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DETERMINATION OF THE WATER RESISTANCE OF THE WOOD-TEXTILE REINFORCED COMPOSITES

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Abstract:

The research of investigating the water resistance of the new proposed composites containing bio-degradable materials in their structure have shown that their use as thermal barriers for building purpose is recommended especially for indoor space. Whilst these composites incorporate in their structure wastes (wood chips and fibers, wool fibres) which gives them the ecological characteristics of green products, their thermal insulating properties are very good compared with other ones. The authors present in this paper six new structures of wood-textile reinforced composites and the investigation upon their water resistance, in order to recommend them for indoor or outdoor use. The fillers used for the six composites are different: clay, ceramic dust, gypsum, cement and acrylic polymers. As the moisture absorption and the thickness swelling are the major drawbacks of the composites used as building materials, the six structures of composites have been immersed in water for a short-time period (4 hours), revealing thus the water absorption and the thickness swelling results. The best results were registered for the structure C8, having the cement as a binder material. Despite the fact that the water absorption rate was higher in case of composites having in their structure acrylic polymers as binding materials, the thickness swelling of these ones proved to be moderate. Unsatisfactory results have been obtained for the structure having clay as filler.

Key words: *composites; thickness swelling; water absorption; mass.*

INTRODUCTION

The actual trend in materials designing is to create composite materials by recycling the wood wastes (Adhikary *et al*. 2008), plastic wastes, polyethylene waste, paper waste (Cerbu *et al*. 2009) and others. Most of the new composite materials are tested to the moisture absorption and thickness swelling, because the moisture absorption and dimensional distortion are the major drawbacks of the wood based composites used as building material (Qingfeng *et al*. 2010). For example, (Adhikary *et al*. 2007) has analyzed the long-term moisture absorption and thickness swelling in case of some specimens made of recycled thermoplastics reinforced with pine wood flour. The procedure of the quantitative assessment of the water absorption is the immersion testing method. The procedures for the water absorption for immersed specimens are subdivided into short-term (2 hours and 24 hours) immersion and long-term immersion. The short-term procedure is recommended for samples having a relatively high rate of water absorption (Klyosov 2007).

The present paper investigates the behavior of new materials made of wood chips and textile (wool) fibers as reinforced materials filled with various binders (cement, ceramic dust, clay or acrylic polymers), when immersed into the water. Their resistance to water was investigated by the short-term immersion, due to the fact that they incorporate in their structure materials with a high rate of water absorption: wool fibers and wood chips.

The proposed structures tested to the water resistance were previous investigated from the thermal insulating properties point of view and recommended to be used in the building purpose as ecological structures for thermal insulation of building walls (Cosereanu *et al*. 2010).

OBJECTIVES

This paper intends to present the investigations of the water absorption and of the thickness swelling on six structures of wood-textile reinforced composites having various types of binders as filling materials. The studied composites are new structures proposed to be used for the thermal insulating of the buildings walls. The investigations were performed due to the fact that the moisture absorption and the dimensional distortion are the major drawbacks of the wood based composites used as building materials. The results will show if the mentioned structures are water resistant in order to be used for exterior walls of the buildings, or recommended for the interior structures of the buildings.

METHOD, MATERIALS AND EQUIPMENT

The materials proposed in the present paper as reinforced materials in order to form the composites subjected to immersion testing are presented in Fig. 1. They are wood chips and fibres and wool waste fibres.

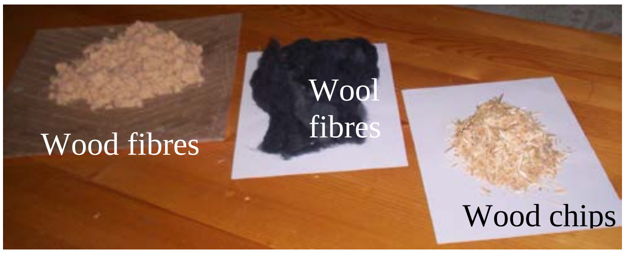

Fig. 1
Bio-degradable materials used as reinforced materials for the composites.

The six new structures were symbolized as shown in Table 1. The components are also presented for each structure and the physical characteristics related to the property of thermal insulating are also present.

Table 1

The structure and characteristics of the studied composites

Symbol	Components	Density, in kg/m^3	Thermal conductivity coefficient
L4	Wood chips, wool fibers, clay and water	435.27	0.0799
A11	Wood chips, wood fibers, wool fibers, acrylic lacquer	174.98	0.0504
G11	Wood chips, wool fibers, gypsum and water	654.85	0.0930
PC2	Wood chips, wood fibers, wool fibers, ceramic dust and water	622.33	0.1085
Lb2	Wood chips, wool fibers, acrylic polymer and water	190.67	0.0700
C8	Wood chips, cement and water	698.19	0.0748

As can be seen in Table 1, the structures have various binder components and good results of the thermal conductivity coefficient, despite the fact that the density ranges from small values (up to 100kg/m^3) to high values (up to 600kg/m^3).

The multitude of the panels obtained by mixing the reinforced materials and the binders are shown in Fig. 2). From all these structures, those with the best structure and the best thermal insulating properties were chosen. Some of the studied structures had a more fragile compactness and they were L4 and A11, for which bad results are expected to the immersion testing.

Fig. 2
Wood-textile reinforced materials designed for thermal insulating of the building walls.

The testing specimens were cut from each type of composite, having the dimensions of 50x50mm (Fig. 3). The specimens were first conditioned at (20±2)°C and (65±5)% relative air humidity. The thicknesses of the specimens were initially measured in point "O" (Fig. 4) and then the specimens were weighed.

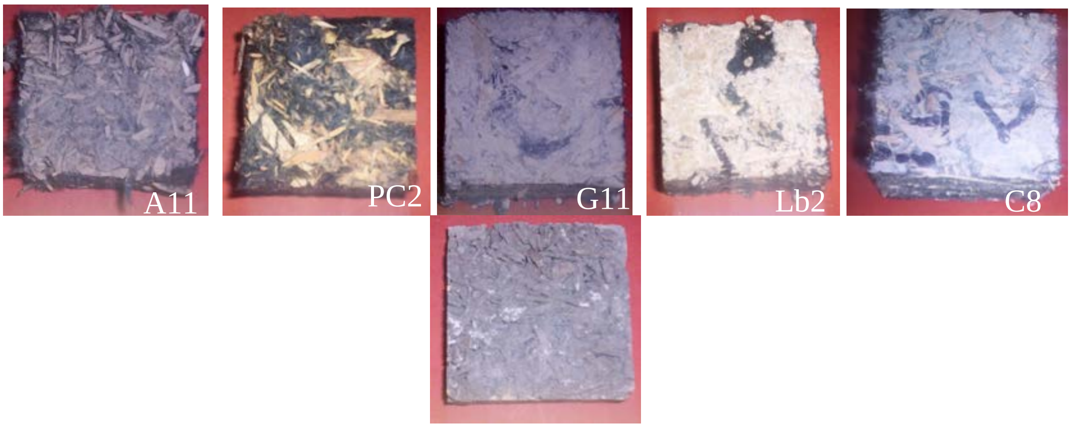

Fig. 3
The samples subjected to the immersion testing.

The accuracy of the measurement in case of thickness was of 0.01mm. The micrometer with an accuracy of 0.01mm was used for the thickness measurement in point "O".

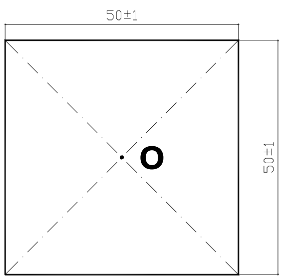

Fig. 4
Sample sizes and the point "O" of measuring the thickness swelling (SR EN 317).

The samples were immersed in distilled water having a temperature of 20°C and this temperature was maintained constant during the test. In order to avoid the contact between the samples and the bottom of the jar, a sieve was placed under them. In order to dip the specimens into the water and keep the distance of

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minimum 25mm between their upper part and the water surface, a stopper was placed on each dipped specimen (Fig. 5). Measurements of the thicknesses and weighing of the samples were performed after 1hour, 2 hours, 3hours, and 4hours, in point "O" marked on them.

The water absorption according to ASTM D1037 was calculated with the following equation.

$$\mathbf{A} = \frac{\mathbf{m_2 - m_1}}{\mathbf{m_1}} \cdot \mathbf{100} \quad , \% \qquad (1)$$

Another indicator of the samples subjected to the immersion in water is the thickness swelling, which is expressed as a percentage of the original thickness, according to SR EN 317, as in the equation 2.

$$\mathbf{G_t} = \frac{\mathbf{t_2 - t_1}}{\mathbf{t_1}} \cdot \mathbf{100} \quad , \% \qquad (2)$$

Fig. 5
The immersion testing of the composites.

RESULTS

As seen in the diagram in Fig. 6, the lowest water absorption belongs to structure C8 (around 25%), which has in its structure cement as binding material. Structures G11 and PC2 have similar trends (approx. 70% water absorption). The structures having acrylic polymers as binding materials have the lower water resistance. The dynamic of water absorption is similar for the structures C8, G11, PC2 and Lb2 (expressed by parallel lines in the diagram), but the water absorption for structure A11 is more dynamic. As regards structure L4, it has disintegrated after 1 hour of immersion in water, and it looked like in the picture from Fig. 8.

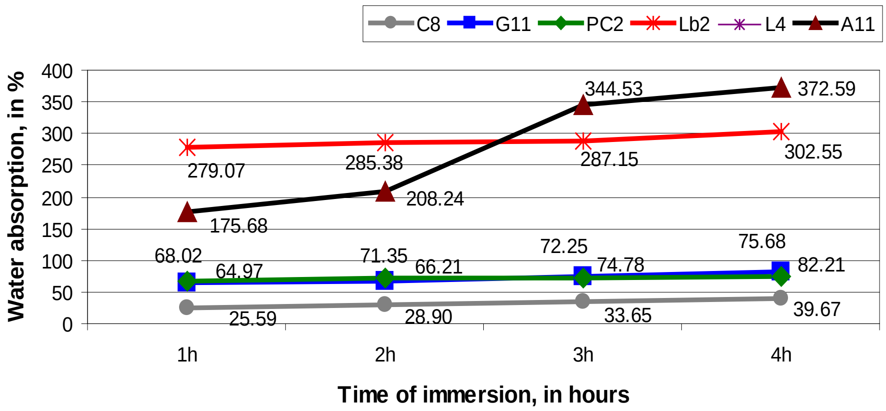

Fig. 6
The water absorption for the tested samples.

Whilst the dynamic of water absorption was moderate for structures G11 and PC2, the thickness swelling had the lowest values after 1 hour of immersion until 2 hours of immersion in water, but was very dynamic after 2 hours of immersion in water (especially for structure PC2) and remains constant after 3 hours of immersion (Fig. 7). Despite the fact that the water absorption rate was very high for structure A11, the thickness distortion is moderate compared with the other structures (approx. 2.8%) and the dynamic is almost constant. A similar behavior had structure Lb2, but the thickness swelling was higher than in the previous case (approx. 4.6%). The best results were registered in this case for structure C8, where the thickness swelling had the lowest rate (0.92% after 4 hours of immersion in water).

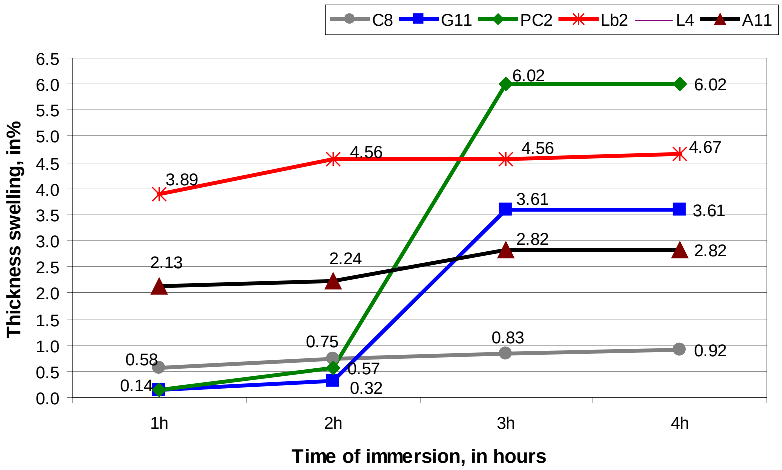

Fig. 7
The thickness swelling for tested samples.

As regards the structures of the studied composites, after 24 hours of immersion into the water (Fig. 8), the single one that suffered damages remained the structure L4, which was destroyed after 1 hour of immersion testing. The rest of the structures have kept the cohesion properties of the components, as seen in Fig. 8. The binding properties of the fillers remained in force also after 3 days of immersion into the water.

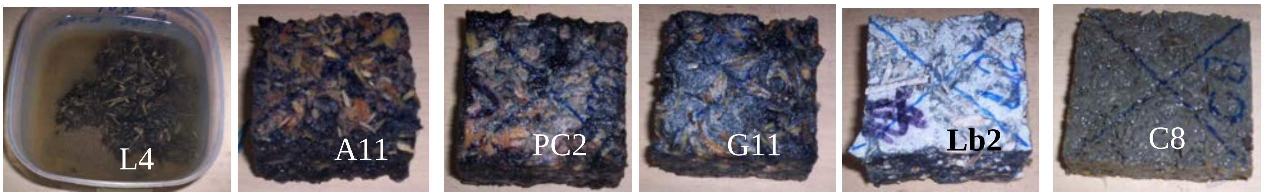

Fig. 8
The specimens structure after 24 hours of immersion testing.

CONCLUSIONS

The conclusions of this study demonstrate that the use of the reinforced textile-wood composites as thermal insulating materials for building purpose in outdoor conditions is sensitive for fillers as clay, gypsum, ceramic dust and even acrylic polymers. They proved to maintain their structure cohesion after the immersion testing (except the composites with clay), but the water absorption is quiet high for almost all structures (except the composites with cement binder). Despite the fact that the water absorption rate was higher in case of the composites having in their structure acrylic polymers binders (over 300% after 4 hours of immersion testing), the thickness swelling of these ones proved to be moderate and almost constant, just from the beginning (after 1 hour of immersion into the water). The behaviour of the structures containing ceramic dust (PC2) and gypsum (G11) proved to be quiet interesting. In the first two hours of immersion into the water, their thickness swelling had the lowest values, even compared with the structure of cement binder composites (0,14 - 0.57%). But after two hours of immersion into the water, the thickness swelling percentage has dramatically increased (till 3.61% for structure G11 and up to 6% for structure PC2), even if the water absorption of these structures have maintained almost a constant trajectory during the 4 hours of immersion into the water (at a percentage of 60-80%). Unsatisfactory results have been obtained for the structure having clay as filler. The structure damaged after 1 hour of immersion testing and the measurements couldn't be done on this structure. Taking all these into consideration, the authors consider that future research on possibilities to protect the outer face of these structures in outdoor conditions are to be done (except the clay binder ones) and on studies of rheology upon these materials, in order to conclude if they return to their initial state. Until then, the recommendation goes to their use in indoor conditions (except those structures that use cement as binder material).

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