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THE NEW THERMAL INSULATION MATERIAL BASED ON THE MISCANTHUS X GIGANTEUS AND FLY ASH

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Abstract

These investigations were carried out to study the fly ash utilization in manufacturing the thermal insulation based on the Miscanthus x Giganteus fibres. This is a brand new cost-effective, ecological and energy-efficient material. In order to increase energy efficiency and resource saving, the lime and fly ash were used instead of cement binder. Two different mixtures were made, one with lime and one with lime and fly ash. The mixture with lime and fly ash showed the higher values of compressive and bending strength. It can be concluded that the addition of fly ash contributes to the mechanical properties of this new material.

***Keywords**: fly ash, pozzolanic properties, eco-friendly, mechanical properties*

1 INTRODUCTION

The construction sector is characterized by many environmental problems, including: exploiting of the non-renewable resources, land use, energy consumption, etc. [1]. Therefore, the important segments of sustainable development are incorporated in this sector, involving the use of resource-saving, eco-friendly and energy efficient construction materials.

This study deals with application of an innovative insulation material, based on theecoremediation plant *Miscanthus x Giganteus* fibres which are generally considered as the cost-effective and resource saving. These attributes are connected to the *Miscanthus x Giganteus* fibres since it deals with waste plant fibres, remaining after remediation. In addition, the introduced principle is emphasized by the use of fly ash, as the waste material, generated during combustion of fossil fuels, i.e. coal.

The fly ash can be defined, according to the standard SRPS EN 450-1 [2], as a fine powder of amorphous particles (usually 1-150 μm), obtained by the coal combustion. It represents a by-product of the thermal power plants, and is found to be an artificial pozzolanic material (material with the latent binding properties). The fly ash is, as a waste, deposited in the landfills that are typically located near the thermal power plants. Every four tons of burnt coal lead to the production of one ton of fly ash making disposal of this by-product a global concern [3]. The properties of fly ash primarily depend on the combusted coal characteristics.

2 EXPERIMENTAL

Fly ash from the thermal power plant Nikola Tesla B was used for the experimental study presented in this paper,

Chemical composition of the used fly ash is given in Table 1, with the maximal allowed compounds quantities prescribed by the standard SRPS EN 450-1:2014 [2]. Chemical analysis was performed by the XRF method in the Institute for Material Testing – IMS, Belgrade.

The basic chemical requirement for the use of fly ash as an addition to the Portland cement concrete, according to the ASTM C618 standard [4] is that the sum of silicon dioxide, aluminum oxide and iron(III) oxide must be minimum 70% for class F or 50% for the class C.

Table 1 *Chemical composition of the used fly ash*

Compounds	Quantity [%]	Allowed quantity [%]
SiO_2	64.14	-
Al_2O_3	19.22	-
Fe_2O_3	4.35	-
TiO_2	0.16	-
CaO	8.32	-
MgO	0.01	4
Na_2O	0.36	5
K_2O	0.66	-
P_2O_5	0.17	5
SO_3	0.86	3
MnO	0.03	-

Table 1 shows that the sum of silicon dioxide, aluminum oxide and iron(III) oxide is greater than 70%, as well as the all other conditions prescribed by the SRPS EN 450-1:2014, so it can be concluded that the used fly ash completely fulfills the all requirements prescribed by both standards.

The two composite insulation material mixtures (marked L and L/FA), with composition shown in Table 2, were prepared. The waste *Miscanthus x Giganteus* chopped fibers, mineral binders, and sufficient quantity of water providing satisfactory workability were used for the production of these mixtures.

Table 2 *Mixture composition (mass ratio)*

Mixture	$m_{Misc.}$ [g]	m_{Lime} [g]	$m_{Fly\ ash}$ [g]	$m_{Water.}$ [g]
L	300	500	-	300
L/FA	300	500	180	300

The investigation of mechanical properties by determination the compressive and bending strength was carried out after drying of samples during 28 days.

Compressive strength was tested in a duplicate on 100 mm cubic samples, and in a triplicate on the prismatic samples (40x40x160 mm). Prior to the compressive strength test, the prismatic samples were used for a three-point bending strength test, with a span of 10.67 cm. All results were presented as the mean values [5]. The mean values of the laboratory measured thermal conductivity of similar series of this material were in the range 0.08 – 0.10 W/(m·K) [6].

3 RESULTS AND DISCUSSION

The values of compressive strength of the investigated mixtures showed the significant differences. For cubic samples of the mixture L, the compressive strength was extremely low while after the compressive strength test of prismatic samples of L series, recorded values were lower approximately 50% when compared to the L/FA mixture samples (Figure 1).

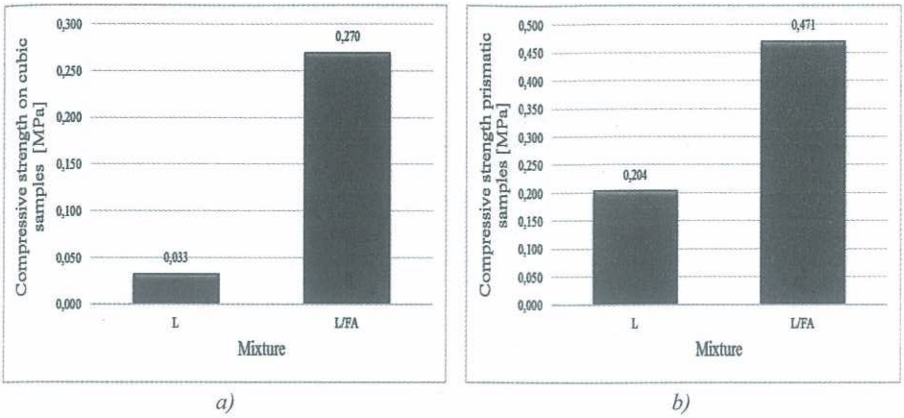

Figure 1 *Compressive strength [MPa]: a) on cubic samples; b) on prismatic samples*

The similar trend was observed on the prismatic samples subjected to bending (flexure). The mixture L/FA showed more than double strength value compared to the samples made with only a lime binder – mixture L (Figure 2).

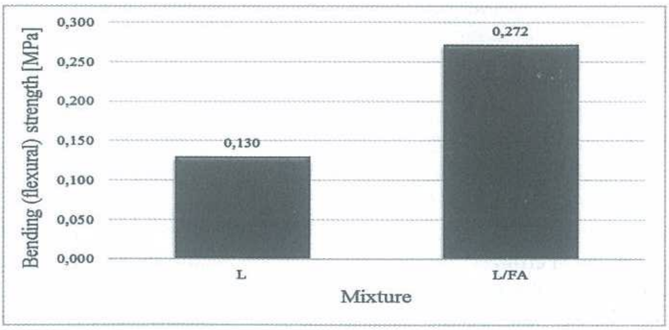

Figure 2 *Bending strength on prismatic samples [MPa]*

Since the mixture with fly ash showed the higher values of compressive and bending strength, it can be concluded that the addition of fly ash, i.e. its pozzolanic properties, highly contribute to the mechanical properties of this new material.

4 CONCLUSION

This research was conducted in order to compare the mechanical properties of two brand new, economical, resource-saving, and energy-efficient insulation materials. In order to increase the energy efficiency, cement was not considered as a binder, since it is extremely energy-inefficient material, as well as a high carbon-dioxide emitter during its production. Therefore, the mentioned two prototype mixtures based on the waste *Miscanthus x Giganteus* fibers were prepared: one with a lime binder, and the other with the lime binder and pozzolanic fly ash. The utilization of *Miscanthus x Giganteus* might significantly contribute to the energy efficiency in construction sector, through a proper treatment of this plant after it was collected from the ecoremediation.

The results of mechanical investigation on both types of samples, cubic and prismatic, have shown that after determination the compressive and bending strength, the mixture with lime and fly ash has shown the acceptable strength results. These improvements in the mechanical properties probably cannot be attributed to the pozzolanic activity of fly ash alone, having in mind the other factors, such as the structure improvement by filling the voids between the fibers with fly ash, and lowering water to binder ratio, which resulted in a higher energy of sample compaction.

This new insulation material has to be further enhanced, e.g. with modification of its composition and preparation method, in order to promote an additional reduction of its thermal conductivity. Nevertheless, according to the results presented in this paper, the investigated composite material with fly ash showed a high potential.

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