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Experimental study of the effect of adding fibers and mineral processed materials on geopolymer concrete

M. H. Mansourghanaei[1], M. Biklaryan[2*], A. Mardookhpour[3]

Abstract

Geopolymer concrete was proposed in order to eliminate the disadvantages (such as low strength and environmental damage) caused by the use of ordinary concrete in structures. In making this type of concrete, processed geopolymer materials from mineral sources such as slag and nanosilica replace cement and produce strong geopolymer concrete. In this laboratory research, a mixing design was made of control concrete containing Portland cement. Then geopolymer concrete was produced in three designs. The first design contains 100% of the slag of the composing furnace and the second and third designs contain 92% of the slag of the composing furnace and 8% of nanosilica, respectively, containing 1 and 2% of polyolefin fibers (4 mixing designs in total). Then, modulus of elasticity and tensile strength tests at 7 and 28 days of processing time at room temperature were performed on concrete samples. SEM test was performed on concrete samples at 90 days of age for validation with other results. The results indicate that increasing the curing age of concrete improved the results. In the modulus of elasticity and tensile strength test, the addition of fibers to geopolymer concrete at the age of 28 days, improved the results in Figure 19 (2% of fibers) compared to Figure 2 (no fibers) by 21.19 and 24.07%, respectively. Increasing the fibers improved the results of tensile strength tests and modulus of elasticity of geopolymer concrete compared to control concrete. The results of the SEM test overlapped with the results of other tests.

Keywords: *Geopolymer concrete, Blast furnace slag, Nano silica, Polyolefin fibers, Tensile strength*

[1] . Department of Civil Engineering, Chalous Branch, Islamic Azad University, Chalous, Iran.
[2] . Department of Civil Engineering, Chalous Branch, Islamic Azad University, Chalous, Iran. M.biklaryan@iauc.ac.ir
[3] . Department of Civil Engineering, Lahijan Branch, Islamic Azad University, Lahijan, Iran.
*** Corresponding Author**

1. Introduction
Extend Abstract

1. Introduction
In recent years, the discovery of materials with pozzolanic properties as an alternative to cement in concrete, which while addressing the environmental concerns of fossil fuels and the release of toxic carbon dioxide into the atmosphere, has superior properties than Cement in concrete has provided a broad perspective in civil engineering research for researchers. Research shows that cement plants are responsible for emitting about 5% of the total carbon dioxide into the Earth's atmosphere (Nosrati et al., 2018). To address this problem, researchers have identified fly ash, metakaolin, composite slag slag, and other pozzolans as suitable alternatives to cement (Nuaklong et al., 2016; Zhuang et al., 2016). Replacement of cement with these pozzolans leads to the production of geopolymer concrete, which can reduce environmental pollution, improve the mechanical properties and durability of concrete, and also significantly reduce the need for cement (Ryu et al., 2013; Mehdipour et al., 2020). The structure of geopolymer concrete was first proposed by a French researcher named Joseph Davidovits in 1972 (Davidovits., 2008). The amount of carbon dioxide produced in the geopolymer process is much less than the cement production process (Neupan, 2018). The production of geopolymer concrete is done by conventional methods of concrete technology (Vora and Urmil, 2013). In geopolymer concrete, alkaline materials containing abundant aluminosilicate materials, which have high adhesion and filling properties in the concrete composition, are replaced by cement. The widespread use of fibers began in the early 1960s in developed industrial countries, and over the past decades the material and shape of fibers as well as the method of making fiber concrete has continuously improved (Hajikarimi and Fallah, 2019). The use of corrugated fibers with a higher length to diameter ratio results in greater strength, research shows that the addition of fibers will increase the tensile strength of concrete (Mohtasham Moein et al., 2019). In the present paper, the production of geopolymer concrete containing processed mineral materials due to its important role in durability and strength, reducing air pollution (due to reduced CO_2 emissions), reducing fossil fuel consumption (in the process of conventional concrete production), preserving cement resources and Environmental protection (due to the use of slag depots in steel mills), has been introduced as an innovative project.

2. Materials and methods
In this laboratory research, the slag of the composing furnace produced by Isfahan Steel Company with a specific weight of 2450 kg/m^3 with a modulus of elasticity of 1.2 Pascals was used under ASTM C989 / C989M standard. Nanosilica produced by the German company Evonic Industries with a purity of 99.8%, a specific weight of 2400 kg/m^3 and a particle diameter of 7 to 14 nm was used. Corrugated polyolefin fibers under the standard ASTM D7508 / D7508M, with a tensile strength of 500 N/cubic millimeter, length to width ratio of 37.5, the product of the Italian company Dorocham Middle East were used. Consumable cement of Portland type II, produced under ISIRI 389 standard, was used.Consumable aggregates are the product of sand factories in Lahijan city and were in the range of ASTM C33 standard in terms of quantity and quality. The alkaline solution used in the manufacture of geopolymer concrete is a combination of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) with a silicate to hydroxide ratio of 2.5 and a molarity concentration of 12, a specific gravity of 1483 kg/m^3.

3. Results

The obtained results indicated that acidic contamination had a strong influence on the strength characteristics of soils, and the mineralogy of the clay fraction as well as the concentration of acid in the pore fluid could significantly influence the stress-strain behavior of studied soil. However, further decrease in pH (pH=3) and increase in rain fluxes (20 years) caused a significant reduction of the strength. Furthermore, the results indicate that the values of the LL, PI and the soil permeability has increased and the unconfined compressive strength and the CBR has decreased as the artificial rain become more acidic or alkaline, and precipitation years increased from one-year to twenty-years.
The modulus of elasticity test under ASTM C469 standard was performed on cylindrical concrete specimens with dimensions of 15 30 30 cm at 7 and 28 days of processing age at room temperature by a concrete breaker jack machine. The tensile strength test of concrete by Brazilian method under ASTM C496 standard was performed on cylindrical concrete samples with dimensions of 15 30 30 cm at 7 and 28 days of processing age at room temperature by a concrete breaker jack machine. SEM test was performed at 90 days of processing at room temperature by scanning electron microscope with FEI Quanta200 model.

4. Conclusion

1. Increasing the processing age in concrete samples has improved the results in all tests. As in the tensile strength and modulus of elasticity test, the results improved at the age of 28 days compared to the age of 7 days in geopolymer concrete in design 4 (GP8NS2PO) (as the best performance compared to other designs of geopolymer concrete) by 42.89 and 75, respectively. / 18% was obtained.
2. Adding polyolefin fibers to the geopolymer concrete design improved the obtained results. In this regard, in the test of tensile strength and modulus of elasticity of concrete, for design 4 (geopolymer concrete containing 2% of fibers), compared to design 1 (geopolymer concrete without fibers), the test results improved by 21.19 and / 07, respectively. Reached 24%.
3. The results of SEM test indicate the superiority of microstructure of geopolymer concrete samples containing polyolefin fibers. In this regard, the proper bonding of the fibers with the hydrated gels in the interfacial transition regions (ITZ) and the localization of the cracks due to the presence of the fibers is evident.
4. The results of the tests in this research indicate the superiority of performance in geopolymer concrete compared to control concrete. All the results of the tests in this article were in line with each other and overlapped with each other.

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