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RESISTANCE OF KAPUR (*DRYOBALANOPS* SPP.) LAMINATED WOOD AGAINST DELAMINATION

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INTRODUCTION

There are two Kapur species that can be found in West Malaysia, namely *Dryobalanops aromatica* Gaertn and *Dryobalanops oblongifolia* Dyer *Dryobalanops aromatica*. It has a wide range of air-dried density, i.e., between 575 and 815 kg m^{-3}. It is a medium hardwood species classified under SG4 in MS544:2001. The air-dried modulus of elasticity (MOE) and the modulus of rupture are approximately 18,700 MPa and 114 MPa respectively (Lim et al. 2016). In terms of timber durability, it is classified as Class 2 durability. The mechanical performance and durability have essentially qualified the species under the Group B classification in the Strength Groups of Malaysian Timbers (Engku 1998b). On that note, Kapur is popular for outdoor exposure especially for outdoor decking. Nevertheless, it is worth noting that kapur is difficult for chemical treatment. It is also prone to surface checking and end-splitting due to high shrinkage.

In this study, the gluing performance of Kapur was investigated to assess its suitability for lamination. The study has focused on the delamination performance of Kapur for total exposure. The gluing performance was assessed based on two types of delamination cyclic tests, i.e., vacuum pressure and water boiling. Subsequently, the strength of the adhesion was further assessed by means of mechanical shearing. Results obtained from the cyclic delamination tests and shear test would complement and confirm the gluing performance of Kapur and its suitability for lamination.

MATERIALS & METHODS

Sample Preparation

Kapur samples were pre-conditioned to 12% moisture content and prepared into glulam samples using resorcinol formaldehyde (RF) adhesive at double-sided glue spread of 400 gm^{-2}. Later, the glulam samples were resized to a nominal dimension of 50 or 75 mm (width) × 800 mm (length) × 40 mm (thickness) test specimens. The width was based on the testing method. Twenty (20) replicates of test specimens were prepared for each of the following test.

Delamination Tests

i. Vacuum Pressure Delamination Test - Method A (MS 758:2001)

Vacuum between 75 and 85 kPa was drawn from the pressure vessel. Test pieces of 75 mm length were placed in the vessel and held for 5 minutes. Later, vacuum was released and a pressure between 500 and 600 kPa was applied for 1 hour. The same process was repeated for the second cycle. Later, all test pieces were removed from the vessel and dried in a conditioning chamber at 65°C. The percentages of delaminations were computed. If delamination occurred for more than 5 % after the second cycle, the above process was repeated for the 3rd cycle for determination of the final delamination.

ii. Boiling water soak test: JAS 1152:2007 Appendix 3(2)

Test pieces of 75 mm length were immersed in boiling water for 4 hours and transferred to water at room temperature (10–25 °C) for 1 hour. Later, test pieces were dried in an oven at 70±3°C until the mass reached between 100–110% of the pretest mass.

Total percentage of delamination was computed as follow:

$$\text{Total delamination, \%} = \frac{\textit{Total delamination length (mm)}}{\textit{Total glue line (mm)}} \; x \; 100\% \qquad (1)$$

Block Shear Test (JAS 1152:2007)

Test pieces at nominal dimensions of 25 mm × 25 mm (Figure 1) were prepared. Test method was based on JAS 1152:2007. The test pieces were placed under shear loading at a constant rate of deformation of 5 mm/min. Both the testing procures, i.e., JAS 1152:2007 and MS 758:2001 were comparable. Comparison of results in accordance with the respective standards' criteria in performance acceptance is discussed in Table 2.

The calculation of shear strength was obtained using Equation 2:

$$\textit{Shear strength, MPa or } Nmm^{-2} = \frac{\textit{Maximum load for shear failure (N)}}{\textit{Area of adhesion } (mm^2)} \qquad (2)$$

RESULTS AND DISCUSSION

The gluing performance of Kapur is summarised in Table 1. It was conducted under two different cyclic delamination testing methods. The aim of running on two different modes of cyclic exposure was not for comparison, but to complement the durability of the adhesive bonding and to confirm that the wood species could perform well under the harshest exposure conditions.

The results showed that RF bonded Kapur specimens had met the test requirement for the boiling water soak delamination test. Unfortunately the same type of glulam specimens had not met the requirement in MS 758.

Further investigation was conducted on the bonding performance using the shear bond test. Results had reconfirmed that RF bonded Kapur met all the criteria specified by MS 758 and JAS 1152 (Table 2).

In view of the contradictory results between the vacuum pressure test and the boiling water soak test, it is to note that the test method adopted for the vacuum pressure delamination was catered for total exposure specified under test method A. When the results were compared to the corresponding bonding performance under mechanical shearing, results showed otherwise and had passed favourably well. Furthermore, the result from Vacuum Pressure test had not failed poorly as required in Test Method A either. This suggests the possibility of Kapur in meeting the criteria for Test Method B or C, where samples tested were meant for applications that require less stringent exposure.

Table 1 Delamination performance for vacuum pressure test and boiling water soak test, the average moisture content and average oven-dried (OD) density of Kapur.

Vacuum Pressure Delamination (%)			Boiling Water Soak Delamination (%)			Moisture Content (%)	OD Density kg/m^3
Requirement MS758	Mean	Req. met	Requirement JAS 1152	Mean	Req. met		
Cycle 2: < 5%			< 5%	0.00	Yes	12.38 [*0.027]	749.40 [*0.032]
Cycle 3: < 10%	12.89	No					

Note: *denotes coefficient of variation (CV)

Table 2 Performance on glue line shear and percentage of wood failure

	Acceptance criteria			Test results		
	MS758		JAS1152	MS758		JAS1152
	Average	Individual	Individual	Individual	Average	Individual
Shear strength (MPa)	≥ 11	≥ 10	8.4–9.6	Criteria met	Criteria met	Criteria met
Wood failure (%)	> 45	> 20	60	Criteria met	Criteria met	Criteria met

CONCLUSION

Kapur has fulfilled the requirements specified in the boiling water delamination test but not for vacuum pressure method A. Nonetheless, it has passed all criteria specified by MS 758 and JAS 1152 for shear bond test. This indicates that Kapur can be well bonded using RF resins and can be a potential laminating feedstock.

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Measurement of the resistance of laminated Kapur towards delamination as an indicator of gluing performance is examined and discussed in this paper. Test samples were subjected to two different testing methods, designed to simulate similar application for outdoor exposure. The selected test methods were specified for testing of structural glulam samples. In general, results showed that Kapur had met all the specified requirements except for the vacuum pressure test. Good bonding performance from shear bond test and boiling water test may be sufficient in suggesting the suitability of Kapur for lamination. Further investigation on its vacuum pressure performance may be required for future study in assessing the suitability of the timber for other applications.

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