THE INFLUENCE OF WEATHER ON THE MECHANICAL PROPERTIES AND THE EFFECT OF PARTICLE SIZE AND ADHESIVE CONCENTRATION ON WATER IMBIBITIONS OF SAWDUST PANELS

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Abstract

The effect of weather on the panels is not much affected by particle size as much as it is affected by the adhesive concentration.- The strengths of the panels reduced within five days of exposure thereafter stabilized at the new levels which suggests some physio-chemical transformation of the resin.

The influence of particle size and compaction load on the water imbibitions is also reported. The corresponding reduction of the amount of water imbibed as the particle size decreased, had further confirmed the earlier report about the effect of particle size on density and thickness. It was also noticed that the volume of water absorbed was inversely related to the compaction load. The curve of water absorption as a function of compaction force clearly indicated a plateau after the lOtons. It was found that the maximum compaction load for all the particle sizes was within this level of compaction.

Keywords: Tensile strength, breaking stress, water imbibitions, particle size, compaction load.

Introduction

The earlier report of this work had shown the effect of compaction load and adhesive concentration on the thickness and bulk density. It also showed the effect of the two on the tensile stress and hardness (Yakubu, Saliu and Kolawole). It was established that a critical compaction load existed above which the particles of the panels started to breakdown. It was seen that the critical load depended on the particle size. The adhesive concentration needed to consolidate the particles of the matrix also exhibited size-dependency. It was found out that for particle size less than 400pm; ***2%*** adhesive gave optimum mechanical response, particle size greater than 400pm up to 500pm; 4% proved better whereas for particle sizes greater than 800pm; 6% adhesive was found suitable. The thrust of this report is the determination of the effect of weather on the tensile properties of the panels and their water absorptivity.

Experimental

Exposure of the Samples to Weather

The samples produced by varying particle size, compaction load and adhesive concentration, (Saliu, 2004) were exposed to weather for 7, 14, 21, 28 and 30 days, from 11 February to 13 March 2003.

Tensile Strength Measurements

The samples so exposed above, were at the end of the periods of exposure, tested for strength using a Tensometer Type W according to ASTM D638. The results are seen in Figures 1 -10. ***Amounts and Rate of Water Absorbed by the Samples***

The samples, after being conditioned at 30 ±2°C and 25% RH were each weighed and then submerged in tap water at a depth of 20mm in a plastic basic according to ASTM D57-. The rate at which absorption took place was recorded after 5,10, 15, 20, 30 and 60 minutes by reweighing and computing the mass of water imbibed as a function of time. The results are shown in figures 11-21 and table 1.

Results and Discussions

Figures 1 to 5 showed the effect of weather on the breaking stresses for the different particles sizes; 355 to 1180pm. Figures 6 to 10 illustrated the breaking stresses for the different adhesive concentrations; 0 to 20 w% adhesive. Figures 1 tO 5 depicted three clear groups. The first group represents 15 and 20 tons compaction loads, which traced similar patterns. The second group represents only to 10 tons compactions change in strength with exposure. The second group indicted intermediate response with increasing days of exposure. The second group indicated intermediate response with increasing days of exposure. In some cases, i.e. the 500pm particle size, the strength remained constant throughout the period of exposure. General, the panel appeared reasonably stable to

weather conditions statistically, irrespective of the compaction loads. The effect of weather on the adhesive is shown in figures 6 -10. In figure 6, where the panels were not applied any adhesive, only the 500pm particle size panel showed a negative slope, which broke at the 7th day exposure. However, the panels consolidated by the use of varying concentrations of adhesive indicated the negative slopes which picked up after the 7th day exposure; this was clearly manifested especially for the 2 and 4% of adhesive concentrations. It is also observed that the strength of the panels for the 2 and 4% adhesive, declined when the unexposed samples were compared with the 30 days exposed samples showed little fall in strength when compared with the 30 days - exposed samples. For the 20% of adhesive concentration in figure 10, the strengths of the other samples 1180pm particle size increased with the time of exposure, otherwise the strengths of the other samples remained constant. However, the strength of ***20%*** adhesive concentration samples were generally lower than for the other adhesive concentrations, the breaking stresses for the 355pm particle size exposed for 21 days were about 38, 90, 110, 70 and 55Nmm"^{2} respectively. It could be inferred, from this, that with no adhesive in the board it could not withstand weather changes and if too much (excess) adhesive was used stability to weather was also impaired. In the absence of adhesive (0%), the board has higher void content for which Agarwal and Broutman (1980), ascertained greater susceptibility to weathering and increased variation or scatter in strength properties. The foregoing shows clearly that for a given adhesive concentration, boards made under compaction level below 10 tons gave poor breaking stress. Furthermore, boards must be insulated from weather condition, to maintain integrity of breaking stress after having bee cured.

Like timber, panels are hygroscopic, especially at their edges and they expand and contract with variations in moisture content. Some irreversible swelling occurs, particularly in the thickness of platen pressboard. Moisture weakens panel, at least as much as it weakens solid wood. The recovery of the strength by re-drying depends on the adhesive bond. Kubler (1980), observed that common board made of long or flat particles swells in length and width of about 0.6% over the whole moisture range. Agarwal and Broutman (1980) observed that moisture content of boards as manufactured is low (10 - 12%). This is in agreement with the determination of Maloney and Mottet (1970), that moisture content of the mats have to be kept below 12% as higher moisture levels interfere with proper resin bonding. It might be expected therefore, that in the presence of moisture, the strength due to the joint would reflect exactly any loss in strength of the adhesive by the imbibitions of water. Wake (1976), reported Kerr and Co-workers who studied epoxide adhesives made into test strips and exposed to saturated atmospheres of water or ethanol in the absence of oxygen. They found that the loss in tensile strength is a linear function of the vapour absorbed and the equilibrium was reached when about 2% water by weight of the board was absorbed. Wake himself established that the physical displacement of resin from an interface by water is characteristic of systems involving only secondary Van der Waal's forces. He further stated the strength loss due to water imbibitions of completely reversible if the surface of the substrate is not change irreversibly by the adsorption of water. He further explained that there are two processes involved in the deterioration of joints under the influence of moisture, the absorption of water by adhesive and at the interface by the displacement of adhesive. The physical adsorption of water at the interface is only possible when a purely physical mechanism of adsorption is considered. The breakdown of adhesive bonds in the presence of moisture is not only a function of the chemical constitution of the adhesive but also on the degree of cross linking which determines the equilibrium content of water vapour and the glass transition temperature, Tg of the adhesive.

Pinto (1955), who continuously soaked panels in water, observed that as one might from a consideration of their chemical composition, the artificial resin used in his tests did not show tendency to weaken. If that tendency is present at all, it was masked by the more rapid weakening of the wood itself. He ascertains that the panels showed a gradual decrease in strength although the artificial resin glues were not unique in their ability to resist exposure of this type. Figures 11 to 15 show the effect of compaction load on the rate of water absorption with changes in the particle size. Figures 16 and 19 show the effect of adhesive concentration on the rate of water absorption with changes in the particle size. Figure 2(/ summarized the effect of compaction load on the volume of water imbibed at different

particle sizes. Figure 21 summarized the effect of adhesive concentration of the volume of water imbibed with changes in particle size. In each case, the area under a given curve is proportional to the internal volume if the panel. As earlier reported (Yakubu, Saliu and Kolawole, 2004), there was a strong correlation between the compaction loads with the void content of the panels. So much that the bulk density was found to increase with the increase in the compaction load, until around the 10 tons loads where a plateau developed in the case of the 355 and 1180pm particles sizes. Very much in tune with the earlier observations, the 355pm particle size has the list void content at the 10 tons compaction load, as also observed here; it produced the smallest area profile. The 425, 500, 850 and 1180pm particle sizes recorded their smallest areas with the 15 tons compaction load. It is however, observed that the area difference between the 15 and 20 tons compaction loads 850 and 1180pm particle sizes is too small. For this reason, and also to obtain panels with better mechanical attributes, the compaction loads should be up to 20 tons for particle sizes above 800pm as recommended by Yakubu, Saliu and Kolawole (2004). It is also observed that for the 355pm particle size, the 15 and 20 tons compaction loads indicated higher void volume. These are caused by the creation of smaller intra-particle spaces brought about by the partial crushing of the fibres that constituted the panels. In all cases, for a given length of soaking, the quantity of water absorbed decreased with increasing compaction load until the limit is reached. It was also reported that, at 10 tons compaction load all the other particle size have the same bulk densities, figures 12 to 15 indicated that the volume of water imbibed as evidence by the area under the respective curves, are the same. This also demonstrated the strength of the correlation between compaction load and particle size as reported. The summary is clearly shown in figure 20, where the 335pm particle size panel gave the least percentage water absorbed in relation to the dry weight at 10 tons compaction load whereas the other particle sizes gave theirs downstream. As reported earlier (Wake, 1976), water or moisture penetrates a matrix either through the binder or through the interface. As the binder in this case is not water-soluble, penetrate of water can be impeded by layers of the adhesive. It is understood by this reason, that the material less covered by adhesive to moisten the sawdust is dependent on the particle size, such that the larger the particle size the more difficult to be moisten. It is observed from figures 18 and 19 that, the volume of water absorbed decreased/void volume with increase in particle size. In the two figures, it is observed that the area under the curves follows the given order 1180pm > 850pm > 500pm > 425pm > 355pm. These confirmed that the smaller particles are more easily moistened than the larger ones. Figures 21, indicated the adhesive concentrations that gave the optimum effects. It showed that the 20% adhesive concentration was able to effectively cover the surface of the different particles sizes; as such, produced panels that absorbed the least amount of water with the exception of the 1180pm particle size. It is also seen by comparing figures 20 and 21 that the amount of water imbibed reduced significantly because of the adhesive, which is more than by increasing the compaction load.

Table 1, gives the coefficient of diffusion of water into the matrix as given by t *'A* Serial No 1- 5 show the effect of compaction load, whereas No 6-9 give the effect of adhesive concentration, with the changes of particle size. With few exceptions, the t ^{x}A due to compaction load variations are higher than those due to adhesive concentration variations. It means that the panel that contained more adhesive are saturated more quickly than otherwise. This may stem from the less available space when the samples are consolidated by adhesive. The 355pm panel gave the least t *A* of 4.55 min at the 10 tons compaction load. The 425pm panel gave the least of 6.54 min at 15 tons, 500pm gave least of **8** min at 15 tons, and 850pm gave the least of 3.91 min at 15 tons.

Table 1: The Effect of Compaction Load, Adhesive Concentration and the Particle Size on the t*Vi* of Water Diffusion

S/N	Compaction Load/Adhesive Concentration	Particle Size (pm)				
		355	425	500	850	1180
1	**0 tons**	**8.18 min**	**8.18 min**	**3.60 min**	**4.50 min**	**7.18 min**
2	**5 tons**	**10.9 min**	**lO.min**	**10.00 min**	**7.72 min**	**8. 18 min**
3	**10 tons**	**4.55 min**	**8.18 min**	**10.00 min**	**7.09 min**	**6.73 min**
4	**15 tons**	**8.18 min**	**6.54 min**	**8.00 min**	**3.91 min**	**8.63 min**
5	**20 tons**	**10.00 min**	**5.45 min**	**8.18 min**	**12.00 min**	**9.09 min**

6	**2%**	**7.27 min**	**3.64 min**	**3.64 min**	**3.27 min**	**3.64 min**
7	**4%**	**9.52 min**	**4.28 min**	**3.81 min**	**3.81 min**	**5.71 min**
8	**6%**	**6.67 min**	**6.67 in**	**9.52 min**	**7.43 min**	**6.67 min**
9	**20%**	**10.00 min**	**6.67 min**	**4. 86 min**	**4.86 min**	**4.75 min**

Conclusion

The result have indicated that the compaction load did not influence the response to weather. It however showed that adhesive concentration influenced the effect of weather on the panels. This adverse effect was more pronounced in the seventh day of exposure, thereafter for concentrations less than but inclusive of ***4%,*** the strength stabilized. However, for concentrations above but inclusive of **6**%, the strength somehow was almost totally recovered when the period of exposure was extended. This phenomenon is attributed to some reversible physio-chemical changes exhibited by the binder during exposure. The results of water absorption, had confirmed the void volume differentials witnessed by changes in the compaction loads. The optimum compaction load due for the different particle sizes could be worked out from the water absorption studies. Similarly, evidence of the blockage of the surface of the particles by the adhesive was quantitatively confirmed by the reduction of the percentage water absorbed and increase in the t V4 by the increase in adhesive concentrations.

References

Agarwal, D. B. and Broutman, J. L. (1980). ***Analysis and performance offibre composition.*** A Wiley - Interscience Publication, New York: U. S. A.

Kubler, H. (1980). ***Wood as building and hobby material.*** A Wiley Interscience Publication. U. S. A.

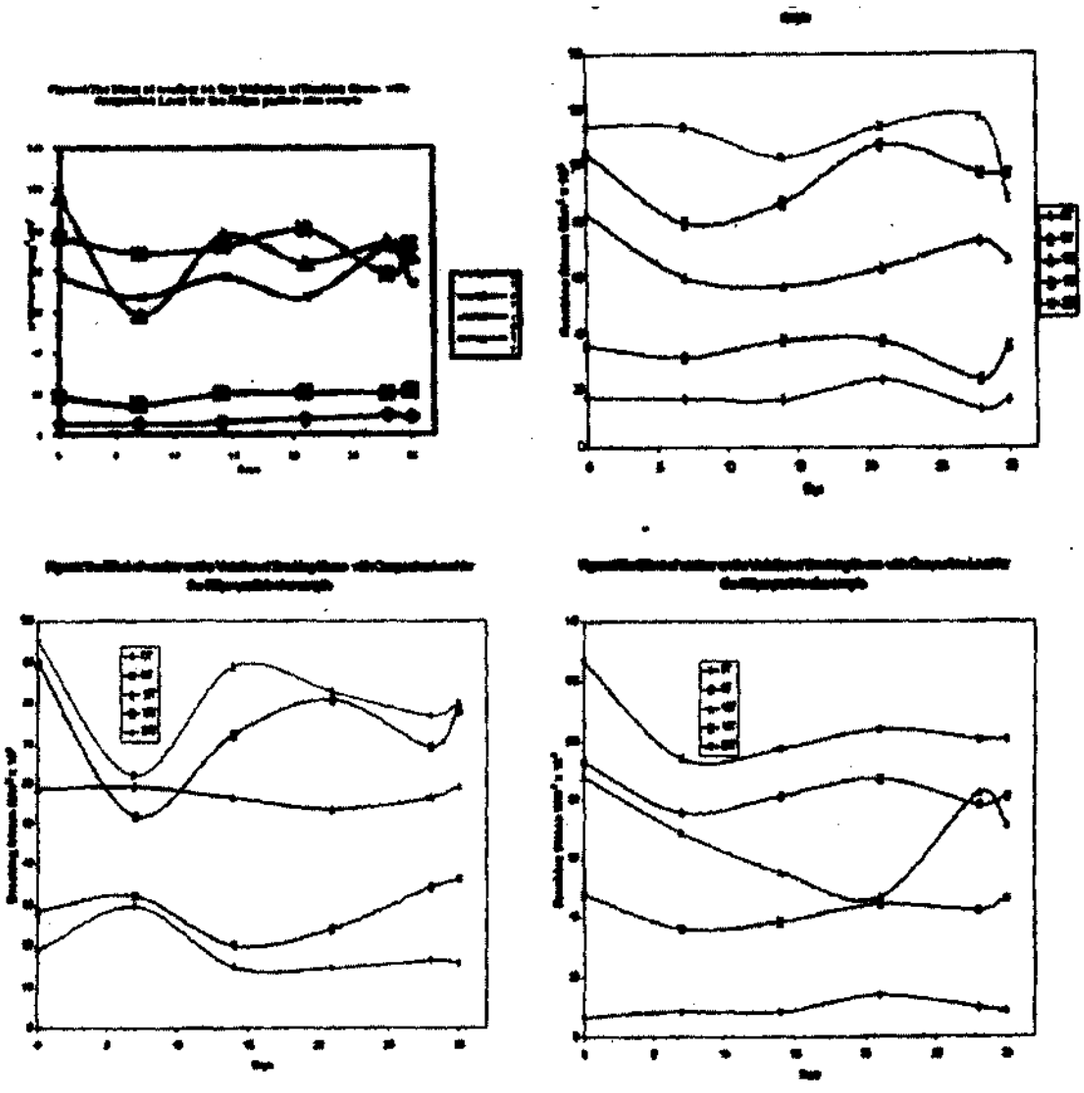
Maloney, M. T. and Mottet, L. A. (1970). ***Particleboard compiled in modern materials: Advances in development and application.*** Edited by Bruce W. Gonser, Vol. 7. Academic Press, New York and London.

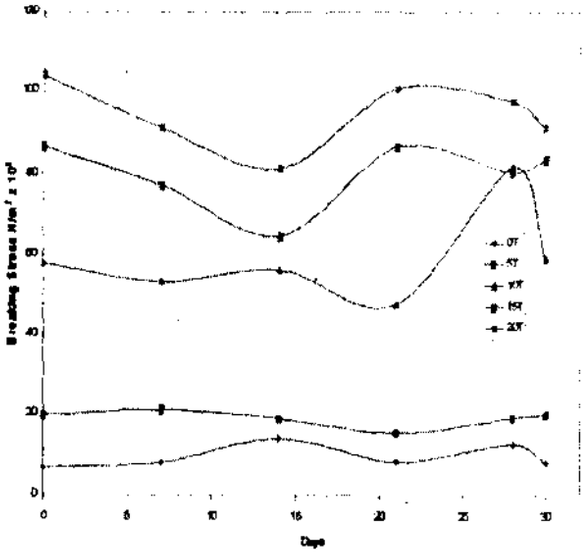
Pinto, H. E. (1955). ***Wood adhesive. First popular edition.*** William Clowes and Sons Limited: London.

Saliu, H. R. (2004). The effect of particle size and adhesive concentration on some physical and mechanical properties of sawdust-based particleboard. MSc Thesis.

Wake C. W. (1976). Adhesive and formulation of adhesive. Applied Science Publishers Limited: England.

Yakubu, M. K.; Saliu, H. R. and Kolawole, E. G. (2007). The effect of particle size and adhesive concentration on some physical and mechanical properties of sawdust panels. The ***Nigerian Journal of Research and Production.*** Vol. 11 No 2.

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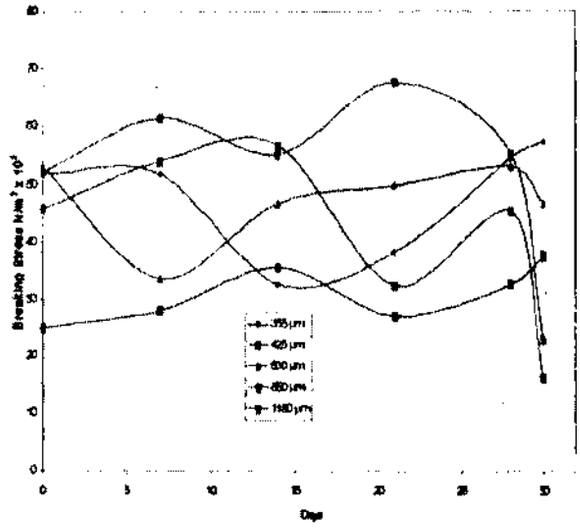
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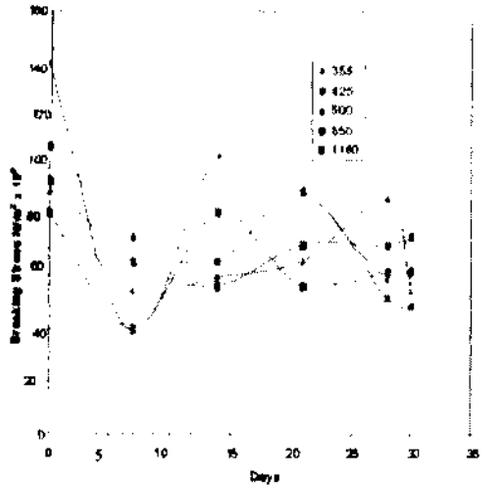
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