Studies on the Influence of Moisture and Specific Gravity on the Strength Properties of Mango Wood *(Mangifera indica)*

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Influence of moisture and specific gravity on the strength of mango wood is discussed. The co-efficient of correlation between specific gravity and breaking strength was found to be nonsignificant. The relation of strength and moisture was found to be highly significant. The mean strength values indicated a reduction in strength when the moisture increased from 8.5 to 18.8%. However no appreciable difference in strength values could be observed when moisture increased above 37%. The strength-moisture relationship is a straight line, passing approximately through the fibre saturation point. By using the exponential formula, the breaking strength corresponding to any moisture level between zero and fibre saturation can be determined.

Timber is a versatile construction material. It has the ability to resist applied forces. The strength of wood depends on various mechanical properties of the wood and it varies from species to species. A basic knowledge of the strength properties of wood is therefore an essential pre-requisite, if timber is to be used in an economical and efficient manner. Extensive studies on the strength properties of 125 native grown and imported soft woods have been conducted by the Forest Products Research Laboratory (Armstrong, 1953). Of late, studies on arsenical creosote (Nair *et al.*, 1972 a, b) for marine structures have shown that secondary species of wood like Mango and Haldu are susceptible to preservative treatment which enhances the life of these timbers. The response of *Mangifera indica* to preservative treatment prompted a detailed study into other basic knowledge of its strength properties. Small differences in moisture content and specific gravity are known to influence the strength properties of timber (Armstrong, 1953). From many points of view a series of methodical laboratory tests are preferred to actual conditions of service as it is economical with reference to material and time and also simplification and standardisation of test procedure. The strength property studies would provide a basis for assessing the utilisation values of this home grown timber, particularly for fishing boat construction.

Materials and Methods

Seasoned mango test panels of size 15 X 4 X 0.6 cm with a central bore of 2 cm diameter were prepared for static bending strength studies. Known moisture concentrations, namely, 8.5, 10, 18.8, 37, 42.2, 58, 69, 81, 90 & 98% were maintained in desi-

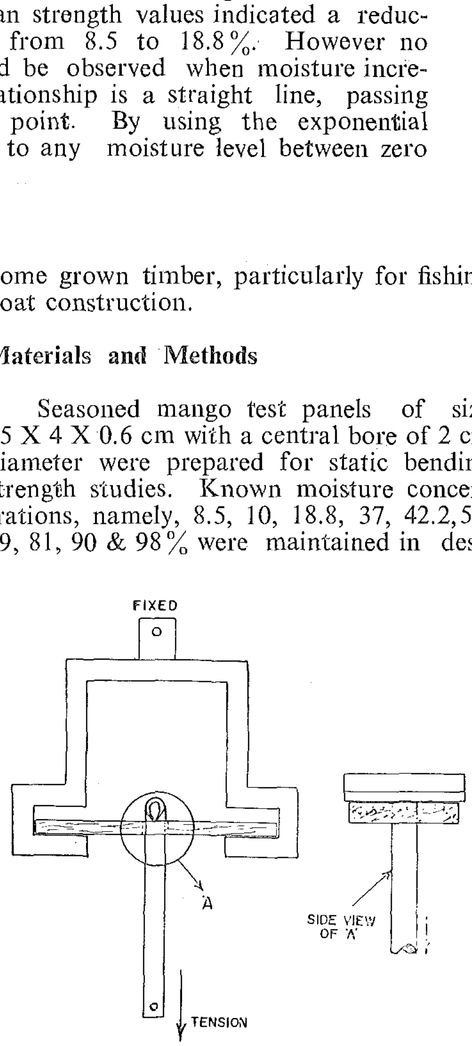

Fig. 1. *Arrangement for determining the static bending strength of the wooden panels*

cators by preparing solutions of zinc chloride, potassium chloride, ammonium sulphate, zinc sulphate and copper sulphate. Static bending strength of each panel was determined in a tester. A special test rig to hold the panels was designed and fitted to the tester as shown in Fig. 1. The panels were divided into ten different groups, each group consisting of five panels of identical moisture content. The mean values of specific gravity, weight, moisture and breaking strength of the panels under different groups are presented in Table 1.

Table 1. *Mean values of specific gravity, weight, moisture and breaking strength of the panels*

Groups	Specific gravity	Weight of panel g	Moisture content %	Breaking strength kg
1	0.560	27.003	8.5	62.10
2	0.586	28.240	10.0	45.50
3	0.581	27.976	18.8	40.40
4	0.557	26.848	37.0	37.60
5	0.581	28.022	47.2	38.60
6	0.582	27.817	58.0	35.00
7	0.590	28.439	69.0	34.80
8	0.696	35.072	81.0	27.00
9	0.556	26.808	90.0	28.40
10	0.562	27.066	98.0	27.05

The data were analysed statistically to determine the specific gravity — breaking strength and moisture–strength relationships. The mean specific gravity was observed to be 0.586 with standard deviation of 0.069 and the mean breaking strength was calculated as 37.62 with SD=13.74.

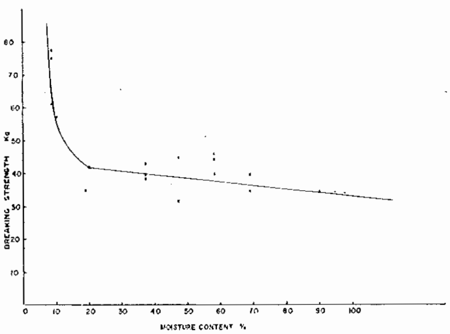

Fig. 2. *Relation of breaking strength to moisture content*

The correlation co-efficient, an expression for the closeness of the relationships between specific gravity—breaking strength and between moisture content—breaking strength was calculated using the formula $e = \frac{\sigma X y}{\sigma X \sigma y}$, σX, σy are standard deviations of x, y respectively.

Results and Discussion

The co-efficient of correlation between specific gravity and breaking strength was found to be C=-0.07 (non-significant at 5% level). Normally, specific gravity—strength relations are positive and significant. But in the present study, specific gravity had no influence over the strength properties. This may be due to the fact that the type of wood and the actual wood substance employed in the study were the same (Mean specific gra-

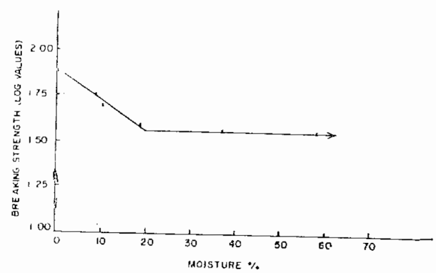

Fig. 3. *Relation of breaking strength (log) to moisture percentage.*

vity 0.586 and SD=0.069). The relation of strength and moisture appears to be highly significant. The co-efficient of correlation in this case was found to be -0.87 (significant at 1% level). The mean strength values clearly indicate that, when there is an increase in moisture content from 8.5% to

Table 2. *ANOVA of group* 1

Source of variations	SS	df	mS	F
Between groups	1364.91	2	682.46	*
Error	2143.38	13	164.80	
TSS	3508.30	15		

*Significance at 5% level

18.8%(Fig. 2), there is corresponding decrease in strength. No appreciable difference in strength values could be observed when moisture increased above 37%. The panels in groups 1, 2, 3 and in groups 4–10 were statistically tested separately to find out the significant differences if any between the means. The results are presented in Tables 2 and 3.

Table 3. *ANOVA of group* 2

Source of variation	SS	df	mS	F
Between groups	783.8982	6	130.65	15
Error	2366.458	27	87.66	
Total	3150.3562	33		

As the mean breaking strength of groups having moisture content 37.0% and above do not differ significantly, it is assumed to represent a straight line. The regression equation to this line was found to be $y=47.002-0.207x$, by plotting the moisture content on the X axis and strength on Y axis. The inclined line representing the groups 1, 2, 3 and the straight line representing groups 4–10 intersect at the point 20, which can be the fibre saturation point (Fig. 2). This means that as the moisture content decreases from 20%, the breaking strength increases, but as the moisture increases above 20% there is no apparent increase in breaking strength. The corresponding breaking strength is noted to be around 42.

Studies conducted by Wilson (1932) have shown that the strength values between zero moisture and fibre saturation point can be represented by an exponential formula, $\log S+\log Sp=K\ (Mp-M)$, where S is the strength corresponding to the moisture content, M, Sp and Mp are the strength and moisture content at the intersection point, K being a constant. In the present experiment Sp was found to be 42 and corresponding Mp was 20. In Fig. 3, the values of breaking strength with the corresponding moisture levels are plotted on a semi-logarithmic paper, with the moisture on the uniformly divided scale and strength on a logarithmically divided scale. As is observed from Fig. 3, the strength-moisture relationship is a straight line, passing approximately through the fibre saturation point. The inclined line also passes through the point at which 'M' is 8.5 and 'S' 62.1. Substituting the respective values, K was found to be 0.015. By using the values of K, Mp and Sp the breaking strength corresponding to any moisture level between zero and fibre saturation can be determined.

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