Appraisal of Timber as Structural Members for Residential Buildings in Nigeria

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Abstract **- Concrete and sand crate blocks are the most common construction materials adopted for residential buildings in Nigeria. They are used in the form of reinforced concrete frames and sand crate block walls. These heavy weight materials are mostly assembled on site by bricklayers or masons. The high demand for these construction materials and the intensive labour required for site placement have led to high cost of these materials and consequently to general high cost of construction in Nigeria. These facts contribute to making the access to good housing by common man very difficult. It therefore becomes very obvious that alternative means of construction should be explored and implemented in order for the average and below average Nigerian citizen to have a decent roof over their heads.**
Based on the rapid advances in the construction materials technology over the recent years, civil engineers have been enabled to produce new solutions of built structures to serve the common needs of society. In that line, this research work seeks to provide an alternative solution in timber as a load bearing member for affordable residential buildings in Nigeria. A case study of 5-bedroom duplex is presented. A concrete design with Orion R16 software and a manual timber design are produced for the building with the corresponding bill of quantities. The comparative studies show that the application of timber as a structural members will help to drive down the cost of residential buildings in Nigeria and make them affordable to common man.

Index Term **- Timber, Concrete, Structural Elements, Affordable Homes.**

1. INTRODUCTION

The technological advancement of every age has a lot to do with the quality of materials available for that age. As the world has transited through the primitive age to the Stone Age, through industrial age into the current information/knowledge worker age, so have the dominant construction materials changed through the ages from earth to wood, to stone to concrete, to steel to FRP composites etc. Although the traditional materials continue to be in use over successive ages, the technological advancement made in every new age depends most on how these materials are combined to the advantage of the society in terms of safety, economy and functionality of built structures. In the last 200 years, rapid advances in construction materials technology have enabled civil engineers to achieve impressive gains in the safety, economy, and functionality of structures built to serve the common needs of society. Through such gains, the health and standard of living of the members of the society have greatly improved.

Generally, the provision of affordable housing for low income workers in developing countries has become a cause for concern for Governments. This problem is very acute in the urban areas with the continuous drift of the masses from the rural areas to the urbanized areas in search of greener pasture.
Nigeria has the largest population and is the second largest economy in Africa [1]. With an estimated population of about 170 million, population growth rate of about 2.55%, GDP growth of 6.81% and annual urbanization rate of change of 3.5%, the nation is in dare need of affordable homes for the teaming population.
As one of the fastest growing economies in the world, it is saddled with so many on-going projects, both technological and infrastructural, executed by Governments and by the private sector, in the form of small scale and large scale projects, all competing to meet up with the high demand created by the nation's large population and the high rate of rural-urban migration. Not minding all the efforts that have been put in place and the massive urbanization taking place, the ultimate goal of making affordable houses available for the masses remain mirage due to high cost of building materials. This high cost of building materials have been severally confirmed by many researchers as the leading cause of sharp practices that have been responsible for the frequent building collapse that occurs in Nigeria [2], [3]. It must be known that over 95% cases of collapsed building structures verified in Nigeria over the years involved concrete and sand crate block structures. This must not be unconnected to the limited ductile behaviour of sand crate blocks which very often are exposed to absorbing excessive loads. The vast variation of the properties of concrete is another great problem to contend with. Every proportion of the components of concrete including the aggregate size has an enormous effect on the quality such that the general compressive strength is very easily compromised [4].
Faced with the escalating cost of conventional building materials, most often imported into the country with hard earned foreign exchange, there is urgent need to explore new idea that seeks to encourage the adoption locally available building materials which will lead to cheaper rural and urban structures accessible to the masses. The good news is that the nation is highly blessed with abundant timber which has not been maximally utilized to the nation's advantage. Nigeria is highly enriched with a surplus supply of timber, with various species of trees that are suitable for construction. The locally-grown timber for building construction can be easily obtained from the available sawmills. This method of construction also

presents environmental advantages and since the superstructure is light, the use of concrete or brick columns as support foundations at the edges of the building is made easy.

Currently in Nigeria, timber is principally adopted for short span roof trusses on sand crate block/concrete buildings. But the problem today is that persistent adoption of the old and traditional approach of building construction is not capable of meeting up with the high demand of the society. In North America, Scandinavia and other developed parts of the world, timber is predominantly adopted as load bearing elements for residential buildings due to the material's economy, high speed of erection, dryness of form and less site activities and other good factors that drive down the cost of buildings. This is one of the reasons for easy access to private homes in these nations. As globalization have opened new frontiers in knowledge and broken barriers between nations on technological transfer, Nigeria must start taking the opportunities of copying good construction procedures from other countries and start exploring new building construction standardization arising from adoption of uniform international standards [5]. In the process of adopting new materials and technology, the people in charge of selection, specification, and quality control have the responsibility of ensuring that these materials meet certain classes of criteria or material properties [6].

Not to be forgotten is that timber structures are environmental friendly and contribute less to the Global Climate warming. As we fell down the trees for construction we can plant new ones thereby maintaining eco system equilibrium.

With the general evolution of construction process worldwide, there are many innovations for timber material. With the invention of engineered woods like Glue-laminated timber, Structural Composite Lumber, Laminated Veneer Lumber, etc. timber can now be used for various building elements. Timber is a renewable material, vastly recyclable, can be pre-fabricated, and has good thermal insulation properties, among many other desired properties which make timber stand out as a good material which can be easily adopted for building construction on a large scale in Africa. With the rapid depletion of the ozone layer and the daily increase in global warming, it is inherent that we seek ways to reduce the use of construction methods and materials which are harmful to the environment. The extraction and production of non-renewable materials for construction and urbanisation have been one of the principal causes of global climate warming [7]. The materials presently used in the Nigerian construction industry, concrete in particular is dangerous to the environment and contribute daily to the depletion of the world natural resources and to the global warming. Timber is an environmentally friendly material and will be more appropriate for the building construction if we are to reduce the effects of global warming. As a construction material, timber also has the lowest embodied energy when compared with other materials meaning that the amount of work put in timber construction is very low.

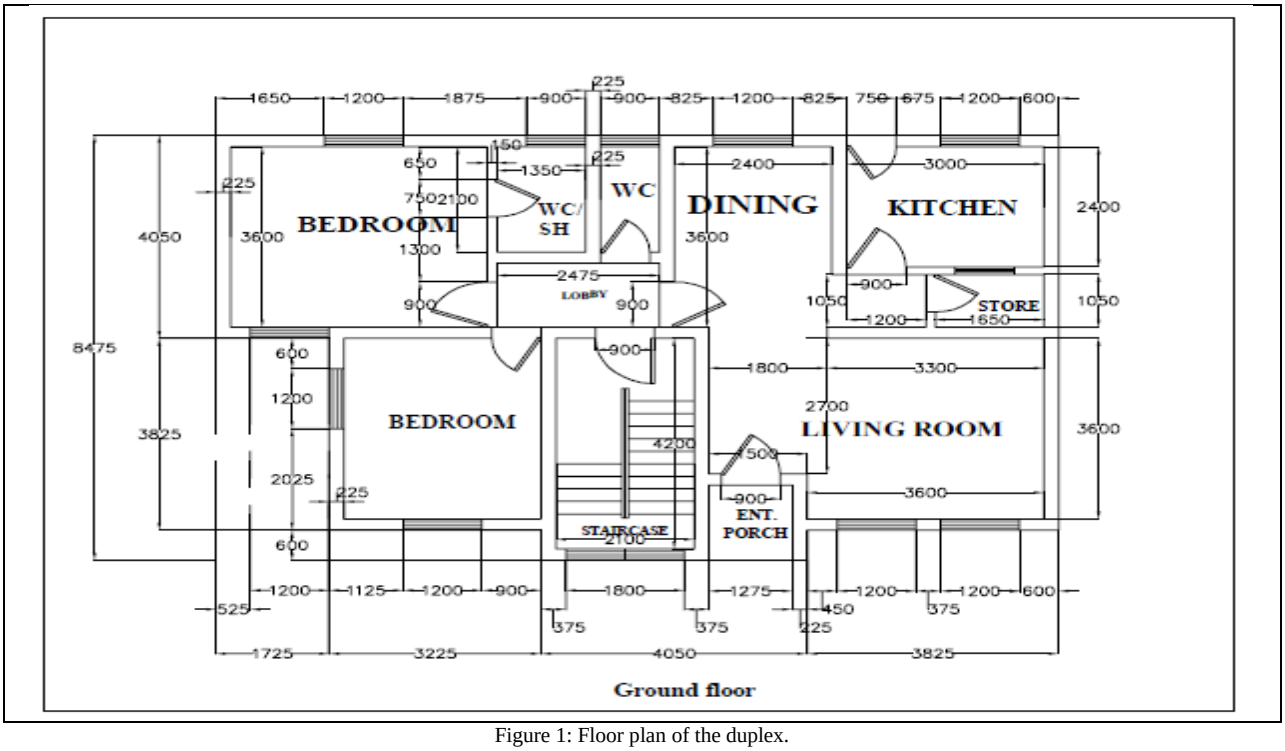

Figure 1: Floor plan of the duplex.

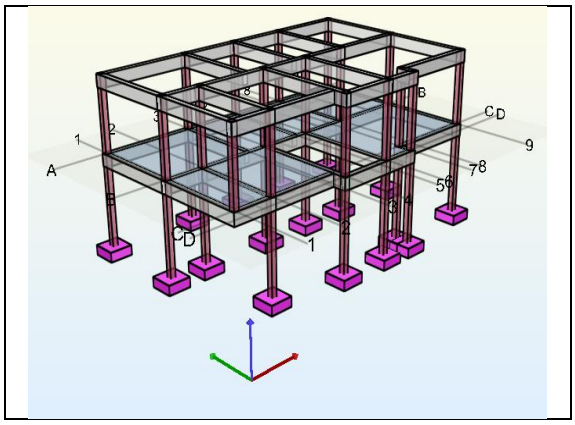

Figure 2: A 3-D view of the Orion modeled building before analysis.

Given all the new advances in material technology and the new frontiers that have been opened to us, it has become imperative to research into the possibility of adopting timber framed structure as alternative to the traditional methods of construction in Nigeria. This research therefore explores the possibility of providing a reliable alternative to the labour intensive/environmentally not friendly concrete technology that has been predominantly adopted in the Country for residential building construction, especially for low cost housing programs needed to curb the acute housing deficits.

2. MATERIALS AND METHODOLOGY

2.1 Research procedure

The various works done in this research for both designs and analysis of the residential building consist of the following:

- Development of structural model for the major components (i.e. the slabs, beams, columns) of the building using AutoCAD.
- Concrete design with Orion R16 software while manual design was carried out for the timber.
- Analysis of the quantity of materials used in both models.
- Cost analysis of each model and their comparison.

The floor plan of the building is shown in figure 1.

2.2 Analysis and Design

2.2.1. Concrete Design

The structural design for concrete was done according to BS codes. The load cases considered for the design are dead loads and imposed loads as specified by the British Standard BS8110 [8] and linked to other British Standards BS 6339 (1996) and BS 648 (1964). Orion R16 software [9] was used for the design and analysis. Guidelines for the design of concrete structures to BS8110 and for the design of timber elements to Euro code [10] were followed. The design methods were based on the limit state principles of which the two principal categories considered are the ultimate and serviceability limit states. The characteristic strength of concrete adopted was 30 N/mm^2 while high yield strength steel of 460 N/mm^2 was used for reinforcement. Cover concrete for steel reinforcements in slabs and column was 25 mm while that of beams was 30 mm. The unit weight of partitioning sand crate blocks was 4.5 kN/m^3. The storey heights were 3.0 m, slab depth was 150 mm, beams sizes were 250 x 500mm and the column sizes were 225x225mm. A new design in Orion starts with identifying the height and the number of stories. After importing the model from Auto card, the grid was selected and the columns located in appropriate positions. The beams and the slabs were positioned. Their sections were then added. After these basic modeling you go into the building analysis. Under pre-analysis, you edit the load combination, the concrete grade, steel grade, unit weight of concrete and unit weight of blocks. In the analysis stage, you check the building model to see if there is any error. Then you check the sections and then you select the steel bars. The software will then control the acceptability of your selections and make some suggestions if necessary. The next step is then to run the analysis. After the analysis, the software will produce results which can be good (green color), fairly good (yellow color) and failed design (red color). The fairly good results are still acceptable with small modifications, while the failed results indicate that that the design must be repeated with improved data. Figure 2 shows 3-D view of the Orion modeled duplex building in reinforced concrete before analysis. Analysis of the model produce a good result (green color), confirming that the assumptions made were correct.

2.2.2 Timber Design

The structural timber design was done manually following the specifications of Euro code for timber design of structures. Analysis and design were carried out on the floor slabs which were designed as timber floor joists, on beams and on columns. The results obtained were used to determine the kind of wood adopted for the timber model, the Opepe specie (hardwood).

2.3 Costing of the models

An estimate of the cost implication of the concrete model was obtained by providing a complete Bill of Quantities. Guiding information was from the Federal Ministry of Lands, Housing & Urban Development Headquarters, Abuja Nigeria. Only the structural elements, i.e. beams, columns and slabs were considered for the building as the estimates will be sufficient for the cost comparison of both models.

For the timber model, the estimate was based on the recent market prices of wood in Nigeria. Based on the results of the analysis of the timber model, Opepe specie (hardwood) which has a density of 735 kg/m^3 was adopted for the timber structural members. For each type of structural element, the elementary cost was estimated and a total sum was obtained for that class of element.

3. RESULTS AND DISCUSSION

3.1 Comparison of Costs for both Designs

The summaries of bill of quantity (BOQ) for the structural elements of the concrete model and the timber model which constitute the basis for comparison are shown in table I below.

The table shows the cost summary of BQQ for the timber and concrete models, comparing directly the costs the framed superstructures (slab, beams and columns) which represent the object of comparison.

The total cost for the structural frame of the concrete model is ₦3234905 while the timber model is ₦1627000, representing about half of the corresponding concrete model.

The cost comparison of the two competing models, i.e. timber structural model and concrete structural model are shown in figure 3 for clear emphasis the economic convenience appears very visible.

Table I
Cost summary of structural elements of the models

S/N	Elements	Timber Model (₦)	Concrete Model (₦)
1	Slab	985000	1660838
2	Beams	359000	945239
3	Columns	283000	630159
4	Total	1627000	3234904

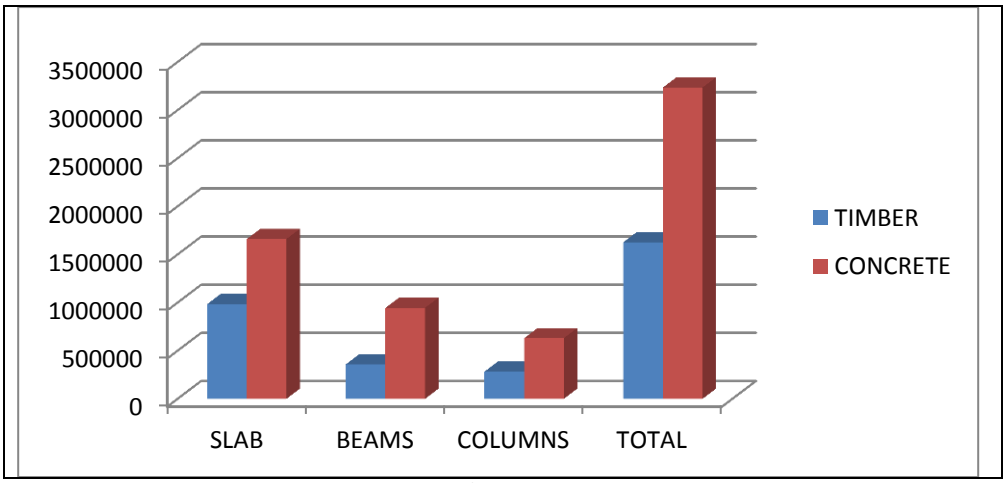

Figure 3: Cost Comparison for the Timber and Concrete models

The impact of this cost margin between the two models will be felt well when automated large scale production method is applied for the fabrication of the elements of the timber model. Automation of the normal concrete model is hardly possible. This places the timber model on a greater advantage over the concrete model. The light weight of the timber model's superstructure, walls and finishes will translate to at least 50% savings on the buildings foundations. When all these savings are summed together, we will experience more than 50% reduction in the total cost of the timber model building when compared to the concrete model.

4. CONCLUSION

From the results obtained, it is evident that the timber model holds a great potential for the future of mass residential housing projects in Nigeria and other sub-Sahara nations. With the costs obtained, the timber model offers a better advantage in terms of costs with respect to the concrete model. Therefore, it will be cheaper to use timber to construct residential buildings especially on a large scale in Nigeria. The adoption of timber as the load bearing material for residential buildings in Nigeria could provide a long-lasting solution to the housing needs in the country.

For timber to be fully adopted as a construction material for residential buildings in Nigeria, it is necessary that all specifications are met and that the structures are properly designed, erected and maintained. There will be need for retraining and certification of craft men and operators in the construction industry. Government will have to take the lead towards forestation and growing of sufficient wood on a continuous basis for the purpose of ever having abundant supply for the construction industry. There must be optimization of timber design and construction methods which will help to establish these methods in the Nigerian industry.

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