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Futuristic Buildings In Nigeria: The Concept Of Green Buildings

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Abstract: *As urbanization surges and environmental concerns intensify, the imperative for sustainable construction practices has never been more pressing. This paper delves into the realm of green building practices, with a particular focus on the Nigerian context. Its aim is to explore, evaluate, and advocate for sustainable and environmentally friendly building methodologies, thereby contributing to the broader global sustainability agenda. It presents a comprehensive assessment of green building practices, conducted in the dynamic urban landscape of Warri, Delta State, Nigeria. It draws its strength from an extensive survey of relevant literature and on-site site investigation at the Appropriate Technology Enabled Development (ATED) Center in Warri, serving as the foundation for a holistic analysis. A detailed model design for a 3-bedroom green residential building was done encapsulating the core principles, methodologies, and cutting-edge technologies associated with sustainable construction. From an environmental perspective, green buildings exhibit remarkable reductions in energy consumption, contributing to lower greenhouse gas emissions and responsible water resources management. They further embrace sustainable building materials, minimizing resource depletion and waste generation. Economically, the higher initial investments in green technologies manifest as prudent long-term decisions, evidenced by substantial operational cost reductions and potential property value appreciation. These financial benefits are amplified as energy costs escalate and environmental regulations tighten. Green buildings prioritize occupant health and well-being, employing advanced engineering solutions for enhanced indoor environmental quality. This focus significantly improves air quality, thermal comfort, and access to natural light, ultimately elevating the quality of life and productivity of occupants.*

Keywords: *Environmental Perspective, Green Building; Greenhouse Gas, Sustainable Construction*

I. INTRODUCTION

In the upcoming decades, Nigeria is expected to undergo a significant increase in the construction of green or sustainable buildings, mirroring the growing trend in the country's construction sector towards high-performance structures. Sustainable construction operations strive to avoid energy, water, and raw material depletion while concurrently mitigating environmental damage throughout the lifespan of facilities and infrastructure (Nordic African Research Institute, 2019). Nigeria is progressively adopting effective waste management systems, utilizing renewable building materials, and optimizing project design facilities to achieve biophysical sustainability (Nwokoro and Onukwube, 2011).

To comprehend the necessity for sustainable building practices in Nigeria, it is imperative to explore the prevailing landscape of conventional buildings, which have historically been the cornerstone of development in the country. Human activities, particularly in construction, exert immense pressure on the environment, exacerbating numerous environmental problems (Celik et al., 2013). Conventional building methods generate substantial waste, consume large amounts of energy and natural resources, and often exhibit higher energy demands due to outdated systems and inefficient practices (Swapinil, et al., 2022).

The challenges posed by conventional buildings are notably evident in their tendency to generate harmful wastes and emissions, significantly contributing to environmental degradation (Swapinil, et al., 2022). The lack of holistic consideration for sustainability principles in their design and construction leads to missed opportunities for incorporating water efficiency, waste reduction, and environmentally friendly materials.

In response to the environmental challenges posed by conventional buildings, green building principles emphasize the use of organic building materials made from natural resources, such as wood and bricks, to minimize harm to the environment (Daramola et al., 2012; Nduka and Ogunsanmi, 2015; Liu, 2022). Embracing green and sustainable concepts in design aims to reduce energy and maintenance costs, enhance the well-being of occupants, and increase overall building efficiency (Rina, et al., 2023).

While various researchers have underscored the advantages of green buildings over conventional structures (Ajayi, et al., 2023; Opoko, 2022; Zhang, et al., 2019; Girgiri, et al., 2021; Imakwu, 2022; Cao, et al., 2022), gaps in the understanding of the subject persist. Previous studies may not have comprehensively addressed certain aspects of green building practices, necessitating further research to contribute to the evolving field.

The identified gaps in existing research include a limited focus on specific environmental aspects, insufficient attention to the cultural context, limited exploration of technological innovations, lack of longitudinal studies, inadequate assessment of economic viability, and limited exploration of policy and regulatory frameworks. Addressing these gaps through rigorous and interdisciplinary research efforts will contribute to a more comprehensive understanding of green building practices, facilitating the development of effective strategies for sustainable construction in Nigeria and beyond.

This research aims to address significant gaps in understanding and awareness of green building practices in Warri and Nigeria. The identified gaps include a lack of awareness among the populace regarding the advantages of green construction, the perceived complexity hindering adoption, and limited recognition of the transformative potential in terms of environmental sustainability, economic viability, and occupant well-being. By highlighting these gaps, the study endeavours to contribute to widespread education and awareness, fostering a more informed and receptive approach to green building initiatives in Nigeria. The ultimate goal is to bridge these gaps and promote a sustainable, eco-conscious future for construction practices in the region.

II. MATERIALS AND METHOD

A. The Study Area

In South-South Nigeria, the city of Warri, depicted in Fig. 1.0, serves as a hub for oil production and is home to a branch of the Delta State Government House. The city lies at coordinates 5°34'47" N, 5°41'28" E. It has a population of 311,970 and functions as the state's commercial hub. The region experiences monsoonal weather with dry and wet seasons, moderate levels of rainfall, and humidity. The area has a tropical monsoon climate, characterized by an average yearly temperature of 32.8°C and 2970mm of precipitation. It typically ranges between 28 and 32 degrees Celsius. The predominant land cover in the area consists of swampland and rainforest (Swapnil, D.S; Mayuri, S.K; Prithviraj, S.D; Rutuja, G; and Rahul, K. (2022).

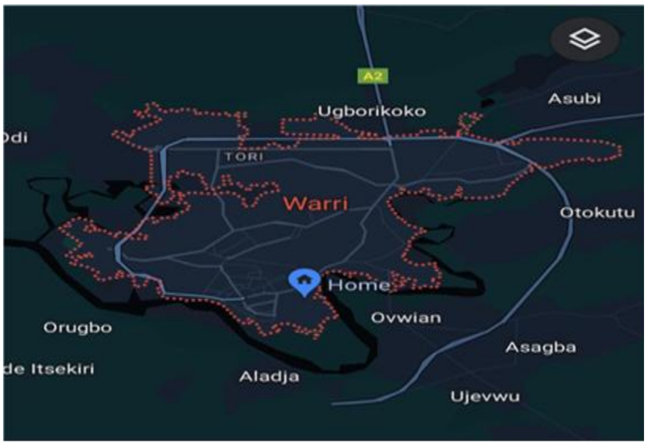

Fig.1 : Google map of Warri City (EDC), PIND-EDC Drive, Egbokodo-Itsekiri, Warri, Delta State, Nigeria

B. Site selection and investigation

The site selected was The Appropriate Technology Enabled Development (ATED) Centre Fig. 2. The Centre is situated at the premises of PIND's Economic Development Centre. The site was selected for consideration and investigation for a green building research due to its unique features and potential for contributing valuable insights to the field. As an existing green building, it provides a real-world example of sustainable construction and energy-efficient technologies, offering a practical case study for researchers to analyze its performance and impact on the environment. Additionally, the site's innovative design, use of renewable resources, and sustainable practices make it ideal for studying the long-term benefits of green buildings and their potential to reduce carbon footprints. By studying this site, it was aimed to identify best practices that can further promote eco-friendly construction and inspire future sustainable projects.

The Appropriate Technology Enabled Development (ATED) Centre building attains a 75% reduction in energy consumption compared to conventional buildings. Achieving this goal involved modelling the building based on the passive house design concept, ensuring year-round thermal comfort with minimal energy expenditure. The ATED Demonstration Center project has engaged local contractors and national and international advisors to create a unique, energy efficient building that also use renewable energy sources. It provides an opportunity to experience firsthand what an energy efficient building can be like. Leveraging on this investment has enabled them to share in their knowledge, raise awareness, gather data and motivate change in attitudes and practices in the construction trades, in consumer demand, and in government policies.

Fig. 2: Google Map Location of PIND Foundation (PIND-EDC Drive, Egbokodo-tsekiri, Warri, Delta State, Nigeria)

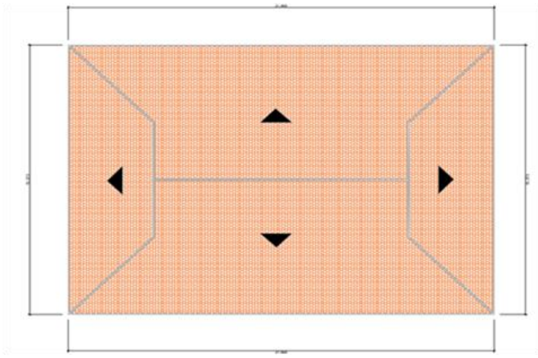

Fig. 3b: 2D Roof Plan

C. Features of the ATED Centre

A Biodigester which converts human and food waste into gas for cooking as shown in Fig. 4f. A Solar water heater which helps to trap energy and heat up water for use in the kitchens Fig. 4d. Hydraform blocks which provide cooling Fig. 4a, b, c, and g . Rainwater harvesting system as shown in Fig. 4d. Solar panel to complement the traditional power sources (Fig.4e).

D. Model Preparation

The research model of the building was prepared in ArchiCAD 2D as well as 3D home deluxe with Renewable energy resources implemented in its modelling. Presented below are the simulated models.

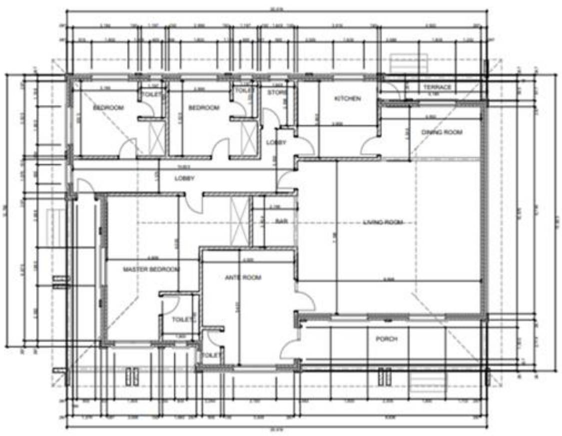

Fig. 3a: 2D Layout Plan

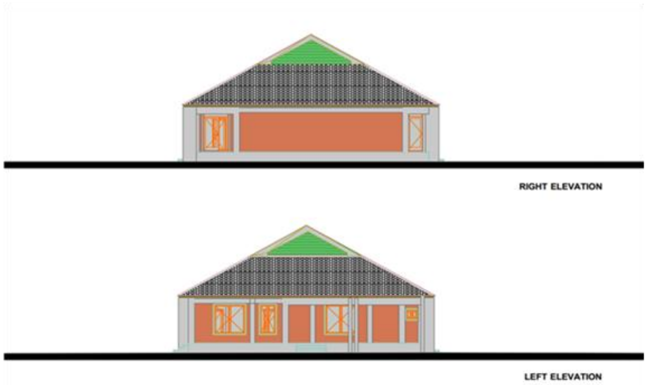

Fig. 3c: 2D Right and Left Elevation

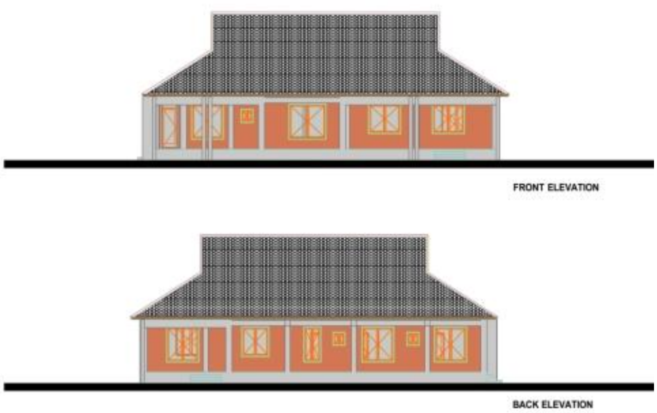

Fig. 3d: 2D Front and Back Elevation

Fig. 3e: 3D View

III. RESULTS AND DISCUSSION

A. Finding from Site Visit

Conducting an on-site visit to a green building situated in Warri provided an opportunity for first-hand exploration of the innovative technologies and features integrated into sustainable construction. Throughout the visit, a thorough examination of the building's infrastructure was carried out, and insightful interviews were held with the Director of the Energy Department, who oversees the site's sustainable initiatives. These immersive experiences proved instrumental in acquiring practical knowledge and fostering a deeper appreciation for the intricacies involved in the design and implementation of green buildings. Utilizing these valuable insights, a detailed 2D and 3D model of a green building was meticulously crafted, serving as a tangible representation of the principles explored throughout this study.

B. Discussion of the Features

Exploration of various elements, including the structure, roofing, insulation, airtightness, air quality, windows, hydroformed bricks, renewable energy, biodigester and Rain Water Harvesting System see Fig.4, was undertaken to assess their collective impact on enhancing the overall efficiency and comfort of the building. The goal was to scrutinize their applicability in diverse construction contexts, with the aim of inspiring cost-effective innovations suitable for adoption in the Niger Delta region and across Nigeria.

a. Structure Side view *b. Structure Front view*

c. Roofing and brickworks *d. Water supply and storage*

e. Solar panels *f. Biodigester*

g. Porch and windows and ceiling *h. Reception area*

Fig. 4: Features of ATED Centre

(a.) Structure

Unusually large overhangs shade the verandas and walls Fig. 4 a, b and c. The walls stay cooler, so less energy is required to cool the air inside.

(b.) Roofing

The roof has large vents and the ceiling over the verandas is open Fig. 4 c. Screening keeps out insects and rodents, yet air can easily travel through. With fresh air, the temperature inside the roof is close to the temperature outside. Daytime temperature underneath the average metal roof in Warri can exceed 70°C, which heats air in the house. Keeping the roof space cooler means less mechanical cooling to keep everyone comfortable. The building positioning helps the venting system by capturing the prevailing wind as it flows across the site.

(c.) Insulation

Insulation has been used in the ceiling and walls Fig. 4c, g and h , acting as a barrier to heat transfer. Just like your home freezer, which has insulation in its walls to keep the cold in and heat out, insulation in the ceiling and walls of this building keeps the cool in and heat out.

Once you cool the air, it will stay cooler for longer, reducing energy consumption for air conditioning. BASF polyurethane spray foam was used to insulate and provide an airtight barrier, keeping cooled air inside, and reducing the need for air conditioning.

d.) Airtightness and Air Quality

Airtightness sounds unusual, but it makes sense. The interior of the building is as airtight as possible to keep hot, moist air from sneaking in, and cool, dryer air from leaking out.

This building has a very efficient air exchange system. Outside air is brought in, slightly cooled, and dehumidified before being circulated throughout the building. Exhaust air is returned outside, but its coolness and dryness are captured on the way out.

(e.) Windows

Windows should radiate light into the interior without bringing in heat Fig. 4c and g. Large, better-quality windows use double glazing with inert gas in between, to keep heat out and cool in, while brightening the interior. This has added value of reducing need for electric lighting. All windows can be opened to take advantage of seasonal and daily changes in weather. All three innovations also cut sound transmission creating a quieter work/living space.

(f.) Hydraform Bricks

Hydraform blocks were used to build the walls Fig. 4a, b, c, d ,g and h . They are made of locally available laterite (90%) and a bit of cement (10%). Simple hydraulic forms compress the laterite and cement to make attractive, long-lasting, and environmentally friendly building blocks. In terms of thermal insulation, they are three times as efficient as concrete blocks and twice as efficient as fired clay bricks.

(g.) Renewable Energy

The power system for this building is a mix of solar, wind, conventional electricity, and back-up diesel generator Fig. 4g. Solar panels offer a reliable complement to traditional power sources. Solar and wind power are renewable sources: energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat.

(h.) Biodigester

This project also has a biodigester Fig. 4f. The bio-digester can be used with flush, pour-flush or dry toilet takes human and organic waste from the site and breaks it down in an airtight chamber. From this comes biogas (used in the canteen to cook) and fertilizer (used on the site to enrich the soil). The bio-digester also captures the methane gas released during the composting process. The biofuel produced by the digester can be used to generate energy, cook and provide lighting. Turning waste into fuel is another example of conserving precious resources.

(i.) Rain Water Harvesting System

Rain Water Harvesting is a simple appropriate technology for collecting rain water in terrains with scarcity of water supply Fig. 4d. At the ATED Centre, it is directly piped to flush toilets.

In conclusion, the ATED Centre stands as a practical and real-world example of sustainable construction practices and energy-efficient technologies, serving as a valuable case study for researchers and a beacon of sustainable development in the green building field. The ATED Centre aligns with numerous LEED Indoor Environmental Quality (IEQ) requirements, prioritizing the health, comfort, and well-being of its occupants

IV. CONCLUSION

This study highlights how green building practices, through innovative designs and technologies, create indoor environments that are conducive to occupants' health, comfort, and overall well-being, making a strong case for their adoption in both residential and commercial construction.

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