Properties of Acacia Mangium WCB in Relation to Particle Size and Additives (Na_2SiO_3)

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Abstract

Particle size and additives (Na_2SiO_3) had significance effect on physical and mechanical properties of wood cement board (WCB). One way analysis of variance (ANOVA) has been used to examine any significance differences between the populations mean. The findings revolved around the mechanical and physical properties of WCB from *Acacia mangium*. The two parameters involved in this study are the particle sizes and the additives (Na_2SiO_3). Particle size, additives (Na_2SiO_3) and the correlation between particle size and additives (Na_2SiO_3) have influence on all the WCB properties. The values of physical properties for particle size effect all met the standards of MS544:2001 except for particle size 2.0 mm of 0% Na_2SiO_3 and 1.5% Na_2SiO_3. In this instance the water absorption (WA) did not met the standards of MS544:2001. Effect of particle size on mechanical properties indicate fluctuation due to the decreasing of particle sizes while the effect of particle size on physical properties also show fluctuation due to the decreasing of particle sizes. Meanwhile 3% of Na_2SiO_3 cause higher values of modulus of rupture (MOR) (13.6 MPa), modulus of elasticity (MOE) (5,979 MPa) and internal bond (IB) (1.56 MPa). For the effect of additives (Na_2SiO_3) on physical properties, the value of WA and thickness swelling (TS) tends to decrease corresponding to the percentage (3%) of Na_2SiO_3.

Keywords: Bio composite, Wood Cement Board, *Acacia mangium*, Sodium silicate.

1. INTRODUCTION

Wood cement board (WCB) is the part of the panel product that has the advantages of inorganic and organic materials. WCB is a panel containing wood, water, cement and chemical additives. Examples of chemical additives used are aluminium sulphate, ($Al_2(SO_4)_3$) and sodium silicate, (Na_2SiO_3). WCB is manufactured from chemically treated particles mixed with the Portland cement, compressed and then cured under controlled temperature and pressure.

Cement board is a panel mainly composed of cements bonded particle board and cement fiber. Wood fibers reinforced cement board use plant fibers as reinforcement while the cement bonded particle board has treated wood flakes as the reinforcement. Wood fibers are mixed together with ordinary Portland cement (or other equivalent cement) in the presence of adequate water and mineralizing fluids, then mat formed and pressed until the cements sets.

2. METHODOLOGY

2.1 Raw Materials and Preparation

Flowchart of WBC process is given in Figure 1. First and foremost, the diameter breast height of trees was measured before cutting down. The middle portion of *Acacia mangium* trees was chosen. It was selected because it was assumed to be more matured rather than top and bottom portion of the trees. All the logs were transported to the workshop for further processing. Logs of trees were cut down into long billets. The billets were debarked manually using sharp "parang". After debarking, the logs will be cut into 1 in x 1 in length and passed through the wood chipper to produce wood chips. The next process step used a knife ring flaker. The small wood particles were screened to obtain the sizes for core and surface materials. The chips were air dried for 1 week before using knife ring flaker.

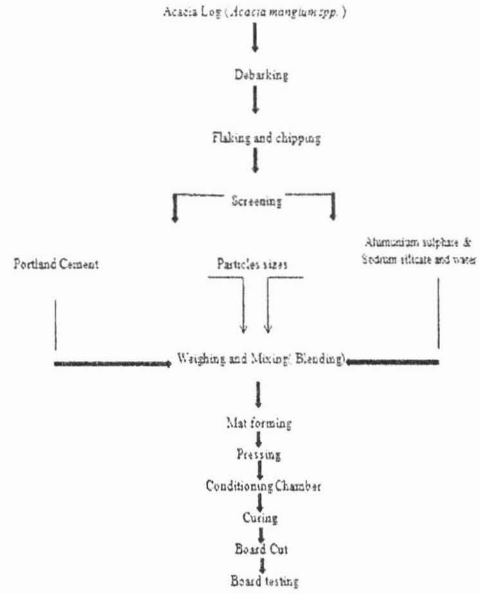

Figure 1: Flowchart of WCB process

2.2 Experimental design

The experimental design of WBC is as given in Figure 2.

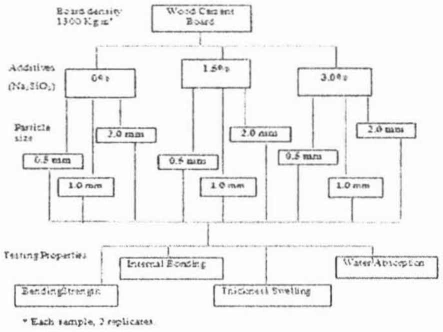

Figure 2: Experimental design for Acacia WCB

3. RESULTS

3.1 Properties of wood cement board according to particle size and additives (Na_2SiO_3)

Table 1 provide the mean values for mechanical and physical properties of produced WCB according to particle size and additives (Na_2SiO_3). The values are further discussed in separate sections.

Table 1: Mean Values

Particle size (mm)	Additives (Na_2SiO_3)	MOR (MPa)	MOE (MPa)	IB (MPa)	WA (%)	TS (%)
0.5	0%	12.97	5284	1.34	29.5	1.6
1.0		12.15	5277	0.86	29.9	1.9
2.0		8.92	4330	0.72	31.2	1.9
0.5	1.5%	13.37	5908	1.53	28.7	1.5
1.0		12.20	5728	0.93	29.6	1.9
2.0		9.45	4338	0.87	30.3	1.8
0.5	3.0%	13.61	5979	1.56	25.6	1.2
1.0		12.51	5859	1.05	29.2	1.5
2.0		11.16	4540	0.94	29.8	1.6
MS544: 2001		≥9	≥3000	≥0.5	≤30	≤2

Notes: MOR: Modulus of Rupture, MOE: Modulus of Elasticity, IB: Internal Bonding, TS: Thickness Swelling, WA: Water Absorption, n.a: not available

3.2 Effect of particle size and additives on mechanical and physical properties

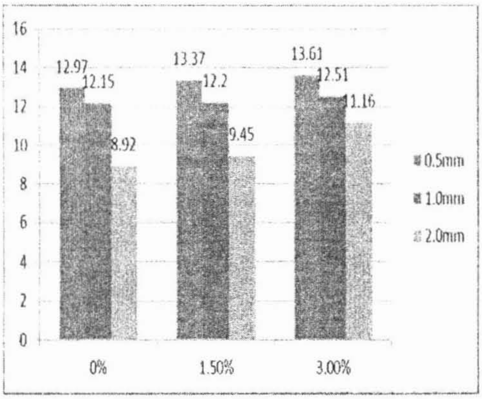

Figure 3: Modulus of Rupture (MOR)

Figure 3 showed the effect of particle size and additives on modulus of rupture (MOR). The size of particles consisted of 0.5 mm, 1.0 mm and 2.0 mm meanwhile the additives consisted of 0%, 1.5% and 3% of Na_2SiO_3. In MOR, the increasing of MOR is due to the decreasing of the particle size but it remained constant in the particle sizes of 1.0 mm and 2.0 mm. It can be explained that small particle tends to give better distribution as it has of large surface area. The increasing of MOR is also due to the increasing of percentage of Na_2SiO_3 and at the gap was smaller between particles for 3% of Na_2SiO_3.

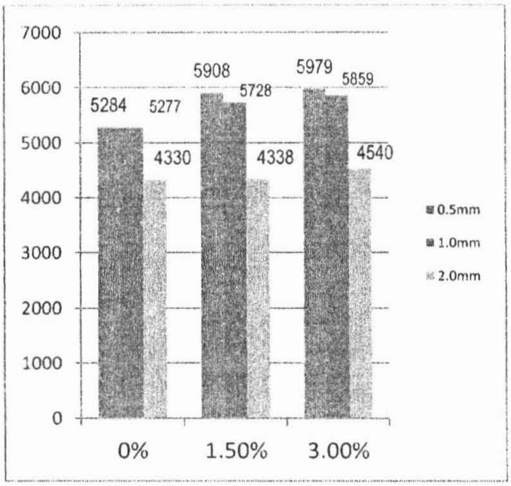

Figure 4: Modulus of Elasticity (MOE)

Figure 4 showed the effect of particle size and additives on modulus of elasticity (MOE). Same size of particles and Na_2SiO_3 content was used. The increasing trends of mean values in the MOE are due to the decreasing of particle sizes and increasing percentage of Na_2SiO_3. According to Olorunnisola (2009), it stated that smaller size of particles was likely to be easily blended with cement in the matrix than the bigger particles thus yields composites with higher MOE.

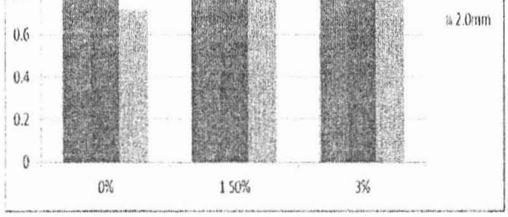

Figure 5: Internal Bonding (IB)

The mean value of internal bond (IB) ranged from 0.72 until 1.56 MPa. The Figure 6 showed an increasing pattern at all particle sizes with different additives. However the particle size of 0.5 mm has the highest mean IB value. Jamaludin *et al.*, (2010) evaluated that the decrease in mechanical properties with increasing of particle size is due to increased cement bonding with the wood particles through encapsulation which ensures continuity within the cement matrix.

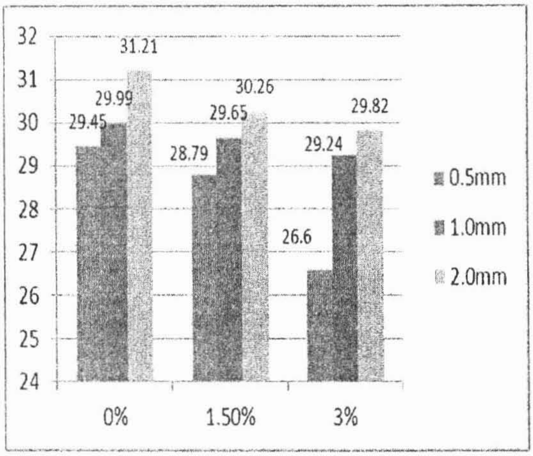

Figure 6: Water Absorption (WA)

Figure 6 showed the mean value of water absorption (WA) ranging from 25.6 until 31.2 % with a decreasing trend as the size of particles increases. Higher WA is due to larger particles that tend to cause incomplete coverage by cement of the particle surfaces, reduced protection and insulation thus enabling absorption of higher volume of water (Jamaludin *et al.*, (2010). Souza et al., (2004) and Marzuki et al., (2011) argued that free internal spaces could be the possible which tends to cause high WA and consequently, higher thickness swelling (TS).

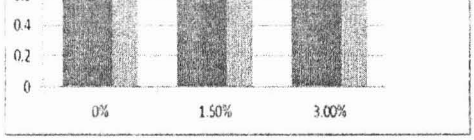

Figure 7: Thickness Swelling (TS)

Figure 7 showed higher values of TS is shown by larger particles. Larger particles have the difficulty to become compact and more stress is required during pressing. Souza et al., (2004) observed that if the board has more latent compression stress, when the boards are exposed to water, they tend to swell much more. Greater internal-void spaces are responsible for greater TS.

4. CONCLUSIONS

For conclusion, the two parameters that involved in the study are the particle sizes and the additives (Na_2SiO_3). Particle size, additives (Na_2SiO_3) and the correlation between particle size and additives (Na_2SiO_3) influence on all the WCB properties. The values of physical properties for particle size effect all met the standards of

MS544:2001 except for particle size 2.0mm of 0% Na_2SiO_3 and 1.5% Na_2SiO_3 for WA. Effect of particle size on mechanical properties indicate fluctuation due to the decreasing of particle sizes while the effect of particle size on physical properties also show fluctuation due to the decreasing of particle sizes.

Meanwhile, the effect of additives which are 3% of Na_2SiO_3 gave highest values of MOR (13.6MPa), MOE (5,979MPa) and IB (1.56Mpa) with 0.5mm particle size. The effect of additives (Na_2SiO_3) on physical properties, the value of WA and TS tends to decrease correspondingly due to the percentage with3% Na_2SiO_3 giving the better performances.

5. RECOMMENDATIONS

For the next study, it recommended the other cement: wood ratio such as 1:2.75 and 1:3.0 could be examined to gain improved result as ratio is likely to influence the strength of the board. Furthermore the board should use 1.0mm particle size as it is more stable and constant. Additionally, the other chemical additives such as $MgCl_2$ could be used then.

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