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The effects of fluidal fly ash on properties of underwater concrete

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ABSTRACT

1. Introduction

Fly ashes, as the by-products of coal combustion, are important and valuable raw materials for the building materials industry, particularly for the producers of cement and concrete. The physico-chemical properties of the fly ashes, and thus the possibilities of their use in the cement concretes, depend on many factors including type of the combusted material, type of the installation, conditions of burning and rate of cooling as well as technology of gases desulfurization. Besides the typical fly ashes, which are the by-products of combustion of the black or brown coal in the so-called conventional combustion beds, new types of ashes are also created in the form of the mixture of the products of simultaneous combustion of the coal and desulfurization of the gases. Fluidized fly ashes are different in its physico-chemical properties and morphological features from traditional ashes ascending in dust furnaces, this applies to both ashes from black coal, as well from brown coal. Ashes from fluidized beds do not contain a vitreous phase, they show very large open porosity, thus increased water-demand. The chemical composition of fluidized ashes is also different from silica ashes. The content of SiO_2 is reduced while the content of CaO and SO_3 increased.

This study presents the properties of underwater concretes (UWC), made with fly ashes obtained from the fluidized beds. Mixtures used for underwater concreting, beside satisfying mechanical properties, should exhibit adequate flowability and washout-resistance in order to be cast underwater without compaction. Underwater concrete should be fluid to facilitate handling and casting and at the same time cohesive enough to reduce washout and segregation. For production of UWC cement was partially substituted with fly ash by 20-50 wt% with a 10 wt% step.

2. Materials and tests

For UWC production Portland cement CEM I 42.5 R, river sand 0/2 mm and natural gravel with the maximum grain size 16 mm were used. The fluidized ashes from Zeran (Poland) electric plant have been used as the mineral addition in the amount from 20 to 50% of the cement mass (referring to the reference concrete B0). The constant value of w/b = 0.4 has been used. The admixture for the underwater concrete (AWA) has been also introduced in the amount of 4 kg/m^3. The composition of the concrete mixes is presented in the Table 1. The amount of superplasticizer was determined in the way to obtain comparable rheological properties of the mixes in the time of 60 minutes.

The research was conducted in two phases. First was to obtain such a consistency of a concrete mix modified with fly ash from the fluidized combustion beds to ensure the consistency required for underwater concreting. The second phase included investigation of physico-mechanical properties of hardened underwater concrete and their development in time. Compressive strength, tensile splitting strength, abrasion resistance (Böhme method), density, water absorption, water penetration depth and freeze thaw resistance were determined for each concrete. The tests were performed on the specimens made in water, depending on the type of test, after 7, 14, 28, 56 or 90 days of curing of concrete under water in the temperature 20±2 ºC. Additionally the compressive strength of UWC was determined on the specimens made and cured in standard laboratory conditions.

Table 1. Mix proportioning of underwater concrete [kg/m^3].

Concrete	Cement	Fluidized ashes	Super-plasticizer	Water	Sand	Gravel	AWA admixture
B0	530	0	4.0	212	593	1028	4.0
B20	424	106	7.5	212	593	1028	4.0
B30	371	159	10.0	212	593	1028	4.0
B40	318	212	12.5	212	593	1028	4.0
B50	265	265	15.0	212	593	1028	4.0

3. Results and discussion

Concretes containing fluidized ashes exhibited better workability than reference concrete (B0). However, increased amount of superplasticizer was required to achieve reasonable workability in these mixes.

Analysis of the development of compressive strength (Fig. 1) and splitting tensile strength of the tested concretes showed that regardless of the age of the concretes, the concretes with addition of the fluidized ashes had in every case the lower compressive and tensile strength than the reference concrete (B0). In addition, the use of fly ash significantly decreased early compressive strength of concrete, after 7 days of curing.

The depth of water penetration of the analyzed concretes was in the range from 10 to 27 mm, and decreased with increment of the amount of fly ashes in the concrete. Moreover, the positive effect of fly ash was observed in reduction of water absorption and increment of freeze-thaw resistance of tested concretes.

The best overall effect of fluidized fly ashes on physico-mechanical properties of underwater concrete was achieved for concrete containing 30 % of fly ashes as the cement replacement (B30).

Presented investigation shows the possibility of using the fly ashes from the fluidized combustion beds for production of underwater concrete, however, development of the detailed recommendation for their use requires further studies.

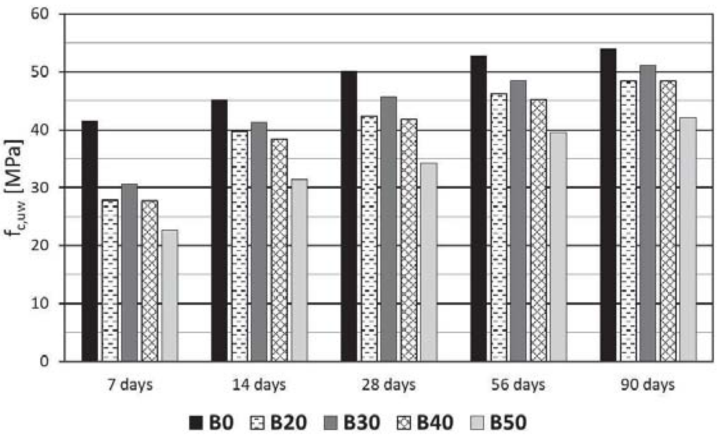

Fig. 1. Compressive strength of underwater concretes after 7, 14, 28, 56 and 90 days of curing.

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