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Super high strength metabentonite based geopolymer

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Abstract

The paper presents the results of the study on the effects of the combination of the low liquid/solid (l/s) ratio and pressure compaction of the fresh pastes on the properties of the hardened based geopolymer paste. It is very well known that the mentioned combination gives the possibility to prepare cement composites with the excellent engineering properties. The object of the study was the metabentonite based geopolymer. The results obtained shown the metabentonite based geopolymer prepared under the combination of the low l/s ratio value and pressure compaction as a super strength material. This strength effect was evidently a consequence of the found high dense nano- or near-nano pore structure of the geopolymer.

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Keywords: Metabentonite; pressure compaction; strength; porosity

1. Introduction

A significant motivation driving the geopolymer research is to catch up the high quality of the engineering properties of the geopolymers. The variations and combinations of the concrete technology processing factors along this line are very interesting. It is well known that when very low water/cement rations are used they result in a significant increase of strengths, durability and the quality of the others engineering properties of concretes may be achieved [1,2].

The object of the paper is to characterize the properties of the metabentonite based geopolymer prepared under the use of the combination of the very low w/c ratio and pressure compaction of the fresh mixture.

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2. Experimental procedure

2.1. Test specimens' preparation and their testing

For the study the metabentonite pastes were prepared with activator solution/metabentonite ratio (l/s) 0.08. The test specimens were 20 mm-edge cubes. The reference test specimens were prepared with l/s 0.70. The alkali activator sodium hydroxide solution was added to the mixture. The portion of the activator corresponded to 7 wt. % of the weight of the metabentonite.

The preparation of the fresh mixtures represented an intensive mixing for 3 min using electrical mixer. The forms were filled by the mixture. Then the mixture with l/s ratio 0.08 was compacted under the application of the uniaxial pressure 300 MPa with the endurance of 1 min. The preparation of the reference test specimens (l/s ratio 0.70) was the same but the manual compaction was used. Then the pressure compacted test specimens hardened 24 hours and the reference test specimens due to their slow hardening 5 days. The ambient temperature of the hardening was 20 °C and relative humidity 95%. After the demoulding, their testing followed. The test specimens were dried at 105 °C and these properties were estimated: bulk weight, compressive strength, specific weight, phase composition, pore structure and morphology of the particles of the matrix.

2.2. Methods used

Bulk weight was calculated using the estimated weight and dimensions of the test specimens. For the estimation of compressive strength a destructive method using the loading press was used. For specific weight estimation the equipment Pentapyc 5200e QUANTACHROME CORPORATION was used. Thermal analysis was carried out on the METTLER TOLEDO, TGA/DSC 1, STAREe System, the sample mass 45 mg, heating rate 10 °C/min, ramping from ambient temperature to 1000 °C in an air atmosphere. For pore structure analysis Pore Master 60 automated mercury porosimeter, using the wetting contact angle 141.3 ° and mercury surface tension 0.48 $N \cdot m^{-1}$ was used [3]. Using the pore analyzes results the water permeability coefficients were calculated [4]. The morphology of the samples was studied by scanning electron microscopy using a Carl Zeiss – EVO 40 HV microscope. Before the scanning process, all samples were coated with gold to enhance the electron conductivity.

2.3. Materials

The metabentonite used was the product of bentonite heat-treatment at 650 °C for 4 hours. The data on the chemical composition, based on the results of the current chemical analytical methods, and specific weight of the both materials are given in Table 1. As it can be seen the consequences of the heating was the increase in the content of SiO_2 and Al_2O_3, and the specific weight. It was evidently a consequence of minimizing the ignition loss content due to the heating. The resulted increase of SiO_2 and Al_2O_3 content seems to be interesting effect because their molar ratio used to be appreciated as a significant factor of the development of geopolymers with performed mechanical properties. This ratio is considered as a main synthesis parameter among alkali content Na_2O/Al_2O_3, water to aluminosilicate ratio, and processing parameters such as curing time and curing temperature and others [5].