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Engineering properties of concrete with polystyrene granules

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Abstract

In the present study, we aim to find how polystyrene granules and fly ash influence the process of obtaining green concrete. In this respect, we prepared the concrete by using aggregates in three sorts, cement, fly ash as replacement of 10% cement and polystyrene granules as replacement of aggregates. Using these components, we analyzed certain characteristics such as density, compressive strength, flexural strength and split tensile strength that were experimentally determined. In addition, the influence of polystyrene granule as replacement of aggregate was analyzed and compared with a control mix of concrete. Our main results underline that effects of polystyrene granules imply smaller densities than that of the control concrete, technical strengths decreased in comparison with control mix without polystyrene and values of tensile strengths were closer to that of control mix.

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Keywords: Polystyrene granule; fly ash; compressive strength; flexural strength; split tensile strength.

1. Introduction

Concrete is the most used material in the construction industry and it is also a huge consumer of natural resources. Use of waste in concrete mix is beneficial for the environment protection [1,2,3]. Waste such as polystyrene, cork, tire, are often used as additional ingredients in building materials because they can improve the thermal and

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acoustical properties [4,5,6,7]. Studies involving concrete-related topics approach different types of building materials with polystyrene granule, such as mortar, concrete, pavement, etc. Effects of polystyrene granule in concrete depend on its type (cement-based concrete or polymer-based concrete), dosage and type of polystyrene, etc. In most cases, increasing of polystyrene dosage will be followed by a decreasing of its mechanical characteristics. Some experiments showed that the thermal treatment of polystyrene improves the behavior of concrete, respectively the characteristics that are related to workability, density, thermal conductivity and shrinkage [8]. A different type of polystyrene treatment consisting in coating the granules was used for obtaining a concrete in which mineral aggregates were replaced with polystyrene [9,10]. In this case, the authors studied the creep of concrete and found that it is higher than that of ordinary concrete.

Several studies related to concrete analysis found that when polystyrene granules are used as ingredients in concrete with natural resin with the increasing of polystyrene, the density, thermal conductivity, compressive and tensile strength decrease while porosity increases [11]. In the case of polymer addition, compressive and flexural strength is better than that of concrete with polystyrene without polymer [12]. When fly ash is used as cementitious material in concrete with polystyrene granules, compressive strength, tensile strength, and secant modulus decrease with increasing polystyrene dosage [13,14].

Following the above-mentioned results, this paper aims to analyze the influence of polystyrene granules as a substitute for aggregate, on the mechanical properties of concrete, in which a dosage of 10% of cement was replaced by fly ash. The replacement of mineral aggregates and cement is used to obtain a lightweight concrete. The use of lightweight concrete has many advantages such as in the process of producing lightweight floors, walls with an improved thermal behavior, lightweight prefabricated elements and other-related advantages that can improve building characteristics and change the current methods of working with concrete.

2. Experimental program

In order to prepare concrete with polystyrene granules, a witness mix (CC1) was used, containing the following ingredients: cement type CEM II 42.5 [15] in a dosage of 360 kg/m^3, river aggregates used in three sorts (sand 0-4 mm: 803 kg/m^3, 4-8 mm: 384 kg/m^3 and 8-16 mm: 559 kg/m^3) and 172 l/m^3 of water. Our experimental mixes were prepared with fly ash (FA) from CET Holboca Iasi, in a dosage of 10%. We used it as replacement of cement and polystyrene granule, respectively as substitution of aggregate sort 4-8 mm in proportions of 20%, 40%, 60%, 80% and 100% of the volume. All mixes were prepared with additive type Glenium-BASF- a superplasticizer in a dosage of 1% from the cement dosage.

Method (EDAX) was used for chemical analysis of fly ash. The principal elements contained by fly ash are Si, O, Al, Ca, Fe, K, Na, Mg and depending on the origins there are also small quantities of P, Ti, V, S, P, etc., Table 1.

Table 1. Elements of coal fly ash from thermal power plant Holboca.

Element	Wt [%]	At [%]
CK	17.15	26.89
NK	01.34	01.80
OK	37.50	44.13
NaK	00.69	00.56
MgK	00.52	00.40
AlK	13.09	09.14
SiK	18.37	12.32
SK	00.70	00.41
KK	01.74	00.84
CaK	03.17	01.49
TiK	01.71	00.67
FeK	04.01	01.35
Matrix	Correction	ZAF