

Basic and Grade Stress for Some Timber in Sarawak

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Abstract—Strength properties' tests are conducted in the small clear sample. This paper aim to acquire the basic and grade stresses of some fast growing species thus identifies its strength group. Thus, the information of wood properties from different species and condition are acquired from strength property's test. The required information namely, bending parallel to the grain, compression stress parallel to grain, shear parallel to grain and modulus of elasticity. The condition of the trees which is referred to green and air-dry condition. Three different species which are referred to exotic species of *Acacia mangium* and indigenous species of Aras. The results from the study indicated that, *Acacia mangium* classified under the strength group SG5, whilst Aras was classified under the strength group SG7. The timber is of medium density Light Hardwood ranging from 0.37-0.52g/cm³ air-dry condition.

Keywords: Bending parallel to the grain, compression stress parallel to grain, shear parallel to grain, modulus of elasticity.

I. INTRODUCTION

Although the density of timber is relatively reflected the strength of the timber, but it should not be the definite measurement of its strength. It had been understood that timber is homogenous material thus some physical testing had to be conducted to reveal and confirmed the timber strength group as identified from its density. The most suitable sample to be tested that had been suggested by using the small clear sample which is the defect free. [4]. Therefore, the strength properties of some species can be compared and to be concluded by identified its strength group classification on the species that base on Malaysian Standard MS544: Part 2 requirements. The strength group classification on the selected species for this study was subject to the testing results that acquired from compression parallel to grain test, shear parallel to grain test, bending parallel to grain and modulus of elasticity. The strength group classification was conducted in two conditions at green and air-dry. Classification on the strength group on the species was depended on the grade stresses results, i.e. grade select, grade standard and grade common. The strength groups can be classified into seven categories, which base on the strength species namely SG1, SG2, SG3, SG4, SG5, SG6 and SG7.

In timber engineering practice, the ultimate stresses obtained from tests are reduced by applying arbitrary factors [6] to obtain what is called working stresses or permissible stress. These arbitrary reduction factors account for variability of timber duration, and conditions offloading, and factor of safety [4].

II. EXPERIMENTAL METHODS

Preparation of specimen

Three timber species namely *Acacia mangium* and Aras were collected from Sabal Reforestation Plot are used in this study. Sampling of test samples was made throughout the whole length of the tree. The logs were then ripped into half through the pith to obtain the flicthes. The flicthes were planed and machined to 20x20mm for static bending tests. The sticks were visually grade, and only defect free green as well as air-dry samples are cut into specified length and tested. The green condition samples were first to be tested whilst for air-dry condition samples stacked properly for air-drying process. This air-dry process is depending on the type of sample, and this process can be more than nine months. A total of 190 timber samples were used for the bending tests both in each testing condition.

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Testing methods

The strength properties' tests are conducted by using destructive test (DT) and results were obtained from two different timber conditions, i.e. green and air-dry conditions. There were four testing results of strength properties were acquired i.e. bending parallel to grain, compression parallel to grain, shear parallel to grain (tangential and radial) and modulus of elasticity. The average shear parallel to grain was from tangential and radial where as the result from the modulus of rupture was referred to the bending parallel to grain. The static bending testing was done in accordance to the British Standard BS 373: 1957 conducted using an Instron Universal Testing Machines with loading capacity of 50kN. A specimen 20 x 20 x 300mm in length is supported over a span of 280mm, and the test is carried out by the three-point bending method. The values of modulus of rupture and modulus of elasticity were electronically calculated by the machine. Compression test results were conducted with 20 x 20 x 60mm specimen in which special care has been taken to ensure that end-grain surfaces are parallel to each other and normal to the longitudinal axis. The specimen was placed between two compression platen and the rate of upper platen descent 0.6mm/min is used. The property determined is the maximum compression strength parallel to grain. The values of compression stress at maximum load were electronically calculated by the machine.

III. RESULTS AND DISCUSSION

Grade stress of *Acacia mangium*

Acacia mangium had been known as the most admired planted fast growing species in timber industries. From Table 1, where at green condition, mean results obtained from compression parallel to grain test reveal the basic stress of 17.1N/mm² thus gave the results for grade stresses select, standard, and common were 13.7N/mm², 10.8N/mm² and 8.6N/mm² respectively. From the result, it has been classified under SG4. Where by the average mean results from shear parallel to grain test reveal that the basic stress value is 3.0N/mm² and thus contributed the grade stresses for select, standard, and common with 2.4N/mm², 1.9N/mm², and 1.5N/mm² respectively. Thus, this has been classified under SG1. Basic stress for MOR or bending parallel to grain is 24.4N/mm² and thus concluded that the grade stresses of select, standard, and common are 19.5N/mm², 15.3N/mm², and 12.2N/mm² respectively. This has been classified under SG2. Whilst, for modulus of elasticity, the grade stresses is 6044N/mm² and identified under SG5. As recommended by Malaysian Standard MS544: Part 2, this can be concluded that strength group for *Acacia mangium* is classified under SG5 as it is the lowest case between strength groups that had been obtained from different tests at green condition.

At the air-dry condition, it is revealed that the basic stress value of compression parallel to grain is recorded 17.3N/mm². These gave the grade stresses results for select, standard, and common with 13.8N/mm², 10.9N/mm² and 8.6N/mm² respectively. Therefore, it has been classified under SG4. Meanwhile, the average mean result of basic stress for shear parallel to grain is given 3.2N/mm² with the grade stresses of select, standard, and common are 2.5N/mm², 2.0N/mm², and 1.6N/mm² respectively thus classified under SG2. Basic stress for bending parallel to grain is 25.5N/mm² thus contributed the results for grade stresses select, standard, and common with 20.4N/mm², 16.1N/mm² and 12.7N/mm² respectively thus fall under SG3. Whilst, for modulus of elasticity, the grade stresses is 7586N/mm² and classified under SG4. This can be concluded that strength group of *Acacia mangium* at the air-dry condition is classified under SG4. Thus for overall conclusion, *Acacia mangium* species is prone to be classified under SG5 as it is the lowest case between the strength group at the green and air-dry condition.

Grade stress of Aras

Aras at green condition reported with the mean compression parallel to grain is 8.3N/mm². This result has contributed the grade stresses for select, standard, and common with 6.6N/mm², 5.2N/mm², and 4.1N/mm² respectively as shown clearly in Table 1. Consequently, from this result, Aras had been classified under the strength group SG6. The average mean shear parallel to grain has reported contributed the results for grade stresses select, standard, and common with 1.4N/mm², 1.1N/mm², and 0.9N/mm² respectively. This gave shear parallel to grain test is classified under SG4. Aras's basic stress for bending parallel to grain is 10.2N/mm² which has contributed the grade stresses of select, standard, and common values with 8.2N/mm², 6.4N/mm², and 5.1N/mm². From the result, it is classified under SG6, which is much lower compared to *Acacia mangium* with SG2. Furthermore, for modulus of elasticity, the grade stresses is 3491N/mm² and classified under SG7. This can be concluded that, at green condition, Aras is classified under SG7 compared to *Acacia mangium* with SG5 as it is the lowest case between strength groups that had been obtained from different tests.

Aras at the air-dry condition has revealed that basic stress for compression parallel to grain with 14.7N/mm². This has contributed the result for grade stresses select, standard, and common with 11.7N/mm², 9.2N/mm² and 7.3N/mm² thus

classified under SG5, which is relatively close to *Acacia mangium* with SG4. The average basic stress for shear parallel to grain is 2.9N/mm^2 with the grade stresses of select, standard, and common are 2.3N/mm^2 , 1.8N/mm^2 , and 1.4N/mm^2 respectively. Thus from the result it is classified under SG2, which is relatively similar with *Acacia mangium*. The basic stress for modulus of elasticity is 16.3N/mm^2 . This has given the grade stresses select, standard, and common with 13.0N/mm^2 , 10.2N/mm^2 and 8.1N/mm^2 respectively. Therefore from the results it can be classified under SG5. Moreover, for modulus of elasticity, the grade stresses is 5507N/mm^2 and it is classified under SG6. The strength group obtained for each test at the air-dry condition thus can be concluded fall under SG6 compared to *Acacia mangium* which is classified under SG4 as it is the lowest case between strength groups. From both conditions, green and air-dry, it is to be concluded that Aras's strength group is prone to be classified under SG7, and it is lower compared to *Acacia mangium* with SG5.

Species	Strength Group	Condition	Bending Parallel to the Grain (N/mm^2)				Compression Parallel to the Grain (N/mm^2)				Shear Parallel to the Grain (N/mm^2)				Modulus of Elasticity (N/mm^2)	
			Basic	Select	Standard	Common	Basic	Select	Standard	Common	Basic	Select	Standard	Common	Mean	Minimum
<i>Acacia mangium</i>	SG5	Green	24.4	19.5	15.3	12.2	17.1	13.7	10.8	8.6	3.0	2.4	1.9	1.5	11421	6044
		Dry	25.5	20.4	16.1	12.7	17.3	13.8	10.9	8.6	3.2	2.5	2.0	1.6	12065	7586
Terbulan	SG7	Green	11.6	9.3	7.3	5.8	7.4	5.9	4.7	3.7	1.4	1.2	0.9	0.7	8022	4860
		Dry	17.6	14.1	11.1	8.8	13.7	11.0	8.6	6.8	2.6	2.1	1.6	1.3	8911	5532
Aras	SG7	Green	10.2	8.2	6.4	5.1	8.3	6.6	5.2	4.1	1.8	1.4	1.1	0.9	6360	3491
		Dry	16.3	13.0	10.3	8.1	14.7	11.7	9.2	7.3	2.9	2.3	1.8	1.4	8214	5507

Table 1 Green and dry grade stresses and modulus of elasticity.

IV. CONCLUSION

The basic and grade stresses for strength groups can be used to facilitate the design, stocking and supply of timber for structural purposes [3]. The species was recommended mainly for general utility for furniture making and other non-structural applications. For structural design purposes, the results from small clear must not be used directly it must be first derived into permissible stresses. Thus appropriate modification factors had to be identified as given British Standard CP 112:1967 or Malaysian Standard MS544: Part 2 should be used. It was found that, exotic species of *Acacia mangium* was obviously known under SG5 and has been also proven in this study. Indigenous species of Aras has been classified under the strength group SG7. It is found that the strength properties' values for bending parallel to the grain, compressive stress parallel to the grain, shear parallel to the grain and modulus of elasticity for *Acacia mangium* are 92.31N/mm^2 , 39.49N/mm^2 , 5.215N/mm^2 and 11742.79N/mm^2 respectively. As for Aras, it is revealed that with 58.93N/mm^2 , 28.28N/mm^2 , 8.76N/mm^2 and 7286.85N/mm^2 respectively.

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