Amirkabir Journal of Civil Engineering

Amirkabir J. Civil Eng., 55(11) (2024) 473-476
DOI: 10.22060/ceej.2023.21710.7803

Durability of geopolymer mortars with suggested percentages of slag and kaolin containing polymer

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ABSTRACT: Geopolymers as cement-free concrete have attracted the attention of researchers in recent years. In making this type of concrete, instead of cement, various materials such as micro silica, metakaolin, zeolite, etc., and chemical solutions are used to complete the geopolymerization process to form the binding adhesive substance. The present study examines the durability of geopolymeric mortars based on blast furnace slag (GGBFS) with different replacement percentages of kaolin in several molar amounts. The GGBFS was used as a substitute for cement, and sodium hydroxide solution with a concentration of 4 and 8 M and sodium silicate (glass water) were used as chemical solutions. For this purpose, kaolin ceramic powder was mixed with GGBFS at 50% and 75%, and a total of 12 mixing plans were made. Compressive strength, rapid chloride migration test (RCMT), electrical resistance, water absorption percentage, loss of compressive strength, and weight after exposure to sulfuric acid solution were studied. The results of kaolin powder and slag reduced the compressive strength, and the lowest value of 33% was observed in BSC50-4; Also, the results of the penetration of chlorine ions in concrete and the weight loss of mortar samples in sulfuric acid solution indicate that the use of kaolin powder and slag increases the durability of BSC50-8 concrete samples by 38% under the conditions of chloride attack caused by Permeability decreases.

Review History:

Received: Aug. 21, 2022
Revised: Sep. 11, 2023
Accepted: Sep. 30, 2023
Available Online: Nov. 23, 2023

Keywords:

Durability
geopolymer mortar
slag
kaolin
RCMT

1- Introduction

Geopolymer concrete is a concrete in which aluminosilicate materials rich in silicon (Si) and aluminum (Al) and alkaline solution are used as adhesives. Blast furnace slag is one of the materials that has an aluminosilicate structure. Research results have shown that concrete mixtures containing slag, if designed and implemented correctly, can control the destructive alkali-silica reaction and increase durability against the sulfate environment[1]. investigated the resistance of geopolymeric mortar against acid and found that geopolymeric mortar has better resistance than ordinary Portland cement mortar[2]. investigated the mechanical properties and permeability of Portland cement concretes modified with three types of waterproof polymers: styrene-butadiene rubber, polyacrylic ester, and organic silicone, and found that these polymers reduce compressive strength and fly ash has a negative effect. It improves it. Also, these polymers can reduce the permeability of concrete[3]. The current study investigates the compressive strength and durability of geopolymeric mortar with 50% and 75% kaolin percentages in 4 and 8 molar at the ages of 7, 28, and 90 days based on the slag of the blast furnace.

2- Materials and Methods

The materials used for the intended test are sodium hydroxide, sodium silicate, slag, kaolin, and SBR polymer and sand. A total of 9 mixing designs were made in Table 1, after which the samples were cured for 24 hours at a temperature of $110\,^{\circ}C$. Then they remained inside it for 24 hours to cool completely. Then, the samples were removed from the molds and kept in the laboratory environment before the tests. To check mortar samples against sulfuric acid attack, after 28 days of curing, samples were placed in sulfuric acid solution with a pH equal to 1 up to 90 days. Then, the test programs were performed after curing on the intended days.

3- Experimental Results and Discussion

The following tests and the subsequent results were performed on samples at different ages as follows: compressive strength at 7, 28, and 90 days; rapid chloride ion migration test (RCMT) in 28 days; Weight loss of samples in sulfuric acid solution in 90 days and water absorption test on 28 days.

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Table 1. Geopolymer mortar mixing plan.

Name	Slag		CP		M	Na_2Sio_3	$NaOH$	$SS+SH/BS$	SS/SH	SBR		Sand
	%BS	kg/m^3	%BS	kg/m^3	Mol/L	kg/m^3	kg/m^3			%BS	kg/m^3	kg/m^3
S4	100	700	0	0	4	250	100	0.5	2.5	0	0	1195
SC50-4	50	350	50	350	4	250	100	0.5	2.5	0	0	1195
SC75-4	25	175	75	525	4	250	100	0.5	2.5	0	0	1195
S8	100	700	0	0	8	250	100	0.5	2.5	0	0	1195
SC50-8	50	350	50	350	8	250	100	0.5	2.5	0	0	1195
SC75-8	25	175	75	525	8	250	100	0.5	2.5	0	0	1195
BS4	100	700	0	0	4	250	100	0.5	2.5	1	7	1195
BSC50-4	50	350	50	350	4	250	100	0.5	2.5	1	7	1195
BSC75-4	25	175	75	525	4	250	100	0.5	2.5	1	7	1195
BS8	100	700	0	0	8	250	100	0.5	2.5	1	7	1195
BSC50-8	50	350	50	350	8	250	100	0.5	2.5	1	7	1195
BSC75-8	25	175	75	525	8	250	100	0.5	2.5	1	7	1195

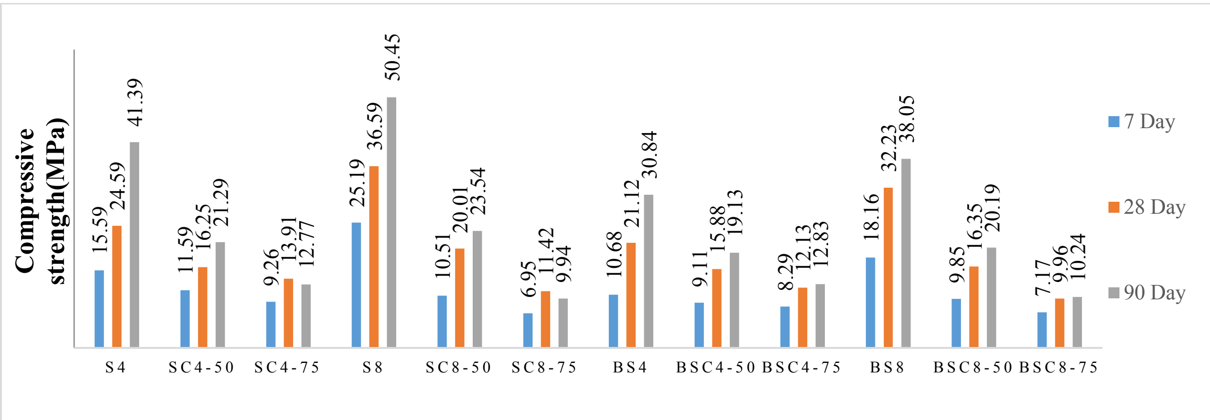

Fig. 1. 7, 28 & 90 days compressive strength diagram of geopolymer mortar and control samples.

3- 1- Compressive Strength

Comparison of the design sample of SC75-8 with that of SC75-4 with the combination of 75% kaolin powder and 25% slag at the age of 7, 28, and 90 days in molarity of 4 showed better resistance than molarity of 8 (Figure 1). A comparison of the control sample with a molarity of 8 showed a better resistance than a molarity of 4 because the selected combination of sodium hydroxide with soluble sodium silicate resulted in the best activator.

3- 2- Rapid chloride ion migration test (RCMT)

The accelerated migration of chloride ions (RCMT) test was performed at the age of 28 days. Figure 2 shows the diffusion coefficient of chloride ions. By reducing the percentage of ceramic powder from 75% to 50%, the diffusion coefficient of chloride ions is reduced in all designs. This research shows the progress of the hydration process with time and the reduction of permeability in the samples.

3- 3- Weight loss

To check the effect of acid, 50 mm cubic mortar samples were placed in sulfuric acid solution environment with a pH of 1 for 28 days. The weight loss was measured at 90 days after being placed in sulfuric acid. Finally, the results were reported as the ratio of the weight loss of the sample to its initial weight (before placing in the acid) in Figure 3. By examining the results, we find that the effect of cement substitutes on reducing the weight of the samples in sulfuric acid environment was positive, which can be attributed to the decrease in permeability.

4- Conclusions

The results of the samples exposed to sulfuric acid attack, in general, show the use of kaolin powder and slag has a negative effect on compressive strength. Meanwhile, the design sample with 50% kaolin powder and 50% slag with molarities 4 and 8 has shown better performance than other mixing design samples in an acidic environment. Although, in

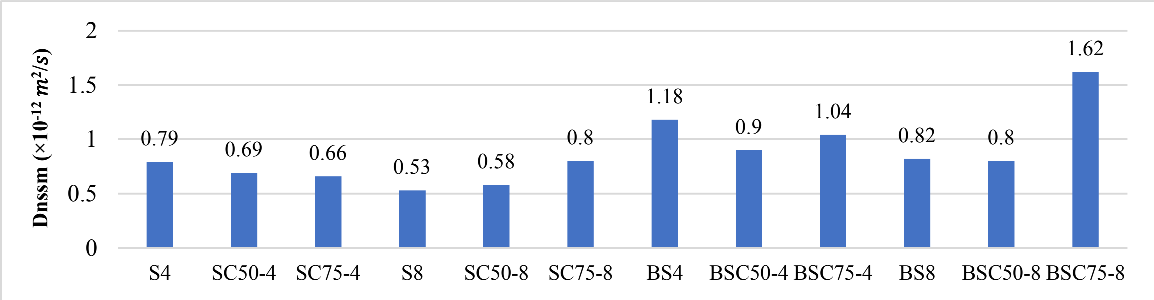

Fig. 2. The results of the accelerated diffusion coefficient of chloride ions.

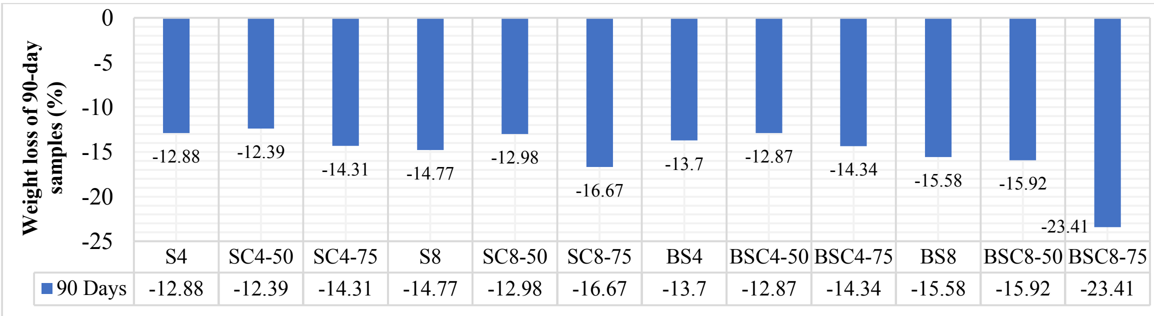

Fig. 3. Percentage of the weight loss of mortar samples in sulfuric acid solution.

general, the performance of the control samples was far better than the rest of the geopolymeric mortar samples. However, in total, the weight loss of geopolymeric mortar samples exposed to sulfuric acid attack is evaluated positively, except for the BSC75-8 sample.

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HOW TO CITE THIS ARTICLE

S. H. Ghasemzadeh Mousavinejad, A. Darvishalinezhad, Durability of geopolymer mortars with suggested percentages of slag and kaolin containing polymer, Amirkabir J. Civil Eng., 55(11) (2024) 473-476.

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