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Effect of Treatment on Surface Modifier and Water Retention Value (WRV) of Natural Fiber

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ABSTRACT

Recently, the growing concern for environmental sustainability, increasing global waste problem, and resource depletion has challenged engineer to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials in building construction. As agricultural waste affect of the environment, the use of these waste materials in construction will realize much benefit. In this study, rice husk (RH), corncob (CB) and coconut coir (CC) was evaluated for the manufacturing of cement-fiber brick. Different treatments were performed to modify the fibers in order to improve the dewatering behavior. A centrifugal method has been applied for the assessment of fibers water retention value (WRV). The results obtained show that linseed oil was effective to reduce the water retention value (WRV) of RH, CB and CC by 44%, 67% and 40%, respectively. Results obtained from this research can be used as a guideline for producing construction materials containing agricultural residues with improved strength and lower moisture absorption, which will be beneficial for developing low-cost architecture.

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INTRODUCTION

Agricultural residues are the main renewable resources which are produced with large quantities annually throughout the world. Agricultural waste such as bagasse, cereal straw, corn stalk, corn cob, cotton stalks, kenaf, rice husk, rice straw, sunflower hulls and stalks, banana stalks, coconut coir, bamboo, durian peel, and oil palm leaves was used as building materials included particleboard, hardboard, and fiber board (Jorge Pinto, 2012). Today, there has been interest in utilizing natural fibers in cement composites and in fabricating products. They are increasingly adopted to replace man-made fibers in building due to their advantages which are renewable and biodegradable (Özge Andiç- Çakir 2014). Furthermore, natural fibers have low density, high toughness and acceptable strength properties, plentifully available, energy-efficient, economical, and eco-friendly (Özge Andiç- Çakir, 2014).

It is well known that utilization of natural fiber in cement composites offer various advantages such as increased flexural strength, post-crack load bearing capacity, increased impact toughness, and improved bending strength (Sedan, 2008; Arsene, 2007; Tonoli, 2009). Based on literature, mechanical performance of fiber polymer concrete depends on the type of fiber, e.g., coconut and sugar cane bagasse fiber increases polymer concrete fracture toughness while banana pseudo stem fiber does not (Reis, 2006). Other researcher found that utilization of coir fiber increased the flexural toughness of cementitious composites by more than 10 times (Wang, 2006).

Plant fibers contain strongly polarized hydroxyl groups are hydrophilic in nature (Tran Huu Nam, 2011). Moisture absorption of these fibers is very high and leads to poor interfacial bonding. It is important to analyze the moisture behavior of the natural fibers. There are several approaches to characterize the natural fibers. Water retention value (WRV) is useful as a reference to evaluate the performance of fibers relative to moisture behavior (Qingzheng Cheng, 2010). The WRV is a measurement of water retained by a material after centrifuging under standard conditions. Many materials have been investigated under WRV such as cellulosic sample (Qingzheng Cheng, 2010). However, there is no standard WRV measurement method for small cellulosic materials. Several factors may influences WRV measurements include sample weights, centrifugal time and force, pore size of filters used in the measurement setup, and sizes of sample (Qingzheng Cheng, 2010).

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In this study, different treatments were applied to study the influence various treatments on the WRV and surface morphologies of the fibers.

Experimental:
Materials:
Raw materials:

The agricultural residues; rice husk (RH), corncob (CB) and coconut coir (CC) was collected from residential around.

Chemicals:

Commercial gelatin, hexamine and linseed oil, and Sodium hydroxide, sodium metasilicate, and aluminum sulphate.

Methods:

In order to improve the water resistance properties of RH, CB and CC wastes, different treatment were carried out. The prepared samples were mechanically as well as chemically treated with different organic and inorganic materials. : The raw corncob, coir, and rice husk fiber were washed 5 times with deionized water till the pH value reached 7.

Grinding and screening:

Samples were ground and screen to three different categories of sizes using light duty mixer. Sieving was carried out in order to separate the fiber according to their size. There are three categories of size which are coarse size was with fiber length less than 10mm and bigger than 6mm, the second was a medium size with fiber length less than 6mm and bigger than 2mm, and the third was a fine size with fiber length less than 2mm.

Chemical treatments with organic substances:

The wastes of CB, CC and RH were treated with a gelatin-hexamine mixture and linseed oil.

Treatment with gelatin-hexamine mixture:

Gelatin-hexamine solutions were prepared by mixing 0.5% (w/w) of gelatin with 1% (w/w) hexamine. The wastes were treating in a ratio of 20/1. Then, the wastes were dipped in 0.5:1 gelatin-hexamine mixture for 30 minutes at room temperature (28 to 30° C) followed by heating at 60° C for 30 minutes.

Treatment with linseed oil:

Linseed oil was added to the different mesh size of wastes in a ratio of 60% w/w (based on the dry weight of the raw material). Then, oil was homogenously distributed by manual stirring. Wastes was left to dry dried in air at room temperature (28 to 30°C) for 30 minutes followed by subjecting to thermal treatment at 120°C for 2 hours.

Treatment with inorganic substances:

The wastes were treated with 15 wt% (based on the dry weight of the wastes) of sodium metasilicate solutions, followed by treatments with the same concentrations of aluminum sulphate. Treatments was carried out in closed system for 10 minutes, left to dry in air, and finally the wastes was heated at 100°C for three hours.

SEM characterization:

Scanning Electron Microscope (SEM) was used to evaluate the effect of treatment on surface morphologies of the fibers.

Water retention value (WRV) measurements:

Water retention value was measured to evaluate the performance of cellulosic materials relative to moisture behavior. A European standard DIN 53 814 was utilized and applied to the assessment of water retention value. About 1.5 g of specimens from samples was accurately weight and immersed in distilled water for 2 hours at ambient temperature. After centrifuging for 20 minutes and at 3000rpm, the wet weight (Wwet) was measured and then the specimens are oven dry at approximately 103°C until they reached constant mass (dry weight, Wdry). The WRV was calculated according to the following equation:

$$WRV = [(W_{wet} – W_{dry}) / W_{wet}] \times 100\%$$

RESULTS AND DISCUSSION

Effect of treatment on the fibers surface:

SEM image of the treated and untreated fibers are shown in Figure 1. It was observed that the outer surface of untreated rice husk was highly ridged and that the ridges included peaks and valley interlay regularly (Fig. 1a). After the gelatin-hexamine treatment, the surface of rice husk is modified. The ridges included peaks were removed and the surface much smooth (Fig. 1b) due to soluble form of gelatin convert into insoluble form. This is because the reaction with formaldehyde, producing a layer around the fibers. In Fig. 1c, linseed oil forms a layer around the fibers and blocking the pores on the surface of the fiber. There are layers of sodium metasilicate-aluminum sulphate on the surfaces of the fibers in Fig. 1d. SEM images of the untreated corncobs shown in Figure 1e. It is clearly shown that there are pores on the surface of the fiber. After the treatment with gelatin-hexamine mixture, the surface structure was damage and pores were removed (Fig. 1f). The structure becomes smooth after treatment of linseed oil (Fig. 1g) meanwhile Fig. 1h shows a layers of sodium metasilicate-aluminum sulphate which is damage the original surface of corn cobs. For the untreated coir fiber, it shows cuticles on the fiber surface (Fig. 1i). The lignin on the fiber surface will be expose due to removal of the cuticle layer. After gelatin-hexamine treatment, some pits are form at the surface of the fiber (Fig. 1j). Presence of pits can be explained due to removing of globular particles. Fig. 1k shows that the globular particles cover the pits on the cell walls are embedded on the fiber surface. For the treatment of sodium metasilicate-aluminum sulphate (Fig. 1l), it shows the layer of sodium metasilicate-aluminum sulphate was form on the coir fiber surface. It can be explained because the impurities was removed on the fiber surface.

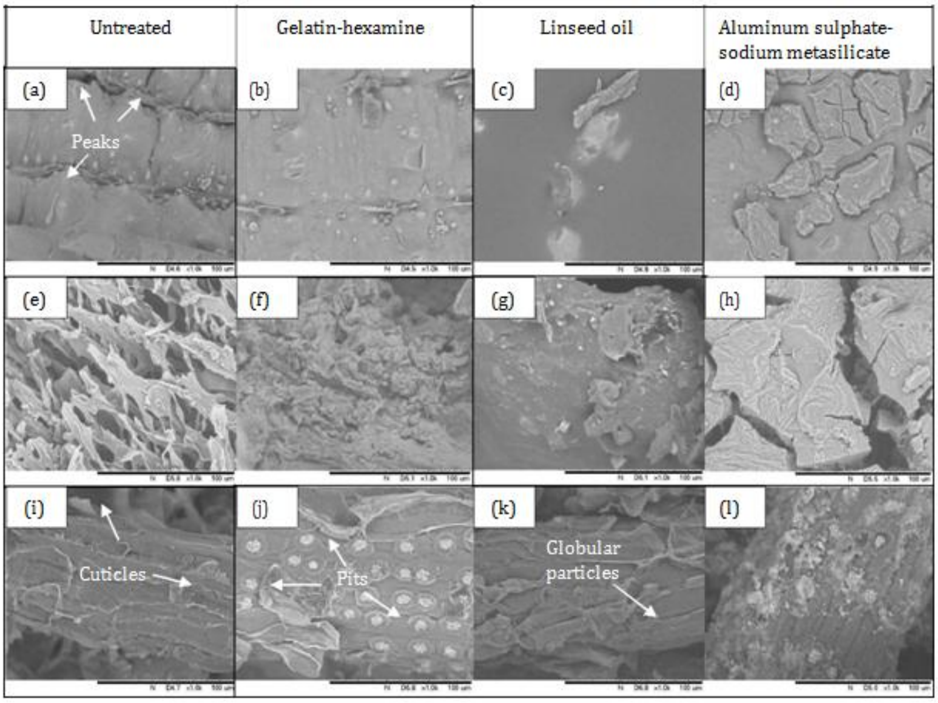

Fig. 1: SEM micrographs of fibers: (a-d) untreated rice husk fiber, gelatin-hexamine treatment, linseed oil treatment, and sodium metasilicate-aluminum sulphate treatment respectively, (e-h) untreated corncob fiber, gelatin-hexamine treatment, linseed oil treatment, and sodium metasilicate-aluminum sulphate treatment respectively, (i-l) untreated coconut coir fiber, gelatin-hexamine treatment, linseed oil treatment, and sodium metasilicate-aluminum sulphate treatment respectively.

Effect of treatment on water retention value (WRV):

Table 1 shows the WRV of the mechanical treated fibers. It shows that there are only slight difference in WRV between coarse size, medium size, and fine size. Meanwhile, there are significant differences noticed for whole fibers. Rice husk shows the lowest WRV compare to others fibers, whereas the WRV reduced from 58 to 25%. However, corncob showed a significant reduction of 46%. All the coarse, medium and fine size were used for further studies.

Table 1: Water Retention Value Percentages (WRV) of Different Mesh Sizes of RH, CB, and CC

Agricultural wastes type		Water Retention Value (%)			
	Coarse	Medium	Fine	Whole fibers	
Rice husk	25	26	27	58	
Corncob	45	49	57	91	
Coconut coir	58	59	62	83	

In comparison between mechanical and chemical treatment, Figure 2 shows that chemical treatments were much effective in reducing WRV than mechanical treatments. The result obtained show that linseed oil was effective to reduce the water retention value (WRV) of fibers. There are significant differences in WRV after treatment with linseed oil. The WRV reduced from 58% to 14% for RH, 91% to 24% for CB and 83% to 43% for CC. Linseed oil were effective to reduce the WRV due to fact that linseed oil forms a layer around the fibers, blocking its pores, which is it can reduces the amount of water absorbed. RH shows the lowest WRV compare to CC and CB. For further studies, untreated and treated fibers will be used to study the properties of the final fabrication of the bricks.

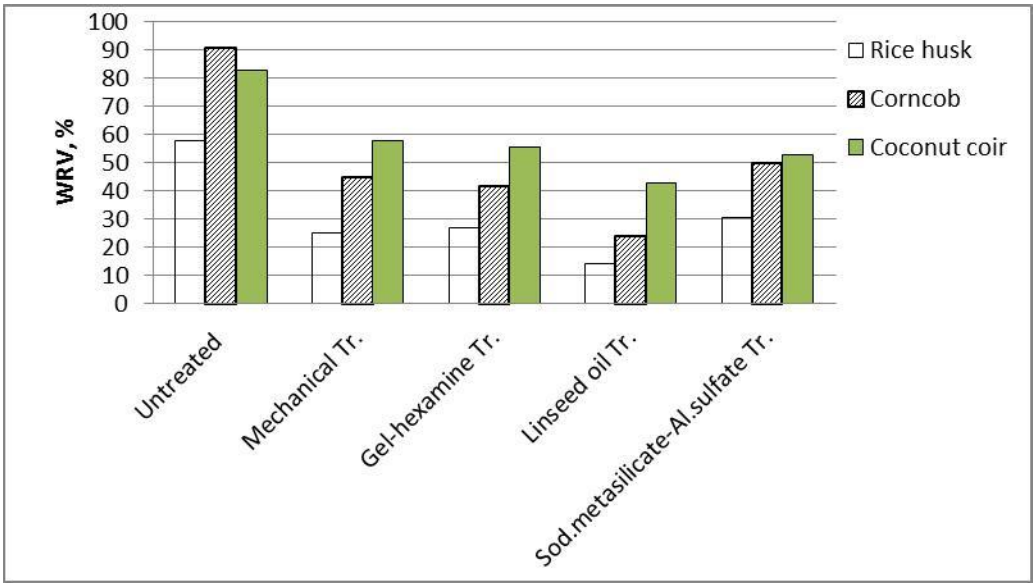

Fig. 2: Comparison between the WRV % of untreated and treated fibers.

Conclusion:

This paper has discussed the effect of treatment on surface modifier and water retention value (WRV) of rice husk (RH), corncob (CB), and coconut coir (CC). It is observed that each treatment has an effect on the surfaces of the fibers. Result obtained by mechanical treatment has no significant differences in WRV between coarse size, medium size, and fine size. After the chemical treatment, there are minor effects on WRV of the fibers. It is shown that linseed oil is much effective to reduce the WRV. Rice husk (RH) shows the lowest WRV compare to other wastes.

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