Strength properties of "tapped" rubber wood (*Hevea braziliensis* muel. Arg.) in the University of Ibadan rubber plantation

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Abstract
Selected mechanical properties of rubber wood, an agricultural bye-product were studied for its application in structural utilization. Five (5) trees were sampled from a 45-year old plantation located in the Teaching and Research Farm of the University of Ibadan, Nigeria. Test samples were collected along the bole height at the butt, 50% and 90% of the merchantable height (MH). Data obtained were subjected to a two-way analysis of variances to determine the significance of variations at 5% level. The mean modulus of rupture (MOR) was 39.47 N/mm² ranging from 38.11N/mm² at the butt to 41.92N/mm² at 50% of MH. Average modulus of elasticity (MOE) was 8029.26N/mm² ranging from 7179.21N/mm² to 9328.21N/mm² at 50% of MH. Maximum drop of hammer (impact bending) was also highest at 50% of MH and lowest at the butt. For all the strength properties studied, variations were not statistically significant at 5% level, showing a sort of axial uniformity in strength properties. Results further revealed that there are great potentials in rubber wood for structural applications as some of the properties studied were not in anyway inferior to those of species already popular in the timber market.

Keywords: Rubber wood, plantation, modulus of rupture, modulus of elasticity, impact bending.

Introduction

Rubber wood (*Hevea braziliensis* Muel. Arg.) is a popular plantation crop in Nigeria used for the production of latex, a raw material in some Nigerian tyre and rubber industries. Tapping of rubber tree for this purpose usually starts from 5th to 7th year of plantation and continues to 25 or 30 years after which latex production declines and the trees are either replaced with new ones or abandoned foi a fresh site. In Nigeria, it is common to find relics of "tapped" rubber plantation, which are usually harvested for fuelwood.

Rubber tree grows to about 30 metres tall within 30 years and is widely distributed all over the world especially in the tropics owing to its ability to survive on a variety of soils. According to Akachuku (1985), out of about 366,000ha of rubber plantation in West Africa, Nigeria has about 225,000ha scattered all over the country, this value present a good case for rubber as a potential source of wood supply when compared to other sources.

Rubber wood has been identified to be useful for a number of products, for instance, according to Salley, (1984), 61 different products made from rubber wood are mainly in furniture and paneling. Because rubber wood is an agricultural bye-product, the cost of products is usually lower than other woods from the plantation, from the economic point of view; rubber tree is capable of contributing meaningfully to the economy. In Malaysia for instance, earnings from export of rubber wood furniture rose from about US$74.2 million in 1991 to about US$683.3 million in 1998 (Killmann and Hong, 2000). The quantity of rubber wood available in Nigeria, the environmental implication of its use and the economic dividends derivable from these, call for a serious attention to the deplorable condition of our rubber plantations. Enabor and Akachuku have also done some work on some utilization potentials of rubber woods in Nigeria. There is need to go further by studying the variation in the strength properties of Nigerian grown rubber wood, especially from stands that have lost the vitality for latex production. This study therefore, evaluates the mechanical properties of "tapped" rubber wood for its potential in wood supply in Nigeria.

Materials and methods

Sample selection

Fifty (50) trees were selectively sampled from a 45-year old Rubber plantation located at the University of Ibadan Teaching and Research Farm. Five (5) of these were randomly selected for the purpose of this study. Three (3) discs each were removed from the butt, 50% and 90% of merchantable height making a total of 15 bolts of 400mm length. Strips of 10mm were removed from the center of each disc using circular saw machine. These were further converted into test specimens of 25mm x 25mm x 350mm dimension. Ten test specimens were systematically selected to cover all the wood types (sapwood and heart wood). A total of 150 test specimens were produced. These were conditioned for one (1) month in the laboratory, before they were finally converted to 20mm x 20mm x 300mm recommended by British Standard (BS 373). This was done exactly one (1) week before the mechanical property test.

Strength property test

Impact bending (IMB) was carried out using the Hatt-Turner Impact Testing Machine, in accordance with British Standard (BS 373). Each standard test specimens of 20mm x 20mm x 300mm was supported over a span of 240mm on a support radiused 15mm, spring restricted yokes were also fitted to avert rebounce. Seventy-five (75) test specimens were subjected each to a repeated blow from a weight of 1.5kg at increasing height initially 50.8mm and then every 25.4mm and then every 50.8mm until complete failure occurred at which point the height was recorded in metre as the height of maximum hammer drop.

Seventy-five (75) standard test specimens of 20mm x 20mm x 300mm were also used to test Modulus of Rupture (MOR) of the species. Each specimen was loaded at 0.1mm/sec with the growth ring parallel to the direction of loading, i.e. specimen was loaded on the radial face. The bending strength of wood usually expressed as MOR, is the equivalent fibres stress in the extreme fibres of the specimen at the point of failure is calculated as:

$$MOR = \frac{3PLN/mm^2}{2bd^2}$$

P = Load in Newton (N)

L = Span in (mm)

b = Width of specimen in (mm)

d = Depth of specimens in (mm)

Another strength property of interest is the Modulus of Elasticity (MOE). This is obtained from the formula:

$$MOE = \frac{PL^3N/mm^2}{4\Delta bd^3}$$

Where P, L, b and d are as above in (MOR). Δ, which is the deflection of the beam center at proportional limit is obtained from the load deformation curve plotted during the static bending test.

Results and discussion

The results obtained from the wood properties evaluated are as shown in Table1. Impact bending has a mean of 0.45m ranging from 0.42 at the butt, 0.49m at 50% of MH to 0.43m at the top. Modulus of Rupture (MOR) also increased from butt to 50% of MH and then decreased toward the top. The trend of Modulus of Elasticity (MOE) is not in anyway different from the trend reported for both IMB and MOR. The mean MOE was 8029.26N/mm^2 at the top with initial value of 7179.21N/mm^2 at the butt, 9328.21N/mm^2 at 50% of MH and 7580.37N/mm^2 at the top. The result obtained in this study is similar to those already obtained by Lee *et. al.* (1982) where mean of 66N/mm^2 and 9240N/mm^2 were obtained for MOR and MOE respectively in their study. Although, the values in their result appeared higher, the lower moisture content of test specimens used in their study might be responsible as moisture content below fibre saturation point is negatively related to strength values.

Table 1: Results of selected strength properties of Rubber wood obtained from plantation

Property	Sampling height			
	Butt	50%	90%	Mean
IMB (m)	0.42	0.49	0.43	0.45
MOR (N/mm^2)	38.11	41.92	38.38	39.47
MOE (N/mm^2)	7179.21	9328.21	7580.37	8029.26

Source: Field work, (2001).

Table 2: Results of the analysis of variance (ANOVA) for IMB in plantation grown *Hevea braziliensis*

Source of Variation	Df	MS	F	P-Level
Sampling height	2	0.006427	0.62791	0.558085
Block (tree)	4	0.004710	0.46019	0.76356
Error	8	0.010235		
Total	14			

Source: Field work, (2001).

Table 3: Results of Analysis of Variance (ANOVA) for MOR in plantation grown *Hevea braziliensis*

Source of Variation	Df	MS	F	P-Level
Sampling height	2	19.9653	0.83395	0.46885
Block (tree)	4	47.5912	1.987886	0.18941
Error	8	23.94061		
Total	14			

Source: Field work, (2001)

Table 4: Results of Analysis of Variance (ANOVA) for MOE in plantation grown *Hevea braziliensis.*

Source of Variation	Df	MS	F	P-Level
Sampling height	2	6969336	4.045114	0.061110
Block (tree)	4	1705266	0.989763	0.465422
Error	8	1722902		
Total	14			

Source: Field work, (2001).

There is general pattern of axial variation for all the strength properties studied. All strength properties increased to 50% of MH and then decreased towards the top. This behaviour is not unexpected, as similar reports had been given in some tropical hardwoods (Sanwo, 1986, Ogunsanwo, 2000). According to Ogunsanwo, (2000) strong relationship exists among strength properties such as IMB, MOR and MOE. In fact, a coefficient of determination, (R^2) of 0.61, 0.66 had been found between IMB & MOR and between MOR & MOE and sampling height.

Unlike the general trend where strength properties varied consistently along the axial direction, the current study shows an inconsistence in variation pattern along the bole. For all the strength, highest values were obtained at 50% of MH, showing that shock resistance, stiffness and flexibility of "tapped" rubber wood is maximum at 50% of MH. Incidentally, this point is close to the point where tapping took place when the tree was alive. There is the possibility of growth stress development leading to the production of wood with high density and hence the observed strength properties around the position. Despite the observed variations in the strength properties along this position, statistical analysis shows that the variations are not significant. This shows that there seems to be uniformity in the wood strength characteristics of "tapped" rubber wood along the bole. The mean values obtained from the wood properties evaluated are encouraging. The results compared well with those of other species currently popular in the timber market as shown in Table 5.

Table 5: Strength properties values for plantation grown rubber wood compared with four other Nigerian grown hardwoods.

Wood property	Species				
	Rubber	Obeche	Omo	Teak	White Afara
IMB (m)	0.45	0.65	0.68	0.71	0.70
MOR (N/mm^2)	39.47	61.90	54.00	86.00	52.00
MOE (N/mm^2)	8029.26	6239.40	6100.00	10500.00	5900.00

Source: Field work, (2001); Ogunsanwo, (2000) and Sanwo, (1983).

Conclusion

This study has been able to show that rubber wood has great potentials in structural applications. The strength properties investigated compared favourably well with those of other species e.g. Obeche (*Triplochiton scleroxylon*), white Afara (*Terminalia superba*) and Omo (*Cordia millenia*), which are already in use. The study particularly showed that in "tapped" rubber wood, strength properties were at maximum at 50% of merchantable height. Though, variations in properties were observed along the bole; they were not statistically significant, giving an indication of axial uniformity in mechanical properties.

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