DETERMINATION OF SOME STRUCTURAL PROPERTIES OF AFRICAN OIL PALM TIMBER (ELAIES GUINEENSIS)

AJIBOLA, K* and FALADE, F**

ABSTRACT

Oil palm trees are abundant in Nigeria but they are hardly used for structural purposes, except in some rural areas where they are used as roof trusses, floor joists and occasionally columns. In this paper tensile strength along the grain direction, compressive strength parallel and perpendicular to the grain direction and the bending strength are reported. The strength of the inner and outer core materials are compared. The results showed that the outer core of oil palm timber has higher strength than the inner core and that the strength of the palm is influenced by the closeness of the black strands. The highest recorded compressive strength parallel to the grain direction is \( 1.32 \) times the strength perpendicular to the grain direction for the specimen taken from inner core and \( 2.37 \) times for the specimen taken from peripheral.

1. INTRODUCTION

One of the readily available, versatile and flexible local building material in Nigeria is timber. The few timber species being used are becoming expensive due to extensive exploitation of their reserves. Most of the trees used as timber at present grow naturally and it takes about fifty to sixty years to mature. The attempt to replant these species in large quantities for use by future generations of Nigerians is not very effective. Various attempts are now being made to supplement these timber species by others. Palm tree trunks is one of such trees being investigated for the purpose.

Generally, little information is available on the properties of oil palm timber. In Nigeria, the cultivation of the oil palm (Elaeis Guineensis) is an important agricultural practice. An estimated 2.5 Mha of wild oil palm plantations in small holdings and about 644,000 ha of commercial plantations are known to exist (Eseigba and Etuk, 1981). Investigation has shown that oil palm timber has been used and is still in use in the rural areas as roof trusses, the palm fronds as thatched roofs and the logs are used in trunk form to make small bridges over gullies and gutters, the width of such bridges depends on the intended purposes (vehicular or pedestrian).

The above observations coupled with other observed physical properties suggest that the versatility of oil palm timber in the construction industry is yet to be exploited. The study of the structural properties therefore paves the way for the determination of the effective utilisation of oil palm timber in the construction industry.

2. STRUCTURE AND GROWTH OF PALM

Palm trees belong to a class of trees known as endogeneous trees. Growth of such trees is inwards. The trees show fibrous mass along the longitudinal direction. Unlike trees from exogenous trees, palms do not have cambial activities which are responsible for annual rings and trunk thickness of trees. Hodge (1961) established that the lack of cambial activities is responsible for lack of increase in diameter and subsequently account for the slender and graceful form of palms and that when palms grow under favourable conditions, they produce large cells. This may be responsible for the bigger trunks observed in the African oil palms.

Tomlison (1961) described the peculiar method of primary growth of palms as follows:

* Dept. of Architecture, Obafemi Awolowo University, Ile-Ife.
** Dept. of Civil Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.
stem proper contributes little to the stem tissues but is largely a leaf producing meristem. The tubular bases of the leaf primordia increase in diameter to keep pace with the increase in diameter of the nodes on which they are inserted. This thickening growth is brought about by the activity of a meristem which is continuous beneath successive leaf bases and in which cell division is largely in a tangential plane. Since it brings about increase only in diameter, it is known as a primary thickening meristem, and internodal elongation only begins where its activity has ended, that is below the bases of which have widened to reach its outer margin and where the stem has almost achieved its maximum diameter.

Observation made during this study shows that instead of a central mass of hard tissues which normally constitute the wood of exogenous trees used for timber purposes, "palms have a soft spongy heart surrounded by a hard ring of strong protective fibres arranged in vertical bundles which serve primarily as the trees conductive system for the transportation of water, mineral elements for food making as well as synthesized food. This outer ring is often so tough as to repel the blows of all but keenest axes, Hodge (1961). This structural composition of palms is reflected in the properties of the palm trunk tested. In addition, test results show that a typical oil palm trunk has properties of both hard and soft wood, and therefore suitable for variety of uses in the building industry.

3. PREVIOUS WORK

Most researches on palm have been focussed on its classification and botanical structure. Notably among these are those of Tomlinson (1961) and Moore Jr. (1961). It has been established that palm stems do not develop true wood in annual rings in the sense that our common deciduous or coniferous tree do. They always have a hard persistent stem that contains numerous bundles of conducting tissues scattered throughout a softer ground tissue. This view was also confirmed by Essiamah (1985) who also noted that palms are less important because of their anatomical structure, for they have no vascular cambium and therefore produce no real wood. But observations on their local use as building materials shows they are strong and durable. This view was confirmed by Bolza and Keating (1961). They noted that palm species are dense, strong and durable; they are not easily worked but suitable for heavy construction. Recent researches have focussed on the use of palm as a reinforcing materials. The works of Fache (1983) and Adelifa (1986) are noted in this area. Other works have been centred on its utilisation for economic purposes such as food and decorative ornaments.

While some researchers hold the view that palms are not suitable for use as timber (Singh and Singh (1976); Findlay (1978); Essiamah (1985). Others, notably Hodge (1961) and Moore (1961), are on the contrary. We believe that this disparity was as a result of lack of proper information on the properties of palm as timber. This paper focusses on those properties of oil palm trunk that will help to determine its suitability as a structural material for building construction purposes.

4. MATERIALS AND EXPERIMENTAL PROCEDURE

The palm used for this experiment was obtained at Obafemi Awolowo University campus, Ile-Ife. After felling the tree, its trunk was cut into logs of suitable lengths. One of the logs, with an average diameter of 300mm was taken to saw machine and converted into sections suitable for testing. The age of the tree was not determinable but the smoothness of the surface indicated it was matured. Samples were taken across the cross-section. The samples used were of three types — 50x50x50mm, 5x165x150mm and 20x20x160mm. Moisture content of each specimen was determined before test. All the specimens have moisture contents of 12%. The testing procedure was in accordance with British Standard 373:1857: Testing small clear specimens of timber and Code of Practice: 112 Part 2:1971: The structural use of timber.
4.1 Specimen Testing for Tensile Strength (parallel to the grain)

The 5x16.5x150mm specimens were tested on tensile testing machine – Mansato Tensometer type “W”. Before placing each specimen in the machine the width was measured with micrometer screw gauge and small pop marks were made at a distance of 50mm apart corresponding to the gauge length of which the extension was to be measured. Two types of specimens were used. Specimen I was taken between 100mm and 140mm inward (inner core) while specimen II was taken between 10mm and 50mm from the outer layer. The test pieces were axially loaded in the direction parallel to the grain through toothed grips applied to its ends. The pieces were tested to destruction using a loading rate of 0.06mm per minute.

4.2 Specimen Testing for Compressive Strength (parallel to the grain)

For this test, cubes of dimension 50x50x50mm were tested on Technotest Compressometer. Each specimen was placed in position between the two parallel plates and subsequently loaded. The load was applied at the rate of 0.10mm per minute to a point when the load remain static and later started to decrease. Failure finally occurred by cracks appearing on the surface and spreading inwards.

4.3 Specimen Testing for Compressive Strength (perpendicular to the grain)

The 50x50x50mm specimens were tested on Technotest Compressometer using the same procedure as in 4.2, but with their grains perpendicular to the crushing plates.

4.4 Specimen Testing for Bending Strength

The 20x20x160mm specimens were tested on Technotest Compressometer machine. A point load was centrally applied to the beam at a loading rate of 0.10mm per minute. The effective span of the specimen was 140mm. Deflections were measured at interval.

5. RESULTS AND DISCUSSION

The results obtained from the tests are presented in Figures 1–7. Generally, the results show that the peripheral part (outer core) of oil palm tree has higher strength than the inner core. Fig. 1 shows load versus elongation for the two specimens (specimen I taken from inner core and specimen II from outer core) of oil palm timber used in the tensile test with the load applied parallel to the grain direction. Fig. 2 shows the relationship between the stress and strain for the same test. The highest attainable stress value for specimen I was $34.3 \text{ Nmm}^{-2}$ and for specimen II $43.8 \text{ Nmm}^{-2}$ while the mean values were $17.94 \text{ Nmm}^{-2}$ and $20.65 \text{ Nmm}^{-2}$ respectively. The mean tensile stresses tend to be low, this signifies hardness and brittleness. As it is common with all brittle materials, the curves have no sharply defined yield point and also curve almost from the origin. Fig. 3 shows the load versus shortening and Fig. 4 shows the stress versus strain for compressive strength test with the load applied parallel to the grain. The load was proportional to the shortening. The highest stress values were $3.9 \text{ Nmm}^{-2}$ for specimen I and $18.7 \text{ Nmm}^{-2}$ for specimen II. The mean values were $2.58 \text{ Nmm}^{-2}$ and $10.76 \text{ Nmm}^{-2}$ respectively. The curves have no sharply defined yield point, this attest to the fact that oil palm timber is a hard material. Figs. 5 and 6 show the curves for the load versus shortening and stress versus strain respectively for the compressive strength test with the load applied perpendicular to the grain direction. The relationship between the load versus shortening and stress versus strain follows the same trend as the test with the load parallel to the grain direction. The highest stress values were $2.95 \text{ Nmm}^{-2}$ for specimen I and $7.90 \text{ Nmm}^{-2}$ for specimen II. The mean values were $2.18 \text{ Nmm}^{-2}$ and $5.72 \text{ Nmm}^{-2}$ respectively. From the result, the highest attainable compressive stress was achieved when the load was parallel to the grain direction. The value was 1.32 times the stress value for the test with load perpendicular to the grain direction for specimen I and 2.37 times for specimen II. Fig. 7 shows
load-deflection curve for the bending test. Specimen I shows that the inner core of oil palm tree has very low resistance to bending while the outer core has the tendency to sustain bending. The failure pattern was diagonal while at the load application point compressive failure was noticed. From the results, it could be inferred that the strength of oil palm timber is determined by the closeness of the black strands. The closer the black strands the lesser the quantity of the brown dust and the higher the strength. This can be said to be responsible for the relatively low strength of the inner core where there is higher quantity of the brown dust with few black strands.

Figure 1: Tensile test - load parallel to the grain

Figure 2: Tensile test - load parallel to the grain

Figure 3: Compressive test - load parallel to the grain

Figure 4: Compressive test - load parallel to the grain

Figure 5: Compressive test - load perpendicular to the grain
Prior to the test, it was observed that the sawn section looked like a composite material made up of both brown dust seemingly reinforced with black strands. The strands were neither in the same direction nor continuous. They were closely packed at the periphery while they were scanty at the core. The colour of the peripheral section was darker than that from the inner core. The outer core is denser than the inner core. During the tensile test, it was observed that when the applied load on the specimen reached the ultimate, the specimen snapped. The specimen had fractured surface showing sharp palm fibres sticking out at different angles. This corresponds to the dotted line on the curve in the figures. During the compressive test, the specimen at ultimate load shortened and failure cracks extend across the surface.

Table 1 shows the representative properties of oil palm timber based on the tests carried out. These values are compared with the structural properties of common Nigerian timber such as Iroko, Opepe and Sapele. From the table, the oil palm timber can be said to have structural properties similar to the locally available timbers.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Oil Palm tree</th>
<th>Iroko</th>
<th>Opepe</th>
<th>Sapele</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bending and Tensile stress parallel to grain (N/mm²)</td>
<td>43 00</td>
<td>23 40</td>
<td>29 00</td>
<td>23 40</td>
</tr>
<tr>
<td>Compression parallel to the grain (N/mm²)</td>
<td>17 00</td>
<td>19 30</td>
<td>24 80</td>
<td>21 70</td>
</tr>
<tr>
<td>Compression perpendicular to the grain (N/mm²)</td>
<td>6 80</td>
<td>6 21</td>
<td>8 27</td>
<td>6 21</td>
</tr>
</tbody>
</table>

Source: Experimental data and CP 112:1971
and propagate inward. During the bending test, it was observed that the specimen suffered compressive failure at the point of load application before any deflection was noticed. The extent of the impression made on the specimen by the applied load depends on the closeness of the black strands. The closer they are, the lesser the impression.

7. CONCLUSIONS

From the study, the following conclusions can be made:

(i) When the results of the test carried on oil palm timber are compared with the structural properties of common Nigerian timber such as Iroko, Opepe and Sapele, oil palm timber can be said to be useful for structural purposes.

(ii) The specimen tested showed that oil palm timber resists more load when the applied load is parallel to the grain direction than when perpendicular to the grain.

(iii) The outer core of oil palm timber where the black strands are closely packed with less brown dust is more viable structurally than the inner core with high concentrations of brown dust and less black strands.

ACKNOWLEDGEMENT

The information presented in this paper emanated from an Obafemi Awolowo University sponsored research on the Investigation of Ironwood and Palms strunks as Building Materials conducted by the authors.

REFERENCES


5. Fache, M.O. "Mechanical Properties and Physical Characteristics of Fan-Palm", Project Report, Department of Civil Engineering, University of Ilorin, 1983.


