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Determination of Stress in Selected Timber (Case Study of Ayin and Iroko in Maiduguri North Eastern Nigeria)

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Abstract: *This paper shows the center on some physical and mechanical properties of Ayin and Iroko timber. The test on the physical properties carried out on a moisture content while mechanical properties include compressive strength test, flexural strength test, shear strength test and tensile strength test from the result the average moisture content for Ayin is 15.2% while Iroko is16.1%, respectively. The characteristic strength for Ayin in compressive test at yield, peak and break are 52.830, 53.193, and 49.687, respectively, while that of Iroko characteristic strength at yield, peak and break are 18.220, 19.567 and 14.230, respectively. The characteristic strength for Ayin in flexural test at yield, peak and break are 14.034, 58.822, and 52.165 respectively. While that of Iroko characteristic strength at yield, peak and break are 5.413, 35.280 and 31.231, respectively. The characteristic strength for Ayin in shear test at yield, peak and break are 2.508, 12.340, and 12.240, respectively. While that of Iroko characteristic strength at yield, peak and break are 1.380, 6.827 and 3.744, respectively. The characteristic strength for Ayin in tensile test at yield, peak and break are 122.258, 122.258, and 122.284, respectively, while that of Iroko characteristic strength at yield, peak and break are 47.645 47,645 and 48.209, respectively.*

Keywords: *Physical properties, mechanical properties, Ayin, Iroko, timber.*

INTRODUCTION

Wood is a very versatile raw material and is widely used in construction especially in this nation where there is an abundance of a good quality timber. Timber is the most sustainable building product available and naturally renewable. It can be wed in a range of structural applications including marine works construction of wharves, peers, cofferdam and heavy civil works: bridges, piles shorting pylon, domestic housing: roofs partition, shutting for precast and in-situ concrete, for brick and stone construction. Timber species are in varieties; they are divided into softwood and hardwood does not refer to the density of the wood but rather the type of the trees that the wood comes from hardwood comes from angiosperm (broad level) while soft wood comes from gymnosperm (narrow leaves) wood is susceptible to biodegradation by variety of organisms. Among the biodegradation organism is termite which is a major threat to the services.

Physical properties are the quantitative characteristics of wood and its behavior to external influences other than applied forces. Physical properties are important because they can significantly influence the performance and its strength of wood used in structural applications. Mechanism properties are the characteristics of material on response to externally applied force. They include elastic properties which characterize the resistance to deformation, deformation and applied loads. The mechanical properties values are given in term of stress and strain. Strength properties means the ultimate resistance of material to applied load, and woods strength varies significantly depending on loading condition, loading duration and number of assorted material and environment factors.

Materials and Methodology

Timber was produce from timber market (saw mill) when sawn to required sizes. It was first smoothened and then shaped and cut to required sizes and desired thickness to prepare specimen to a standard of 50mm, a width of 200mm and standard length of 3600m. A length of 50mm, thickness of 6mm 3mm was used to perform the tensile strength, specimen were also cut and shaped for flexural strength with thickness of 20mm, width of 20mm, and a length of 300mm for compressive strength the 20mm thick, 20mm width with length of 60mm was used. For shear strength the thickness of 20mm, width of 20mm and length of 20mm was used. The moisture content was also determined on the specimen.

Preparations of the Specimens

The wood was cut and shaped to required dimension for the determination of physical properties of the air dried timber (moisture content) and mechanical properties (compressive, flexural, tensile and shear test). Three samples of (20 x 20 x 60mm) for both Ayin and Iroko were cut from a test specimen of the air dried timber. The cut specimens were weighed using weighing balance and dimensions was recorded to vary the change in the size and dimensions for compressive strength determination. There samples of 20 x 20 x 20mm for both Ayin and Iroko were cut from the test specimen of air dried timber. The cut specimen balance dimension was recorded weighing balance and dimension was recorded to vary the change in the size dimensions for the shear strength determination. Also, three samples of 20 x 20 x 300mm for both Ayin and Iroko were also cut from the test specimen of air-dried timber. Balance and dimension was recorded for the determination of flexural strength. Lastly, three samples of 50 x 6 x 3mm for both Ayin and Iroko were cut from the test specimens. Weighing balance was wired to determine the weight of the sample. The change in size and dimension were recorded for the determination of tensile strength for all the experiments carried out on the mentioned specimen to determine the mechanical properties for the timber.

Physical and Mechanical Properties Test

The physical properties tests carried out on the timber specimen were moisture content, mechanical properties, the compressive, tensile, flexural and shear strength

Moisture Content

Moistures content was taken as a percentage of the water in the timber after being over dried to a constant weight. It is certainly well known that the moisture content in timber has tremendous effect on the strength of timber pieces. Within the range of 20-25% maximum

moisture content the strength of timber does not alter, but as timber dries its strength increases.

Apparatus

1. Oven
2. Weigh balancing
3. Three samples specimen of the air dyed timber for the Ayin and Iroko

Procedure

The cut specimens were weighed using a weighing balance and this was recorded as wet weight (W1) and the weighed specimens were put into the oven and heated to a temperature of 700°C for 2 hours at 30 minutes interval. The specimens were then weighed again and recorded as dry weight (W2), the average of the wet weight and the dry weight were then obtained and moisture content was calculated as

$$\textbf{Moisture content} = \frac{Weight\ wet\ Sample - Weight\ of\ dry\ Sample}{Weigh\ of\ dry\ Sample}\ x\ 100\% \quad \textbf{..... (3.1)}$$

Compressive Strength

The compressive strength of timber can be determined by the universal testing machine (UTM), the specimen of 20 x 20 x 60mm was placed between the compressive chalk test was brought near each other by turning the speed wheel to applied load.

Apparatus

1. Universal Testing Machine (UTM)
2. Tension meter machines
3. Base plate
4. Apply wheel load
5. Specimen of 20 x 20 x 60mm

Procedure

The dimension specimens were taken, the bearing surface of the testing machine was cleaned and then the specimen was placed in automated machine in such a manner that the load would be applied to the opposite of the cube cast and aligned centrally on the base plate of the machine. The machine was switched on until the specimen failed, the maximum load was failed. The maximum feature in the type of failure was noted.

Calculation

The formula for compressive strength at limit of proportionality = $\frac{P}{A} N/_{MM^2}$ ..... (3.2)

Where, p = load at limit of proportionality (b d) = A = cross-sectional area of specimen.

Mean = $\frac{x_{1+}\, x_{2+}\, x_3}{n}\ or\ \ \frac{\varepsilon x}{n}$ ..... (3.3)

Standard deviation = $\sqrt{\frac{\varepsilon f(x-x)^2}{\varepsilon f}}$ ..... (3.4)

Characteristic Strength = Mean – Standard Deviation

Tensile Strength

The specimen was cut and shaped in accordance with the standard dimension of tensile strength specimen. After the shaping of the specimen the cross sectional dimension were measured with venire caliper and recorded. The machine is to be used to determine the tensile strength in universal testing machine (UTM). The edges of the specimen in bit wider than the cross sectional area, this allow for proper gripped by the tensile machine.

The Avery Tension machine accessories were than arranged on the tensile space in the upper part of the testing machine. Then the specimen was placed in the jaw (Accessories) of the universal testing machine. The bolts in the wedge were heightened so that slippage of the specimen will not occur during the test.

Before load was applied to the specimen the load pointer position was adjusted to initial reading (Zero), then the load was applied by operating the Avery Tension machine automatically and an the load was applied the bolts to wedge were continuously lightened until a failure sound is experienced on the specimen, then the final reading was read on the dial pointer and recorded which give failure of the specimen.

$$\textbf{Tensile strength} = \frac{Loadatfailure\ (N)}{Crosssectionalarea\ (MM)} \quad \text{..... (3.5)}$$

$$\textbf{Mean} = \frac{x_{1+}\, x_{2+}\, x_3}{n}\, n\, \frac{\varepsilon x}{n} \quad \text{..... (3.6)}$$

$$\textbf{Standard deviation} = \sqrt{\frac{\varepsilon f(x-x)^2}{\varepsilon f}} \quad \text{..... (3.7)}$$

Characteristic Strength = Mean – Standard Deviation

Flexural Strength

Flexural strength is the measure of modulus of rupture or bend strength of beam the flexural strength represent the highest stress experienced within the material at its moment of tiled; materials that deform significantly but do not break, the load at tiled, typically measured at 5% deformational stress or outer surface. B reported as flexural strength. The sample is place between two supports and initiating a load using a third points or with points which are respectively call 3 point break testing. The maximum stress are calculated on the applied load on the specimen of 20x20x300mm.

Apparatus

1. Universal testing machine (U .T .M)
2. Specimen (20x20x300mm)

Procedure

The specimen was placed on the flexural testing machine, the feeler gages leaf type of 0.10mm and 0.38mm was employed and the space between the specimen and the load to be applied using leather shims

The loading system was placed centrally in relation to the applied force. The applying force was in contact with the specimen surface at the loading points. The load was applied at 6% of the ultimate load.

The specimen was loaded continuously without shock until the point of failure was noticed.

Calculation

The flexural strength of the specimen shall be expressed as the modulus of rupture

MR = $\frac{3pl}{2bd^2}$ …….. (3.8)

Where

MR= modulus of rupture

P = ultimate applied load indicated by Test machine

(b) = Average with of the specimen

L= span length

d = Average depth of the specimen

Mean= $\frac{x_{1+}\,x_{2+}\,x_3}{n}\,n\,\frac{\varepsilon x}{n}$ ……(3.9)

Standard deviation = $\sqrt{\frac{\varepsilon f(x-x)^2}{\varepsilon f}}$ ……(3.10)

Characteristic Strength = Mean – Standard Deviation

SHEAR STRENGTH PROCEDURE

The shear strength of timber can be determined by the use of universal testing machine (U.T.M) the specimen of 20x20x20mm the specimen was placed in the machine in the manner that the load would be applied to opposite side aligned centrally on the machine. The machine was stressed on until the specimen failed.

Calculation

The shear strength was computed using shear strength = $\frac{p}{bd}\,N/_{mm^2}$ ……(3.11)

P = load at limit of proportionally

b = width

d = depth or thicken s

Mean= $\frac{x_1+x_2+x_3}{n}\,n\,\frac{\varepsilon x}{n}$ ……(3.12)

Standard deviation = $\sqrt{\frac{\varepsilon f(x-x)^2}{\varepsilon f}}$ ……(3.13)

Characteristic Strength = Mean – Standard Deviation

RESULT AND DISCUSSION

Physical Properties

Moisture Content

Specimen – Ayin

Temperature – 105 $\pm 2^0C$

Samples – Four

TABLE 1: MOISTURE CONTENT OF AYIN TREE

Description	Sample 1	Sample 2	Sample 3	Sample 4
Weight 7 (g) wet sample	12	20	10	6
Weight 77 (g) dry sample	10.56	18.00	8.56	5.00
Moisture (g) content	0.136	0.111	0.168	0.200
% moisture content (g)	13.6	11.1	16.8	20.0
Average (g) % moisture content		15.4		

The moisture content for Ayin Determination shown were in the table above the average moisture content 651.40% according to the result given above its shows that the Ayin timber is in standard Win ASTM.

SPECIMEN – IROKO

Temperature – 105 $\pm 2^0 C$
Samples – Four
Table 2: Moisture Content Of Iroko Tree

The moisture content for Iroko determination shown were in the table above. The average moisture content is 16.5% according to the result given above its shows that the Iroko timber is in standard with ATM.

RESULT OF FLEXURAL STRESS IN TIMBER

Description	Sample 1	Sample 2	Sample 3	Sample 4
Weight Of Wet Sample	8.00	15.00	4.00	3.00
Weight Of Dry Sample	6.65	13.00	3.56	2.56
Moisture Content	0.22	0.15	0.12	0.17
% Moisture Content	22.0	15.0	12.0	17.0
Average % Moisture Content		16.5		

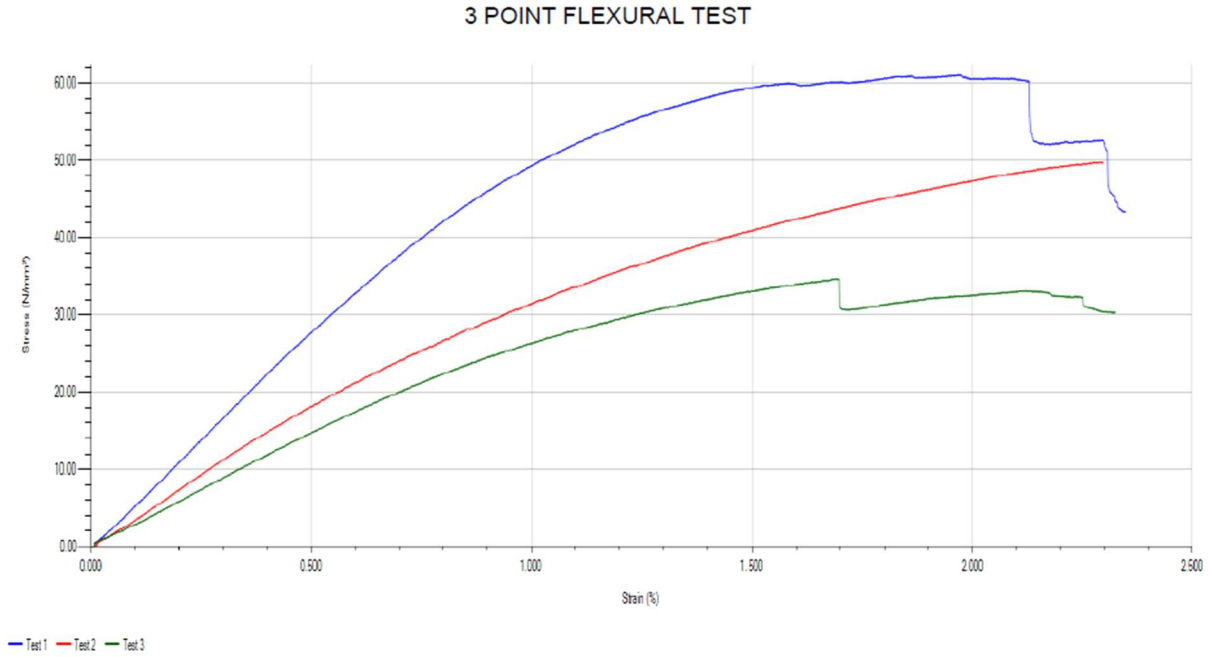
AYIN TIMBER FLEXURAL

TABLE 3 FLEXURAL STRESS IN AYIN TIMBER

Sample	Bending @ Yield N/mm^2	Bending @ Peak N/mm^2	Bending @ Break N/mm^2
1	23.310	69.510	69.300
2	23.992	87.045	75.075
3	63.052	154.455	153.877
Mean	36.785	103.67	99.417
Standard Deviation	22.751	44.848	47.252
Characteristic Strength	14.034	58.822	52.165

The table 1 shows the summary of flexural stem of Ayin timber. From the sample minimum stem at yield, Peak and Break are 23.310, 69.510 and 69.300 respectively maximum stem at yield Peak and Break are 63.052, 154.455 and 153.877 respectively. More so characteristic strength value are 14.034, 58.822 and 52.165 for the stresses at yield, peak and at break respectively.

graphical representation of the stress/strain curve for Flexural stresses of Ayin timber



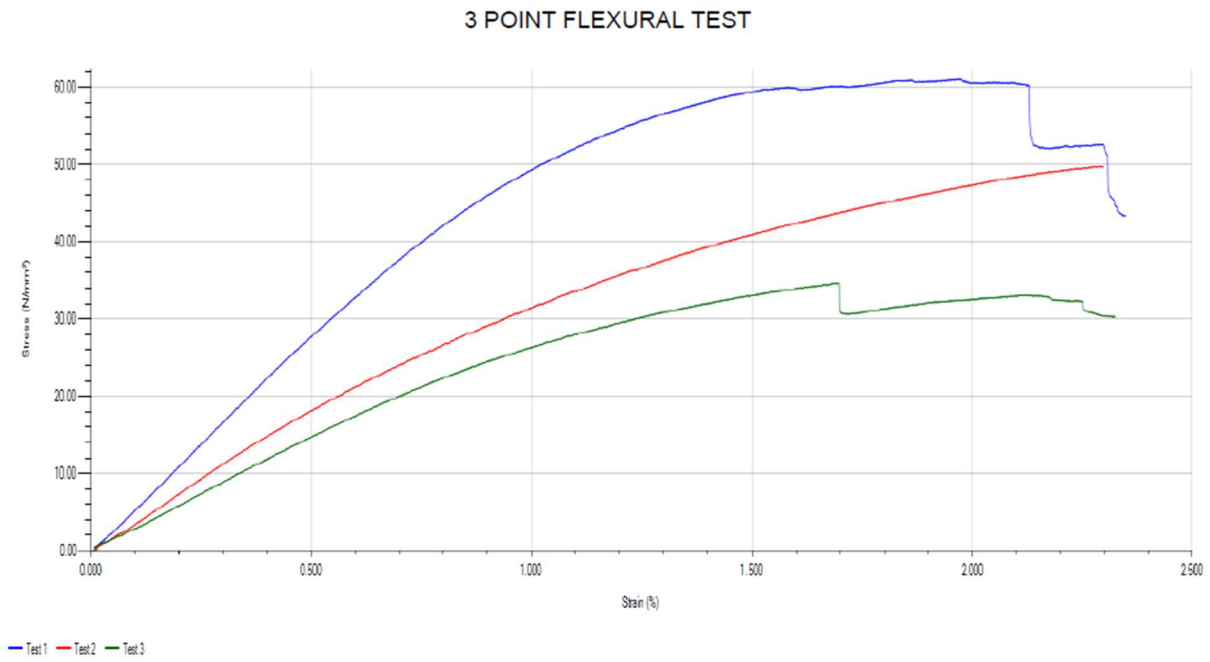
AYIN TIMBER FLEXURAL

TABLE 4 FLEXURAL STRESSES IN IROKO TIMBER

Sample	Bending @ Yield N/mm^2	Bending @ Peak N/mm^2	Bending @ Break N/mm^2
1	55.282	61.110	43.365
2	20.738	49.770	49.612
3	10.533	34.703	30.293
Mean	28.857	48.528	41.090
Standard Deviation	23.444	13.248	9.859
Characteristic Strength	5.413	35.280	31.231

Table shows the summary of flexural stresses of IROKO timber from the sample minimum stress at yield, peak and break are 10.553, 34.703 and 30.293 respectively maximum stress at yield, peak and break are 55.282, 61.110 and 49.612 respectively. More so characteristic strength value are 5.413, 35.280 and 31.231 for the stress at yield, peak and break respectively.

Graphical representation of the stress/strain curve for flexural stresses of IROKO timber.



RESULT OF COMPRESSION STRESS IN TIMBER

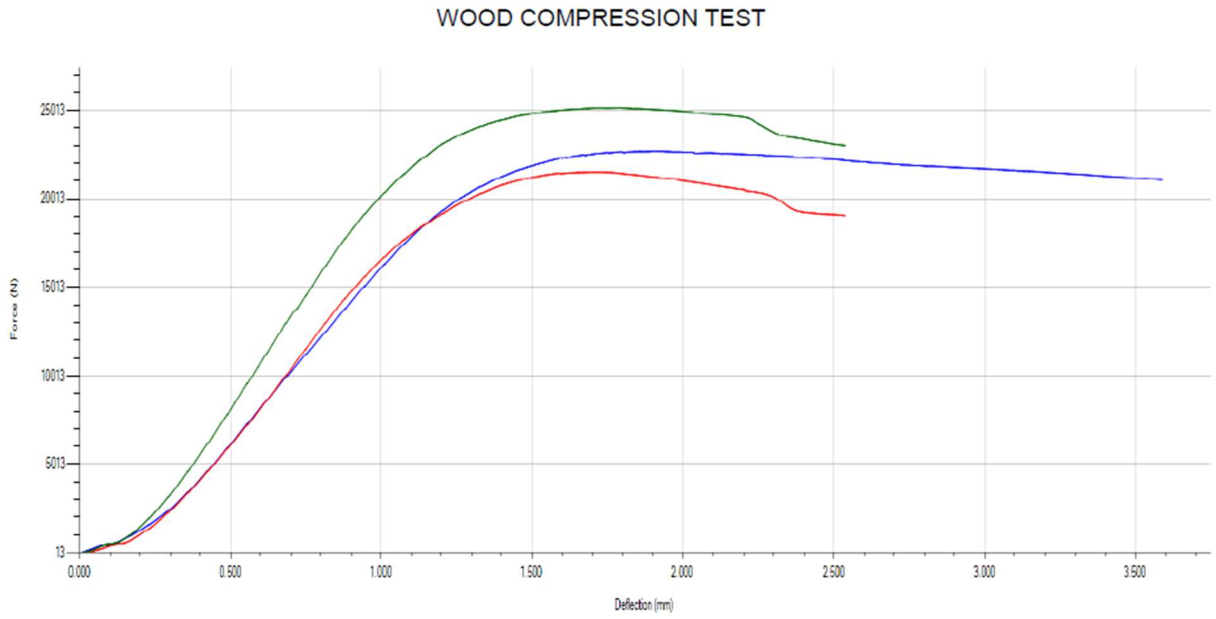
AYIN TIMBERCOMPRESSION STRESS

TABLE 5 COMPRESSION STRESS IN AYIN TIMBER

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	56.275	56.775	52.700
2	53.650	53.825	47.650
3	62.950	62.950	57.525
Mean	57.850	57.850	52.525
Standard Deviation	4.795	4.657	4.938
Characteristic Strength	52.830	53.193	47.687

The Table 2 show the summary of compression stresses of Ayin timber. From the sample minimum stressed yield, peak and break are 53.650, 53.775 and 47.525 respectively. While maximum stresses at yield, peak and break are 62.950, 62.950 and 57525 respectively. More so the characteristic strength values are 52.830, 53,193 and 47.687 for yield, peak and break respectively.

Graphical representation of the stress/strain curve for compression stresses of Ayin timber.



IROKO TIMBERCOMPRESSION STRESS

TABLE COMPRESSION OF IN IROKO TIMBER.

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	26.825	27.600	27.600
2	19.880	22.703	22.403
3	19.955	19.980	19.727
Mean	22.220	23.428	23.243
Standard Deviation	3.988	3.861	4.003
Characteristic Strength	18.232	19.567	19.240

The summary of compression stresses of iroko timber, from the sample minimum stresses at yield, peak and break are 19.880, 19.980 and 19.727 respectively. While maximum stresses at yield, peak and break are 26.825, 27,600 and 27,600 respectively. More so the characteristic strength values are 18.232, 19.567 and 19.240 for the yield, peak and break respectively.

Graphical representation of the stress/strain curve for compression stresses of Iroko timber.

RESULT OF SHEAR STRESS IN TIMBER

AYIN TIMBER SHEAR STRESS RESULT

TABLE: SHEAR STEM IN AYIN TIMBER

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	2.792	13.385	13.312
2	2.500	12.493	12.360
3	3.035	15.072	14.905
Mean	2.776	13.650	13.526
Standard Deviation	0.268	1.310	1.286
Characteristic Strength	2.508	12.340	12.240

The table shows the summary of shear stresses of Ayin timber, from the sample minimum stresses at yield, peak and break 2.500, 12.493 and 12.360 respectively. Maximum stresses at yield, peak and break are 14.905, 15.072 and 3.035 respectively more so the characteristic strength values are 2.508, 12,340 and 12.240 for yield, peak and break respectively.

Graphical representation of the stress/strain curve for shear stresses of Ayin timber.

IROKO TIMBER SHEAR STRESS RESULT

TABLE SHEAR STRESS IN IROKO TIMBER

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	1.710	8.475	3.528
2	1.425	7.085	6.040
3	1.468	7.327	6.777
Mean	1.534	7.629	5.448
Standard Deviation	0.154	0.742	1.704
Characteristic Strength	1.380	6.887	3.744

The table shows the summary of shear stresses of Iroko timber. From the sample minimum stresses at yield, peak and break are 1.425, 7.085 and 3.528 respectively. Maximum stresses at yield, peak and break are 1.710, 8.475 and 6.777, respectively. The characteristic strength at yield, peak and break are 1.380, 6.887 and 3.744, respectively. In addition, the figure 4.6 shows the graphical representation of the stress/strain graph of shear stress in Iroko timber.

RESULT OF TENSION STRESS IN TIMBER

AYIN TIMBER TENSION STRESS

TABLE TENSION STRESS IN AYIN TIMBER

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	204.278	204.278	204.278
2	119.000	119.000	119.000
3	172.889	172.889	172.889
Mean	165.389	165.389	165.370
Standard Deviation	43.131	43.131	43.106
Characteristic Strength	122.258	122.258	122.264

The table shows the summary of tension stresses of Ayin timber. From the sample minimum stresses at yield, peak and break are 119.000, 119.000 and 119.000 respectively. Maximum stresses at yield, peak and break are 204.278, 204.278and 204.278 respectively.
Characteristic strength values are 122.258, 122.258 and 122,264 for the yield, peak break respectively. More so, the figure 4.7 shows the graphically representation of the stress/stain grapy of tension in Ayin timber

IROKO TIMBER TENSION STRESS

TABLE TENSION STRESS IN IROKO TIMBER

Sample	Stress @ Yield N/mm^2	Stress @ Peak N/mm^2	Stress @ Break N/mm^2
1	62.333	62.333	62.056
2	52.500	52.500	52.500
3	49.611	49.611	49.611
Mean	54.315	54.315	54.722
Standard Deviation	6.670	6.670	6.513
Characteristic Strength	47.645	47.645	48.209

The summary of tension stresses of Iroko timber. From the sample minimum stresses at yield, peak and break are 49.611, 49.611 and 49.611 respectively. Maximum stresses at yield, peak and break are 62.333, 62.333 and 62.056, respectively. Characteristic strength at yield, peak and break are 47.645, 47.645 and 48.209, respectively. Figure 4.8 shows the graphically representation of the stress/stain grapy of tension in Iroko timber.

RESULT AND DISCUSSION

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The moisture content test shows when Ayin and Iroko timber is used as primary structure in a building. It is required to have a service life as long as the environmental condition and catastrophes to which it may be exposed. We explored the factors affecting the life span of the timber. Weather that is an abrupt end of its service life due to fire, or more gradually delay due to fungi or insert.

Stresses in Ayin and Iroko timber have been determine relatively Ayin timber has high flexural strength than Iroko and thus, Iroko has characteristic strength that make it suitable to be use as shealthing in formwork. Ayin has high compression stresses which make it suitable to be use a share in formwork. In roof trusses, Ayin is suitable for rafter, the beams and braces and king post while Iroko is good for lithe in the roof e.g. The mechanical properties can be enhanced with adequate seasoning and preservative treatment of their timbers are for structural purpose

RECOMMENDATION

This suggests that Ayin timber is particularly structurally efficient material in structure or parts of structure, in which a high proportion of load to be resisted is the self-weight of the structure itself. Examples are roofs, bridges and gravity load resisting system of tall building. The intrinsic high hardness and strength of Ayin timber recommends it as a structural maternal structure for trusses. Massive forestation practices should be promoted to reduce the death of these trees and other notable trees in the forest.

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