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Cement Bonded Particle Board Production from Rice-Husk in Southwestern Nigeria

J.A. Bamisaye
Department of Civil Engineering, University of Ado-Ekiti, Nigeria

Abstract: Effort to remove natural defects from timber led to the development of particle board industry which made use of saw dust, planer shavings and other relatively homogeneous waste materials produced by the wood industries. This study reports on the production of cement bonded particle board from rice husk which is readily available in large quantities in various areas where rice is grown. The chemical additive used to accelerate the setting of cement board during hydration was aluminium Chloride ($AlCl_3$) due to its availability and the cement to rice husk mix ratio used were 2:1, 1.75:1, 1.5:1, 1.25:1 and 1:1. High density boards were produced and physical property test such as moisture content, density, water soak and linear expansion were carried out while the mechanical properties tested for were static bending test used to determine both moduli of rupture and elasticity and impact resistance. The cost analysis revealed that the production of 600 by 600 mm rice husk particle board costs N145.75 while that of wood shavings was N160:00. It was therefore concluded from this study that durable particle board could be produced by using rice husk to totally replace the conventional wood shavings. Thus, its adoption will further enhance local content development in the construction industry.

Key words: Rice-husk, particle-board, local-content development, total replacement

INTRODUCTION

The need to dispose of large quantities of saw dust, planer shavings and other relatively homogeneous waste materials produced by wood industries led to the growth of particle board industry. Particle board was discovered out of the need to remove the natural defect that solid timber suffers from. The basis of its production according to[1] is that by breaking the wood into relatively small pieces and reassembling the pieces with some kind of binder, the effect of the original grain structure and natural defects are removed and a more uniform product can be obtained.

They are produced by hammer milling these waste materials into small particles, spray application of adhesive and consolidating a loose mat with heat and pressure.

Rice husk like other lignocelluloses have physical and chemical properties that does not enhance good interaction with adhesive binders necessary to form the anticipated interfacial bonds. It contains a lot of silica and has poor resistance under alkaline and acidic conditions. The type of wood, mineral binder, formation process, board density and chemical adhesives can affect the properties of the board[2], hence production of particle board with good interfacial bonds largely depends on proper characterization of rice husks and by slightly modifying its properties.

According to[3], the raw materials that can be used for composite board production includes bagasse, cereal straw, coconut coir, corn stalk, cotton stalks, jute, kenaf e.t.c. Thus the objective of this study is to evaluate the performance of particle board produced from rice husk by determining their physical and mechanical properties.

Rice is grown in more than one hundred countries and across every continent of the world, thus ensuring large availability of its husk in such places. In most places where they are available, the husk is put to little economic use and is rather seen as a waste product constituting environmental nuisance. Its use in production of cement bonded particle board will therefore help remove the so called environmental nuisance and turn such waste to wealth, thereby improving the local content development in the construction industry.

The properties of grades of particle boards are usually determined by[4] and such properties either suggest or limit its use as described in the standard.

MATERIALS AND METHODS

Rice husk was the main lignocellulose material used and was collected from the rice milling and processing site at Igbemo Ekiti, in Ekiti State, south west Nigeria while the ordinary Portland cement that conformed with the requirements of[5] was used. The chemical additive used to accelerate the setting of cement board during hydration was aluminium chloride, $AlCl_3$ which is readily available in agro-chemical shops. Distilled water was also used.

The cement to rice husk mix ratio used were 2:1, 1.75:1, 1.5:1. 1.25:1 and 1:1. The quantity of additive used was 3% of cement weight while the board density adopted was 1200 kg m^{-3} (high density board). Particle geometry influences the board properties as the length of flake-type particle is probably most important as it influences maximum strength according to[6,7], hence board thickness of 6 mm and mould of 350 by 350mm with pressing pressure of 1.23 N mm^{-2} was adopted.

The rice husk was pre-treated with hot water at 80° to reduce its sugar content that could cause poor rice husk-cement compatibility before it was air-dried to remove excess moisture. The amount of materials required for each board production was then weighed and mixed in the mixing bowl according to the mix ratio. The mats were hand formed uniformly inside the wooden mould and covered with polythene sheet to prevent the sticking of the boards on the metal plates.

After the board formation, plywood caul was placed on top of mats and pre-pressed to reduce the thickness and thereafter the plywood caul was replaced with metal caul covered with polythene sheet. The mould was then transferred to the press and cold- pressed under 1.23 N mm^{-2} pressing pressure for 24 h. The cauls were removed after the boards were set and then kept in the Laboratory under environmental condition of relative humidity of 65±2% and temperature of 20±1° C prior to tests.

Tests were carried out in conformation with the procedures in[4]. The tests carried out were physical property tests such as moisture content, density, water soak test and linear expansion while the mechanical properties tested for were static bending used to determine both modulus of rupture and elasticity and impact resistance.

RESULTS AND DISCUSSION

The density test result shown on Table 1 reveals density values that ranged from 1020 to 1530 kg m^{-3} after 24 h of oven dry. The value decreases as the mixing ratio of the board decreases. The particle board was therefore of high density according to[4] classification that classifies particle board with density greater than 800 kg m^{-3} as high density board.

Figure 1 shows the result of the moisture content test with lowest and highest value of 13.68 and 18.06%, respectively. The moisture content increases as mixing ratio of the board decreases. The thickness swelling and water absorption test result is shown on Fig. 2. The mean values obtained for thickness swelling ranged between 2.94 and 6.82% and that of water absorption ranged between 1.65 and 6.47% after 24 h of submersion in distilled water.

Table 1: Density test result

Mix ratio	over dry weight (Kg)	Density (Kg m^{-3})
2.0:1.0	0.203	1530
1.75:1.0	0.189	1390
1.5:1.0	0.169	1270
1.25:1.0	0.156	1200
1.0:1.0	0.131	1020

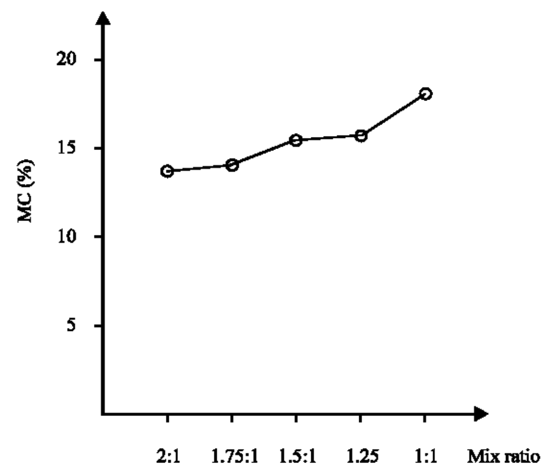

Fig 1: Moisture content test result

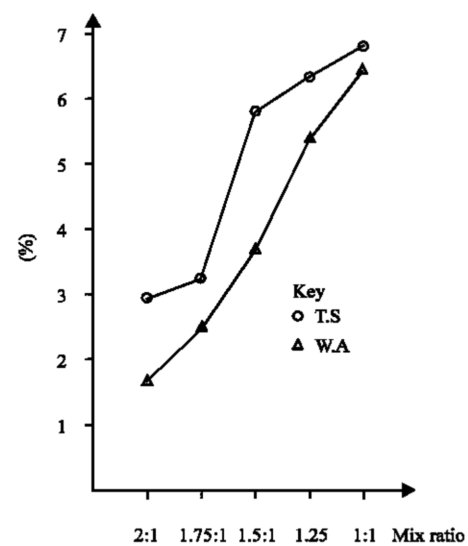

Fig. 2: Thickness swelling and water absorption test result

The result shows that the thickness swelling values obtained for mixing ratio of 2:1 and 1.75:1 were found to be most dimensionally stable. The thickness swelling properties of cement bonded particle board decreases as the mixing ratio increases. The particle board produced with a mixing ratio of 2:1 was found to be most

Table 2: Linear expansion impact and static bending strength result

Mix ratio	Linear expansion(%)	Impact strength (mm mm^{-1})	Modulus of rapture (N mm^{-2})	Modulus of elasticity (N mm^{-2})
2.0 : 1.0	0.0125	127.0	11.52	1339.20
1.75 :1.0	0.2745	121.9	11.12	1094.04
1.5 : 1.0	0.2063	106.7	10.79	972.41
1.25 : 1.0	0.2609	96.5	5.54	565.53
1.0:1.0	0.4534	88.9	4.56	391.68

dimensionally stable from the water absorption test with 1.65% value. The values also increased as the mixing ratio decreased.

The result obtained from the test carried out to determine linear expansion of the particle board produced with all the mixing ratio revealed values that fell within the recommended range by[4] except for 1:1 mixing ratio at 0.45% as shown on Table 2. The recommended average maximum linear expansion was 0.35%. The linear expansion increases as the mixing ratio decreases.

The result of the static bending strength as measured by the Modulus of Rupture (MOR) and Modulus of Elasticity (MOE) is shown on Table 2 and both shows reduction in value as the mixing ratio decreases.

The most dimensionally stable boards were produced at mixing ratio of 2:1 and 1.75:1 with MOR values of 11.52 and 11.12 N mm^{-2} and MOE values of 1339.2 and 1094.04 N mm^{-2}. These results agreed with the findings of[8] that concluded that MOR should be greater than 11.0 N mm^{-2} and MOE should not be lesser than 1000 N mm^{-2}. The impact strength ranged from 88.9 to 127.0 mm mm^{-1} and it decreases as the mixing ratio decreases.

The production cost comparison revealed that a piece of 600 by 600 mm rice husk particle board was ₦ 145.75 while that of wood shaving particle board was ₦ 160.00. A piece of 1200 by 1200 mm of rice husk board cost ₦ 584:00 compared with ₦ 640:00 of wood shaving board and ₦ 600:00 for the conventional asbestos.

For mass production and using appropriate technology, the production cost of rice husk particle board could still be lowered.

CONCLUSION

Rice husk has been put to use in many engineering works such as in partial replacement for cement in concrete[9]. This study has reported on the possibility of using rice husk in the production of cement bonded particle board. Technically sound boards were produced with thickness swelling, water absorption and linear expansion properties of the board decreasing as the board density and mixing ratio increases.

The mechanical properties also increased as the board density increases with the test results agreeing with the findings of previous works.

The production cost of the board compared favourably with what obtained with those produced from wood shavings and conventional asbestos. Its use will not only provide an avenue for turning hitherto waste product to useful item, it will go a long way in assisting government effort at improving the material local content development in the construction industry.

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