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RESEARCH ARTICLE

COMPARATIVE STUDY OF SOME ENGINEERING PROPERTIES OF TEAK, MAHOGANY AND AGBA STRUCTURAL TIMBERS IN MAKURDI, NIGERIA

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ABSTRACT

Structural Timber plays major role in housing and bridge construction programmes of many developing nations. In Makurdi, Nigeria many types of structural timber are used for roof truss. This research finds some of the engineering properties of Teak, Mahogany and Agba structural timbers, commonly used for this purpose. Laboratory experimental procedures were used for the research work. Teak was discovered to have about 17 and 12 percent more moisture content than mahogany and agba respectively. The water absorption values of agba, mahogany and teak are 29, 26 and 38 percent respectively. These results indicate that teak could have the most cellular structure of the timbers. The mean compressive strength of agba, mahogany and teak are 10, 32 and 40 N/mm^2 respectively. Teak has the greatest modulus of elasticity of about 92 N/mm^2. When the timbers were subjected to oven temperature of 105 degrees Celsius, for 24 hours, the tensile strength of the timbers was reduced by about 94 percent

INTRODUCTION

Timber is got from mature tree trunk. Timber is one of the oldest known materials of construction. Skills in its use combined with understanding of its nature have produced solutions to structural problems throughout the ages. This ranges from the simplicity of primitive hut, the Gothic screens and roofs to the elegance and strength of many structures of today (Jackson, 1984). The potential strength of timber is known all over the world (Ezeagu and Nwokoye, 2009). The strength of timber is affected by factors such as density, moisture content, grain structure and defects. The denser a timber is the stronger it is (Jackson, 1984). The purpose of this research is to determine the strength properties of agba, mahogany and teak structural timbers. They often used for roofing and building of bridges across streams in Makurdi, Nigeria. Structural timber is generally classified into Hard or Soft wood. A tree trunk is usually converted to market sizes. Structural timber may contain some defects, often cause by fungi, chemicals and many other natural factors. The general basic stress, in bending, of timber is given by (Ozelton and Baird, 1987)

$$f_{bs} = \frac{f_m - k_p \sigma}{k_r} \quad \text{.....[1]}$$

f_{bs} is basic bending stress parallel to grain
f_m is mean value of failure load
k_p is probability coefficient
σ is standard deviation
k_r is reduction factor (factor of safety)

African mahogany is a hard wood available from all parts of Africa and has a density about 560kgm^{-3}. It has an interlocking grain which gives beautiful figuring, but can be problematic in handling. It is moderately resistant to decay and is liable to infestation by furniture's beetles. It is used for high quality joinery and as a source of plywood. Agba is a hardwood from West Africa. It has a density of about 500kgm^{-3} in a seasoned condition. It is a strong structural timber. Teak is a hard wood with a density of 640 to 720kgm^{-3}. It is the most valuable hardwood because of high strength, durability, resistance to fire, acids and decay. It is used extensively in the construction industry for piling, heavy construction work, roof truss and interior joinery (Jackson, 1984). Durability of timber is the measure of its natural resistance to decay. Timber is prone to infection caused by fungi, insects, etc. Durability classification of timber is shown in Table 1. Timber is one of the most ubiquitous products used in construction, but in order to perform adequately, it needs to be carefully prepared, stored and maintained. To ensure satisfactory preservative treatment, accurate machining and efficient fabrication; and to avoid problems due to dimensional changes and distortion in use, its moisture content most be controlled. Moisture content (MC) of timber is calculated as the difference between the weight of the

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sample of wet (green) timber specimen and the weight of the same sample after oven drying (to remove moisture content), expressed as percentage of oven-dry weight. Moisture is contained within the cells and the cell walls of timber. The condition when all the cells are empty of moisture but the cell walls are still saturated is referred to as Fibre Saturation Point; about 27 per cent moisture content. All timber is hygroscopic and tends to achieve equilibrium moisture content with its environment (Jackson, 1984).

$$MC = \frac{W_w + W_d}{W_d} x100 \quad \text{..... [2]}$$

W_w is weight wet of timber specimen
W_d is dry weight of the specimen

It is predicted that the thickness and width of a piece of timber might increase by 0.25 percent for every 1 percent increase in moisture content above 20 percent, and to shrink by the same amount for every 1 percent reduction in moisture content below 20 percent (KLIGER, 2000). Moisture content below 18 percent is required at the time of erection of timber member and it must be adequately protected on site, both before and after installation, to prevent moisture content from rising (BS 5268-Part 2, 1977). Water absorption is the quantity of a known dry mass of material can absorb when completely soaked in water for 24 hours. Water Absorption (WA) is given by

$$WA\ (Percentage) = \frac{M_2 - M_1}{M_1} x100 \quad \text{..... [3]}$$

M_1 is dry mass of material
M_2 is surface-dry mass of material

MATERIALS AND METHODS

Materials

The main materials used for this study are mahogany, agba and teak commercial timber. They were purchased from the Timber Market in Makurdi, Nigeria.

Methods

Moisture Content

The timbers were cut into 25x25x600 mm sizes. One specimen was weighed (M_1). It was allowed to dry in an oven at a temperature of 105 degree Celsius, for 24 hours and then weighed (M_2). This procedure was carried out for 5 specimens of mahogany, agba and teak timber. Moisture content was calculated using equation [2].

Water Absorption

Five of the timber specimens each, were selected and weighed (M_1). They were then soaked in water for 24 hours, removed from the water and allowed to surface-dry. Each specimen was then weighed (M_2). Equation (3) was used to calculate water absorption.

Compressive Strength

Each of the timber was cut into 50x50x225 mm size. One specimen was loaded into Universal Testing Machine and the compression load was applied perpendicular to the direction of the grain. The load was continued until failure of the specimen occurred. The load and deformation of the specimen were recorded by gauges of the machine. This process was repeated for all the remaining specimens. Compressive strength is load per cross-section area.

Tensile Strength Test

Each of the timber specimens was cut into 10x20x600mm size and fixed into Universal Testing Machine. Tensile load was applied parallel to the grain of the timber. The load was continued until fracture of the specimen occurred. The load and deformation of the specimen were recorded by gauges of the machine. This process was repeated for all the remaining specimens. Tensile strength is load per cross-section area.

Heat Effect on Strength the Timber

The three different species of the timbers were cut into 10x20x600mm sizes, weighed and placed in the oven at 105 degree Celsius, for 24 hours. They were then removed and weighed. The specimens were subjected to Tensile Strength test.

RESULTS AND ANALYSIS

Moisture Content

The results of moisture content tests of the timbers are shown in Table 2. Teak has about 17 and 12 percent more moisture content than mahogany and agba respectively. Moisture content is related to both age and cellular nature of timber's structure.

Water Absorption

The results of water absorption tests of the timbers are shown in Table 3. Agba has 3 percent more of water absorption than mahogany while teak has 12 percent more of water absorption than mahogany. The results indicate that structure of teak could be the most cellular.

Compressive Strength

The results of the compressive strength tests are shown in Table 4. Teak has an average compressive strength of about 40 N/mm^2. The strength is 4 and about 1½ times that of agba and Mahogany respectively.

Tensile Strength

The results of stress-strain curves of the timbers are shown in Figure 1. Teak shows high modulus of elasticity as compared to mahogany and agba. Agba is obviously, the weakest of the timbers.

Effect of Heat on the strength property of the Timbers

The effect of heat on the tensile property of the timbers is shown in Table 5. It is observed that the tensile strengths of agba, mahogany and teak were reduced by heat by about 97, 95 and 91 percent respectively.

Table 1. The durability classification of timber

S/No.	Grade of durability	Approximate life in contact with ground
1	Very durable	>5 years
2	Durable	15-25 years
3	Moderately durable	10-15 years
4	Non-durable	5-10 years
5	perishable	<5 years

(Source: Kliger, 2000)

Table 2. Moisture Content Results

Timber	Specimen No.	Initial weight, W_1 (g)	Final weight, W_2 (g)	Moisture content, MC (%)
Agba	1	244	172	42
	2	305	222	37
	3	395	297	33
	4	289	197	47
	5	297	217	37
		Mean MC		39.2
Mahogany	1	305	223	37
	2	316	241	31
	3	232	145	39
	4	312	239	31
	5	304	207	34
		Mean MC		34.4
Teak	1	244	156	56
	2	211	132	59
	3	242	164	48
	4	233	152	53
	5	237	157	51
		Mean MC		51.0

Table 3. Results of Water Absorption

Timber	Specimen No.	Initial weight, W_1 (g)	Final weight, W_2 (g)	Water Absorption, WA (%)
Agba	1	64	84	31
	2	103	125	20
	3	82	103	26
	4	73	97	33
	5	79	105	33
		Mean WA		28.6
Mahogany	1	110	140	27
	2	110	136	24
	3	109	141	29
	4	107	137	28
	5	112	134	20
		Mean WA		25.6
Teak	1	80	113	41
	2	86	117	36
	3	83	115	39
	4	79	110	39
	5	87	118	37
		Mean WA		38.4

Table 4. Compressive Strength Results

Timber	Specimen No.	Load (KN)	Compressive strength (N/mm^2)
Agba	1	23	9.2
	2	25	10.0
	3	26	10.4
	4	24	9.6
	5	27	10.8
	Mean Compressive Strength		10.0
Mahogany	1	76	30.4
	2	80	32.6
	3	79	31.6
	4	81	32.4
	5	78	31.2
	Mean Compressive Strength		31.6
Teak	1	88	36.8
	2	92	32.4
	3	81	37.2
	4	93	37.2
	5	95	38.0
	Mean Compressive Strength		35.9

Table 5. Heat Effect on the Timber Specimens

Timber	Specimen No.	Maximum load (KN)	Tensile stress (N/mm^2)
Agba	1	59.1	0.30
	2	64.2	0.32
	3	60.1	0.30
	4	65.2	0.33
	5	63.2	0.32
	Average Tensile stress		0.31
Mahogany	1	113.2	0.57
	2	100.9	0.51
	3	103.0	0.52
	4	117.2	0.59
	5	104.9	0.53
	Average Tensile stress		0.54
Teak	1	144.8	0.72
	2	144.8	0.72
	3	147.8	0.74
	4	153.0	0.77
	5	163.1	0.81
	Average Tensile stress		0.75

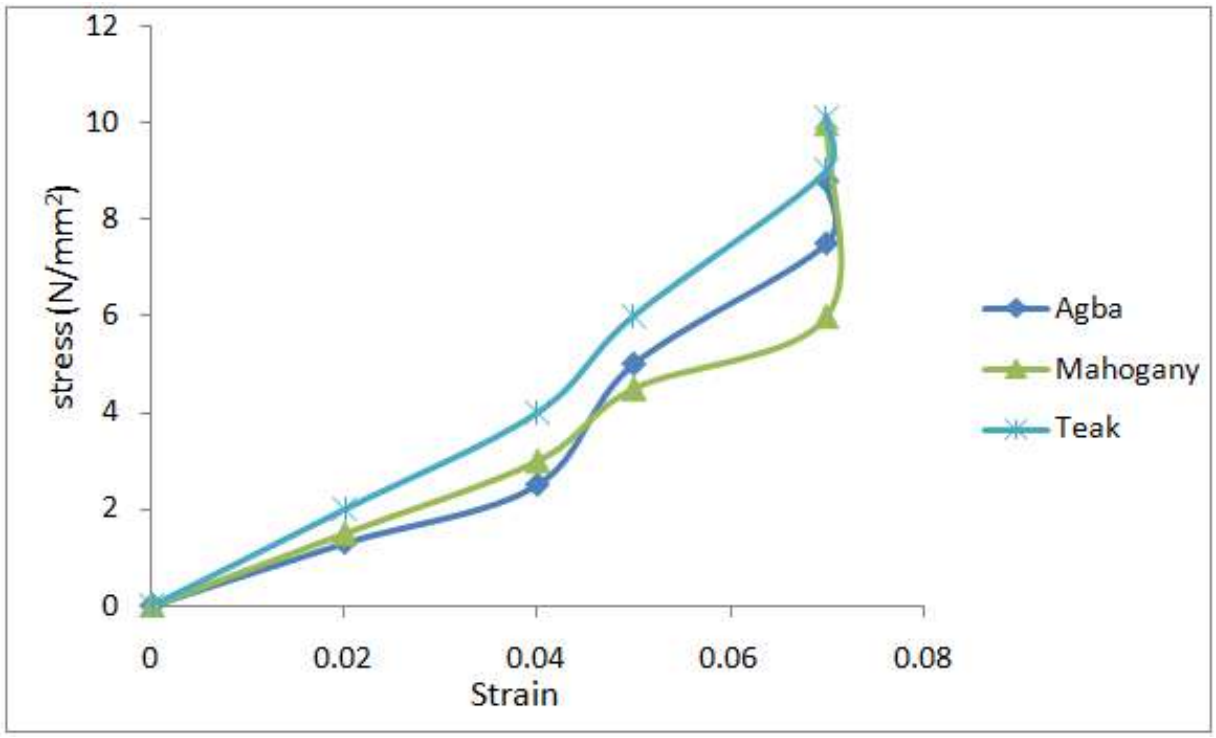

Figure 1. Tensile Stress-Strain Property of the Timbers

Conclusion

Timber is one of the oldest known materials of construction. The structural use of timber includes bridge and canoe construction, roofing and flooring of buildings, etc. The potential strength of timber is known all over the world (Ezeagu and Nwokoye, 2009). The strength of timber is affected by factors such as density, moisture content, grain structure and defects. The denser a timber is the stronger it is (Jackson, 1984). The research work compares some of the strength properties of Teak, Mahogany and Agba Structural timber. Timber is one of the most ubiquitous products used in construction, but in order to perform adequately, it needs to be carefully prepared, stored and maintained. To ensure satisfactory preservative treatment, accurate machining and efficient fabrication; and to avoid problems due to dimensional changes and distortion in use, its moisture content most be controlled.

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When the timbers were subjected to 105 degree Celsius in oven, for 24 hours, the tensile strength of the timbers was reduced by about 94 percent.

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