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FURTHERING THE LOW CARBON BUILDING EFFORTS IN EDO NORTH OF NIGERIA

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Abstract: Threats to environment due to global warming have made control of carbon emission a subject of recent research. Low Carbon Buildings (LCB) is grouped as buildings designed such that materials, construction and uses shall be with minimum release of carbon or no-carbon. Earlier researches identified relevant factors as proper building design considerations, choice of material, construction process and services. This paper applied these factors to a model of Low Carbon residential development in a tropical environment, Auchi in Nigeria. Background studies were conducted, which include site analysis, microclimate and case studies. Appropriate alternative energy was identified and used for the model. The results were translated into architectural design decisions and concept presented in Architectural drawings as a model of low carbon building in a developing tropical environment.

Keywords: Low Carbon Building, Compressed Earth, Energy, Sustainability.

1.0 INTRODUCTION

Buildings play important role in the reduction of carbon dioxide (CO_2) emission, which is a major green-house gas thereby mitigating climate change (Jennings et. al. 2011). The building sector accounts for 39% of carbon dioxide emissions from fossil fuel in the United States per year, more than any other sector (USGBC 2016); (USDOE 2008). The inter-governmental panel on climate change identified buildings with the greatest potential for carbon reduction, particularly because reduction that result from improved building performance also yield substantial economic benefits (Metz et. al. 2007). The emission of carbon from building is increasing on daily basis, this is as a result of the operational activities and choice of building material or method of construction. Orszag (2007) identified two main effects for limiting CO_2 emissions; it would affect the immediate economic costs as the use of fossil fuels decreases, also long-term economic benefits would appear as environmental harm is alleviated.

Measures to reduce green-house gas (GHG) emissions from buildings fall into one of three categories; reducing energy consumption and embodied energy in buildings, switching

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to low-carbon fuels including a higher share of renewable energy, or controlling the emissions of non-CO_2 green-house gases. Renewable and low-carbon energy can be supplied to buildings or generated on site by distributed generation technologies. Steps to decarbonize electricity generation can eliminate a substantial share of present emission in buildings.

Studies conducted by Centre for Climate and Energy Solutions (C2ES 2017) analysed Building related emissions in respect of Embodied Energy, Building design, Building envelope, on-site or distributed generation, Energy end uses in buildings and other Building Services (Lighting, Space heating, Cooling and Air conditioning).

Embodied Energy – Keefe (2005) compiled from various sources, the embodied energy consumption of selected building materials. Cement, for example, is one of the major material used extensively in Nigerian building construction industry. The manufacturing process requires high amount of heat and hence high emission of CO2. The replacement of materials that require significant amount of energy to produce (such as cement, concrete and steel) with materials requiring small amount of energy to produce (such as earth brick, wood products) will reduce the amount of energy embodied in buildings.

Building Design and material – The size and arrangement of internal spaces in relation to the microclimate; size and arrangement of openings and overhangs etc., are building design decisions that can help determine the amount of lighting, heating/cooling a building will require. Architects are being creative and resourceful in developing natural lighting and heat efficient buildings (USDOE 2009). The building envelope separates the Interior from the Exterior. The choice of material and components shall be done with a focus on minimising heat transfer through the building envelope. According to Glavind (2009), the production of 1 kg of cement generates approximately 0.8 – 0.9 kg of CO2 emission. In contrast, compressed earth wall has the merits of sustainability - environmentally friendly, low cost, heat insulation, etc (Minke 2000); (Real 2010).

Energy, Building Services and equipment – Carbon emission released through electricity consumption is one of the biggest contributor to climate change and these emissions are through gadget/equipment/apparatus. Measures to reduce green-house gas (GHG) emissions from buildings include reducing energy consumption; switching to low-carbon fuels including a higher share of renewable energy. Renewable and low-carbon energy can be supplied to buildings or generated on site by distributed generation technologies. Low Carbon Energy uses in buildings is enhanced by the use of efficient

technologies. Building services and equipment that are based on renewable energy like solar energy is desirable.

In summary, a significant share of carbon emission, in the built environment can be avoided through architectural design decisions, material choices and methods that are energy efficient. A special attention need be given to building envelopes, heating and cooling systems, hot water heating, lighting and appliances.

On the background of the foregoing, this research aims to study the existing efforts in Low Carbon Buildings in Edo North of Nigeria and develop a model of low carbon residential building as a sustainable housing option in tropical environment of Auchi in Nigeria.

2.0 MATERIALS AND METHODS

The Federal Government of Nigeria in collaboration with the French Embassy established the Centre for Earth Construction Technology (CECTech) in the National Commission for Museums and Monuments, with the aim of promoting earth construction in Nigeria (Lamort 1993). The low carbon building effort in Edo north have been focused mainly on open planning architectural design to reduce energy required for air conditioning, the use of 'soil' for wall construction, and alternative energy (mainly solar energy).

Architectural Case studies of building of similar objectives were conducted in Edo North. It is important to observe that no building in the locality has a full low carbon consideration. We were however attracted to buildings that aimed to reduce energy with open planning design, used none or low cement material (like compressed earth) as wall envelope and alternative energy installations. Two buildings were identified i.e. Community Social Centre of Mary the Queen Catholic Church, Ekpoma; and Office building for Construction Engineering Company, Ekpoma. The two buildings were studied and presented with basic architectural design drawings.

A model project aimed at furthering the efforts of low carbon building in Edo North was proposed to combine earth wall and tap the abundant solar energy that is readily available in the area. The focus of the model was mainly on Architectural Design with due consideration of the microclimate for natural lighting and ventilation, material of wall construction, alternative energy source.

The project is located in Auchi the administrative headquarters of Etsako West Local Government Area of Edo State in Nigeria. The location of the project along the Auchi-Aviele axis of the town makes it easily accessible and can be sighted from the Benin-Okene expressway. The soil of the site is the Aviele laterite soil, which was analysed by Egenti et

al. (2014) with Liquid (LL) of 33, Plastic Limit (PL) of 18, and Plasticity Index of 15. The result of other analysis, like particle size distribution and shrinkage limit, confirmed the suitability of the soil for Compressed Earth Block (CEB) production and construction. The micro-climatic conditions are always of high temperature, mean maximum monthly temperature are in the range of 39°C to 29°C. The wind blows from south-west to north-east from March to October, and vis-visa in November to February. Relative humidity falls between 55% and 90% in wet and dry seasons. The site analysis in respect of sun and wind movement is shown in Fig. 1.

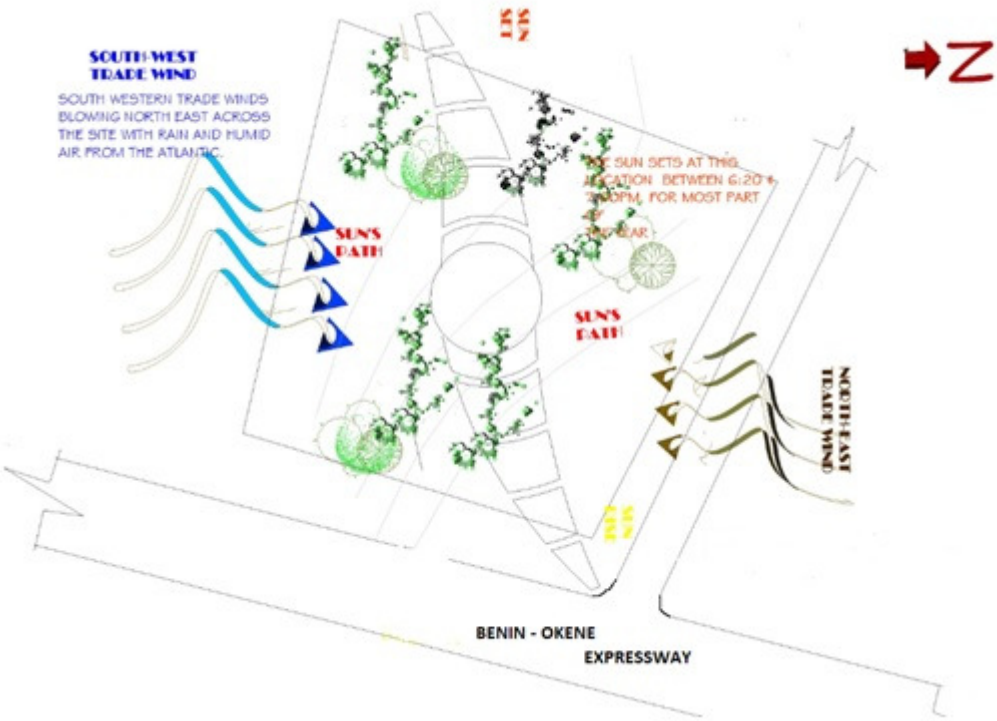

Fig. 1: The analysis of Site in respect of Sun and Wind movement

The proposed low-carbon building is designed to provide adequate natural lighting and ventilation for the occupant. The design is intended to minimize the rate of embodied carbon from buildings.

3.0 RESULTS AND DISCUSSIONS

3.1 Case Studies

The results and discussions of the two case studies carried out in Edo North were to create background information upon which the course of Low Carbon Building can be advanced in the locality.

3.1.1 Community Social Centre of Mary the Queen Catholic Church, Ekpoma

Community Social Centre of Mary the Queen Catholic Church (MQCC), is located along Ukpen road in Akahia, Ekpoma, Edo State. The Centre, which was built with the assistance of Irish ambassador to Nigeria, was completed in July 2002. The building has an event hall and offices on the ground floor; and a conference hall and bedrooms on the first floor as shown in Figures 2 and 3. The front and side views are shown in Figures 4 and 5.

The Architectural design is with extensive fenestrations for adequate natural lighting and ventilation. The walls/building envelope is of Compressed Earth Block (CEB). External and Internal faces of walls are in the natural brick condition without an application of plaster. The walkway surrounding the conference hall protects the interior from the hatch tropical sun. The building is framed structurally with reinforced concrete (RC) to sustain the span and the dead load of reinforced concrete upper floor. The choice of louvre window was appropriate as it allows full opening of windows with obstruction of the walkways. The interior of the building is relatively cool.

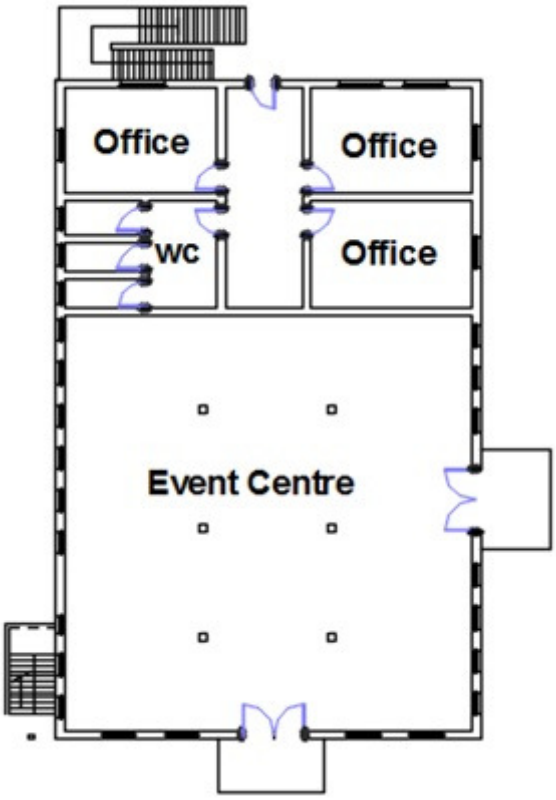

Fig. 2: Ground floor plan of Community Social Centre of MQCC, Akahia Ekpoma

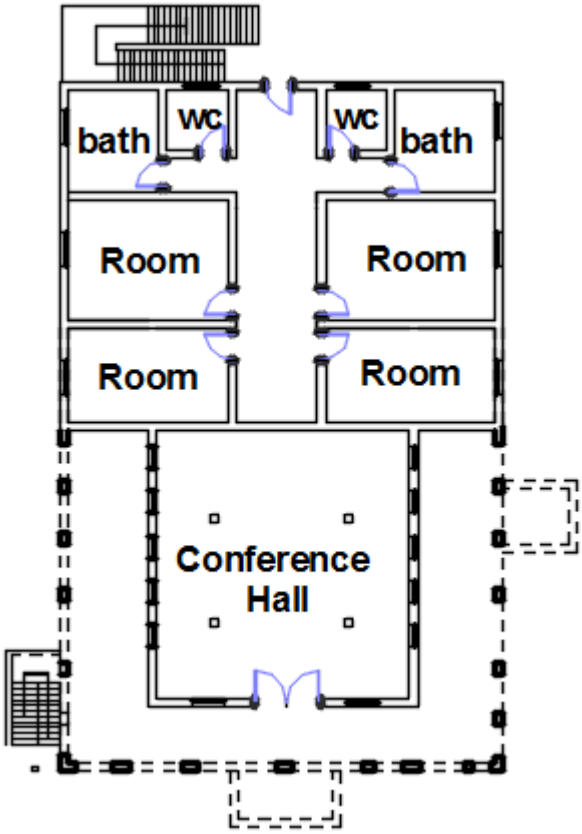

Fig. 3: First floor plans of Community Social Centre of MQCC, Akahia Ekpoma

Fig. 4: Front view of Community Social Centre of MQCC, Akahia, Ekpoma

Fig. 5: Side view of Community Social Centre of MQCC, Ekpoma

3.1.2 Office building for Construction Engineering Company, Ekpoma

A small Office building in the yard of Construction Engineering Company in Ekpoma is built with compressed earth. The gatehouse and store house in the yard were all built of compressed earth. The floor plans and views are shown in Figures 6, 7 and 8. The large windows of 1.8m x 1.2m provide adequate lighting and ventilation. Interior of building is relatively cool with no air-conditioning. The use of Compressed Earth was extended to external flooring with compressed earth interlocking tiles. This had a positive effect on interior temperature as a result of reduction in external heat radiation. The building is architecturally pleasing. Long span aluminium was used to cover a fairly voluminous roof space.

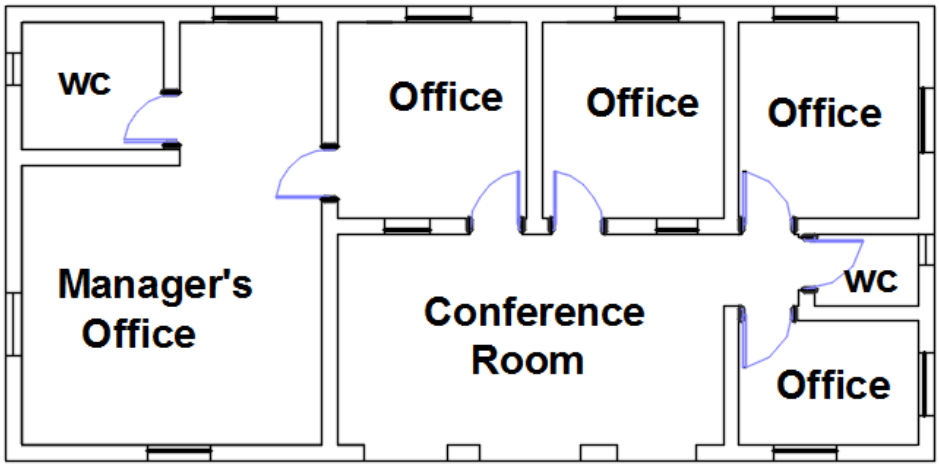

Fig. 6: Floor Plan of Office Block

Fig. 7: Front view of construction engineering yard, Ekpoma

Fig. 8: Front view of construction engineering yard, Ekpoma

3.1.3 Alternative Energy

In the area of alternative energy pilot projects have been initiated and implemented in Edo North of Nigeria, by governmental agencies and politicians using solar energy. Efforts have been concentrated only on the use of solar energy for street lighting. Auchi Polytechnic, Ambrose Alli University, Ekpoma and Politicians have made a mark in this regard. It is expected that efforts shall be extended to domestic house uses.

3.2 A model to further the Low Carbon Effort in Edo North

The Model is a six-bedroom family bungalow home including ante-room, living room, family bedroom room all en-suite, two guest rooms, dining, kitchen space, power house where battery and inverter are stored. The Floor plan (Fig. 9) shows twin bedrooms

arrangements projecting into external space for lighting and ventilation. Two sides of each bedroom have the advantage of direct access to external environment. The same arrangement applies to the master bedroom, living room and kitchen at the rear of the building. The above named spaces were connected by lobbies in the central core of the floor plan. Roof vents (Fig. 10) were provided to allow escape of warm and used air; fresh air comes from windows. All liveable spaces are properly ventilated with wide windows (Fig. 11), which help to allow in and take out air.

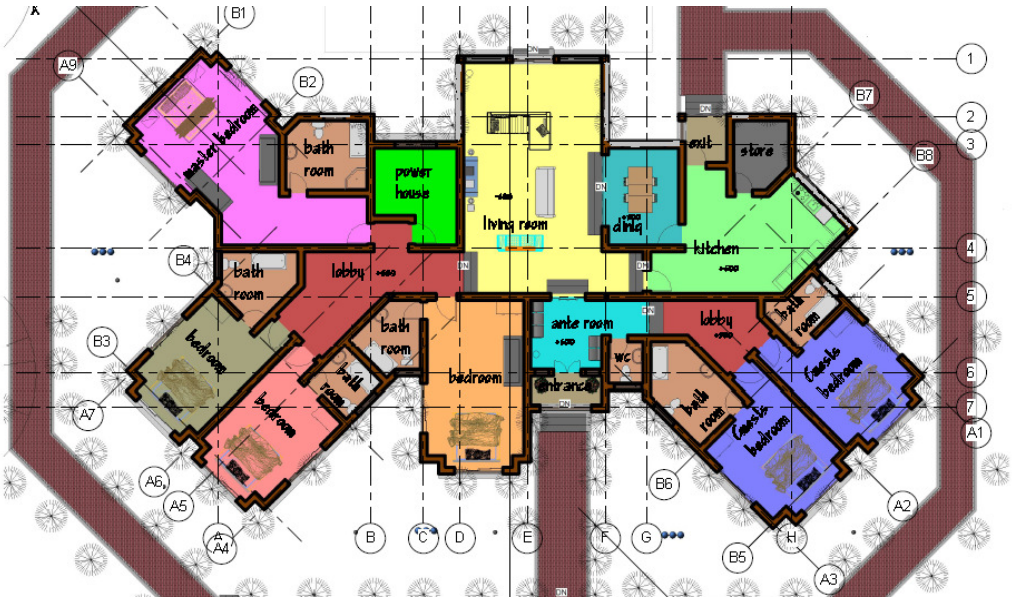

Figure 9: Floor Plan of Model

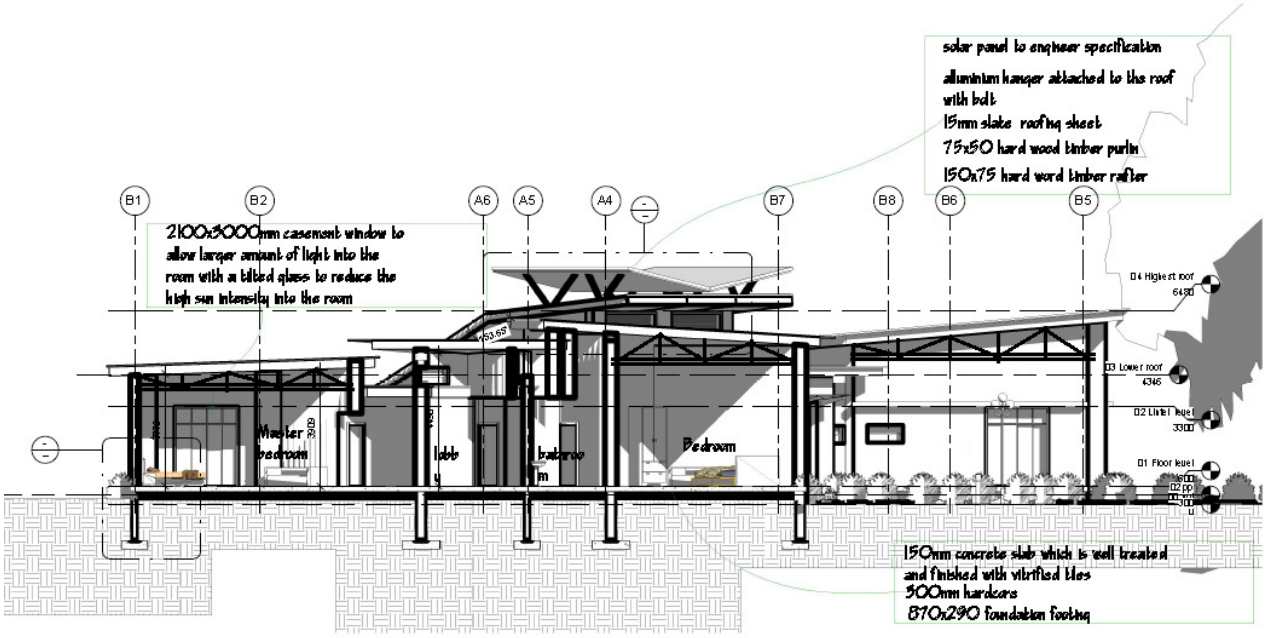

Fig. 10: Section through the bedrooms

Fig. 11: Front Elevation

Walls are constructed with compressed earth bricks. To ensure proper lighting in the building fixed light were placed on the top of the walls to allow light into the lobby, and also a skylight was introduce on the roof of the living room to provide adequate daylight into the building thereby reducing the use of artificial lights. The entrance of the building is on the North side of the building under the translucent overhanging canopy of flat roof and with shrubs at the entrance, which present an atmosphere of nature.

The effect of natural lighting was duly considered within the building, large fenestrations were provided within each space for effective luminosity, the use of skylight in the living room brings in natural daylighting – a marriage of exterior and interior. Also fixed window at the side of the wall also help to provide natural lighting to the lobby. Artificial lighting will be in the form of energy bulbs of fluorescent luminaries with purpose-made reflectors, which will maximize direct light to the space, and this artificial light will be powered by solar panels, which are attached to the roof-top of the building.

Large air space and adequate openings are some design strategies put in place to achieve proper ventilation within the building. The use of stack effect ventilation in the living room help to provide natural ventilation for that space.

Thermal control within the building is largely achieved through the masonry material used for wall construction, which is compressed earth brick with thickness of 290mm, passively, temperature control is achieved via the orientation of the building on site in the north-east direction. Roofs are simple ventilated pitch roof.

Electrical energy is supplied to the building by a system of solar panels mounted on the roof and linked to storage batteries in the power house, which is incorporated in the building.

Points of aesthetic interest in the design are the design façade, the use of recesses and fenestration and wide glass as spicing on the elevations.

4.0 CONCLUSION

The effort in Edo North towards low carbon buildings has been minimal with less focus on residential development. A model of a residential development was proposed in Auchi where natural materials (compressed earth dug from the site) was used for walls; natural lighting through adequate openings, natural cross ventilation (horizontal and vertical); and artificial lighting at night, from solar power installation. It is expected that the execution of this pilot project (in Edo North) should sensitise developers in the environment to appreciate and embrace the course of modern research efforts in low carbon building.

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