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YOUNG'S MODULUS AND POISSON'S RATIO OF MERPAUH, KAPUR AND SESENDUK SPECIES

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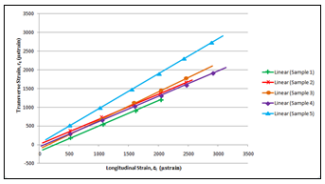
Graphical abstract



Abstract

Young's Modulus and Poisson's ratio are the mechanical properties that need to be determined for the production of engineering design or information for the numerical analysis of timber. In this study, Merpauh, Kapur and Sesenduk species were selected. This experimental investigation focuses on the elastic properties of those timber species. The Modulus of Elasticity (MOE) and Poisson's ratio were determined by means of tensile tests. In addition, Modulus of Rigidity (MOR), tensile strength capacity and its moisture contents were also determined. The deformation during testing was measured by means of mechanical extensometer. The MOE of the studied species range from 36.7 N/mm2 to 119.2 N/mm2, whereas Poisson's ratio values show less variability. The result of the study also shows that the mechanical properties for the species are related. The larger the density value, the larger value of stress and strain will be. Thus, the value of Poisson ratio will also increase, respectively.

Keywords: Young's Modulus, Poisson's ratio, Merpauh, Kapur, Sesenduk, Moisture Content

1.0 INTRODUCTION

Timber is a unique material, which could be described as orthotropic materials consisting of their own specific mechanical properties in longitudinal, radial and tangential directions (Kretschmann, 2010). Timber is called as an orthotropic material because of its character, orientation and arrangement of the grain (Markwardt and Youngquist, 1956) and is said as one of the most environmental-friendly materials (Hossain and Awal, 2012). Regrettably, there is some limitation on the existing record and publication on mechanical properties of tropical timber species. The timber usage in Malaysia is very limited (Ahmad, 2010) and problem arises when the necessary information are needed for numerical analysis or Finite Element Method (FEM). The FEM is used to model and design the structural strength capacity and behavior predictions of the structure. Without the exact mechanical properties values of the designs materials inserted during the calculations, the predicted results from the FEM shall not be accurate. Therefore, the main objective of this research is to determine the poisson's ratio, modulus of elasticity (MOE), modulus of rigidity (MOR) and the tensile strength capacity of Merpauh, Kapur and Sesendok timber species. The comparisons of results were also observed within diferent strength group of timber species, since Merpauh and Kapur species is from strength group 4 (SG 4) while Sesendok is from strength group 7 (SG 7) as classified in Malaysian Standard 544 (MS 544: Part 2: 2001).

2.0 MATERIALS AND METHODOLOGY

2.1 Specimen Preparation

The specimens for the Poisson's ratio were prepared according to Ahmad (2010) specimen's measurement. There is some modification in the measurement that has been made by Ahmad through the BS 373:1957, since there is no standard code mentioned about the width of the specimen for the determination of Poisson's ratio. The middle section measurement is set

to be a little wider in width as two strain gauges are needed to be placed in the middle part of the specimen for the Poisson's ratio identification. The middle section is set to be 20mm in width to accommodate the strain gauge since the length of the strain gauge is 12mm as done by Ahmad (2010). This specimen samples shape resembles the dog bone shape as shown in Figure 1. For each timber species, 7 samples specimen were provided. The samples specimen produced and cut in the direction parallel to the grain.

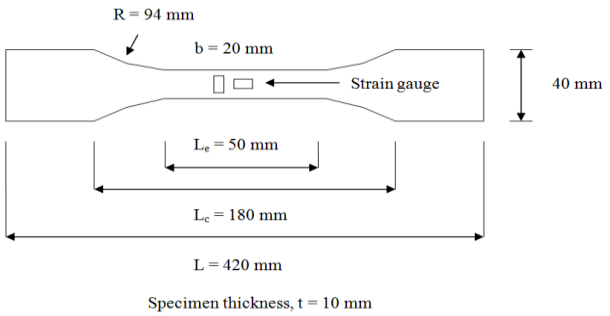


Figure 1 Small clear specimen according to Ahmad

2.2 Tensile Test

Tensile test is performed to find the value of the ultimate tensile strength, ultimate strain and modulus of elasticity of timber (Ahmad, 2010). The value of Poisson's ratio can be determined by operating the tensile test to determine the ultimate strain values which will contribute to the production of Poisson's ratio value. For all the procedures on how the tensile test to be performed is referred to BS 373:1957 as done by Ahmad (2010). The procedures to conduct the tensile test can also be referred to the ASTM D143–9. To be precised, the tests were conducted in ambient temperature and relative humidity that varied from 75 to 80%. During the tensile test, two strain gauge needs to be attached at the middle part of the specimen to determine the value of longitudinal strain and transverse strain. The positions of the strain gauges were located in two directions (x and y), which are parallel to the grain and perpendicular to the grain. The deformation of the specimen was measured using mechanical extensometer. The test is carried out using 1000kN Universal Testing Machine (UTM) as shown in Figure 2.

Figure 2 Tensile test set-up

2.3 Moisture Content Test

For this test, the moisture content of the specimens is also recorded. It is necessary to determine the value of moisture content for timber because it may affect the properties of the timber and also for future references. The procedure of moisture content test is done according to BS 373:1957. Each sample was prepared with the same member and closes to the small clear specimens for the Poisson's ratio specimens. After cutting, the samples must be free from sawdust before the weight of the sample can be measured. After weight has been determined, the samples were dried in a well ventilated oven to maintain the temperature limits. After 24 hours, the samples were weighted and then be placed back in the oven. This step was repeated until the mass of the samples becoming constant. The loss in weight of the final oven-dry weight was taken as the moisture content for the sample. The measurement test should be carried out in the standard room conditions where the temperature is in between 25 ± 2°C and relative humidity in a range between 70 ± 5% as stated by Ahmad (2010). Three (3) samples from each timber species were chosen to represent the sample before the tensile test while another three (3) samples from each timber species were chosen to represent the sample after the test. The samples were chosen randomly from timber beam from each species. Thus, 9 samples in total were used to determine the level of moisture content before the tensile test and a total of 9 samples were used to determine the level of moisture content after the tensile test. The moisture content before tensile test and after tensile test were then analyzed and compared.

3.0 RESULTS AND DISCUSSION

3.1 Tensile test Results

Figure 3, Figure 4 and Figure 5, depict the tensile test results from the timber species studied, namely, Merpauh, Kapur and Sesenduk respectively. The mechanical properties needed were determined from these graphs. The detail values of the properties are tabulated in Table 1. Some specimens were found failed at grip thus only the success specimens, which failed in the middle of the specimens were analysed.

The first observation was set to determine any similarities or differences between Merpauh species and Kapur species which fall in the same strength group of SG 4. The average value of Poisson's ratio for Merpauh and Kapur which falls on the strength group of SG 4 shows more likely in similarities. This is due to the both average Poisson's ratio value is vary within species but still within its range. Merpauh species has the Poisson ratio value of 0.78 while Kapur species has the Poisson's ratio value of 0.69. The difference between those value is just 0.09 or 11.5%.

The next observation continues with differences in Poisson's ratio value obtained between SG4 and SG 7 species studied. The average Poisson's ratio value for SG 4 timber which is Merpauh and Kapur is 0.74 while the Poisson's ratio for SG 7 timber which is Sesendok is 0.53. The Poisson's ratio value between those SG showed a big difference in its range. The difference between those values is 0.21 or 28%. As expected, this result is due to its differences in the strength group. Thus, for this study, it can be concluded that higher strength group of timber species will yield lower values of Poisson's ratio.

From the observed results, Poisson's ratio values show less variability; SG 4 – 0.69 and 0.78, whereas SG7 - 0.53 value. The tensile strength of the species are 36.7 N/mm^2 for SG 7, while SG 4 having 116.7 and 119.2 N/mm^2 strength respectively. The MOE values range from 5590 N/mm^2 to 11457 N/mm^2 whereas MOR value ranges from 1827 to 3209 N/mm^2. The mechanical properties of the species are found related. The larger the density value, the larger stress and strain value will be. It reflected to the value of Poisson ratio, which will also increased. The higher the Poisson's ratio, contributes to the higher tensile strength, MOE and MOR value of the timber species tested.

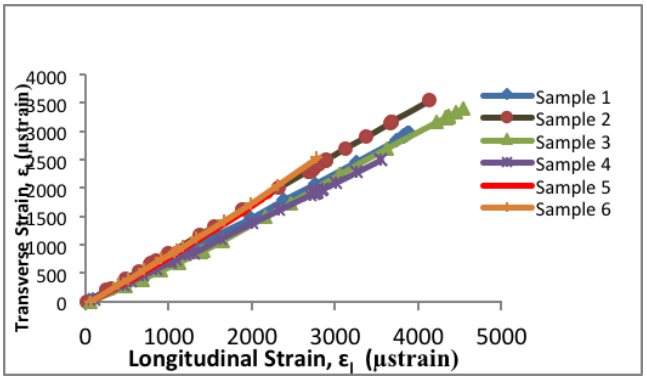


Figure 3 Transverse versus longitudinal strain for Merpauh species

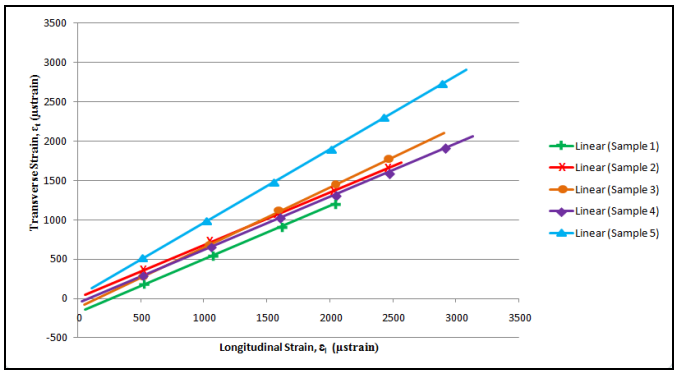


Figure 4 Transverse versus longitudinal strain for Kapur species

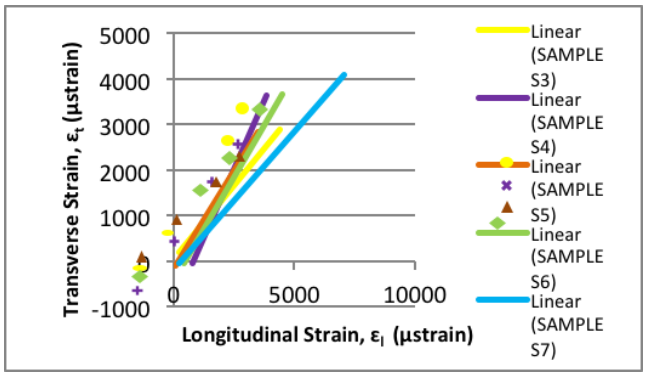


Figure 5 Transverse versus longitudinal strain for Sesendok species

3.2 Moisture Content Test Results

For the moisture content test, Table 2 and Table 3 show the tabulated results. Before tensile test, the moisture contents value show no pronounced differences between SG4 (10.6 % and 11.5 %) and SG7 (9.9 %). But after tensile test done, the moisture contents were 50% differ between the two timber species (SG4 and SG7) studied. In this study no further relations were made between the determined mechanical properties to the moisture content since the recorded data is only for the record purposes and not to study the relations between the properties. Specific preparation of

samples with control environment for the moisture content is needed if the relations of moisture content to the mechanical properties were to be measured. Nevertheless, it can be summarized that, for the timber species studied, having higher Poisson's ratio lead to higher tensile strength, MOE and MOR values. It seems that some study on the wood anatomy is suggested to investigate further on the relations as the Molecular considerations may offer possible explanations of these mechanisms.

Table 1 Selected mechanical properties of Merpauh, Kapur and Sesenduk species

Sample	Tensile Strength, σ_u (N/mm²)			Poisson's Ratio, v			Modulus of Elasticity, E (N/mm²)			Modulus of Rigidity, G (N/mm²)		
	M	K	S	M	K	S	M	K	S	M	K	S
1	87.4	106.1	x	0.75	0.50	x	6724	7872	x	1921	2624	x
2	162.8	132.1	x	0.85	0.67	x	13092	12432	x	3538	3722	x
3	152.1	129.4	31.8	0.71	0.68	0.62	12592	10923	2486	3682	3251	767
4	86.5	128.4	39.3	0.69	0.64	0.48	11533	6688	7154	3412	2039	2417
5	94.3	87.4	38.8	0.82	0.95	0.44	11832	9463	6992	3251	2426	2428
6	132.1	x	36.6	0.88	x	0.65	12971	x	6959	3450	x	2109
7	x	x	37.1	x	x	0.48	x	x	4360	x	x	1416
Average	**119.2**	**116.7**	**36.7**	**0.78**	**0.69**	**0.53**	**11457**	**9476**	**5590**	**3209**	**2812**	**1827**

Note: x = Specimen sample failed during test, M = Merpauh Species, K = Kapur Species, S = Sesendok Species

Table 2 Moisture content value before tensile test

Type of Timber	Sample	Weight before oven-dry (g)	Weight after oven-dry (g)	Moisture Content (%)	Average Moisture Content (%)
Merpauh (SG 4)	1	87.9	78.8	11.5	11.5
	2	84.0	75.5	11.3	
	3	86.0	76.9	11.8	
Kapur (SG 4)	1	91.0	82.3	10.6	10.6
	2	82.8	74.7	10.8	
	3	90.5	82.0	10.4	
Sesendok (SG 7)	1	61.6	56.1	9.8	9.9
	2	66.8	60.7	10.0	
	3	60.3	54.8	10.0	

Table 3 Moisture content value after tensile test

Type of Timber	Sample	Weight before oven-dry (g)	Weight after oven-dry (g)	Moisture Content (%)	Average Moisture Content (%)
Merpauh (SG 4)	1	103.7	94.0	10.3	10.6
	2	107.1	96.7	10.8	
	3	116.5	105.1	10.8	
Kapur (SG 4)	1	117.0	105.8	10.6	10.1
	2	118.2	107.3	10.2	
	3	120.8	110.3	9.5	
Sesendok (SG 7)	1	99.2	93.6	6.0	6.8
	2	88.5	82.9	6.8	
	3	96.2	89.5	7.5	

4.0 CONCLUSION

From this study, the conclusions can be outlined as follows:

1) Poisson ratio value for Merpauh species is 0.78, Kapur species is 0.69 and Sesendok species is 0.53. The Poisson's ratio value for Merpauh and Kapur species is 0.78 and 0.69 respectively and within its range. The difference between those values is about 11.5%. The Poisson's ratio values for Merpauh and Kapur species is on its range because it falls in the same strength group of SG 4. The average Poisson's ratio value for SG 4 timber is 0.74, whereas SG 7 timber is 0.53, which has 28% difference range.

2) The tensile strength of the selected species are 36.7 N/mm^2 for SG 7, while SG 4 having 116.7 and 119.2 N/mm^2 strength. The MOE values range from 5590 N/mm^2 to 11457 N/mm^2 whereas MOR value range from 1827 to 3209 N/mm^2. The higher Poisson's ratio value contributes to the higher tensile strength, MOE and MOR value of the timber species accordingly.

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