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Testing Water Vapour Permeability of Sawdust and Banana Peels Ply Board as Non-Veneer Panel

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Abstract This experimental study aimed to measure the moisture performance of sawdust and banana peels ply board as non-veneer panel for construction projects. The goal was to measure the vapour permeability values of sawdust and banana peels ply board, compare the results with those done for oriented strand board and to investigate the efficiency of structures through these panel products. Structures made of different materials have different drying efficiencies under high relative humidity conditions that are representative of their application as non-veneer panel in cold climates

Keywords Banana Peels, Sawdust, Construction Materials, Ply Board

1. Introduction

Today, onlyone-fourth of the land surface is forested[1]. Nonetheless, with the right planning andconservation of the environment, forests, and wood, a never-ending supply of wood couldbe available in the future.

The historical records available all over the globe shows that the basic materials used in construction were either derived from the earth made from wood. Wood is one of the construction materials were being used of the civil engineer to build a house, building and bridge[2][23]. For the most part of the native origin and satisfied environmentally compatibility as well as financial constraint.

Wood has been used throughout human history. However the variety of uses ofwood today would amaze our ancestors. These developments in wood technology havebeen made possible by scientific research[3],[6]. Three growths have been improved. Plywoodand its manufacture have been made better .The plywood or ply board is a panelproduct composed of 3 or more thin layers of wood that are glued and united underhigh temperature and pressure. The grain of each layer runs at right angles to the grain ofthe layer it faces. Plywood is light, strong, stable, waterproof and very versatile[5]. Theseproperties make it the product of choice for many construction applications. It is easilycut to size and nailed. The large sheet size is convenient for roofing or flooring jobs.

Structural plywood is used extensively in residential and commercial construction and inindustry. Construction uses include light-frame structures, roof and wall sheathing, subfloors, underlayment and siding. Industrial uses include plywood for van liners, furniture,cabinetry, signs, pallets, crates and concrete forms[7],[10]. Plywood is also used in the manufactureof engineered building components such as I-beams. Decorative plywood uses hardwoodveneers to face the panels[8]. This type of plywood can be used in wall panelling andfor furniture manufacturing. The fiber by-products from sawmills and low grade logs canbe used to manufacture a range of particle-based panels and lumber products such as particleboard,wafer board, oriented-strand board and composite lumber[9].[12]. Particleboard isproduced using glue and compression to form small particles of wood into a panel. Byvarying the wood particle size, the amount of resin is used. The lamination of timbers havebeen made possible by new glues and adhesives[13]. Thermosetting resins are used in adhesives, finishes, and moldedobjects[14],[17]. Urea-formaldehyde resin'sattribute includes high tensile strength, flexural modulus and heat distortion temperature,low water absorption, mold, high surface hardness, elongation at break, and volumeresistance [15]. Urea-formaldehyde foam insulation started being used in the 1950s. In the1980s, concerns began to develop about the toxic formaldehyde vapour emitted in thecup process, as well as from the breakdown of old foam[18],[20]. Consequently, its use wasdiscontinued. Science will continue to make wood ever more useful in the future.

The manufacturer of the lumber is the oldest industry. Thus, wood technology is highly developed. Waste in forestry and wood processing is now being made into useful products[19]. The increasing demand for wood materials will probably strengthen this trend.

The use of wood and wood products continues to increase even in this age of spacecraft, computers, and unusual alloys. About two million housing units are built every year. The average one-family wood home has about 11,595 board feet

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($23m^3$) of lumber and 7510 square feet of plywood and other wood products[21].[24]. The lumber and wood products industries continue to develop and expand, partly because of more efficient forestry practices.

In recent years, there has been a great increase in the use by products of lumber production. Among the wood products that are rapidly expanding in use are particleboard and hard board[22]. These are used more and more in the production of furniture, cabinets, houses, mobile homes and interior panelling in both residential and commercial buildings.

The never ending demand of wood is inevitable and unstoppable as one of the major commodities, as long as there is an enough trees to be cut out from the forest, but this well also leads to the rapid destruction if we become so much dependable into our forest, and as well know, our forest takes a major role in the balance of our ecosystem.

In the Philippines, deforestation is so rampant and abusive compared to the forestation.The results due to the programof the government that is not well implemented and most often violated by corrupt public bribery just to approve the operation of illegal loggers[4],[23]. That's why there is a need to protect it, and one way of protecting is to conserve the use of wood, and preserve the forest by making use of waste materials coming from wood processing.

Sawdust is made available from sawmills and to thelarge-scale manufacturers of wood product. As a waste it has many uses, it can use forsoaking up oil spills. It can beused in pottery making, as firewood for cooking[26].

The researcher attempts to use sawdust and banana peels as onecomponent of a non-veneered panel for interior wall in response to the problem of thegrowing high cost of different wall materials.

2. Literature Review

"Kaatoan Bangkal" was made into a three-layer type particle board bonded with banana peel extract[4],[6].[22]. Three board densities (200, 300, and 400 kg/m^3) were produced varying their pressing conditions depending on the densities. The highest board density gave the largest values for all the mechanical properties. Dimensional stability determined particularly water absorption was also lowest compared with the lower board densities. At 400 kg/m^3 board density, the following values were obtained: modulus ofrupture= 6.65 MPa, modulus ofelasticity =1.48 x 10^3MPa, internal bond strength= 0.34 MPa, screw withdrawal = 16.4 kg, thickness swelling = 11.8% and water absorption = 68.8%[5].[27]. Analysis of variance and Duncan multiple range test showed that all the data were highly significant [22]. The use of "isocyanate" resin adhesive as a new binder in the production of particle board lowered down the compaction ratio of the board produced without sacrificing its properties and qualities[24].

Stylex Research Institute states that the particle board such as veneers which are constructed from high quality sawdust and banana peel extract is being selected for their suitability in all commercial situations[22]. All panels are made from 33mm Highly Moisture Resistant (HMR) particle board, laminated both sides with a decorative hard wearing melamine surface. The HMR core is manufactured from Australian Plantation Pine to Australian Standards 1859 for HMR grade particle board/veneers and meets the specification of the international V313 test[18],[22].

The HMR core board is sandwiched between layers of decor paper which provides the colored finish. The board is being impregnated with banana peel extract resin and dried[18]. The sandwich is then brought together in a press where the treated mixture are thermoset and polymerized under high pressure (28kg/cm^2) and at high temperature (180c) creating a hardened surface and an extremely powerful bond[19].[23].

3. Experimental Investigation

3.1. Project Design

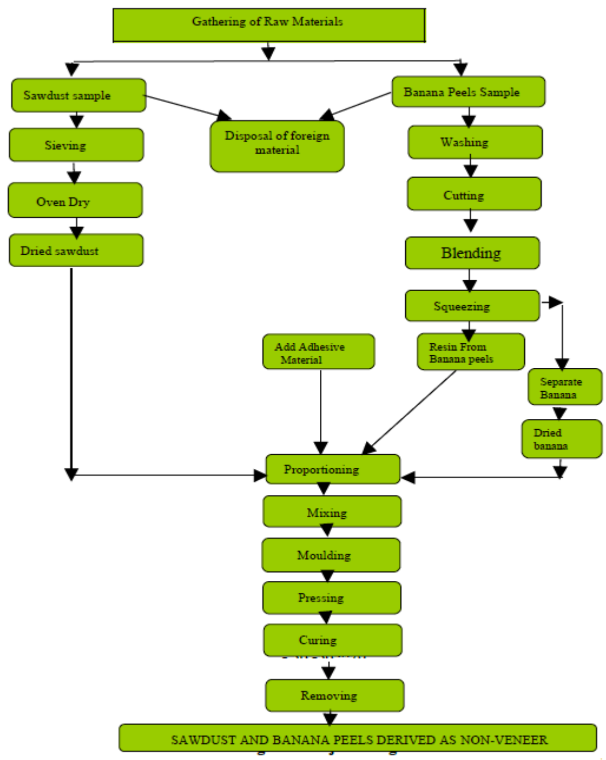

Figure 1. Project design

As shown in figure 1, research study is done by the use of sawdust and banana peel derived as non-veneer panel for interior wall. These materials undergo series of test by collecting all the materials being used and discard all the foreign materials. Separate the sawdust and sun dried, and sieve in #10. Wash the banana peels sample and discard all the unused materials. Grin until the texture as smooth as the sawdust, squeeze to separate the resin and place in an oven dry stage. Combine all the components of dried sawdust and dried banana peels with resin of banana peels as additives.

Mixed gradually, then place into the molding pan. After the process of making non-veneer and has been cured for seven days. Remove from the molding pan. The result of the product is called sawdust and banana peels derived as non-veneer

3.2. Products Used in the Experiment

Table 1 presents the sawdust and banana peels ply board products used in the experiments. Nine different products were studied: Four sawdust and banana peels ply board products and five oriented strand board products. One of both products were Philippines (code PH), the other products were Asia (code AS). All the products were meant to be used also as panel board. The dry densities of sawdust and banana peels plywood products were 497- 897 kg/m^3 and that of oriented Strand board 680.4 kg/m^3. The measured average product thickness was in the range of 9.5 mm – 16.7 mm.

Table 1. Products used in the experiments

Product Code	Thickness, (t), mm	Dry density, (ρ), kg/m^3
Sawdust & banana peels ply board PH (3 PLY)	10	520.6
Sawdust & banana peels ply board PH (5 PLY)	13.5	520.1
Sawdust & banana peels ply board PH (2 PLY)	9.8	530.4
Sawdust & banana peels ply board PH (4 PLY)	13.7	497.2
Oriented Strand board	9.5	706.5
Oriented Strand board AS	13.9	680.4
Oriented Strand board AS 2	13.4	695.5
Oriented Strand board AS	16.7	690.3
Oriented Strand board PH	12.3	678.8

3.2.1. Water Vapour Diffusivity Measurements

Water vapour transmission properties were determined by a cup method based on standard EN 12086, All nine materials were tested in four different humidity conditions at constant temperature T = 22 °C (Table 2) using five parallel samples and one 'blind cup' without salt solution in the cup.

Table 2 shows that dry and wet cup tests, one very wet (110/87% RH) and one moisture safe set of relative humidity conditions (90/69 % RH) were used. The conditions 90/69 % RH represent high, but still safe level of humidity because a humidity level of 90 % RH is considered to be the pivot value for the starting risks of fungal growth. When the temperature is lower than 15 °C, this critical level of relative humidity starts to increase[25],[26]. Typically the temperature of the ply board panel is close to outdoor air temperature, and thus the relative humidity conditions that are less than or equal to 90 % RH can be considered safe in cold and moderate climate conditions. This level can be exceeded for some periods without causing moisture risks to structures. Higher humidity levels mean also higher vapour permeability level of the panel board and better drying efficiency for the structure.

Table 2. Conditions used in the water vapour permeability tests

RH (1)	RF (2)	RH_{ave}
10	60	35
69	90	79.5
59	103	81
87	110	98.5

3.2.2. Cup Test Results

The dry cup conditions correspond to those near the inside surface of a structure during the heating period in cold and moderate climates. Under these conditions, the vapour permeability of sawdust & banana peels plyboard was about half of that of the oriented strand board products. Under high but safe humidity conditions (90/69% RH), however, the vapour permeability of the plywood products is 3 to 4 times higher than that of the oriented strand board products. In these representative drying conditions, the vapour permeability of sawdust & banana peels ply board was in the range 3.8 – 6.0 ·10^{-12} kg/(m.s Pa) while that of oriented strand board products was 1.4 - 2.6 ·10-^{12} kg/(m.s Pa) shown in table 3. The vapour resistances from wet cup tests were in same level as those measured under the so called safe conditions.

Table 3. Measured water vapour permeability values under 90%/69% RH conditions

Product Code	Minimum δp (kg/m.s.Pa)10^{-12}	Maximum δp (kg/m.s.Pa)10^{-12}	Mean δp (kg/m.s.Pa)10^{-12}
Sawdust & banana peels ply board PH	5.70	6.12	5.90
Sawdust & banana peels ply board PH	3.11	4.51	3.81
Sawdust & banana peels ply board PH 2	4.73	5.30	5.02
Sawdust & banana peels ply board AS	4.90	4.87	4.89
Oriented Strand board	2.35	2.71	2.52
Oriented Strand board PH	2.20	2.90	2.55
Oriented Strand board PH 2	1.50	3.00	2.25
Oriented Strand board PH	1.25	1.62	1.44
Oriented Strand board	2.35	2.94	2.05

3.3. Experimental Method in Drying Efficiency

A simplified test method has been developed to study the drying efficiency of structures exposed to atemperature gradient[24],[27]. In this test, the 1-dimensionalintersection of the building envelope structure is sealed in a chamber, open from above to the cold side air.

The warm side of the structure section is closed with a water vessel. This watervessel is bounded to the warm side air. The drying of the structure is based only on diffusive moisturetransport through the outer material layers and it is monitored by periodical weighing of the wholeinstallation frame of each structure section together with the initially set additional water.

3.3.1. Drying Set up

The test device consisted of 20 frames in which the different structure sections were installed. Due to the sealing of the sides and the edge insulation, the temperature and moisture flow fields were as 1-dimensional as possible. The top surface of each test structure was in contact with the controlled cold side air. The warm side temperature below the test frames was maintained constant with controlled heating of the air space shown in figure 2.

As shown in table 1, drying efficiency of all the products was studied using two parallel structure components for each product.

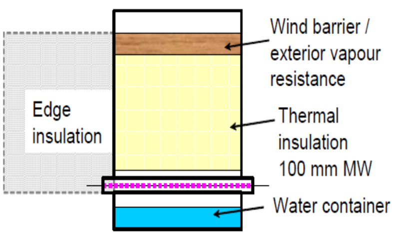

Figure 2. Test device for drying efficiency experiments

3.3.2. Test Conditions

In the experiments the warm side air temperature was maintained at +25 °C with less than 19 °C range of variation. The tests consisted of two measuring periods having different cold side air temperatures shown in table 4. The cold side temperature had about 20 °C variation from the set value. After the first period one of each parallel structure was removed to determine their moisture distribution.

Table 4. Cold side temperature in drying experiment

Cold side temperature)	Measuring period, days
21°C	55
24°C	34
24°C, 2^{nd} set	30

The other parallel structures were maintained in the tests till the end of second period.

The first cold period represented rainy conditions which caused moisture to condense and cold surface of the wind barrier. The following period with just above rainy conditions represented closeto yearly average temperature conditions in Philippines. Due to continuous moisture source, moisture flow andcondensation on the cold side of the structure the experiments represent quite extreme conditions.

4. Conclusions

The results show clearly the differences between oriented strandboards and,sawdust and banana peels ply board products. The products are not interchangeable and the climate conditions and moisture loads have to be studied to evaluate their suitability and moisture safety aspects in different applications. In additions to drying efficiency, there are other performance properties that have to be considered when applying exterior sheathing products.

The vapour permeability values and vapour resistances determined in 90/69% RH conditions represent the safe level that can be used when analyzing the performance of the ply board products under continuous conditions. These results were in the same range as those derived from wet cup tests and thus the wet cup results give a good approximation for the possible continuous vapour resistance of the exterior ply boards during drying conditions in a cold climate.

The drying experiments confirmed what was found in the vapour permeability measurements. When the exterior sheathing board is under freezing conditions, the drying efficiency was quite low both with sawdust and banana peels ply board and oriented strand board. In above freezing conditions the amount of moisture dried from the structures with ply board sheathing were about 10 times higher than that dried from the structures with oriented strand board.

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REFERENCES

[1] Cabangon, R. J., Cunningham, R. B., & Evans, P. D. (2002). Manual strand orientation as a means of improving the flexural properties of wood-wool cement boards in the Philippines. Forest products journal, 52(4), 53-59.

[2] Fu, Y., Chen, J., Guo, H., Chen, A., Cui, J., & Hu, H. (2009). The role of non-timber forest products during agroecosystem shift in Xishuangbanna, southwestern China. Forest Policy and Economics, 11(1), 18-25.

[3] Greber, B. J., & White, D. E. (1982). Technical change and

productivity growth in the lumber and wood products industry. Forest Science, 28(1), 135-147.

[4] Hearmon, R. F. S. (1948). The elasticity of wood and plywood. Special Report, 7.

[5] Hirota, H. (1972). U.S. Patent No. 3,654,044. Washington, DC: U.S. Patent and Trademark Office.

[6] Ajmal, M., Hussain Khan, A., Ahmad, S., & Ahmad, A. (1998). Role of sawdust in the removal of copper (II) from industrial wastes. Water Research, 32(10), 3085-3091.

[7] Happi Emaga, T., Andrianaivo, R. H., Wathelet, B., Tchango, J. T., & Paquot, M. (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. Food chemistry, 103(2), 590-600.

[8] Sakurai, M. (1973). U.S. Patent No. 3,758,370. Washington, DC: U.S. Patent and Trademark Office.

[9] Hudson, D. V. (1999). U.S. Patent No. 5,968,625. Washington, DC: U.S. Patent and Trademark Office.

[10] Bryan, E. L. (1961). Photoelastic evaluation of the panel shear test for plywood. ASTM STP, 289, 90-94.

[11] Takami, I. (1964). Panel and Plate Shear Test of Plywood. Mokuzai Gakkaishi, 10(0), 19.

[12] Nusselder, J. J. H., & Stijnen, H. M. C. (2006). European Patent No. EP 1681147. Munich, Germany: European Patent Office.

[13] Wentworth, I. (1982). U.S. Patent No. 4,364,984. Washington, DC: U.S. Patent and Trademark Office.

[14] Pollock, M. W., Wetula, J. J., & Ford, B. M. (1995). U.S. Patent No. 5,443,894. Washington, DC: U.S. Patent and Trademark Office.

[15] Radcliffe, S. H., Lee, T. L., & Palardy, R. D. (2000). U.S. Patent No. 6,136,408. Washington, DC: U.S. Patent and Trademark Office.

[16] Madsen, B. (2001). Behaviour of timber connections. Canadian Journal of Civil Engineering, 28(3), 546.

[17] Henson, A. B., Fridley, K. J., Pollock, D. G., & Brahler, C. J. (2002). Efficacy of interactive Internet-based education in structural timber design. JOURNAL OF ENGINEERING EDUCATION-WASHINGTON-, 91(4), 371-378.

[18] Kermani, A. (1999). Structural timber design. Blackwell Science Ltd.

[19] Nugroho, N., & Ando, N. (2000). Development of structural composite products made from bamboo I: fundamental properties of bamboo zephyr board. Journal of wood science, 46(1), 68-74.

[20] Adams, R. D., & Bacon, D. G. C. (1973). Effect of fibre orientation and laminate geometry on the dynamic properties of CFRP. Journal of Composite Materials, 7(4), 402-428.

[21] Aydin, İ. (2004). Activation of wood surfaces for glue bonds by mechanical pre-treatment and its effects on some properties of veneer surfaces and plywood panels. Applied surface science, 233(1), 268-274.

[22] Bekhta, P., Hiziroglu, S., & Shepelyuk, O. (2009). Properties of plywood manufactured from compressed veneer as building material. Materials & Design, 30(4), 947-953.

[23] MacPeak, M. D., Burkhart, L. F., & Weldon, D. (1987). Mill study of the quality yield, and mechanical properties of plywood produced from fast-grown loblolly pine. For. Prod. J.;(United States), 37(2).

[24] Okuma, M. (1967). Studies on the mechanical properties of plywood. Bull Tokyo Univ Forest, 63, 1-60.

[25] Lebow, S. T., & Winandy, J. E. (1998). The role of grade and thickness in the degradation of fire-retardant-treated plywood. Forest products journal, 48, 88-94.

[26] Hojilla-Evangelista, M. P. (2010). Adhesion properties of plywood glue containing soybean meal as an extender. Journal of the American Oil Chemists' Society, 87(9), 1047-1052.

[27] Ozacar, M., & Sengil, I. A. (2005). Adsorption of metal complex dyes from aqueous solutions by pine sawdust. Bioresource Technology, 96(7), 791-795.