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A NOTE ON THE EFFECTS OF PRESSURE ON THE BONDING QUALITY OF MERANTI BUKIT (*SHOREA PLATYCLADOS*)

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Various factors are known to affect the gluing properties of timbers. Among them are moisture content of wood at the time of gluing, open and close assembly time, type of adhesives used, surface quality of the gluing surfaces and clamping pressure (Chugg 1964, Anonymous 1982). The use of proper clamping pressures ensures intimate contact between gluing surfaces, produces glue film of sufficient thickness and minimises the risk of stress concentration particulary when substrates of uniform thickness are already in use. Too low a pressure causes insufficient contact between mating surfaces whereas over-pressing results in excessive squeeze-out of glue, giving rise to poor bonding results.

Meranti bukit (*Shorea platyclados*), a dark red meranti (DRM), was used in this experiment. The timber is one of the most popular timber species in this country and for export, due mainly to its easy working properties and other amenable characteristics. The objective of this study was to determine the effects of clamping pressure on the glue bond integrity of glued-laminated members. Two different types of adhesives were employed, *i.e.*, phenol resorcinol formaldehyde (PRF) and polyvinyl acetate (PVAc). PRF is a weather-boil-proof (WBP) adhesive suitable for structural use while PVAc is commonly used in the furniture industry.

Timbers of approximate dimensions of 25 × 55 × 700 *mm* were conditioned at about 20°C and 65% relative humidity (RH) until a moisture content equilibrium of 12-16% was achieved. The final dimensions of the timbers used for the gluing process were 19 × 55 × 700 *mm*. Gluing was carried out shortly after final planing to minimize possible contamination of the bonding surfaces. A glue spread of 300 $g\,m^{2}$ was applied manually using a hand roller by double spreading. Clamping was carried out using a hydraulic cold press immediately after glue application, allowing practically no open assembly time. Five levels of pressure of 0.64, 1.00, 1.36, 1.75 and 2.14*MPa* (90, 140, 190, 245 and 300 *psi*) were used to press the laminates. This was maintained for a duration of 24 *h* at ambient conditions of 25°- 30°*C* and 60 - 80% RH. For each pressure level, ten laminations were prepared. A conditioning period of one week was allowed to the assemblies to facilitate proper curing of adhesive. Block shear test and vacuum-pressure cyclic delamination test as stipulated in the current Malaysian Standard, MS 758:1981 (Anonymous 1981), were used to assess the bonding quality of the laminates. The block shear test was meant to evaluate the shear strength of the bonded specimens in dry or interior conditions. The delamination test, on the other hand, assesses the gluing performance of the bonded specimens under simulated service environments. The dimensions, test conditions and assessment procedures for both tests were as described in Appendices B, C, and D of the Malaysian Standard, MS 758:1981 (Anonymous 1981).

The results of the block shear test which were expressed as failing stress and percentage of wood failure are summarized in Tables 1 and 2. The results show generally that PVAc glued specimens produced superior bonding shear strength and higher percentage of wood failure as compared to the PRF glued specimens. The bonding shear strength was also not much affected by the different pressure levels applied. The full factorial analysis of variance (ANOVA) revealed that there was signigicant interaction between adhesives and pressures ($p \leq 0.05$; $F = 2.75$). This led to a different approach in analysis. One-way ANOVA of individual adhesives carried out subsequently to determine the effect of different pressure levels indicated that pressure did significantly affect the bonding shear strength of PRF ($p \leq 0.05$; $F = 2.78$) glued specimens. Further analysis using Duncan's Multiple Range test to verify the difference for PRF glued specimens (Table 3) indicated that the 1.36*MPa* pressure was significantly superior to any other pressure levels in terms of bonding shear strength exhibited. However, its effect was not significantly different from those of the highest (2.14 *MPa*) and lowest (0.64 *MPa*) pressures employed or other pressure levels, with the exception of the 1.75 *MPa* pressure.

Table 1. Mean and minimum values of bonding shear strength of PRF and PVAc laminated specimens

Adhesive type	Pressure level (*MPa*)				
	0.64	1.00	1.36	1.75	2.14
PRF	10.87 (9.15) ((1.16))	11.06 (8.44) ((1.01))	11.49 (8.41) ((1.38))	10.35 (8.01) ((1.51))	11.18 (9.63) ((0.86))
PVAc	11.82 (10.76) ((0.97))	11.15 (8.37) ((1.52))	11.35 (9.54) ((1.25))	11.63 (10.10) ((0.89))	11.68 (9.95) ((1.12))

[1] All bonding shear strength values were corrected to 19% moisture content. The sample size for each assembly pressure level was 20;

( ) - values denote the minimum values;

(( )) - values denote standard deviation.

Table 2. Mean percentage of wood failure of PRF and PVAC laminated specimens

Adhesive type	Pressure level (*MPa*) 0.64	1.00	1.36	1.75	2.14
PRF	73	91	75	81	88
PVAc	100	100	97	99	98

Table 3. Significance of the differences in the bonding shear strength of PRF glued specimens resulting from different pressure levels applied

Pressure level (*MPa*)	Bonding shear stress (*MPa*)	Significance*
1.36	11.49	a
2.14	11.18	a
1.00	11.06	ab
0.64	10.87	ab
1.75	10.35	b

*Pressure levels with the same letters are not significantly different ($p \leq 0.05$).

For PVAc glued specimens, the bonding shear strength was found not significantly affected by the different pressure levels employed. The bonding shear strength was the highest at clamping pressure of 0.64 *MPa*, which was the lowest pressure level employed in this experiment. Nevertheless, all pressure levels applied produced high bonding shear strength values, with the mean and minimum values exceeding the minimum requirement of 9.47 *MPa* and 5.24 *MPa* respectively, as calculated based on the stipulation in the Malaysian Standard, MS 758:1981 (Anonymous).

The vacuum-pressure cyclic delamination test produced zero delamination for all pressures applied using either PRF or PVAc adhesives. Such a result, in addition to the excellent block shear test results, will then qualify meranti bukit for structural glue-lamination when PRF is used. For meranti bukit bonded with PVAc adhesive, although the bonded blocks met the requirement of bonding integrity test for structural glue-lamination, the flow characteristics of the adhesive during continuous loading render the product unsuitable for structural purposes. Nevertheless, PVAc bonded products qualify for non-structural use.

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ERRATA

In JTFS.6(2),

(1) page 105, Table 4 should read:

Table 4. The grade index assessment for meranti tembaga (*Shorea leprosula*) of 0.75 × 0.75 × 24 in size at upper ground after exposure for 60 months

(2) page 109, Figure 10 should read:

Figure 10. The amount of dry salt retention in CCB and CCA treated kempas at two different test sites for sample size of 1.5 × 0.25 × 24 *in*

(3) page 110, Figure 12 should read:

Figure 12. The amount of dry salt retention in CCB and CCA treated meranti tembaga at two different test sites for sample size of 1.5 × 0.25 × 24 *in*

(4) page 112, Table 5 should read:

Table 5. The percentage of individual compounds in treated kempas stakes at 0, 6 and 12 months exposed in the test plots