THE EFFECT OF CURING TEMPERATURE ON STRENGTH GAIN OF GEOPOLYMER CONCRETES PRODUCED FROM FERROCHROME SLAG

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Abstract - Ferrochrome slag (FS), the waste product of ferrochrome operation, was used as a binder in the geopolymer concrete produced in this study. This binder was activated with alkali-activators and mixed with river aggregate to produce geopolymer concrete samples. The silica module of the produced geopolymer concrete samples was determined to be 1.50. The compressive strength values of the samples were obtained at different curing times (24, 48, 72 and 96 hours) and at different curing temperatures (23, 40, 60, 80 and 100oC). According to the results of the tests, it was found that compressive strength values increased as curing time and curing temperature increased.

Keywords - Geopolymer Concrete, Ferrochrome Slag, Curing Temperature, Alcali-Activator

I. INTRODUCTION

For a long time, mankind has used different materials as binding material in construction sector. Today, the most commonly used binder is cement. Scientists have started to work on alternative binders due to adverse weather conditions of the concrete exposed to the external effects and air pollution in the product preparation processes. Today, artificial pozzolans, which are waste products of the industry, are used to produce more durable and durable geopolymer concrete.

Ever since the definition of geopolymer linkers by Davidovits in 1978, geopolymer linkers have been interested in engineering as well as the field of chemistry. In recent years geopolymers have emerged as a possible alternative to normal Portland cements due to their high early strength, acid and sulphate resistance, as well as being environmentally friendly. Although geopolymers are produced from raw materials containing of high silica and alumina, such as fly ash, silica fume, grinded granular blast furnace slag, fly ash-based geopolymers attract more interest today. Geopolymer binders can be a good alternative in the production of acid-resistant concrete because geopolymers are aluminosilicate-based rather than calcium silicate hydrate binders for building integrity [1].

Ferrochrome slag (FS) is a metallurgical slag that has been heat treated in eletric-arc furnaces and is similar of formation to blast furnace slags. It is included in the class of metallurgical slags "Ferrous slag", in other words "Iron-alloy slags" subclass. Ferrochromium is a metal compound commonly used in the production of stainless and heat-resistant steel. Ferrochrome and silicoferrochrome slag are waste materials that are released from the electric arc furnace of the ferro-chrome-producing plants [2]. The ferro-chrome slag that is the subject of study is the Elazıg ferrochrome plant waste. Since annual production at this plant is 150.000 tons and 1 kg of slag per 3 kg of produced ferrochrome is produced, the amount of slag taken in a year is 50.000 tons. Slag contains 3-5% Cr_2O_3 [3]. Therefore, it is very important to reduce this waste material by using in concrete.

The aim of this work, is to produce geopolymer concrete by using FS and with various activators. In this study, geopolymer concrete samples were produced by mixing FS, activator and river aggregate. The compressive strength values of these geopolymer concrete samples were investigated under different curing conditions (curing temperatures of 23, 40, 60, 80 and 100^oC and curing times of 24, 48, 72 and 96 hours).

II. EXPERIMENTAL

2.1. Materials

FS was provided as a waste product of Elazığ ferrochrome plants. In order to increase the reactivity of FS with the alkali activators, it is milled to pass through 45 μm sieve to bring it to the grain size of normal Portland cement. The chemical composition of the used FS is given in Table 1. The FS dosage in the test mixtures was fixed at 400 kg / m3. As the alkali activator, sodium hydroxide and sodium metasilicate (Na_2O = 8.9%, SiO_2 = 28.7%, H_2O = 64.8% by weight) were used. The silica module is 1.50 and the sodium hydroxide molarity is determined to be 10 M. Thus, the amount of activators used in the mixture was determined. The volumes of these materials were subtracted from 1 m^3 and the total aggregate volume was found. For geopolymer concrete samples, fine aggregate (0-4 mm) was used as river sand and coarse aggregate (4-8 mm) was used as river gravel. In the experiments, 70% of 0-4 mm and 30% of 4-8 mm size aggregates were used. The amounts of the materials to be obtained are given in Table 2.

To produce geopolymer concrete samples with river aggregate, first of all the alkali activators were mixed for 5 minutes, then FS, sand and coarse aggregates were added in order to homogenize the mixture. A laboratory type of mixer was used while preparing the mixtures. Concrete samples were produced by concrete mix ratio given in Table 2. After curing for 24, 48, 72 and 96 hours in the oven at 40, 60, 80 and 100°C temperatures, the concrete samples were removed from the oven and allowed to stand at ambient temperature until the day of the experiment.

ASTM C39 test method was used to determine the compressive strength of geopolymer concrete samples. The cube samples were placed at the position where the load application direction would be perpendicular to the concrete casting direction. As a result, 28 days compressive strength measurements of geopolymer concrete samples were made. Three samples were produced from each group and the results of the experiments were obtained by taking the average of these three samples.

Table 1. Chemical composition of FS

Compound (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3
FS	33.80	25.48	0.61	1.10	35.88	2.12

Table 2. Mixing ratios of 1 m^3 geopolymer concrete

Materials	FS	Na_2SiO_3	NaOH	Water	Aggregates	
					0-4 mm	4-8 mm
Weight, (g)	400	218,22	13,27	33,18	1095,72	500,02

III. RESULT AND DISCUSSION

The compressive strength values of the geopolymer concrete samples prepared by curing at different temperatures and times are given in Table 3 and shown in Fig 1. According to the test results, when geopolymer samples cured at 40°C for 24 hours are taken as reference, with the increase of the curing time to 96 hours, the value of compressive strength increased from 9.03 MPa to 12.48 MPa . It was seen that the increase was 38%. In the same way, samples taken for 24 hours at 40°C were taken as reference, the compressive strength value increased from 9.03 MPa to 10.18 MPa with an increase of the curing temperature to 100°C and a 13% increase was observed. The highest compressive strength value (16.63 MPa) was reached at 96°C at 100°C. A 34% increase was achieved compared to the value obtained at room temperature.

In situations where higher strengths are intended in the short term, increasing the curing temperature is an important parameter for the samples to gain fast strength [4]. In the work done by Kantarcı [5], it was found that as the curing times of the geopolymer mortar samples increase, the compressive strengths increased. Tempest et al. [6] have shown that the development of compressive strength depends on the activator concentration, aging time and duration of curing. It was also stated that the application of an additional day of curing at high temperature increased the compressive strength by 12%.

Görhan and Kürklü, [7] have shown that increasing the curing temperature in the work increases the compressive strength, but did not have a significant effect on the physical properties of the concrete. İlkentapar [8] determined that early strength development of hot-cured alkali activated slag mortars was much faster than normal portland cementitious blends. Atiş et al. [9] reached the highest value (120 MPa) in samples cured at 115 ° C for 24 hours in a pressure-strength test on geopolymer mortars produced using F-class fly ash.

Table 3. The compressive strength values of geopolymer concrete samples at different curing temperatures and times

	Time (s)	Temperature, (°C)				
		23	40	60	80	100
Compressive strength, MPa	24	12,45	9,03	9,40	11,26	10,18
	48	12,45	9,50	13,30	12,90	15,00
	72	12,45	11,88	13,88	13,48	15,03
	96	12,45	12,48	15,93	14,73	16,63

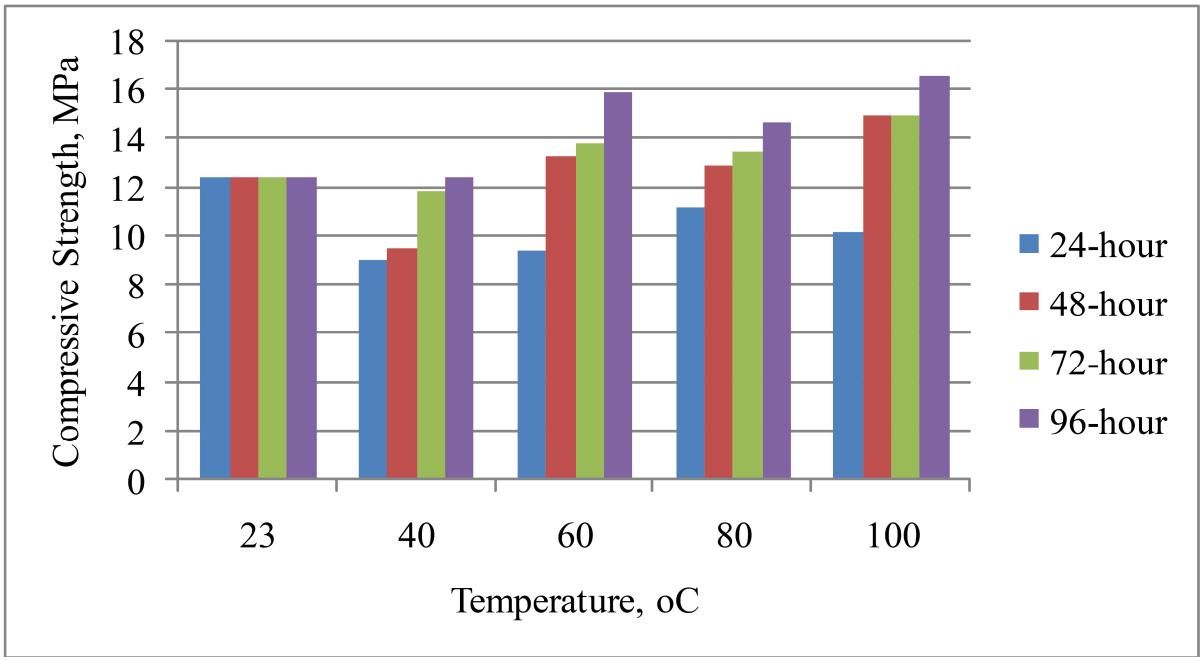


Figure 1. Compressive strength values of geopolymer concrete samples made with FS

CONCLUSION

As curing temperatures and curing times of geopolymer concrete samples increased, compressive strength values increased. The highest compressive strength value was obtained from samples with a curing time of 96 hours and a curing temperature of 100°C. As a result, it is seen that geopolymer concrete samples are produced using FS. Higher pressure strength values can be obtained by changing the parameters used.

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