Influence of Adhesive on Physical, Mechanical, and Thermal Properties of Corrugated Fibers Composite Roofing from Bagasse Fiber in Sugar Industry

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Abstract: The purpose of this research is to study the properties of the corrugated fibers composites roofing from sugarcane bagasse fibers in the sugar industry. The adhesive substance is phenol formaldehyde. The density standard of the corrugated roofing 400, 600, and 800 kg/m^3 were investigated. The physical, mechanical, and thermal properties were performed according to industry standards. The physical properties results reveal the high density had low moisture content, low water absorption, and low thickness swelling, as the mechanical properties and thermal properties. The phenol formaldehyde adhesive is optimal with the corrugated roofing 900 kg/m^3 obtained the highest mechanical, and trend to alternative material for roofing tiles.

Keywords: *sugarcane fibers; bagasse; roofing sheet*

1. Introduction

Natural fiber is commonly categories rely on its genesis which divided into three categories composed of plant, animal, and mineral. Cellulose is the major comprise of plants, protein is the major of animals, and asbestos mainly consists of mineral. In addition, plant fibers are suitable for cultivation in many countries[1]. Thailand is one agricultural country, oil palm, corn, bean, and sugarcane are famous an agriculture productivity. The large number of residues wastes after processing. focus on efficiency with the high application of residue wastes reduces the environmental impact and economic. The extremely agriculture wastes contain three main sort of organic chemical components, including cellulose, hemi cellulose, and lignin cellulose in 4:3:2 ratio[2].

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The studied of natural fibers can be improved in any product and tests. The sugarcane bagasse particle board was an execute, and the results found no change in thickness swelling and dimensional [3]. The studied of mechanical behavior of sugarcane bagasse-aloevera as hybrid natural fiber composite[4]. The properties of natural roofing from agriculture residues were studied by mechanical and physical test[5]. Roofing sheet were developed by groundnut shell as the major material mix with epoxy resin as the composite material[6]. The strength of corrugated roofing made from coconut coir were studied[7].

In this title, the researchers were attempted to develop the corrugated fiber composite roofing from the sugarcane bagasse combination with phenol formaldehyde adhesive, which the most thermoset binder utilizing in fiber board industry and test within roofing standard.

2. Material and Methodology

The corrugated fiber composite roofing was made out of bagasse residue from the sugar industry in Kanjanaburi Province, Thailand. To form the corrugated bagasse fiber composite roofing, bagasse residue fiber was cleaned up with water, soaked in sodium hydroxide (NaOH) for 24 hours, and rinsed with water after soaking. Then they were dried, cut, and chopped to an average particle size of about 5 mm. The moisture content was checked and controlled to be less than 12%. Bagasse fibers were weighed according to density ratios of 400, 600, and 800 kg/m^3 (384, 576, and 768 g, respectively). In the forming process, blended 7 wt% phenol formaldehyde and two additives containing 2 wt% ammonium chloride (NH4Cl) and 1 wt% paraffin emulsion were added and sprayed to distribute evenly on the prepared bagasse fibers. Preform the bagasse fiberboard and use the hot process to manufacture the corrugated bagasse fiber composite roofing with a 400mm width, 400mm length, and 6mm thickness with a 150 kg/m^3 bulk density at 120 ^oC for 15 minutes after preform. The densities of bagasse fiber composite roofing were 400, 600, and 800 kg/m^3, respectively. The corrugated fiber roofing was preserved at room temperature for any tests. The production process for bagasse fiber composite roofing is presented in Fig. 1.

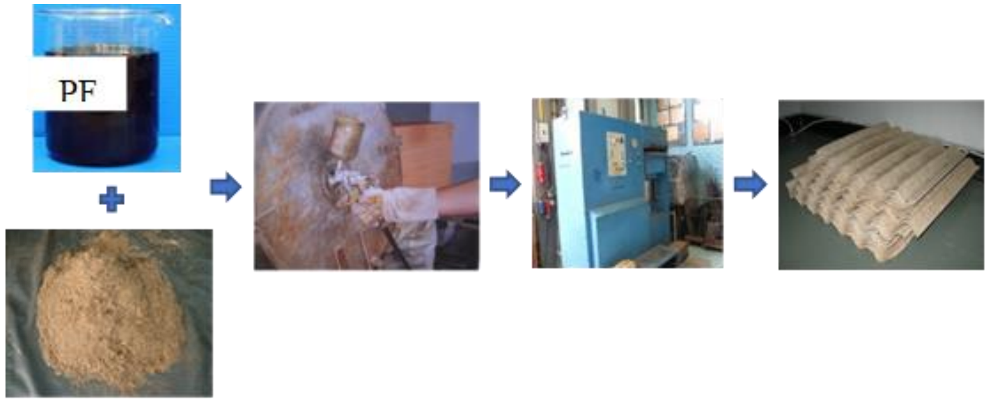

Figure 1 The bagasse fiber composite roofing production process

An investigation of the mechanical, physical, and thermal properties was evaluated in five replicates of specimens according to JIS A 5908-2003, TIS 535-2556, TSI 876-2547, ASTM C177-2010, and ASTM D 256-2006a.

Table 1 Physical, mechanical, and thermal properties test

Physical properties	Mechanical Properties	Thermal Properties
Densities	Modulus of Elasticity	Thermal Conductivity
Moisture Contents	Modulus of Rupture	Thermal Resistance
Thickness swelling	Impact Strength	
Water Absorption at 2 and 24 h		

3. Results

This title focuses on the influence of 7 wt% phenol formaldehyde adhesive in bagasse residue corrugated roofing. The results of the test are divided into three categories reports are composed of physical properties, mechanical properties, and thermal properties following the table 1 within the density standards of 400, 600, and 800 kg/m^3, respectively.

3.1 The results of physical properties

Densities

The densities of the corrugated bagasse residue fiber roofing were tested following 400, 600, and 800 kg/m^3 standards which reveal 409.94, 623.85, and 819.87 kg/m^3, respectively.

Moisture Contents

The results of moisture contents of densities 400, 600, and 800 kg/m^3 disclosed 12.14%, 10.52%, and 9.82%, respectively.

At 2 h and 24 h water absorption

The average of water absorption at 2 h and 24 h of densities were tested; the results reported were 22.38%, 16.24%, and 12.52% at 2 h, respectively. While the 24 h absorption results indicated 39.01%, 21.89%, and 12.73%, respectively.

At 2 h and 24 h thickness swelling

For the corrugated roofing densities of 400, 600, and 800 kg/m^3. The thickness swelling at 2 h presented 9.28%, 8.34%, and 6.67%, respectively. After the next 24 hours, they were 9.65%, 8.58%, and 7.50%, respectively.

3.2 The results of mechanical properties

Modulus of elasticity and modulus of rupture

The densities standard of the corrugated roofing were 400, 600, and 800 kg/m^3, and the average modulus of elasticity expose was 1,584, 2,294, and 2,336 MPa, respectively. For modulus of rupture reveal 7.52, 12.65, and 17.19, respectively.

Impact strength

The measure of tensile strength indicates that the highest roofing density allows the highest impact strength. The results disclose 0.63,1.31, and 2.04 J/m, respectively of the density standard 400, 600, and 800 kg/m^3.

3.3 The results of thermal properties

Thermal conductivity and thermal resistance

The sugarcane bagasse using to produce the corrugated fiber composite roofing combination with 7 wt% phenol formaldehyde according to the densities of 400, 600, and 800 kg/m^3. The average thermal conductivity were 0.123, 0.134, and 0.162 W/m.k, respectively. The moderate thermal resistance were 0.332, 0.332, and 0.335 m2.k/w, respectively.

4. Conclusion

The physical, mechanical, and thermal properties of the corrugated fibers composite roofing were investigated. The corrugated were manufactured by sugarcane bagasse blend with phenol formaldehyde adhesive by weight. The results demonstrate the density of 900 kg/m^3 have an excellent regulation. The tests of the moisture content, at 2 and 24 h water absorption, at 2 and 24 h thickness swelling, modulus of elasticity, modulus of rupture, and impact strength have emerged which permit the standard specification. In addition, the density of 900 kg/m^3 are appropriate criteria. The sugarcane bagasse fibers have an ultimate thermal conductivity and thermal resistance, an phenol formaldehyde adhesive were placed in the vacancy of sugarcane bagasse fibers take receipt of enlarge the thermal conductivity.

5. References

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