International Journal of Advanced Culture Technology Vol.3 No.1 86-89 (2015)
http://dx.doi.org/10.17703/IJACT.2015.3.1.86

IJACT 15-1-11

Mechanical and Physical Properties of Roof Tile Prepared from Sugar Cane Fiber

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Abstract

Sugar cane, renewable fiber resources, were used for roof tile production. Urea formaldehyde, phenol formaldehyde and isocyanate resin were used as binders in this study. Roof tile specimens with 400 mm wide, 400 mm long and 5 mm thick were prepared by compression molding. Physical and mechanical properties of the specimens were analyzed by water absorption ,thickness swelling, thermal conductivity, density, modulus of rupture and modulus of elasticity. From the results, water absorption at 1 and 24 hours was 19-47 % and 38-57 %, respectively. Thickness swell at 24 hours was 15-29%. Thermal conductivity was 0.016, 0.017 and 0.019 W/m.K when using isocyanate, urea formaldehyde and phenol formaldehyde, respectively. Density of the specimens was 770-860 kg/m3. Modulus of rapture was 255-280 MPa. Modulus of elasticity was 5.1-7.6 GPa. Physical and mechanical properties of the specimens indicated that they would be applied for roof tile and construction.

Keywords*: sugar cane, roof tile , phenol formaldehyde, water absorption, thermal conductivity*

1. INTRODUCTION

Natural fibers are light weight, biodegradability and high value of specific strength. Natural fibers are valuable for applied in various applications such as reinforced polymer composites in automotive and building construction. Bagasse and maize husk fibers are from agricultural wastes. They are natural resources and promising for developed to useful products. In this study, bagasse fibers and maize husk fibers were made as roof tiles using various kinds of binders. Physical properties, mechanical performance and thermal properties of roof tiles from bagasse and maize husk fiber were investigated in order to apply as thermal insulation and other applications.

Manuscript Received: Mar. 5, 2015 / Revised: Apr. 10, 2015 / Accepted: May 6, 2015
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2. Experimental

2.1 Materials

Bagasse and maize husk fiber were used with ratio of 50/50 wt%. Three kinds of binders were 10% of urea formaldehyde (UF), 13% phenol formaldehyde, (PF) and 7% polymeric isocyanate (PMDI).

2.2 Sample Preparation

Fibers were cut, grinded, washed and dried. The fibers were measured average pH and acid buffering capacity. After that the fibers were mixed with each binder and hardener then subjected to compression molded in a 100 tons hot press machine. The size of the sample was 400 mm wide, 400 mm long and 5 mm thick.

2.3 Characterization

The samples were carried out on physical and mechanical testing including, density, moisture content, water absorption, modulus of rapture and elasticity, impact strength and thermal conductivity. All test methods were done according to TISI 876-2547, TISI 535-2540 and JIS A 5908-2003.

3. Results and Discussion

Table 1 summarizes physical properties of roof tiles made from bagasse and maize husk with various binders. From the results, density and moisture content of the roof tile using PMDI binder are the highest values as compared to another. Density and moisture content of roof tiles could be considered to the compaction of fibers and the binders as well as volume of void.

Table 1. Density and moisture content of roof tiles with various binders.

Binders	Density (kg/m^3)	Moisture content (%)
UF	600.96	2.07
PF	664.14	3.87
PMDI	800.40	4.08

Figure 1 shows thickness swelling of roof tiles with various binders after immersed in water for 1 and 24 hours. It can be seen that roof tiles using PMDI as a binder exhibited the lowest thickness swelling after immersion for 1 hour. It might be due to good compaction between fibers and PMDI binder. However, the thickness swell of PMDI binder roof tile were higher than roof tile from UF binder after immersion for 24 hours. The highest values of thickness swelling for 1 and 24 hours were found in roof tile using PF as a binder. It could be indicated that bagasse and maize husk fibers were not good compaction with PF binder. The order of binders for lower of thickness swell in these roof tiles was UF, PMDI and PF, respectively.

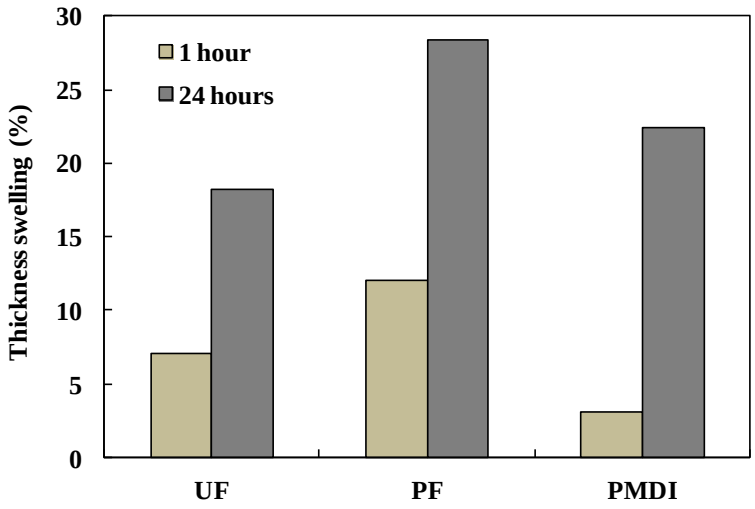

Figure 1. Thickness swelling of roof tiles with various binders for 1 and 24 hours.

Mechanical properties of roof tiles with various binders are presented in Table 2. Modulus of rupture (MOR) of the roof tiles using PMDI binder showed the highest values, followed by PF binder and UF binder. MOR of the roof tiles was influenced by networking of binder and fibers in the roof tiles as well as void volume. UF binders and the fibers were good compaction and good in networking inside the roof tile, which aided stress distribution and good transferred stress after received the loading.

Table 2. Mechanical properties of roof tiles with various binders.

Binders	MOR (MPa)	MOE (GPa)	Impact strength (J)
UF	222.75	68.80	1.93
PF	249.87	44.52	0.55
PMDI	270.27	59.39	0.64

Table 3 tabulates thermal conductivity and thermal resistance of roof tiles with various binders. Thermal conductivity and thermal resistance values of roof tiles using UF and PF were almost similar while thermal conductivity and thermal resistance of roof tile using PMDI were the lowest. These thermal properties were depended on materials density and the thickness of insulations. The roof tile with PMDI binder was good in thermal insulation while it was poor in thermal resistance. Therefore, it was good heat transferred from inside and outside temperature. However, it could not protect heat from outside the building construction.

Table 3. Thermal properties of roof tiles with various binders.

Binders	Thermal conductivity (W/m K)	Thermal resistance (m^2 K/W)
UF	0.013	0.345
PF	0.015	0.348
PMDI	0.012	0.289

4. Conclusions

Roof tiles from bagasse and maize husk fibers were successfully prepared. Three kinds of binders exhibited the difference in physical, mechanical and thermal properties of the roof tiles. The roof tiles using PMDI binder showed the highest values in density and modulus of rupture and the lowest values of thermal conductivity and thermal resistance. Therefore, roof tiles from bagasse and maize husk fibers would apply as thermal insulation and building construction materials.

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