Shear Block Test Performance of Melunak and Mengkulang Parallel to Glue Line

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Abstract. This experimental research is conducted on shear strength performance of glue laminated timber parallel to glue line using Malaysian tropical hardwood Melunak and Mengkulang. The objective of this research was to determine the shear strength values of Melunak and Mengkulang with the observation and comparison of the wood and glue failure percentage of both species. Total 30 numbers of wood specimens which; 15 numbers of wood for Melunak and 15 numbers of wood Mengkulang. The block specimen dimension was 50x50x50mm, then tested using a shear block fixtures and Universal Testing Machine (UTM). The Malaysian Standard, MS758:2001 was used in conducting shear block test and to obtain the shear strength values for both specimen. Both wood tested specimen results in 9.05% different in its shear strength values, where Melunak average shear strength was higher 0.92N/mm² than Mengkulang. Test result of shear failure to grain direction in both specimen shows that failure occurred in wood was due to wood surface area. The Melunak average percentage failure of wood and glues area 93.7% and 6.3% respectively. While for Mengkulang average failure percentage for wood and glue area were 89.7% and 10.3% respectively. The difference in result of wood failure of both specimen area directly related to the density of specimens, in which Mengkulang wood has a higher density than Melunak. Both specimens reached to its minimum shear strength capacity that was about 6N/mm² set by the Malaysian standard MS758:2001. Both Melunak and Mengkulang wood tested specimen results in 9.05% different in its shear strength values, where Melunak average shear strength is higher about 0.92N/mm² than Mengkulang.

1. Introduction

Engineered woods such as glulam are manufactured and available around the world. Glue-laminated timbers are one of timber products whose ability to resist shear loading along glued surface need to be known through authenticated testing methods in order to be used. The evaluation of the shear strength of adhesive bonds between solid timber materials using standard test method outlined ASTM 4501-01 (2001) [1] shows that adhesive bond performs excellently against shear when the shear loading acts parallel to the timbers grain along the bonding surface. There are quite a number of researches done on woods products (engineered) in Malaysia, but more emphasis was placed on the woods strength and its bending leading to the scarcity of proven information on shear block test in determining the shear strength along bonded surface of local Malaysian timbers (Melunak and Mengkulang). This lack of information creates limitations on the use of Malaysian wood as it is paramount to be fully aware of the structural ability of combined wood in this case, glued wood against the most likely and frequent loading to face, (in-plane shear loading). This tease was opted by the shortage or inadequate...
information on the shear block strength, lack of data with respect to percentage of bond failure, inadequate information on the comparison of behavior of bonded tropical Malaysia timbers which are specifically Melunak and Mengkulang. Hence, the shear block test was carried out in this report to help generate reliable information on some of the most abundant wood species in Malaysia (Melunak and Mengkulang). This study was slightly important because it used typical Malaysian (Melunak and Mengkulang) woods and using Malaysian standardized design method for structural timber as it is in MS758:2001 [2]. This study is designed to experimentally analyse the in-plane shear strength capacity of Melunak and Mengkulang wood block in accordance to structural use of timber under the Malaysian Standard MS758:2001 [2] using shear block test. It is specifically to determine and compare the shear strength for Melunak and Mengkulang parallel to the glue line thus to observe the failure percentage between glue and wood.

2. Research Methodology

2.1. Preparation of timber specimen

Two type Malaysian timbers, which are Melunak and Mengkulang. Both was conducted an experimental research in this project. The shear block test was conducted in UiTM structural laboratory and for the timber specimens were prepared in structural laboratory, SEGi University. The 15 block specimens for each species were dimensioned using size of (50mmx50mmx50mm) in correspondence to BS EN 392:1995 [3] and MS758:2001 [2].

2.2. Timber band saw machine

The wood used in this experiment were firstly acquired in large block form, hence, the need to cut it to dimension to fit the requirement of this experiment was a necessity. It was required that a specimen should have a dimension measuring (50mmx50mmx50mm). The band saw machine was used to execute this cutting with precision and with the availability of strong locking edges, the large timber block was able to fit properly during the cutting without disturbance.

2.3. Shear fixtures

In accordance to BS EN 392-1995 [3] requirements for a shear test device relating to adhesive bond quality assessment, the test apparatus was set up as shown in figure 1. The lapped block shear test method was used to specifically deduce the quality of adhesive on the bonded wood.

![Figure 1. Fixtures of shear block test.](image)

3. Result and Discussion

3.1. Melunak specimen

Figure 2 shows the Melunak specimen No11 graph of load (kN) versus deformation (mm), has its ultimate load applied (Fu) of 30kN and maximum deformation of the specimen 3.25mm. The specimens were loaded with 6kN at its initial stage until its reached the ultimate load of 30kN a sudden break is recorded at the ultimate load, results in 3.25 mm of deformation in the wood specimen. The load versus deformation increments also observed to be linear along the load increment, although little drop in deformation can be seen but still considered as consistent deformation at gradual load.
Figure 3 shows the ML14 (Melunak wood specimen) that had the maximum load (Fu) applied of 38.84kN and the maximum shear strength achieved is 15.39N/mm². The specimens determine to be the highest outlier amongst all the 15 wood specimens as its split in two pieces under the highest load. The specimens failed 100% in wood because it was achieved its shear strength limit, determined by the Malaysian timber council which was 10.8N/mm². Most of the specimens that fail 100% in wood achieved shear strength limit because it fails in wood also indicating that the adhesive bond performed excellently against shear loading allowing the load to cause the wood failure at its shear strength limit. Some of the specimens fail 100% in wood while it did not achieved its shear strength limit, could be cause by the undistributed loading from the shear block test or the moisture percentage contain in the specimen. Timbers tend to have higher strengths when the water content is low and lower strength when the water content is high.

Figure 2. Load versus deformation for Melunak specimen.

Figure 3. Melunak typical shear failure specimen.

3.2. Mengkulang specimen
Figure 4 shows the MK4 (Mengkulang wood specimen) graph of load (kN) versus deformation (mm). It has its ultimate load applied (Fu) of 28.16kN and maximum deformation of the specimen 2.7mm. The specimens were loaded with 0.75kN at its initial stage until it was reached the ultimate breaking load of 28.16kN results in 2.7mm of deformation in the wood specimen. The load versus deformation increments also observed to be linear along the load increment while a few small drops in deformation seen along different load interval but had a consistent deformation at gradual load. Figure 5 shows the MK13 (Mengkulang wood specimen) that had the maximum load (Fu) applied of 29.88kN and the maximum shear strength achieved was 11.95N/mm². The specimens determine to be the highest outlier amongst all the 15 wood specimens as its split in two pieces under the highest load. The specimens failed 100% in wood because it was achieved its shear strength limit, determined by the Malaysian timber council which was 10.8N/mm². Most of the specimens that fail 100% in wood achieved shear strength limit because it were failed in wood also indicating that the adhesive bond performed excellently against shear loading allowing the load to cause the wood failure at its shear strength limit. Some of the specimens failed 100% in wood while it did not achieved its shear strength limit, may cause by the undistributed loading from the shear block test or the moisture percentage containing by the specimen.
3.3. Comparison percentage failure between Melunak and Mengkulang specimen

Figure 6 shows the percentage failure that evaluated by the two wood specimen (Melunak and Mengkulang) experimental test conducted. The failure of the wood and its percentage differences between wood and glue in terms of shear failure in direction of surface grain of the wood specimen. In this experimental test result, where glue can resist strength and resulting in less percentage of failure occurs. The occurrence of failure in wood itself was because of its contact surface area to the force applied to shear the wood. It also shown the failure occurred in Melunak surface area and glued laminated are 93.7% and 6.3% respectively. While Mengkulang result in 89.7% and 10.3% failure in surface area for wood and laminated glue area respectively (Malek et. al., 2018) [4] found both specimen failed in wood. The difference in failure results for both Melunak and Mengkulang were entirely depends on the wood density, is that Mengkulang density is higher than Melunak result it in less failure than Melunak by 4% in wood and higher in glue failure. The higher the density of timber the less failure occur in wood area, and the lower the density the higher the failure in wood area (Vick and Okkonen, 1998) [5]. The structural adhesive was stronger than the timber in most of the joint. Thus, the failure in shear occurred in wood and not in the glue lines.
Figure 6. Percentage failure comparison of shear failure between wood and glue for Melunak and Mengkulang glulam.

4. Conclusion
Based on the result discussed, it could be concluded that the difference in result of wood failure of both specimen areas directly related to the holding density of specimens, in which Mengkulang timber holding a higher density then Melunak. Testing the specimens parallel to glue line, results indicating that the adhesive bond performed excellently against shear loading and allowed the wood to reach to its shear strength limit. However, Melunak showed higher average shear strength than Mengkulang average shear strength due to its differences in density and grain patterns. The higher the density the stronger the wood may result in less failure in wood and the lighter density the less stronger wood may resulted in high failure crack in wood. This can be concluded that to utilize the full strength capacity of wood under the load and less failure occurs in wood. The glue bond should be higher in shear stress resistance than wood. Due to the good adhesive bonding the shear failure occurs mostly in wood area rather than in the glue line, showed good bonding performance of both Melunak and Mengkulang wood species with glue.

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