EFFECT OF CURING TEMPERATURES AND NAOH CONCENTRATIONS ON COMPRESSIVE STRENGTH OF GEOPOLYMER PASTES PRODUCED FROM ELAZIĞ FERROCHROME SLAG

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Abstract - Recently, an increasing interest has been appeared for geopolymer as a binding material because of the benefits that it brings via, using of industrial waste materials such as ferrochrome slag, fly ash, blast furnace slag and reduction in greenhouse gas emission caused by cement production. The objective of the present work is to investigate effect of different NaOH concentrations and curing conditions on mechanical properties geopolymer pastes produced from Elazığ ferrochrome slag (EFS). EFS was alkali activated with NaOH solutions prepared with different molarities (8, 10, 12, 14 and 16M). Liquid/binder ratio was determined as 0.28 experimentally. Specimens produced in this way were cured at 50, 100, 150°C and laboratory conditions for 72h. For each specimen produced using this different parameters, the change in compressive strength was determined with time (3 to 28 day) for geopolymer pastes which were both cured in laboratory conditions and cured in oven three different curing temperatures. Additionally, ultrasonic pulse velocity values of geopolymer paste samples were obtained. The values obtained from compressive strength tests proved that there is an significant effect of different curing temperatures on mechanical properties of samples. It was also observed that the molarity of NaOH has a considerable effect on compressive strength. Overall results indicated that the mechanical properties of EFS based geopolymer pastes were significantly affected by different molarity of NaOH and curing temperatures.

Keywords - Geopolymer paste, Elazığ ferrochrome slag, compressive strength, UPV

I. INTRODUCTION

In the present case, the traditional Portland cement is a leading building material all over the world with annual production capacity of 4 billion tons and a growth rate of 4% [1]. The amount of this astronomic production leads to many environmental problems such as energy consumption in the production process and high amount of CO_2 released into the environment. Because of the worldwide increase in demand for traditional Portland cement, cement production can represent about 10% of the anthropogenic carbon dioxide which aggravates environmental pollution released in the near future [2].

In order to minimize these problems, the studies have concentrated directly on the usage of an alternative binder material to the cement. As a result of this quest, the usage of geopolymers rich in silicate and aluminate had a high level popularity. Especially in recent years the tendency of people to preserve natural resources has also increased the use of geopolymer materials such as fly ash, granulated blast furnace slag, metakaolin and ferrochrome slag. The chromite deposites, 10% of the world reserves, are processed in Elazığ Ferrochrome Factory in Eastern of Turkey. Elazığ Ferrochrome slag (EFS) as a by-product of the factory is produced about 50.000 tons in a year. Because the storage of this by-product is a serious problem, the evaluation of this waste material in building applications is very important. Therefore, this paper aimed to examine the effect of different curing conditions and NaOH solution concentration on the mechanical properties of EFS based geopolymer pastes.

II. MATERIALS AND METHODS

EFS was obtained from Elazığ Ferrochrome Factory in Eastern of Turkey and ground as fine as cement. EFS was ground to less than 45 µm particle size in order to increase the reactivity. The chemical composition of EFS is presented in Table 1. Sodium hydroxide (NaOH) was selected as the alkaline activator used for geopolymerization with its different concentrations (8, 10, 12, 14 and 16M). Optimum water/solid ratio was determined as 0.28, experimentally. Compressive strengths were tested in accordance with the ASTM C109 standard and ultrasonic pulse velocity (UPV) values were obtained according to ASTM C597.

Comp.	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3
EFS	33.80	25.48	0.61	1.10	35.88	2.12

Table1: The chemical composition of EFS, (% wt)

III. RESULTS AND DISCUSSION

3.1. Compressive Strength

3, 7 and 28-day compressive strength of geopolymer paste samples at different concenrations and curing

conditions are tabulated in Table 2 and presented in Figs. 1-3. The results showed that the compressive strength increased progressively from 3 days to 28 days curing period [3]. Compared to other samples, increase in compressive strength from 3 to 28 days of 16MLAB is higher. It was observed that the samples cured at 100°C resulted in better geopolymerization and that the compressive strength values were higher for this reason.

As clearly seen Figs 11-3. compressive strengths did not appear to increase with the temperature increase above 100 °C. Results obtained indicated that high heat process leads to crack propagation because of shrinkage especially at the 150°C. Therefore, curing at 100 °C is found to be more efficient than curing at 150 °C [4]. Test results also showed that maximum compressive strength was obtained from 16M100 samples cured at 100 °C. Generally, the increase of the molarity of NaOH has increased the compressive strength in accordance with previous studies [5, 6]. The reason of this situation can be explained by high alkalinity matrix resulting from the increase of NaOH concentration as stated by Ryu et al. [7].

	Mix ID	Curing conditions	Compressive strength (MPa)		
			3-day	7-day	28-day
8M	8MLAB	Lab. Cond.	0	1,17	5,67
	8M50	50°C	4,87	5,92	6,17
	8M100	100 °C	12,08	17,91	18,83
	8M150	150 °C	9,8	14,73	12,32
10M	10MLAB	Lab. Cond.	0,8	1,72	8,5
	10M50	50°C	5,26	6,8	6,9
	10M100	100 °C	14,3	22,3	20,2
	10M150	150 °C	13,6	16,6	18,5
12M	12MLAB	Lab. Cond.	1,54	3,71	14,36
	12M50	50°C	5,1	7,3	8
	12M100	100 °C	20,1	23,2	30,2
	12M150	150 °C	10,6	25,2	20,49
14M	14MLAB	Lab. Cond.	1,98	4,77	16,23
	14M50	50°C	6,1	6,2	7,6
	14M100	100 °C	25,5	23,9	27,1
	14M150	150 °C	23,6	20,51	16,5
16M	16MLAB	Lab. Cond.	2,63	5,02	18,43
	16M50	50°C	10,6	11,6	11,9
	16M100	100 °C	27,1	34,17	38,5
	16M150	150 °C	18	13,5	16,7

Table 2. Compressive Strength Values of Geopolymer Paste Sampes

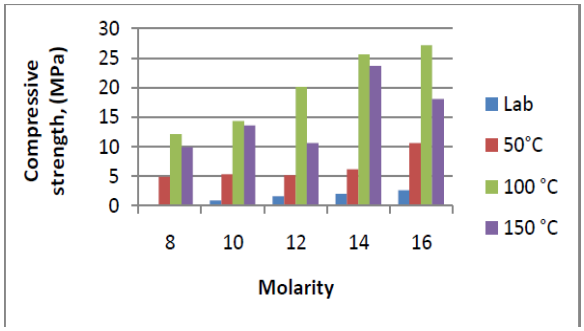


Fig.1. 3-day compressive strength of geopolymer paste samples

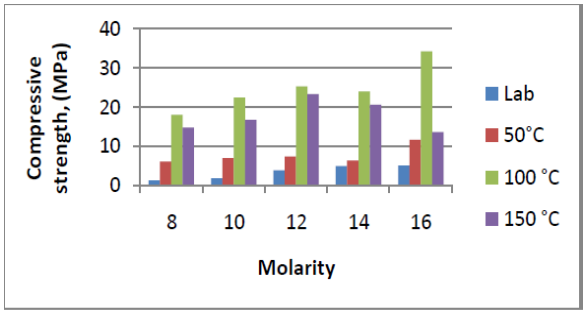


Fig.2. 7-day compressive strength of geopolymer paste samples

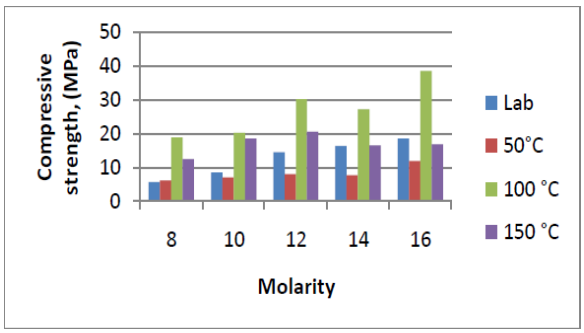


Fig.3. 28-day compressive strength of geopolymer paste samples

3.2. Ultrasonic Pulse Velocity

UPV values are given in Fig. 4. As can be seen clearly, maximum UPV value was obtained from 16M100 sample which have highest compressive strength. Likewise, minimum UPV values were obtained from 8MLAB samples which have lowest compressive strength values. All parameters that increase the compressive strength have also increased UPV values[8].

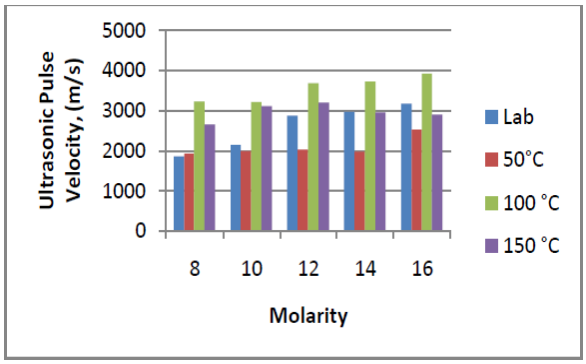


Fig.4. UPV values of geopolymer paste samples

CONCLUSIONS

The objective of the present work is to investigate effect of different NaOH concentrations and curing conditions on mechanical properties geopolymer pastes produced from Elazığ ferrochrome slag (EFS). The experimental study led to the following conclusions:

1. Optimum curing temperature and NaOH concentration in the production of geopolymer pastes produced using EFS is 100°C and 16M, respectively.
2. Increase in NaOH concentration brings about increase of compressive strength of all samples. The reason of this circumstance can be caused by high alkalinity matrix resulting from the increase of NaOH concentration.

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