STRENGTH PERFORMANCE AND DELAMINATION BEHAVIOUR OF MULTI LAMINAR BIO-COMPOSITE BOARD AT DIFFERENT HOT PRESSING TIMES AND LAYER ORIENTATIONS

Shahril Anuar Bahari and Wan Nor Raihan Wan Jaafar

Bio-Composite Technology Program, Faculty of Applied Science, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

Introduction

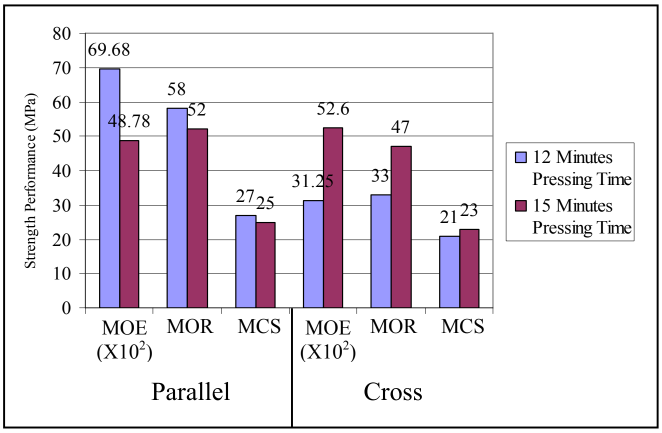
Malaysia has a lot of alternative forest resources such as bamboo and oil palm as materials for multi-laminar board. A study on the strength performance and delamination behaviour of multi-laminar bio-composite board (MLBCB) made from bamboo strips and oil palm trunk veneers (OPTV) was conducted. The parameters were different hot pressing times and different veneer layer orientations.

Experimental

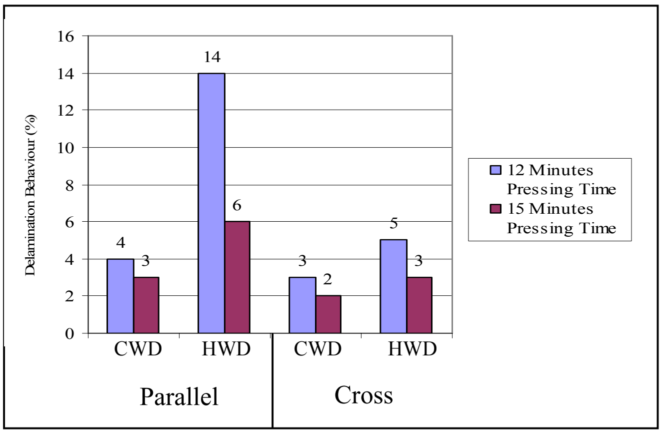
The dried bamboo strips and OPTV were laid-up and pressed together alternately (using phenol formaldehyde resin) with two different types of layer orientation, such as parallel and cross orientation to each other. The total number of layers was 7. The composite was pressed using hydraulic hot pressing machine at two different pressing times such as 12 and 15 minutes. The targeted thickness of MLBCB after pressing was 18 mm. The MLBCB was cooled, trimmed, sanded and cut for testing. The strength test, such as bending and compression, and delamination test, such as cold water delamination (CWD) and hot water delamination (HWD) tests, were based on Japanese Agricultural Standard for LVL JAS: SE-10 [1]. All samples were conditioned in a conditioning chamber. A flatwise bending test (3-point loading) was conducted to determine modulus of elasticity (MOE) and modulus of rupture (MOR). Compression perpendicular to the grain test was conducted and maximum compression stress (MCS) was calculated. The CWD was determined by submerging the samples in cold water for 24 hours, and oven-dried at temperature of 60±3^{o}C for 24 hours. The HWD was determined by submerging the samples for 5 hours in boiling water, followed by 1 hour in cold water, and oven-dried at 60±3^{o}C for 24 hours. Delamination ratio should not more than 10% of total glue lines.

Results and Discussion

Figure 1 shows the mean strength and delamination values of MLBCB at different pressing times and layer orientations, while Table 1 shows the significant difference of those values. From Figure 1 (a) and Table 1 (a), MOE and MOR of parallel orientation at 12 minutes pressing time was significantly higher than 15 minutes. MCS of parallel orientation at 12 minutes was insignificantly higher than 15 minutes. MOE and MOR of cross orientation at 12 minutes pressing time was significantly lower than 15 minutes. MCS of cross orientation at 12 minutes was insignificantly lower than 15 minutes. Longer pressing time has only influenced the increment of strength for cross orientation. This was due to the cross laminates orientation that influenced the strong bonding behaviour between bamboo strips and OPTV under longer pressing time. At 12 minutes pressing time, strength performance of parallel was significantly higher than cross. At 15 minutes pressing time, MOR of parallel was significantly higher than cross. MCS of parallel orientation was insignificantly higher than cross orientation. However, MOE of cross orientation was higher than parallel, although the difference was not significant. The results showed that cross orientation of bamboo strips and OPTV has good influence only on MOE. Poor adhesion between bamboo strips and OPTV was believed to influence poor strength performance of cross orientation. Additionally, the density of oil palm stem is generally low with considerable density variability over the stem [2], thus reduces the strength. From Figure 1 (b) and Table 1 (b), CWD of parallel at 12 minutes pressing time was insignificantly higher than 15 minutes. However, HWD of parallel at 12 minutes was significantly higher than 15 minutes. CWD and HWD of cross at 12 minutes pressing time were insignificantly higher than 15 minutes. At 12 minutes pressing time, CWD of parallel was insignificantly higher than cross. In contrast, HWD of parallel was significantly higher than cross. At 15 minutes pressing time, delamination of parallel was insignificantly higher than cross. Low delamination values were due to the cross orientation of bamboo strips and OPTV that influenced good bonding behaviour, thus reduced the potential of delamination.



(a)



(b)

Figure 1. The Mean Strength and Delamination Values of MLBCB at Different Hot Pressing Times (12 and 15 minutes) and Layer Orientations (Parallel and Cross Orientations): (a) The Mean MOE, MOR and MCS Values, (b) The Mean CWD and HWD Values

Table 1. The Significant Difference of Strength and Delamination Mean Values of MLBCB at Different Hot Pressing Times and Layer Orientations: (a) The Significant Difference of MOE, MOR and MCS Mean Values, (b) The Significant Difference of CWD and HWD Mean Values (Notes: Means with the same letter are for comparison between two variables, different numbers indicate the variables are significantly different at $\alpha = 0.05$)

(a)

MLBCB	Pressing Time (min.)	Strength Performance (MPa)		
		MOE	MOR	MCS
Parallel	12	$6968^{A1, G1}$	$58^{C1, I1}$	$27^{E1, K1}$
	15	$4878^{A2, H1}$	$52^{C2, J1}$	$25^{E1, L1}$
Cross	12	$3125^{B1, G2}$	$33^{D1, I2}$	$21^{F1, K2}$
	15	$5260^{B2, H1}$	$47^{D2, J2}$	$23^{F1, L1}$

(b)

MLBCB	Pressing Time (min.)	Delamination Behaviour (%)	
		CWD	HWD
Parallel	12	$4^{M1, Q1}$	$14^{O1, S1}$
	15	$3^{M1, R1}$	$6^{O2, T1}$
Cross	12	$3^{N1, Q1}$	$5^{P1, S2}$
	15	$2^{N1, R1}$	$3^{P1, T1}$

Conclusion

This study showed that the longer pressing time has increased the strength performance and delamination behaviour of MLBCB, except for strength performance of parallel orientation board. Cross orientation has increased the bonding strength behaviour between OPTV and bamboo strips, thus influenced the good modulus of elasticity value and low delamination percentage.

References

1. Anonymous. Japanese Agricultural Standard (JAS) for Structural Laminated Veneer Lumber Japan, Ministry of Agriculture, Forestry and Fisheries. (1993).
2. S. C. Lim and K. S. Gan. Characteristics and Utilization of Oil Palm Stem. Timber Technology Bulletin No. 35. Forest Institute of Malaysia. (2005).