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Wooden materials in building projects: Fitness for roof construction in southwestern Nigeria

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A survey of building projects in south-western, Nigeria was conducted to assess wood usage in building roof projects in the zone and to determine the efficiency of wood utilization in building constructions prior to and during oil economy in south-western Nigeria. Based on various purposes of wood utilization in building projects, wood usage in building can be classified as structural, functional and decorative/aesthetics. Buildings in the rural area have the worst wood usage efficiency followed by roofs in the sub-urban area, while roofs in urban area are partially efficient. Based on roofing condition alone, approximately half of all the buildings surveyed (n = 1720) in the three zones are categorized as either substandard or deemed to have failed. Based on functional consideration, some of the urban and sub-urban housing roofs and only few of the rural areas attained the good-scoring grade. This is attributed in part to many houses owned by low income earners, which means the houses are built to satisfy emotional needs while engineering factors such as strength of materials and structural purposes are ignored due to lack of strong government policy on housing standard in the country. More than half of the roofs surveyed have least or more identified major defects. Recommendations include government directed policy on the minimum housing standard; possible built and lease programme for the low income earners; a vigorous programme of housing and health education; enhanced collaboration between stakeholders to develop enforceable standards for existing housing stock and future builds.

Key words: Housing roofs, wood usage, Nigeria, structural purpose, decorative/aesthetic purpose, functional purpose.

INTRODUCTION

Housing as one of the most important basic necessities of mankind is known to tremendously affect human health and well-being. Researchers have shown that housing can affect mental and physical health, both positively and negatively (Fanning, 1967; Macpherson, 1979; Riaz, 1987). Roof has been defined by various authors but Ezeji (2004) defined it as a framework on top of a building comprising of trusses on which a covering material is placed.

The World Health Organization (WHO) recognizes that the roof is one of the important requirements for a house to be considered well (WHO, 2005). This is because while a house may be inhabited without some elements of buildings such as partition walls, beams or columns, a house without a roof is not conducive for human and even animal accommodation.

Most Nigerian cities, with the exception of the newly developed Federal capital city of Abuja have experienced

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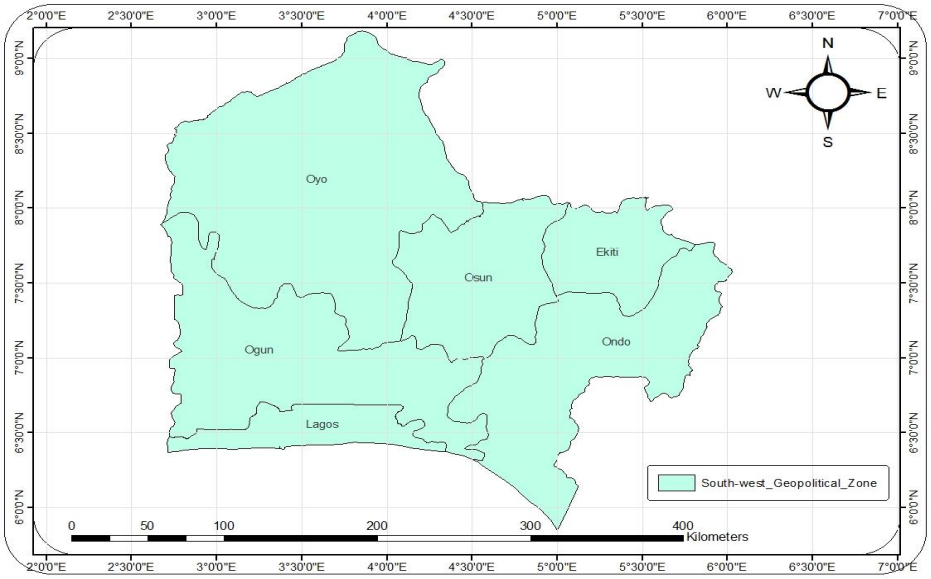

Figure 1. Map of Nigeria showing southwestern states.

Table 1. Location of houses.

Location	No. of buildings	Percentage of availability
Rural area	530	30.81
Sub-urban area	830	48.26
Urban centres	360	20.93
Total	1720	100.00

decay in housing especially in roof failures. According to Mijinyawa et al. (2007), roof failures are manifested in different forms. Unlike developed nations, the mortgage industry is still in its infancy stage in Nigeria with the real estate sector contributing less than one percent to the nation's GDP (Punch Newspapers, 5th September, 2007).

The quality of a residential area not only mirrors the city development, planning and allocation mechanisms between socio-economic groups, but also shows the quality of life of the urbanites. The realisation of a decent home in a suitable living environment requires the availability of clean air, potable water, adequate shelter and other basic services and facilities. The present study was aimed at investigating housing quality as well as the quality of the environment in which such houses are sited. This is pertinent in view of the increasing incidences of disease and epidemics in Ibadan confirmed by the studies of Sangodoyin and Coker (2005) and Aluko (2006).

STUDY METHODOLOGY

This study was carried out in Southwestern Nigeria comprising Oyo, Ogun, Lagos, Ekiti, Ondo and Osun states (Figure 1). The region has a bi-modal wind pattern with peaks occurring in April and August associated with rainstorm causing damage to buildings with the roofs being mostly affected (Adenekan, 2000). The year and the annual range temperature between 3 and 6°C with high rain intensity favour roof failures.

The method of research was the structured questionnaire survey to evaluate the use and efficacy of building materials with particular reference to the roof structure before and after oil boom in Nigeria.

Based on ethical considerations, the traditional head of each place to be surveyed in the three zones (rural, sub-urban and urban cities) were initially visited to seek their voluntary cooperation with the study team. The greatest co-operation was obtained in the sub-urban cities where many residents occupy the houses on a rented basis. The majority of the houses in the rural areas are owner occupied and some of those approached declined to participate. In this zone, houses are passed down from one generation to the next by inheritance and are largely owner-occupied. The least co-operation was given to the study in the urban centers. However, houses surveyed in the urban (n = 360), sub-urban (n = 830) and rural (n = 530) zones are considered to be representative of the general situation in the zones (Table 1).

Similarly, the class of each surveyed house roof was determined using the environmental score as below: Good (0–19); Acceptable (20–39); Borderline (40–59); Substandard (60–79); Unfit (80 or above) (APHA, 1950). Using a life span of building roof to be 40 years and roof rating to be acceptable from APHA, the suitability or otherwise of buildings both at pre and post oil boom were established using student's "t" method at 5% confidence level.

Table 2. Roof truss materials.

Type of truss materials	No. of respondents	Percentage of roof truss materials
Timber	1135	66
Concrete	189	10.98
Steel	69	4.01
Raffia palm	327	19
Total	1720	100

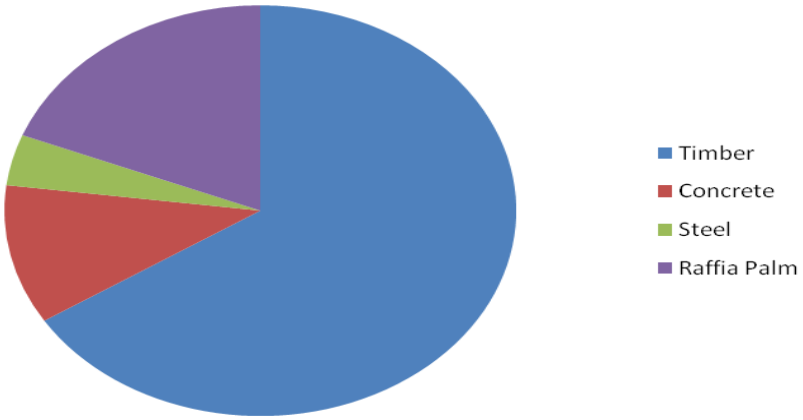

Figure 2. Roof truss materials.

RESULTS

Materials of construction

During the survey, it was discovered that the most common roof truss materials in the zone are timber, concrete, raffia palm and steel in the same order (Table 2 and Figure 2). The choice of materials were influenced by the economy of the house owner, however, timber material is the leading material of construction both at the pre and post oil economy.

Purposes of wood use in building

Wood is used in building for various purposes, viz: decorative, functional and structural, as shown in Table 3 and Figure 3.

Woods frequently used in the zone

Table 4 show most frequently used woods in the zone - Omo (*Cordia millenii*) and Afara (*Terminalia ivorensis*), and least frequently used woods - Opepe (*Nauclea diderrichii*), Ayo (*Holoptalia grandis*) Agba (*Gossweilerodendron balsamiferum*) Erun (*Erythrophum suavecolens*), Apado (*Conluea gradiflora*) and Iroko (*Melicea excels*).

DISCUSSION

Omo (*C. millenii*) and Afara (*T. ivorensis*) appears to be the most favored wood species used in buildings projects. From Table 4, about 90 of the building projects in the zone involved the utilization of Omo, while 86 uses Afara.

Iroko (*M. exelsa*) Opepe (*N. diderrichii*), Ayo (*H. grandis*) Agba (*G. balsamiferum*) Erun (*E. suavecolens*), Apado (*C. gradiflora*) are the least used wood species.

Omo and Afara are mostly favored in recent building projects because of their various uses as can be found in Table 3. They can be used for structural, functional and decorative purposes. Teak (*Tectona grandis*), Arere (*Triplochiton scleroxylon*), Apa (*Afzelia africana*), Oro (*Nasogoidonia papaverifera*) are in fair demand because they can be used for both structural, functional and decorative purposes.

The demand of the following wood species: Iroko, Opepe, Agba, Erun and Apado are in low demand as found in Table 3 because of their limited use. They are found only suitable for structural purposes. Therefore their use in building projects is restricted. This accounts for their low demand.

Table 3. Purpose of use of various wood species in building projects.

S/N	Local name	Botanical name	Purpose of use		
			Decorative	Functional	Structural
1	Afara	*Terminalia ivorensis*	,,	,,	,,
2	Apado	*Conluoa grandiflora*			,,
3	Erun	*Erythroplum suaveolens*			,,
4	Agbonyin	*Piptadeniastrum africanum*	,,		,,
5	Akokokoigbo	*Lovoa trichiloides*		,,	,,
6	Teak	*Tectona grandis*		,,	,,
7	Omo	*Cordial millenii*	,,	,,	,,
8	Mahogany	*Khaya ivorensis*		,,	,,
9	Agba	*Gossweilero tendron balsamiferum*			,,
10	Arere	*Triplochiton acleroxylon*			,,
11	Apa	*Afzelia Africana*			,,
12	Oro	*Nassogoidonia papaverifera*			,,
13	Araba	*Ceiba pentandra*			,,
14	Ayo	*Holoptalea grandis*			,,
15	Ayin	*Anogeissus leicarpus*			,,
16	Opepe	*Nauclea diderrichii*		,,	,,
17	Iroko	*Melicea excels*		,,	,,

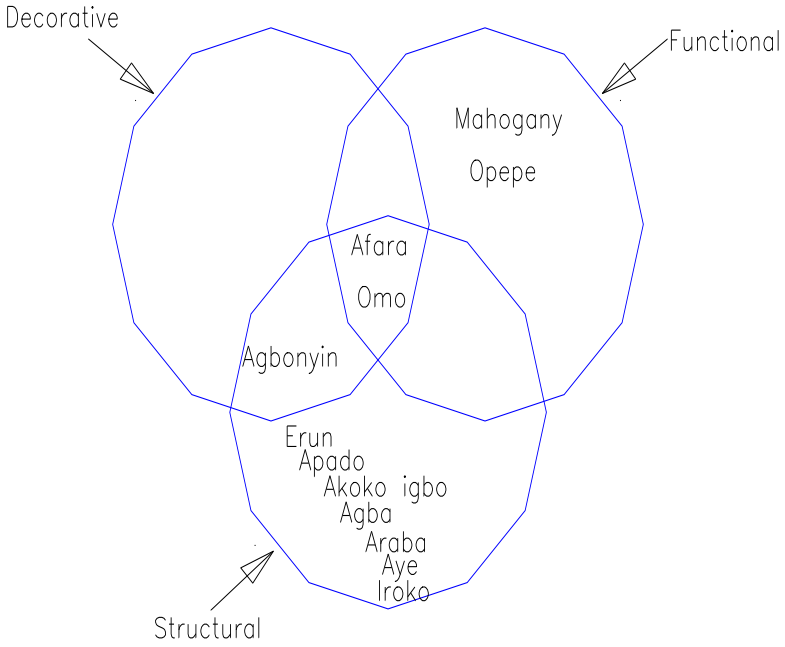

Figure 3. Purpose of use of various wood species in building projects.

Another reason for the results in Table 3 could be given as the availability of Omo and Afara in Southwestern Nigeria market. These species are in good quality in Ibadan but species such as Iroko, Ayo, Erun etc. are not available in good quantities to meet their demands despite their good mechanical properties.

Omo and Afara are mostly used because of their mechanical properties. Afara is a very important species, yellowish-brown in color, rather coarsely textured with somewhat variable grain. Afara seasons well, stable when dry and have good strength properties. It works well (including turning) and stains and polishes excellently.

According to Brough (1964) Omo is fragrantly scented,

Table 4. Frequency of use of various wood species in building projects.

S/N	Local name	Botanical name	Frequency
1	Afara	*Terminalia ivorensis*	86
2	Apado	*Conluoa grandiflora*	25
3	Erun	*Erythroplum suaveolens*	25
4	Agbonyin	*Piptadeniastrum africanum*	30
5	Akokokoigbo	*Lovoa trichiloides*	30
6	Teak	*Tectona grandis*	50
7	Omo	*Cordial millenii*	90
8	Mahogany	*Khaya ivorensis*	25
9	Agba	*Gossweilero tendron balsamiferum*	20
10	Arere	*Triplochiton acleroxylon*	35
11	Apa	*Afzelia Africana*	38
12	Oro	*Nassogoidonia papaverifera*	35
13	Araba	*Ceiba pentandra*	16
14	Ayo	*Holoptalea grandis*	24
15	Ayin	*Anogeissus leicarpus*	40
16	Opepe	*Nauclea diderrichii*	15
17	Iroko	*Melicea excels*	15

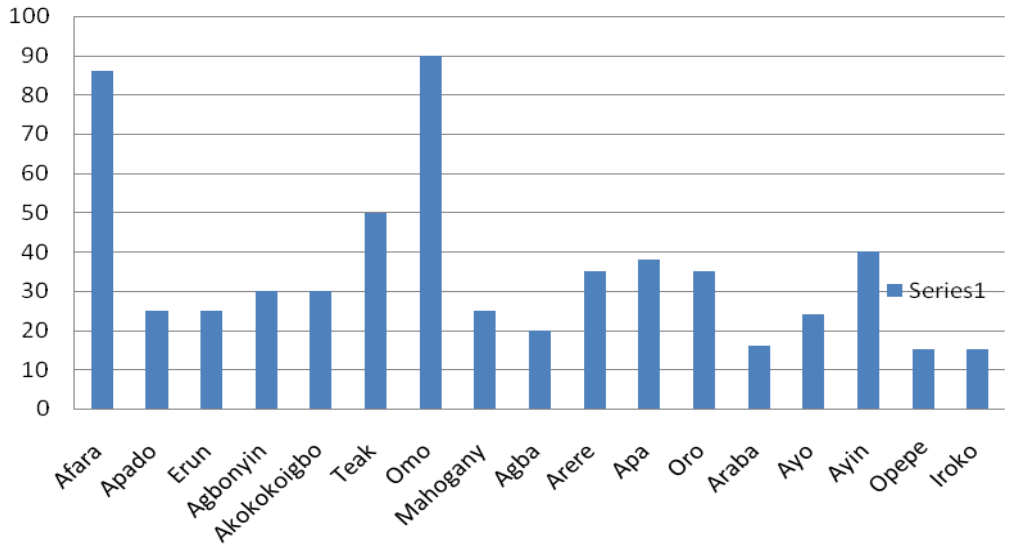

Figure 4. Frequency of wood use in building projects.

durable and strong; it takes kindly to glue and stain but is rather soft and open for polish. The colour varies from a pale yellow to a deep pinkish red, and under the tool, it gives a surface which in smoothness, has no equal. As an outdoor constructional timber, it would be most valuable on account of its durability and resilience properties.

On the other hand Iroko is a fine wood, loosely called “African teak” but of quite a different family. It is of excellent working qualities. It is a strong, moderately hard, very durable timber of fairly open grain, pale to dark brown in colour and of good appearance. Although somewhat cross-grained it planes well and will take a good polish when filled. Iroko is will adapted for work that requires a strong durable wood of good appearance for indoor and outdoor purposes. This good quality wood species is not in common use in recent building project in this area of study probably because of inadequacy to produce enough quantity to meet their demand. Most of these good quality wood species are not in recent building projects because they have been exhausted from the forest.

Table 5. Ratings of pre oil boom building roofs in rural Areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	28, 20, 23, 25, 24, 26, 22, 23	23.88
10 – 19	41, 42, 40, 39, 40, 41, 39, 39	40.13
20 – 29	42, 45, 43, 43, 42, 44, 44, 42	43.13
30 – 39	46, 48, 47, 47, 46, 45, 45, 46	46.25
40 +	51, 53, 55, 52, 51, 52, 52, 52	52.25

Table 6. Ratings of post oil boom building roofs in rural areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	21, 20, 22, 22, 22, 24, 22, 22	19.13
10 – 19	31, 30, 31, 31, 29, 29, 30, 29	30.00
20 – 29	31, 31, 32, 31, 33, 33, 33, 32	32.00
30 – 39	35, 34, 35, 36, 34, 34, 34, 36	34.75
40 +	38, 38, 36, 38, 38, 38, 38, 38	37.75

Table 7. Ratings of post oil boom building roofs in sub-urban areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	19, 17, 17, 17, 18, 1819, 19	18.00
10 – 19	25, 26, 28, 29, 25, 22, 28, 29	26.50
20 – 29	28, 27, 28, 27, 26, 28, 27, 29	27.50
30 – 39	28, 29, 28, 29, 29, 30, 28, 31	29.00
40 +	31, 34, 32, 31, 35, 33, 34, 33	32.88

Table 8. Ratings of pre oil boom building roofs in sub -urban areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	21, 19, 20, 21, 20, 18, 20, 21	20.00
10 – 19	28, 30, 30, 31, 28, 30, 29, 28	29.25
20 – 29	34, 34, 34, 34, 32, 35, 33, 34	33.75
30 – 39	38, 37, 37, 39, 38, 38, 35, 37	37.38
40 +	40, 39, 40, 38, 38, 39, 38, 38	38.75

Opepe is uniformly yellow or yellowish-brown in colour, normally interlock grained, though a few straight grained planks are obtainable, with a rather attractive ribbon stripe figure when quarter sawn. Works well but has tendency to pick in planing and to split in nailing. It is not an easy timber to be treated with preservatives and may be slightly damaged by borer beetles. Opepe as a coarsed textured wood and has some tendency to split or check during seasoning.

Agba is yellowish-pink to reddish-brown in colour, with a straight grain and a fine even texture. Though it works easily, but it is sometimes rather gummy and may be damaged by borer beetles. It also seasons well.

Table 9. Ratings of pre oil boom building roofs in urban areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	33, 33, 35, 34, 33, 33, 36, 35	34.00
10 – 19	31, 34, 34, 33, 33, 36, 36, 34	33.88
20 – 29	40, 38, 39, 43, 43, 38, 40, 39	40.00
30 – 39	44, 40, 42, 44, 44, 43, 46, 48	43.88
40 +	47, 47, 46, 46, 47, 43, 45, 46	46.25

Oro is lustrous red-brown with fine texture but slightly greasy feel, strong, durable and apart from a tendency to pick up when quarter-sawn, it works well: turns satisfactorily and polishes will. It limitation is the tendency to warp slightly in seasoning but it is stable when dry.

Agbonyin sapwood light in colour and easily distinguished from the light golden-brown heartwood, which has some resemblance to Iroko. It is not an easy timber to work, tends to split in nailing. Though it stains and polished well, fairly resistant to decay and may be attacked by borer beetles. It seasons slowly but stable when dry and moderately strong though rather brittle.

Arere is a timber light in weight and colour some what open pored. The wood is soft and its natural colour pale straw. Some of the logs are figured and rock, and are very difficult to manipulate with the plane owing to the overlapping and alternate grain.

Teak is characterized by its open grain and little coarse texture and has a surface which is noticeably greasy to the touch. The rays are not visibly, but pores are easily distinguished. It is fairly hard to work. Shrinkage in slight and it does not warp or twist. It has, further, very high fore-resisting qualities and is immune from the attack of the white ant. Its resistance to crushing and transverse strain has rendered it practically indispensable for railway carriage construction. The timber stands up well to alternate wet and due conditions, hence its popularity for ships' decking. As a constructive timber its only rival is British oak. This wood species is in little use in recent building in the zone due to inadequate quantities to meet their demand.

Adequacy of wood in building projects

To check for the adequacy of wood in wooden materials in building projects, Tables 5 to 10 shows the performance ratings of the buildings. The class of each surveyed house roof was determined using the environmental score as below: Good (0 to 19); Acceptable (20 to 39); Borderline (40 to 59); Substandard (60 to 79); Unfit (80 or above) (APHA, 1950). Using a life span of building roof to be 40 years and roof rating to be acceptable from APHA, the suitability or otherwise of buildings using both wood and other building materials were established using student's "t" method at 5% confidence level.

Table 10. Ratings of post oil boom building roofs in urban areas.

Ages (years)	Ratings of buildings	Average rating
0 – 9	20, 20, 21, 20, 20, 20, 20, 21	20.25
10 – 19	29, 28, 29, 30, 28, 29, 28, 28	28.63
20 – 29	31, 32, 32, 31, 30, 32, 31, 32	31.38
30 – 39	34, 33, 33, 36, 32, 32, 34, 34	34.75
40 +	35, 35, 35, 34, 36, 35, 35, 37	35.13

t values for tables 4, 5, 6,7, 8, 8 are 4.75, 1.38, -0.51, 9.39, 2.51, 0.051 respectively indicating that there are no significant difference in the use of wood and other truss materials in all the state economy.

CONCLUSIONS AND RECOMMENDATIONS

Based on the survey carried, the following conclusions are made:

1. Wood species are widely used for structural, functional and decorative purposes in building
2. The species of wood in common use in building projects in Southwestern Nigeria are Omo and Afara probably due to their local availability in market and the mechanical properties of Omo.
3. There are still numerous designated building components parts that wood could be used other than roof and frame construction.
4. Wood supply is dwindling down with a high cost of procurement. There is therefore the urgent need to utilize other timber species particularly lesser used one that are not yet in use for construction.
5. Although due to buoyant economy during the oil boom, taste and elegance dictate the use of other materials in roofing construction rather than functional or structural requirement. However, it is concluded that there is no statistical difference between the use of wood at pre oil boom in roofing conditions and other building materials at post oil boom.
6. Wood is efficient in use, reliable in service and good for all state economy.
7. To avert the problem of shortage of dwelling units and its attendant menace in urban cities, wood structures are canvassed for because of its low cost compared to other building materials.

It is thus recommended that:

1. Further studies should be conducted into the modes of jointing of structural members and more research works could be employed into the connector of structural members.
2. The national housing requirement between 500,000 and 600,000 units, considering the prevailing occupancy ratio of between three and four persons per room should be strictly adhered to.
3. Built and lease programme can be encouraged in view of the escalating cost of building materials.
4. There could also be research into the engineering properties of lesser used timbers.

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