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Research paper

Shear Block Test Performance of Melunak and Mengkulang

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Abstract

This paper presented results of shear block test performance of tropical glued-laminated timber (glulam) from species of melunak and mengkulang. Glulam blocks were manufactured in accordance with MS758:2001. The shear block test for glue lines and the shear strength tests of melunak and mengkulang were conducted and evaluated in accordance with BS EN 14080:2013. Melunak and mengkulang produced average shear strength values of 10.62 N/mm^2 and 8.19 N/mm^2, respectively. In terms of wood and glue failure percentage, the results showed that melunak and mengkulang were mainly failed due to wood surface area and not due to the glue lamination in which both melunak and mengkulang showed a good bonding performance**.**

Keywords: *Shear strength; glued laminated timber; shear block test; wood and glue failure percentage; glue lamination.*

1. Introduction

Malaysia is rich in timber; however, its application is not as much as steel and concrete. Timber is one of renewable construction materials available. It is naturally grown and can be engineered, which helps in the removal of greenhouse gases from the atmosphere making it an environmentally friendly material. Glued-laminated timber (glulam) is an engineering wood product that consists of timber lamination that is glued together, manufactured in different sizes and shape, which can be formed into columns or beams. For the selection of timber species for laminating, the two important characteristics are the glue ability and the dimensional stability with changing atmospheric conditions. Lamination in glulam is referred to a structural member that is made up of length of timber of some thickness. Then, with the use of adhesives, the laminations are joined together under pressure (Abbott and Whale, 1987) [1]. When compared pound to pound with steel, glulam is stronger and has greater strength and stiffness compared to a sawn timber. Glulam improves product performance and it is easily installed with less cost than other constructional material, making glulam a preferable choice for certain projects (Moody and Hernandez, 1997) [2].

Shear block test is a test that uses a small clear specimen to test the fundamental mechanical property of timber, which is the shear strength parallel to grain. Shear block test strength values are considered as small clear specimens acquired without the influence of wood defects. Testing using a full size of timber such as a three-point bending test and a four-point bending test may affect the shear strength values (Khokhar *et al*., 2010) [3].

There were several tests reported and documented on the behavior of glued laminated timber; however, most of those tests (BS EN 14080:2013) [4] were only concerned with the embedment strength and bending properties of timber. Therefore, this study was performed to determine the shear block performance of glued laminated timber of melunak and mengkulang.

2. Methodology

Melunak and mengkulang species were selected as glulam timber specimens in this study. These timbers are naturally durable (MS 544: Part 2:2001) [5], untreated and suitable for outdoor environment conditions. Melunak and mengkulang are hardwoods in which melunak is classified as a light hardwood and mengkulang is classified as a medium hardwood. The glulam specimens were fabricated in accordance with (MS 758: 2001) [6] in which 15 specimens of each melunak and mengkulang were fabricated and prepared into a size of 50 × 50 × 50mm based on the minimum requirement.

With reference to BS EN 14080:2013 [4], 30 specimens were prepared using melunak glulam and mengkulang glulam to determine the shear block performance on the glue line of each species using a shear block equipment and a universal testing machine. The shear blocks specimens were fabricated from a glulam beam member using a timber cutting band saw as shown in Fig. 1 to cut into 50 × 50 × 50mm dimension of the specimen required as shown in Fig. 2. The timber specimens were drawn on the timber block prior to cutting and placed on the blade under the band saw. Fig. 3 shows the side view of the timber block with glue line. The specimen was locked into the shear fixture as shown in Fig. 4 in accordance with BS EN 14080:2013 [4], and then inserted into the universal testing machine (UTM) as depicted in Fig. 5 for the load to be applied on the glue line of the specimen.

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Fig. 1: Timber cutting band saw



Fig.2: 50 × 50 × 50mm specimens

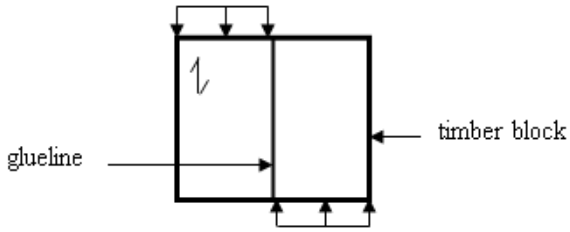


Fig. 3: Side view of timber block with glue line



Fig. 4: Shear block equipment



Fig. 5: Universal testing machine (UTM)

The acceptance criteria according to MS 758, 2001 [6] for shear strength of each glue line shall be at least 6.0 N/mm^2. For lighter density timbers, a shear strength of 4.0 N/mm^2 shall be regarded as acceptable if the wood failure percentage is 100% (Engku Abdul Rahman Chik, 1988b) [7]. The quality of the glue line can be significantly varied between and within members. Therefore, multiple samples must be considered to obtain reliable global estimations of member's properties for the effect of irregularities. Based on BS EN 14080: 2013 [4], the sheared area and the maximum loads were recorded and the shear strength (fv) was computed for each specimen using Equation (1).

$$\text{Shear strength } (fv) = k\,(F_u / A) \quad (1)$$

where:
F_u is ultimate load, in newton
A is the sheared area (for a test bar A=bt, and for a drill core A=lt)
k is a modification factor (k = 0.78 + 0.0044 t);
t is the thickness, in millimeters
Besides the shear strength, the wood failure percentage needs to be determined to identify the quality of a bond, which usually measured by visual examination. However, the wood failure percentage of the specimen in average or individual values should not exceed the minimum wood failure percentage as stated by MS 758, 2001 [6].

3. Results and Discussion

Fig. 6 shows the comparison of shear strength and percentage difference between melunak glulam and mengkulang glulam in which the value resulted in 22.8% of percentage difference. The melunak shear strength was 2.43 N/mm^2 higher than mengkulang shear strength. The shear strength of melunak was 10.62 N/mm^2 with a standard deviation of 3.54 and coefficient of variance 33.33% while the average shear strength of mengkulang was 8.19 N/mm^2 with a standard deviation of 2.82 and coefficient of variance 34.43%.

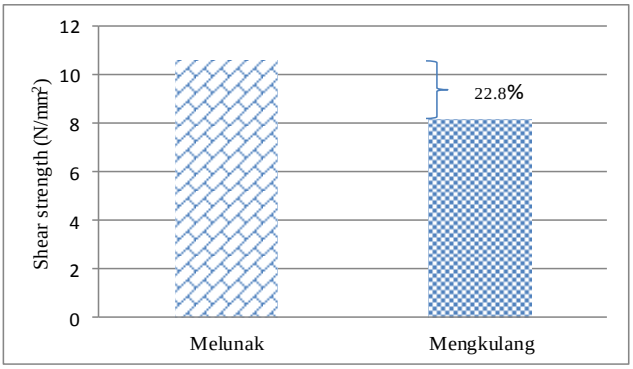


Fig.6: Shear strength value and percentage difference of melunak and mengkulang

Two types of failure modes were identified, which were wood failure and glue failure. Wood failure was 100% failure surface for both timbers of melunak as shown in Fig. 7. However, Fig. 8 shows the melunak block specimen of wood failure of 75% and the remaining 25% failed at the glue line. Fig. 9 shows the glue failure at 75% and 25% of wood failure for mengkulang while Fig. 10 shows 50% for both wood and glue failures. Both failures were determined through visual inspections using the proportional method as applied by Bhkari *et al.*, 2010 [8]. The timber specimen was divided into four quadrants to determine the percentage failure between either wood or glue, in which each quadrant represented 25% of the whole sheared area. The wood failure was signified by a surface of the timber brown color with less appearance

of the adhesive, while the glue failure was signified by a dark brown or black surface of the adhesive.

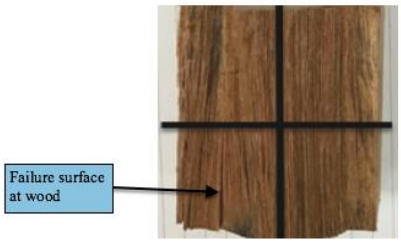


Fig. 7: Wood failure at 100% for melunak

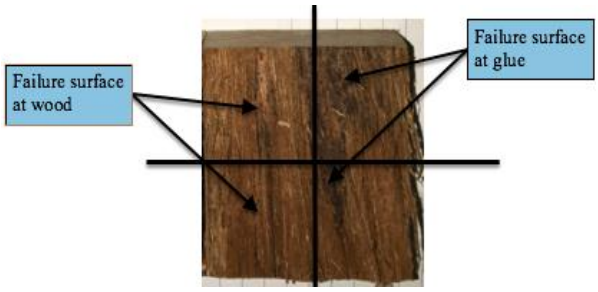


Fig. 8: Wood failure at 75% and 25% glue failure for melunak

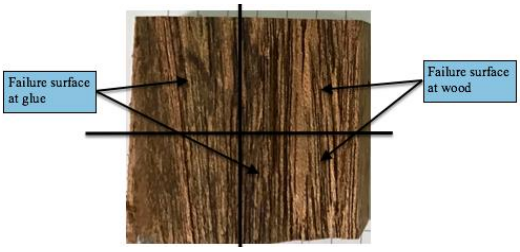


Fig. 9: Glue failure at 75% and wood failure at 25% of mengkulang

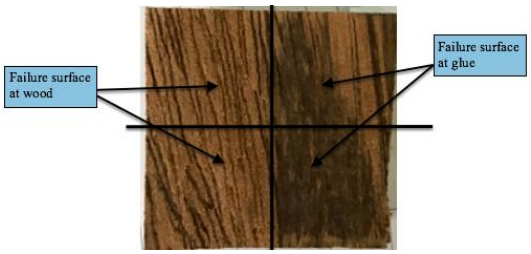


Fig. 10: Wood and glue failure at 50% of mengkulang

Fig. 11 shows the comparison of wood versus glue failure between melunak and mengkulang timber. The shear failure parallel to grain direction for melunak and mengkulang showed that the timber failed in shear due to the wood surface area and glue area with 87.4% and 83.4% of percentage difference, respectively. Failure not due to glue lamination in which melunak average percentage of failure for wood surface area and glue lamination area are 93.7% and 6.3% respectively, whereas mengkulang average percentage of failure for wood surface area and glue lamination area are 91.7% and 8.3% respectively. The difference in wood failure percentage between melunak glulam and mengkulang glulam are dependent on the density of the timber in which mengkulang timber has a higher density than melunak timber, the higher the density of timber, the less failure to occur in the wood area, the lower the density of the timber, the higher the failure in the wood area (Vick and Okkonen, 1998) [9].

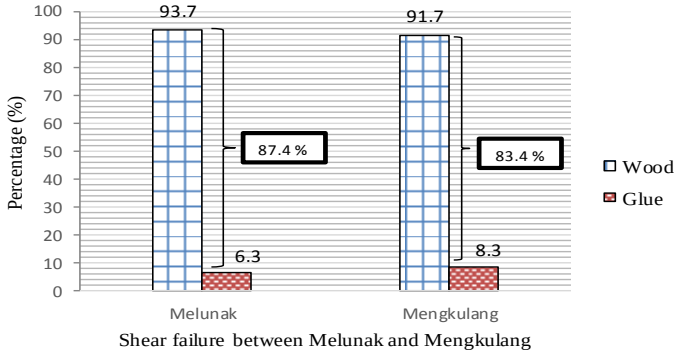


Fig. 11: Comparison and percentage difference of shear failure between melunak and mengkulang glulam

4. Conclusion

The average shear strength value of melunak was 10.62 N/mm^2 with a standard deviation of 3.54 while the average shear strength of mengkulang was 8.19 N/mm^2 with a standard deviation of 2.82. The minimum requirement for shear strength value is set at 6 N/mm^2 in accordance with MS758:2001 for the timber species of melunak and mengkulang in which both species achieved the minimum requirement. The shear strength parallel to glue line of the timber species of melunak and mengkulang had a 22.8% of percentage difference. The melunak average shear strength was 2.43 N/mm^2 higher than mengkulang. The shear failure parallel to grain for melunak and mengkulang showed that the timber failed in shear due to the wood surface area and not due to glue lamination in which melunak average percentage of failure for wood surface area and glue lamination area were 93.7% and 6.3%, respectively. Meanwhile, mengkulang average percentage of failure for wood surface area and glue lamination area were 91.7% and 8.3%, respectively. The difference in wood failure percentage between melunak glulam and mengkulang glulam are dependent on the density of the timber in which mengkulang timber has a higher density than melunak timber. The higher the density of timber the less failure to occur in wood area, the lower the density of the timber the higher the failure in wood area. For a good bonding, the bond shear strength should be stronger than the wood shear strength and the failure should occur in the wood rather than in the glue line, and from the results above, both melunak and mengkulang showed a good bonding performance.

Acknowledgement

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