Physical Sciences Research International
Vol. 2(3), pp. 49-53, September 2014
Full Length Research Paper

Mechanical and physical properties of natural fiber cement board for building partitions

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Accepted 25 August, 2014

ABSTRACT

The study includes the preparation of fiber-cement panels made from the husks of rice paper and old newspapers, which are used in the prefabricated building panels, and manufacturing of these panels using two types of polymers as materials. The flexural strength reaches 6.99 MP compared with imported panels of 3.5 MP; thus these manufactured panels are resistant to combustion. The present study used rise husk with waste of newspaper at different rate in addition to cement and polymer materials consist of poly vinyl astate (PVA) and poly ol (PO) with rate (3:1) respectively. Physical and mechanical properties were determined in this study. In this paper rice husk fibers, old newspapers and silica were used to make natural fiber cement boards for the building partition. Experimental results show that the unit weight of natural fiber cement boards are about 1408 to 1630 kg/m^3. The flexural strength of natural fiber cement boards is 70% higher than that of typical building materials and thermal conductivity with 0.217 to 0.430 Watt/m°K shows a good combustion-resistant capability.

Keywords: Rice husk, old newspaper, silica, cement, poly vinyl astate, poly ol.

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INTRODUCTION

The development of natural fiber reinforced composite-based products to substitute traditional engineering materials is becoming a trend in engineering application. Despite the inherent advantages of low cost, low density, competitive specific mechanical properties and sustainability (Coutts and Warden, 1990).

Fiber-reinforced cement-based materials have been used in many aspects of construction. Steel, polymers and cellulosic fibers are most commonly used to reinforce cement-based materials, which may range from cement paste to mortar to concrete (Mohr, 2005).

However, the replacement of asbestos with cellulosic fibers is not without its own sustainability concerns. Thus, to ensure the satisfactory performance of fiber cement materials, improved understanding of their expected long-term performance is essential (Bledzki and Gassan, 1999).

The use and processing of rice straw in the manufacture of cement-bonded fiberboard were evaluated by group of researchers (Fernandez and Taja-on, 2000).

Strength and dimensional properties of cement bonded wastepaper and sawdust composite boards were evaluated by Osuntuyi (2002). This work showed that the values of MOR ranged from 4.85 to 11.69 N/mm^2, MOE values ranged from 2800 to 5573 N/mm^2. Water absorption (WA) values range from 11.46 to 26.38% for 1 h, 18.18 to 40.49% for 24 h, and thickness swelling (TS) values ranged from 1.68 to 6.58% for 1 h, and 3.55 to 12.13% for 24 h (Osuntuyi, 2002).

Ismail (2006) worked on the compressive and tensile strength of natural fiber-reinforced cement based composites and the results showed that the tensile strength of composite increases, this increase in strength is about 53%, while the compressive strength decreases as the fiber volume fraction is increased. It has been observed that composites with roselle particle reinforcement showed more tensile strength which was followed by short fiber and long fiber reinforced composites and compressive strength of urea-formaldehyde resin matrix has been found to increase when reinforced with fiber (Ismail, 2006).

Properties of natural fiber cement boards for building partitions were prepared by Liu (2010, this search used bamboo fibers, coconut fibers, rice-husks and sugar cane-dregs, respectively. Experimental results showed that the unit weight of natural fiber cement boards are about 1430 to 1630 kg/m^3. The flexural strength of natural fiber cement boards was 80% higher than that of typical building materials, except for rice-husks cement board. The length change in the absorption test is within the range of 0.09 to 0.16%, and the thermal conductivity with 0.201 to 0.296 kcal/m°C·h shows a good heat-resistant capability (Liu, 2010).

In 2011, mechanical and physical properties of fly ash foamed concrete were studied by Khalid. Ali. M. Gelim. This research studied physical properties (work ability, water absorption, drying shrinkage and carbonation) and mechanical strengths properties (compressive, splitting tensile and flexural strengths) and determined the relationships between the various mechanical properties parameters of the fly ash foamed concrete, namely the compressive strength, flexural strength, splitting tensile strength, and mathematical equations were derived (Gelim, 2011).

In 2013, Biodegradable Composites from Rice Straw and Cornstarch Adhesives was investigated by Junjun Liu and Chuanhui Huang. Results showed that all treatments were efficient in partially changing RS surface properties, as evidenced by FTIR and improving wettability of RS. The dependence of physical-mechanical properties of obtained composites on treatments performed on RS was studied. Hot-water treated straw composites displayed the best set of final mechanical properties. The composites exhibited poor waterproof performance, but considerable moisture resistance and environment-friendly properties (Liu and Huang, 2013).

EXPERIMENTAL

Materials

Rice husks fibers, silica with volume graduate (200 µm) and old newspaper, were added to the cement board (matrix). A comparison material is the cement board without adding natural fibers inside.

NFCB consists of cementitious matrix and natural fibers including: (1) Type I Portland cement (ASTM C150); (2) poly vinyl acetate (PVA) and poly ol (3:1); and (3) water-to-cementitious matrix ratio 0.6.

To prepare rice husks, we first removed the impurities, then washed and dried for two days in the air under the sun in the last grind the rice husks with volume graduate (600 µm) (Figure 1).

Old newspapers cut into small pieces and weighed and then placed in an electric blender, mixed, the water drained from them and then weighed again and weight of the paper before shredding subtracted from the resulting value, the final output subtracted from the weight of the water that will be added to the concrete mix.

Mixture proportions

The mixture proportions of natural fiber cement board are shown in Tables 1 and 2 where the water-to-cementitious matrix ratio is 0.6 by weight, and the PVA to PO ratio is 3:1 by weight, respectively.

In order to compare the effect of natural fibers, we add 10% of PVA in volume to cement board. The total percentage for each of the husks of rice and old newspapers together was 5%, which added to the concrete mix, shown in Table 1. The total percentage for each of the silica and old newspapers together was 5%, which added to the concrete mix (Table 2).

Experimental part

Natural fibers are difficult to mix well with the cementitious material. The mixture method for NFCB is conducted as follows:

For the cement fiber boards with old newspapers and rice husks (type-1) or with old newspapers and silica (type-2):

1. Weigh the constituents as shown in Tables 1 and 2.
2. Mix the cement and the rice husks (type-1) or silica (type-2) together during two minutes at dry condition.
3. Cut the old newspapers to small pieces and weigh. Then put into electric blender, mix, then drain the water and squeeze, and weigh again and subtracted weight of the paper before shredder from the resulting value, the final output subtracted from the weight of the water that will be added to the concrete mix.
4. Mix PVA and PO together and add the water to the mixer step-by-step then add the old newspapers to the mixer with moving continual and add to the cement gradual with moving.

Each batch of materials was prepared for nine samples with the size of 50 × 50 × 50 mm for compressive test, three samples with 100 × 100 × 10 mm for the absorption test and bulk specific gravity test, six samples with 250 × 350 × 20 mm for bending test, one with 200 × 200 × 10 mm for heat-resistant capability, and one with 220 × 220 × 10 mm for fireproof capability test, respectively.

All samples were placed on the vibration table to shake one minute. The surface of cement boards was leveled to be smooth by the trowel, and then one hour later, a surcharge with 30 g/cm^2 were loaded to confine the size of NFCB. Samples were removed from the mold 24 h later, and placed indoor for curing and testing.

Bulk density and water content of NFCB in accordance

Figure 1. Preparation of rice husks.

Table 1. Mixture proportions of NFCB.

Material	Water	Cement	PVA	PO	Rice husk	Paper	Rice/paper
A1	51.3	85.5	7.125	2.375	0	5	0
A2	51.3	85.5	7.125	2.375	1.67	3.33	0.5
A3	51.3	85.5	7.125	2.375	2.5	2.5	1
A4	51.3	85.5	7.125	2.375	3.33	1.67	2

Table 2. Mixture proportions of NFCB.

Material	Water	Cement	PVA	PO	Silica	Paper	Silica/paper
B1	51.3	85.5	7.125	2.375	0	5	0
B2	51.3	85.5	7.125	2.375	1.67	3.33	0.5
B3	51.3	85.5	7.125	2.375	2.5	2.5	1
B4	51.3	85.5	7.125	2.375	3.33	1.67	2

with ASTM C1185, compression strength test (ASTM D1037) and flexural strength test (ASTM C1185), and the thermal conductivity in accordance with ASTMC518, cement boards were tested by incombustibility test claimed by ASTM E84.

RESULTS AND DISCUSSION

Bulk density and water content

We measure bulk density and water content of NFCB in accordance with ASTM C1185, and results are shown in Table 3. In Table 3, the bulk density of the comparison material is about 1860 kg/m^3. Obviously, the bulk density of natural fiber A1, A2, A3, A4, B1, B2, B3, and B4 are all lighter than that of the comparison material about 12.3, 15.05, 21.2, 23.11, 12.3, 18.17, 23.6 and 24.3%, respectively. It is anticipated to reduce the bulk density of NFCB if the fibers adding to cement board are more than 5% in volume.

In Table 3, the water absorption of all NFCB with the value from 30.1 to 40.6%, respectively, is higher than that of comparison material.

Compressive strength and flexural strength

The specimens were tested at the material age of 28 days in compression (ASTM D1037) and flexural strength test (ASTM C1185), and the experimental results are shown in Table 4. The compressive strength of natural fiber cement boards with the value 17.5 ~ 22.1 N/mm^2 is lower than that of the comparison material with 26.9 N/mm^2. This is because the intrinsic quality of natural fibers can strengthen the tensile strength but not the compression.

The compressive strength of the cement board (A1) is 22.1 N/mm^2, and is only 17.8% less with respect to the comparison material.

On the contrary, the flexural strength of natural fiber cement boards is higher than that of the comparison material, shown in Table 4. For example, the flexural strength of (A4) (6.99 N/mm^2) is almost 70% stronger

Table 3. Bulk density and water content of cement boards.

Material	Bulk density (kg/m^3)	Water content (%)
Comparison	1860	10.7
A1	1630	40.6
A2	1522	37.2
A3	1420	35.15
A4	1408	31.7
B1	1630	40.6
B2	1580	35.4
B3	1465	33.4
B4	1430	30.1

Table 4. Strength of cement boards (N/mm^2).

Material	Compressive strength	Flexural strength
Comparison	26.9	4.15
A1	22.1	4.8
A2	21.5	5.28
A3	20	6.78
A4	19.3	6.99
B1	22.1	4.8
B2	20.3	4.53
B3	19.06	5.36
B4	17.5	5.98

than the comparison material (4.15 N/mm^2).

Thermal conductivity

To be building partitions, cement boards should have heat-resistant capability. Here, we examine the heat resistant capability of cement boards by using the thermal conductivity in accordance with ASTMC518, and results are shown in Table 5. The thermal conductivity of the comparison material was measured and is 0.826 Watt/m·°C.

For natural fiber cement boards, the values of thermal conductivities is within 0.217 and 0.430 Watt/m·°C, lesser than comparison material. Therefore, NFCB have desirable heat-resistant capability.

Fireproof capability

Fireproof capability is also an important index for building partitions. Cement boards were tested by incombustibility test claimed by ASTM E84, and the results are shown in Table 6.

Fireproof capability of A1 to B4 as that of the comparison material. The materials satisfy the 2nd standard of incombustibility.

This paper attempted to make use of natural fibers collected from useless agricultural products such as the rice husk to make natural fiber cement board as the material of building partitions.

In this research, the volume fraction of natural fiber added to cement board is 5%. The mixture method of making natural fiber cement boards is also presented. Experimental results show that most of material properties for cement boards containing waste paper and rice husk are better than those of the comparison cement board (without natural fibers), including the incombustibility satisfied the national standards.

Although the bulk density of natural fiber cement boards we made is about 1408 to 1630 kg/m^3, higher than 1400 kg/m^3 claimed by the code, we can afford to add natural fibers of more than 5% volume fraction to lower the weight of natural fiber cement boards in future. It seems that we can use those two natural fibers to make the natural fiber cement board used as building partitions in the building industry.

Table 5. Thermal conductivity of cement boards.

Material	Thermal conductivity (Watt/m.°C)
Comparison	0.826
A1	0.430
A2	0.296
A3	0.266
A4	0.217
B1	0.430
B2	0.316
B3	0.334
B4	0.374

Table 6. Incombustibility of cement boards.

Material	Incombustibility rank
Comparison	2nd standard
A1	2nd standard
A2	2nd standard
A3	2nd standard
A4	2nd standard
B1	2nd standard
B2	2nd standard
B3	2nd standard
B4	2nd standard

CONCLUSIONS

1. The bulk density of the comparison material is about 1860 kg/m^3. Obviously, the bulk density of natural fiber was lighter than that of the comparison material according to ASTM C1185.

2. The compressive strength of natural fiber cement boards with the value of 17.5 to 22.1 N/mm^2 is lower than that of the comparison material with 26.9 N/mm^2 according to ASTM D1037.
3. The flexural strength of natural fiber cement boards is higher than that of the comparison material according to ASTM C1185.
4. The thermal conductivity of the comparison material was measured and is 0.826 Watt /m·°C. For natural fiber cement boards, the values of thermal conductivities is within 0.217 and 0.430 Watt/m·°C, lesser than comparison material according to ASTM C518.
5. Fireproof capability for natural fiber cement boards as that of the comparison material claimed by ASTM E84.

REFERENCES

ASTM C150 / C150M. Standard Specification for Portland Cement, 2012.

ASTM C1185 Standard Test Methods for Sampling and Testing Non-Asbestos Fiber-Cement Flat Sheet, Roofing and Siding Shingles, and Clapboards, American Society for Testing and Materials, 2008.

ASTM C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus, 2010.

ASTM D1037, Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials, 2012.

ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials, 2001.

Bledzki AK, Gassan J, 1999. Composites reinforced with cellulose based fibers. Prog Polym Sci, 24:221-274.

Coutts RSP, Warden PG, 1990. Effect of compaction on the properties of air-cured wood fiber reinforced cement. Cement Concrete Compos, 12:151-156.

Fernandez EC, Taja-on VP, 2000. The use and processing of rice straw in the manufacture of cement-bonded fiberboard. Wood–Cement Composites in The Asia–Pacific Region, Editor: P.D. Evans, Canberra, Australia, 10 December.

Gelim AMK, 2011. Mechanical and physical properties of fly ash foamed concrete. Master's Thesis, Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia (UTHM).

Ismail MA, 2006. Compressive and tensile strength of natural fiber-reinforced cement base composites. Physics Department, College of Education, Mosul University.

Liu J, Huang C, 2013. Biodegradable composites from rice straw and cornstarch adhesives. Adv J Food Sci Technol, 5(1):41-45.

Liu YW, 2010. Properties of natural fiber cement boards for building partitions. Challenges, Opportunities and Solutions in Structural Engineering and Construction – Ghafoori (ed.). Taylor & Francis Group, London.

Mohr BJ, 2005. Durability of pulp fiber-cement composites. Ph.D. Thesis, Georgia Institute of Technology.

Osuntuyi OE, 2002. Strength and dimensional properties of cement bonded wastepaper and sawdust composite boards. Master's Thesis, Wood Products Technology of the Federal University of Technology, Akure.

Citation: Shawia NB, Jabber MA, Mamouri AF, 2014. Mechanical and physical properties of natural fiber cement board for building partitions. Phys Sci Res Int, 2(3):49-53.