details are represented in energy simulation software – Energy 2D. A study on various green building rating systems is to be conducted. Rate of water consumption and electricity consumption, waste generated in the selected building were collected for grading the building using LEED certification. A model showing all elements of green building such as rainwater harvesting plant, biogas plant, grey water filter, cooling tunnel, etc. were made.

Keywords: green building, construction, Conventional building.

INTRODUCTION

The construction sector stands as a significant contributor to global energy consumption and greenhouse gas emissions, comprising nearly 40% and one-third, respectively. Moreover, construction and demolition activities generate approximately 40% of the world's waste. With the burgeoning global population, there's an increasing demand for housing and infrastructure, making the housing sector a pivotal player in environmental resource utilization, including land, water, materials, and energy. Recognizing the imperative for sustainable development, the United Nations introduced the Sustainable Development Goals (SDGs) in 2015, comprising 17 objectives aimed at addressing various global challenges, including poverty, gender equality, clean energy promotion, responsible consumption, and climate action. Goal 9 of the SDGs underscores the importance of building resilient infrastructure, promoting sustainable industrialization, and fostering innovation for economic development, social progress, and climate resilience.

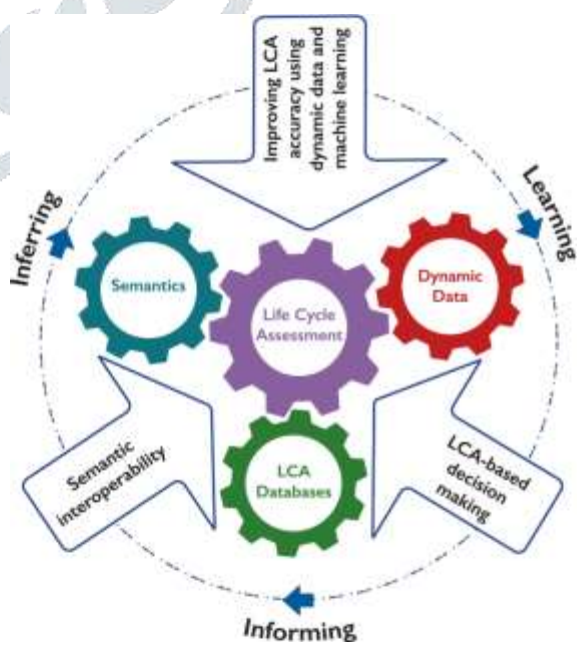

Figure 1: Life cycle assessment

Figure 2: Conventional building Vs Green building

OBJECTIVE

1. Compare environmental impacts of green vs. conventional materials across lifecycle stages.
2. Analyze economic implications including initial, operational, and maintenance costs.
3. Evaluate energy efficiency and performance in various building applications.
4. Assess social benefits and drawbacks for occupant health and well-being.

LITERATURE REVIEW

Dabhade, A. N et al. (2022), The study investigates the development of recycled aggregate geopolymer concrete (RAGC) using various effluents, aiming for sustainability in the construction industry. Findings indicate that RAGC produced with textile mill effluent demonstrated a 25% increase in compressive strength, while effluents from fertilizer and sugar mills showed positive effects on tensile strength, chloride ion migration resistance, and resistance to sulphuric acid attack. The research suggests that these studied effluents can be effectively utilized to create eco-friendly green materials, promoting sustainable and durable concrete for large-scale construction.

Hunag, L. J et al. (2022), This paper explores the properties of Recycled Concrete Aggregate (RCA) and its impact on concrete material properties and structural members. Findings reveal that while replacing natural aggregate with RCA decreases compressive strength, it yields comparable splitting tensile strength. Despite slightly reduced modulus of rupture and elasticity, full-scale beams with RCA exhibit acceptable structural performance, suggesting that RCA is a viable option for structural use, although further testing is recommended to address variations in RCA quality from different sources.

Khoshnava, S. M et al. (2021), This research explores the recycling and reuse of waste concrete aggregate, addressing the significant challenge of construction industry waste in India, amounting to 10-20 million tons annually. The study investigates the replacement of conventional coarse recycled aggregate with recycled aggregate in concrete mixes, analyzing workability, compressive strength, and split tensile strength. Results indicate a reduction in workability with increased recycled aggregate content, while both compressive and tensile strengths exhibit gradual improvement up to 20% recycled aggregate replacement.

Du Toit et al. (2021), This study investigates the incorporation of waste tire powder and waste LCD glass sand as recycled materials in lightweight aggregate concrete, with fly ash and slag as cement replacements. Results indicate that while workability decreased with rubber powder addition, the concrete met design slump requirements. Compressive strength varied with replacement rates, with 10% glass sand showing optimal ultrasonic pulse velocity, and resistivity improving with the addition of recycled materials, highlighting the potential for enhanced durability in lightweight aggregate concrete.

Bribián, I. Z et al. (2020), This study explores the potential of fully hybrid bio-based bio composites as green building materials (GBMs) in comparison to petroleum-based composites, focusing on volatile organic compound (VOC) emissions and human health impacts. Using life cycle assessment (LCA) methodology and small chamber tests, the results indicate that substituting petroleum-based composites with bio composites could significantly reduce indoor and outdoor human health impacts by over 50%, emphasizing the environmental and health benefits of adopting bio composites in construction materials. The findings suggest that bio composites, with their non-toxic, natural, and organic compounds, contribute to improved indoor air quality and overall human health outcomes.

METHODOLOGY

Details of Selected Site

- Moshi in Pune district of Maharashtra.
- City Moshi is situated in the Northwest of the west Indian state of Maharashtra.

Geography

- It lies between 18° 32″ North latitude and 73° 51″ East longitude.
- It is situated in hillock, which allows rainwater to automatically drain out the city.
- Ponds and small rivers act as natural drainage system for the city.

Climate

- City features a Tropical monsoon climate with only minor differences in temperatures between day and night, as well as over the year.
- Maximum average temperature in summer season is 33 °C.
- Minimum average temperature in summer season is 22.5 °C.

- Maximum average temperature in winter season is 29 °C.
- Minimum average temperature in winter season is 20 °C.

Figure 3: Plan, Elevation of Selected Building

CONVERSION TO GREEN BUILDING

Rainwater Harvesting

Figure 4: Rainwater Harvesting

Design of Rainwater Harvesting Plant

Average rainfall in the area = 2806.7 mm = 2.806 m
Area of catchment or roof top = 8.8*9.44 = 83.072 m²
Total rainfall = area * average rainfall
= 83.072 * 2.8
= 259.588 m³
= 233100.03 litres

Runoff Coefficient = 0.7
Coefficient of evaporation, spillage & first flush = 0.8
Total amount of rainfall = 259588.67 * 0.8 * 0.7
= 145.369 m³
= 130536.01 litres

Tank capacity has to be designed for dry period i.e., the period between 2 consecutives rainy.
seasons with monsoon extending for 4 months, the dry season is of 245 days.
Drinking water requirement of a person per day = 10 litres
Drinking water requirement for 3 persons = 3 * 10
= 30 litres/day
Amount of water required for 245 days = 30 * 245
= 7350 litres
Safety factor = 20%
Water required = 7350+20% of 7350
= 8820 litres
Storage tank: Length = 3 m
Width = 3 m
Depth = 1 m

Recharge Pit

Generally
Width = 1m to 2m
Depth = 2m to 3m
Pit filled with pebbles and boulders.
Cleaning is done annually.
Cost of construction = Rs.3000/-

Purification Filters

- Mesh filter (100,500,1000 grades)
- Water purifier

Solar panel system

Power consumed monthly = 5.36 x 30
= 160 kWh
Power consumed annually = 160 * 12
= 1920 kWh
Specifications of system:

- Solar system size = 3.5 kW
- Approximate roof space = 25.5 m²
- Typical cost = Rs.4,00,000 /-
- Typical annual output = 3,000 kWh

Biogas plant

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food Biogas is a renewable energy source and, in many cases, exerts a very small carbon footprint. Biogas can also be produced by anaerobic digestion with anaerobic organisms, which digest material inside a closed system, or fermentation of biodegradable materials.

Biogas is primarily methane and carbon dioxide and may have small amounts of hydrogen sulfide, moisture and siloxanes. The gases methane, hydrogen, and carbon monoxide can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

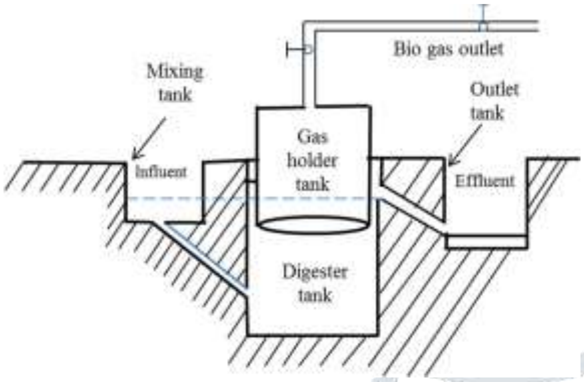

Fig 5: Components of Biogas Plant

Energy Calculation for Cooking

For cooking

For cattle dung maximum gas production per kg = 0.05 m^3

Total gas = Total dung in kg * 0.05

Medium stove uses 9 MJ of energy per hour.

For 3 animals each producing 8 kg dung,

Amount of fuel to run the stove = 8 * 3

= 24 kg dung

= 1.2 m^3

Duration to run the stove of 1.2 m^3 dung = 1.2 * 19 MJ (1m^3 = 19 Mega Joules)

= 22.8/9

= 2.5 hours

Manure of 3 animals (24kg manure) is used as fuel to run the stove for 2.5 hours.

Fig 6: Biogas Plant

Grey Water

It can be defined as any organic wastewater produced, excluding sewage. The main difference between grey water and sewage is the organic loading. Sewage has a much larger. organic loading compared to grey water. Two major benefits for grey water use are:

- Reducing the need for fresh water. Saving on freshwater use can reduce household water bills, but also has a broader community benefit in reducing demands on public water supply.
- Reducing the amount of water entering sewers or onsite treatment systems. Again, this can benefit the individual household, but also the broader community.

Design of Grey Water Filter

As per Manual for Design, Construction Operation and Maintenance.

Following layers are present.

I. 25 cm gravel layer at bottom
II. 10 cm gravel layer at top
III. Two 10 cm M sand
IV. Two 10 cm charcoal layer
V. 60 cm sand at middle

Thickness of layer = 10 + 25 + (2 * 10) + (2 * 10) + 16

= 1.35 m

~ 1.4 m

As per guidelines for greywater reuse in sewered, single household residential premises. For 3 persons per household approximately 339 litres of grey water produce per house per day. To accommodate 339 litres a portion of 0.8 m * 0.7 m *0.7 m is required.

Therefore, total depth of the tank = thickness of layers + 0.7

= 1.4 + 0.7

= 2.1 m

Length of tank = 0.8 m

Width of tank = 0.7 m

CONCLUSION

Environmental Impact: Green building materials generally have lower environmental footprints across all life cycle stages due to reduced energy consumption, resource use, and waste generation compared to conventional materials.

Economic Implications: While initial costs may be higher for green materials, they offer long-term savings through reduced operational expenses and maintenance costs, making them economically competitive over time.

Energy Efficiency and Performance: Green building materials consistently outperform conventional materials in terms of energy efficiency, insulation, and overall building performance, leading to enhanced comfort and lower utility bills.

Social Benefits: Green materials contribute to occupant health and well-being by minimizing exposure to harmful chemicals and pollutants, creating healthier indoor environments.

Barriers to Adoption: Challenges such as resistance to change, limited accessibility, regulatory constraints, and perceived higher costs hinder widespread adoption of green building materials.

Conclusion: Transitioning to green building materials is crucial for sustainable development, offering opportunities to mitigate environmental degradation, improve economic viability, enhance social well-being, and foster resilience against global challenges like climate change. Overcoming barriers through collaboration and innovation can accelerate this transition toward a more sustainable built environment.

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