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# Effect of Natural Zeolite and Air-Entraining Agent on the Properties of High Strength Concretes

(abstract)

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Concrete belongs to the most frequently used materials in the building industry for many years. Ordinary concrete usually contains about 12% of cement and 80% of fine and course aggregate by weight. This means that annually globally concrete production accompanies by a significant consumption of sand, gravel, and crushed rock at the rate of 10 to 11 billion tons and fresh water approximately 1 billion m3. It should be noted that lack of durable materials has serious environmental consequences. Therefore increasing the service life of concrete products is a long-term and easy solution for preserving the earth's natural resources (Jana 2007; Kumar Mehta 2001; Najimi et al. 2012).

On the one hand, partial substitution of Portland cement by active mineral additives permits not only to obtain positive economical and ecological effects, but together with air-entraining agent also durability, especially against freezing and thawing cycles. Among the famous mineral additives zeolite is of great interest. Despite clearly expressed crystal structure it possesses excellent pozzolanic activity (Franus and Dudek 1999; Sanytsky, Sobol, and Markiv 2010; Sobol et al. 2014). It is reported, that natural zeolite increases compressive strength due to its pozzolanic property and moreover enhances durability of concrete (Sabet, Libre, and Shekarchi 2013).

On the other hand, application of high performance materials in construction combines the advantages of reducing the use of materials, cross-section and reinforcement congestion. Although the application of high strength concrete (HSC) has been gaining popularity in high-rise building construction, parameters affecting the performance of HSC especially crack resistance are still under investigation (Poznyak, Kirakevych, and Stechyshyn 2014; Solodkyy 2008).

In this study the effect of natural zeolite and air-entraining agent on the properties of HSC was researched. Portland cement CEM I 42.5R and clinoptilolite type of natural zeolite coming from Sokyrnytsia (Ukraine) as well as fine (0–2 mm) and coarse (5–20 mm) aggregates were used in this investigations. Commercially available polycarboxylate-based superplasticizer with a specific gravity of 1,07 and solid content of 36% and an air-entraining agent were used for providing targeted consistency of concrete mixes and properties of hardened concretes.

The obtained results show that compressive strength of HSC incorporating zeolite decreased from 41 to 27–30 MPa in comparison with the control concrete (without zeolite) at early age of structure formation. However, the percentages of strength reduction were generally reduced with increasing the age. It was found that the strength reduction of concrete (on the basis of concrete mix of consistency class S1) containing zeolite was almost 5% after 28 days of hardening. The highest strength reduction (15%) was observed in concrete on the basis of concrete mix of consistency class S4.

Investigation of HSC crack resistance and record parameters of full deformation diagram of samples with artificially created crack were carried out using special equipment with sensor displacement and computer with a specially designed program «p_sens». The investigations of fracture toughness characteristics were studied on the basis of the method and criteria of fracture mechanics.

The obtained diagrams allow to make a qualitative analysis of concrete crack resistance in subcritical (until move of macrocrack) and aftercritical phase (during extending macrocrack) stages of deformation. It should be noted that the HSC containing mineral additives, superplasticizer and air-entraining agent on the basis of concrete mix of consistency class S1 characterized the biggest load at the point of chart breaking. This concrete resists the best the spread of cracks in subcritical and aftercritical stages.

Configuration of complete deformation diagrams investigated concrete fully correspond with the complex of calculated power and energetic characteristics of crack resistance, including: specific energy expenses at the beginning of static destruction, effective specific energy expenses for static destruction, static critical intensity stress coefficients.

Thus, HSC incorporating natural zeolite, plasticizing and air-entraining agents characterizes by the highest specific energy expenses in the aftercritical stage, integrated energy expenses on the destruction as well as strength parameters and modulus of elasticity. This is caused by modification of concrete microstructure and by formation of uniformly distributed pores due to the use of air-entraining agent which prevent the intensive spread of crack under load and provide improved crack resistance of concrete. Generally, proposed technology solutions have permitted to increase fracture toughness characteristics by approximately 15–18%.

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