Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 196 (2017) 97 – 104

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2017, CCC 2017, 19-22 June 2017, Primosten, Croatia

Properties of underwater concretes containing large amount of fly ashes

Elżbieta Horszczaruk*, Piotr Brzozowski

West Pomeranian University of Technology Szczecin, Department of Civil Engineering and Architecture, Al. Piastow 50, 70-311 Szczecin, Poland

Abstract

The results of the testing of the underwater concretes, containing fly ashes from circulating fluidized bed combustion (CFBC) of the black coal, are presented in the paper. The concrete mixes were designed in such a way that the content of the binder was 400 kg/m3 and water to binder ratio w/b was equal to 0.48. Five mixes are prepared with the content of fly ashes: 0, 20, 30, 40 and 50 per cent of the cement mass, respectively. The consistence of the mixes was controlled by adding the suitable amounts of superplasticizer. The content of AWA admixture was constant for all mixes and equal to 1% of the binder mass. The following properties were tested for the concrete mixes: slump-flow, viscosity using V-funnel and passing ability using L-box. The wash-out losses were also determined. All tests of the concrete mixes were carried out immediately after mixing the components and after 60 minute after mixing. For the hardened underwater concretes, the following properties were determined: compressive strength after 7, 28 and 56 days of curing as well as the depth of water penetration under pressure and water mass absorbability. The best composition, regarding to the properties of the mix and hardened concrete, appeared that with 30% of the fly ashes.

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2017

Keywords: circulating fluidized bed combustion, fly ashes: underwater concrete, mechanical properties;

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. This is reflected in the valid standards, which give

* Corresponding author. Tel.: +48-91-449-4900; fax:+ 48-91-449-4369
E-mail address: elzbieta.horszczaruk@zut.edu.pl

Peer-review under responsibility of the scientific committee of the Creative Construction Conference 2017
doi:10.1016/j.proeng.2017.07.178

precise requirements for the fly ash used as an addition to cement (PN-EN 197-1:2012) or concrete (PN-EN 450-1:2012).

As a consequence of the strict requirements referring to the emission of CO_2, SO_3 and NO_x, introduced by European Union, the growing number of combustion systems with fluidized beds is installed in the Polish energy plants as a part of their modernization. Therefore, the amount of the conventional siliceous fly ashes, produced by the Polish energy industry, is decreasing. There are more than 300 circulating fluidized bed combustion (CFBC) systems working over the Europe, including 14 in Poland. The volume of unused wastes from the fluidized beds is growing recently, and according to the data by Central Statistical Office is about 0.8 mln ton annually [1].

The fly ashes from the fluidized beds are the mixture of the products of ash removal from the exhausts and the residues of the sorbent. Thus, they often contain high amount of SO_3 and CaO and show high loss on ignition [2,3], and do not meet the rigorous requirements of European Standards for the mineral additions to cement and concrete. For this reason they are often considered unuseful for traditional technologies of cement production. According to the requirements of the standard PN-EN 197-1, the fly ashes from fluidized bed combustion may be used in the cement production in the amount up to 5%, as the secondary mineral addition.

The interest in use of the fly ash from the fluidized beds to the production of building materials, including cement composites, has rapidly grew. Because of the strict requirements referring to SO3 content, it can be used in the production of concrete as a substitute of the natural aggregate, usually the sand. The fly ashes from CFBC are utilized for stabilizing the soil substrate and as a basis for the road construction, as well as in the manufacturing of the roller compacted concrete for the roads and hydraulic structures [4-6]. The technologies of using the CFBC ashes for the production of the autoclaved aerated concrete were also developed [7].

The subject of the authors' research was determination of the impact of CFBC ashes on the properties of underwater concrete mixes and on the basic properties of the hardened underwater concretes (UWC), including their development over time. The CFBC ashes were used in tests as the substitute of cement, in the amount from 20 to 50% of the binder mass. The rheological properties of the mixes are important when designing UWC; considering the technology of the underwater concreting, the UWC are usually designed as almost self-compacting concretes. Therefore, the authors have determined the rheological properties and wash-out loss of the mixes containing CFBC ashes.

2. Materials and mix proportions

The investigation of the effect of CFBC ashes on the properties of underwater concretes was conducted on the concretes containing the fly ash from the fluidized beds as the substitute of the cement in the amount: 0, 20, 30, 40 and 50% of the cement mass. The ashes from the combustion of the black coal were used; their chemical composition is presented in the table 1. All mixes contained: Portland cement CEM I 42.5 R, river sand and fractioned gravel with the maximum grain size 16 mm, stabilizing admixture for the underwater concretes, containing polysaccharides, and superplasticizer containing naphthalene sulfonates. The content of the superplasticizer was increased together with growing amount of the fly ashes in the concrete mix for keeping the value of the slump-flow above 400 mm. Constant amount of the stabilizing admixture – 4 kg/m^3 – was added into all UWC mixes. The composition of the concrete mixes is presented in the table 2. Below is an example which the authors may find useful.

Table 1. Chemical composition of CFBC ash.

Content of the component [mass %]										
LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	SO_3	TiO_2	P_2O_5
10.31	39.06	21.01	5.55	10.74	1.87	0.54	1.98	6.83	0.80	0.64