Comparative Cost Analysis of Reinforced Concrete and Timber Floor System for Effective Low Housing Scheme

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Abstract. In Nigeria, housing is grossly inadequate especially in urban area due to migration from rural area to urban area which results in poor environmental quality. In this paper, the cost analysis of 6 m x 6 m square suspended floor, constructed with reinforced concrete and wooden floor for housing units was carried out. The results show that wooden floor system is 21.6% cheaper than using reinforced concrete in construction. The use of timber in building construction should be encourage, as it will minimize the dead load and reduces the cost of building construction that will be sustainable and affordable for the low income earners.

Key words: Environmental Quality, Suspended Floor, Sustainable, Low Income Earner

1. Introduction

Large dependency on concrete which increases the cost of building construction prevents the low income earner from having access to good shelter in developing countries like Nigeria. This increasing cost of materials for concrete production slowed down the provision of shelter and other infrastructural facilities in developing countries [1]; while [2] aver that majority of people in in urban area lives in slum and some do so at outrageous cost. The increasing needs for infrastructure leads to greater needs for construction materials for housing; however, lack of affordable and good houses is due escalating cost of the traditional processed construction materials such as steel and Portland cement. Hence, people in the construction industry seek to find alternative such as by-products to replace partially or wholly the non-renewable materials. These alternative materials are used as aggregate for concrete production [3]. Natural aggregate from riverbeds constitutes fine aggregate that are used in the production of concrete. The use this non-renewable natural sand is very high and this hindered the supply of infrastructural development. The use of eco-friendly materials by incorporating huge deposit of solid waste to produce light weight concrete and reduces pollution is gaining popularity. Thus, there is need to explore its usage to benefit the environment and maintained the material standard requirements.

Timber is a renewable resource that are used in the construction of infrastructure for various purposes such as beams, columns, trusses, girders, and railway sleepers among others. It is good in both tension and compression which make it suitable as flexural member. According to [4], reinforced concrete is mostly used as building material, but the production process of cement is accompanied by large emission of CO2, a major factor causing greenhouse effect and climate change side the depletion of the natural resources (sand and quarry stone). In addition, the incorporation of mass timber for various building elements has offer new opportunities for the building industry. It offers accelerated construction schedules, superior sustainability characteristics, and improved environment for occupants. Mass timber products used in building construction however have a wide application in Europe, Canada and United States of America.
2. Housing Problems and Needs in Nigeria

Many countries in Africa, Asia and Latin America have witness great increase in human populations without a commensurate improvement in infrastructure, which resulted in the shortage of housing. The UN estimates aver that the urban population of the developing world alone will increase from 2.7 billion in the year 2011 to 5.1 billion by 2050 [5]. The implication is that there is need to adequately make provision for shelter to accommodate the growing urban population like Nigeria. However, most low-income households have limited access to affordable housing units in developing nations; thus, focusing on sustainable low-cost housing will serve as a panacea to housing shortages.

Housing is also considered as a basic necessities of life after food [6]; On the other hand, millions lived in an overcrowded serviced accommodation, while [7], stressed that housing shortages have been recorded in both rural and urban communities of all African countries but is more critical in urban communities. Hence, housing shortage is a worldwide phenomenon that is mostly evident in developing countries and Nigeria in particular where its delivery is a highly politicized.

The provision of affordable and sustainable housing contributes to the well-being of citizen of every country, which enables her meets the needs of both the present and future generations. [8] in their opinion adduce that sustainable housing provision is the gradual, continual and replicable process of meeting the housing needs of the populace, mostly the poor.

3. Comparative Cost Analysis of Suspended Floor Constructed from Reinforced Concrete and Timber

The cost implication index of the timber structure was compared with reinforced concrete structure using a suspended floor of 6 m by 6 m for the analysis. An imposed load of 1.5 kN/m² was used on slab for residential purposes.

3.1 Details of the Reinforced Concrete Suspended Slab

The design parameters for two way reinforced concrete slab, simply supported on all the four edges are:

- The characteristic strength of concrete (f_{cu}) = 20 N/mm².
- The characteristic strength of steel reinforcement (f_y) = 460 N/mm².
- Thickness of Slab = 150 mm
- Reinforcement diameter = 12 mm
- Reinforcement spacing: 150 mm centre to centre.

3.2 Details of the Timber Suspended Floor

The detail of the timber used is as follows:

- Type of Timber: Hardwood
- The bending strength characteristic (f_{m,k}) = 24 N/mm².
- Safety class 2: γ₀ = 0.91.
- The modification factor for load duration class “M: and service class 1 k_{mod} = 0.8.
- Size factor for depth greater than 150 mm, k_h = 1.0

After the design the following dimensions were determined:

- Timber floor planks: 1 by 12 by 12 and timber joist of 2 by 6 by 12, spaced at 1.5m centre to centre.
Tables 1 and 2 show that the cross sectional area of timber flooring in square metre is 21.6% cheaper than that of reinforced concrete. For multi-storey buildings, the reduction in self-weight of the flooring system will have reduction effect on the sizes of foundations, columns and beams, which will further reduce, the volume of concrete to be used and the total cost of the building project.

Table 1: Cost implication for construction of concrete slab

| S/N | Description                                      | QTY | Unit  | Rate | Amount (₦) |
|-----|--------------------------------------------------|-----|-------|------|-------------|
| 1.  | Concrete slab of mix ratio 1:2:4                 | 5.4 | m³    | 32,000 | 172,800    |
| 2.  | Y12 bars @ 200 mm c/c                           | 31  | mm    | 2,800  | 86,800     |
| 3.  | Planks for formwork: 1 x 12 planks              | 40  | mm    | 1,500  | 60,000     |
| 4.  | Shoring: 2 x 2 @ 1 m c/c                         | 49  | mm    | 500    | 24,500     |
| 5.  | Removal of formwork                             | 36  | m²    | 170    | 6,120      |
| 6.  | Rendering                                       | 72  | m²    | 500    | 36,000     |
|     | Total                                           |     |       |        | 386,220    |

Table 2: Cost implication for construction of wooden floor

| S/N | Description                          | QTY | Unit  | Rate | Amount (₦) |
|-----|--------------------------------------|-----|-------|------|-------------|
| 1.  | Hardwood: 1 x 12 x 12                | 42  | mm    | 2,600 | 109,000     |
| 2.  | Hardwood: 2 x 6 x 12                 | 13  | mm    | 2,600 | 33,800      |
| 3.  | Finishes: 36 + 36 + 21.6             | 93.6| m³    | 800   | 74,880      |
|     | Total                                |     |       |       | 317,680     |

Embracing the use of wood in our construction industry will bring reduction in the quantity of concrete materials and the volume of concrete, this will reduce the cost of construction for a particular building project. Figures 1 to 4 shows samples of wooden for flooring systems with cost per metre square from United State of America and Nigeria. The usage of wooden flooring systems will expand the market for the wooden industry and create employment opportunities for the teaming youth in the country. It will also reduce the greenhouse effect arising from the production of cement.
Figure 1: Walnut solid wood flooring

Figure 2: White brushed parquet oak solid wood.US $9.0 – 25/m² flooring. US $17.0 – 20/m² flooring.

Figure 3: Antique oak vinyl wood flooring

Figure 4: Sugar oak vinyl wood flooring

The analysis shows using timber in the construction of low housing scheme has advantages such as availability of materials, affordability for the urban poor, reduction to a near zero carbon emission and sustainability among others. Training the end user in the techniques on the usage of wood for building construction purposes will enable low income earners to affordable homes. Also, research should be carried out on factors mitigating the embrace of timber in construction industry.

4. Conclusion

Reference

[1] Olutoge FA 2010 Investigations on Sawdust and Palm Kernel Shells as Aggregate Replacement, ARPN Journal of Engineering and Applied Sciences, 4 (5), 7-13.

[2] Olugbenga NT 2001 Housing Finance in Nigeria - Need for Reengineering. Ideal Habitat Cooperative Housing Initiative.

[3] Adewuyi, AP and Adegbeke T 2008 Exploratory Study of Periwinkle Shells as Coarse Aggregates in Concrete Works, ARPN Journal of Engineering and Applied Sciences, 3 (6), 1-5.
[4] Olanitori LM and Tifase TO 2019 Effect of Small Transverse Service Holes on Shear Strength of Reinforced Concrete Slender Beams. *Journal of Applied Sciences and Environmental Management*, **23**(3):539 – 543.

[5] UN (2012) World Urbanization Prospects. The 2011 Revision. Highlight, NewYork. UN Department of Economics and Social Affairs, Population Division.

[6] Taiwo A and Albert A 2013 Sustainable Housing Supply in Nigeria Through the Use of Indigenous and Composite Building Materials, *Civil and Environmental Research*, **3** (1):79-84.

[7] Arayela O and Taiwo AA 2010 Stabilized laterite bricks as an appropriate walling material technology for increasing housing stock in some selected African countries. *Proceedings of XXXVII IAHS,World Housing Congress*, October 26-28, Santacher (Cantabria, Spain) on CD.

[8] Adedeji YMD, Arum C and Ajayi B 2011 Affordable housing initiative in Nigeria: use of composite panels, West Africa Built Environment Research (WABER) Conference 19-21 July 2011 Accra, Ghana Proceedings of the WABER 2011 conference, pp 78-90.