EFFECT OF NAOH CONCENTRATIONS AND CURING TEMPERATURES ON MECHANICAL PROPERTIES OF GEOPOLYMER PASTES PRODUCED FROM FLY ASH AND ELAZIĞ FERROCHROME SLAG

[1]İBRAHIM TÜRKMEN, [2]MEHMET BURHAN KARAKOÇ, [3]FATİH KANTARCI, [4] ENES EKİNCİ

[1,2,3,4]Civil Engineering Department, İnönü University, Malatya, Turkey
E-mail: [1]ibrahim.turkmen@inonu.edu.tr, [2]mehmet.karakoc@inonu.edu.tr, [3]fatih.kantarci@inonu.edu.tr, [4]enes.ekinci@inonu.edu.tr

Abstract - The effective researches are required for the purpose of minimize environmental pollution due to accumulation of industrial wastes such as fly ash (FA) and ferrochrome slag. The disposal, removal and storage of by-products which are produced apart from the main product is a big problem. In this experimental study, it was attempted to investigate effect of different NaOH concentrations and curing temperatures on mechanical properties of FA and Elazığ ferrochrome slag (EFS) based geopolymer pastes. FA was obtained from Iskenderun Iron & Steel Plant and EFS was obtained from Elazığ Ferrochrome Plant. The raw materials were mixed at equal rate (50%). Liquid/binder ratio was determined as 0.36 experimentally. NaOH concentration were selected as 8, 10, 12, 14 and 16M. After casting, all samples were cured at 50, 100, 150°C and laboratory conditions for 72h. For each sample produced using this different parameters, 3, 7 and 28-day compressive strengths were tested. In addition, ultrasonic pulse velocity (UPV) values were obtained. When considering compressive strength results, it was observed that obtained values increased from 0 to 82.5MPa with increasing concentration and curing temperatures. Overall results indicated that different NaOH concentration and curing temperatures have a huge impact on compressive strength and UPV values of geopolymer pastes. The experimental findings have also showed that the usage of FA and EFS together as an alternative binding material was advantaged.

Keywords - Geopolymer paste, fly ash, ferrochrome slag, compressive strength

I. INTRODUCTION

Since the late seventies of the 20th century geopolymers have been considered for replacing traditional structural materials by reason of their excellent properties and high performance [1,2]. During the last decade, increased research efforts have been directed to this area due to the wide range of potential applications of these materials besides civil engineering in many other branches of industry [3]. The chromite deposits located in Elazığ (Turkey) are 10% of the world reserves. These deposits are processed in Elazığ ferrochrome plant. In addition to main product, many by-products are generated in the plant. The disposal, removal, and storage of by-products are serious problem. One of these by-products is Elazığ Ferrochrome Slag (EFS). Fly ash (FA), generated during the combustion of coal for energy production, is an industrial by-product which is recognized as an environmental pollutant. If these waste materials, are used as a binder instead of cement in cement technology, industrial and air pollution will be reduced. Moreover, the energy saving will be achieved by decreasing the demand for cement.

In this experimental study, effect of different NaOH concentrations and curing temperatures on mechanical properties of FA and EFS based geopolymer pastes were investigated. NaOH concentration were selected as 8, 10, 12, 14 and 16M. After casting, samples were cured at 50, 100, 150°C and laboratory conditions for 72h. It was observed that compressive strength of geopolymer pastes samples increased from 0 to 82.5MPa after changing activator concentrations and curing temperatures.

II. MATERIALS AND METHODS

The raw materials used in this research were EFS and FA. EFS obtained from Elazığ Ferrochrome plant and FA was obtained from Iskenderun Iron & Steel Plant. The chemical composition of EFS and FA are given in Table 1. The raw materials were ground as fine as cement. The raw materials were mixed at equal rate (50%). Liquid/binder ratio was determined as 0.36 experimentally. Sodium Hydroxide (NaOH) was used as alkaline activator in producing geopolymer pastes. NaOH concentration were selected as 8, 10, 12, 14 and 16M. After casting, all samples were cured at 50, 100, 150°C and laboratory conditions for 72h. For each sample produced using this different parameters, 3, 7 and 28-day compressive strengths were testedin accordance with the ASTM C109 standard. In addition, ultrasonic pulse velocity (UPV) values were determined according to ASTM C597.

Com. (%)	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3	Na_2O	LOI
EFS	33.80	25.48	0.61	1.10	35.88	2.12	-	0.90
FA	63.04	21.63	6.77	1.07	-	-	2.79	2.6

Table 1. Chemical composition of EFS and FA, (% 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 2and presented in Figs. 1-3.

Molarity	Curing Condition	Compressive Strength,			UPV, (m/s)
		3-day	7-day	28-day	
8M	Lab.	0,37	1,56	10,75	2670
	50°C	19,27	20,85	22,4	3220
	100 °C	32,15	27	29,2	3725
	150 °C	38,1	22,95	24,9	3273
10M	Lab.	1,2	2,35	13,4	2735
	50°C	22,57	21,64	23,47	3260
	100 °C	35,27	29,15	27,1	3570
	150 °C	41,15	32,05	36,23	3870
12M	Lab.	1,97	4,25	18,9	3155
	50°C	27,53	26,27	21,9	3240
	100 °C	43,6	34,45	33,8	3800
	150 °C	54,8	46,15	40,4	3966
14M	Lab.	2,38	6,24	21,36	3271
	50°C	29,1	33,35	39,1	3970
	100 °C	54,3	59,7	42,6	4037
	150 °C	50,4	53,8	58,3	4230
16M	Lab.	3,47	8,91	26,75	3479
	50°C	32,65	35,67	37,45	3948
	100 °C	67,65	82,5	80,8	4469
	150 °C	65	55,6	60,2	4208

Table 2. 3, 7 and 28-day compressive strengths and UPV values of geopolymer paste samples

As seen in Figs. 1-3, there was an enormous increase in compressive strength of geopolymer paste samples with changing activator concentrations and curing conditions. In all age groups, maximum compressive strength was obtained from the samples cured at 100°C and having 16M activator concentrations. Minimum compressive strength was obtained in laboratory conditions in all age groups. In 3-day samples, maximum compressive strength was obtained from was 100°C curing condition and 16M concentrations with 67.65 MPa. At low concentrations values (8, 10, 12M), curing temperatures at 150°C was optimum. However, at higher concentrations values (14, 16M), maximum compressive strength was obtained at 100°C. In all concentrations, minimum compressive strength was obtained at laboratory conditions. Increase in curing temperature and activator concentrations affected compressive strength of geopolymer paste samples positively in 3 days age group.

In 7-day samples, maximum compressive strength was obtained at 100°C curing condition and 16M concentration with 82.5 MPa and this compressive strength was the highest value obtained in this research. Minimum compressive strength was obtained from samples cured under laboratory condition.

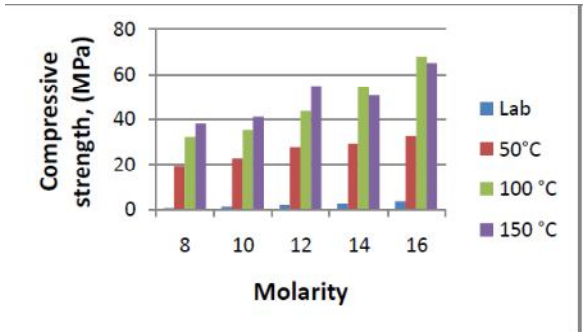


Fig.1. 3-day compressive strength of geopolymer paste samples

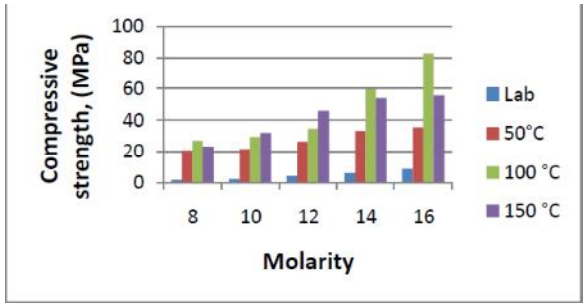


Fig.2. 7-day compressive strength of geopolymer paste samples

In 28-day samples, there was a significant increase in compressive strength of paste samples cured at laboratory conditions compared to 3 and 7-day values. This may be due to positive effect of thermal curing on reaction kinetics of pastes samples. It was observed that there was not important increase or decrease in 28-day compressive strength of samples cured at different temperatures compared to 3 and 7-day samples. Compressive strength findings based on experimental study results are confirmed by several studies [3-5].

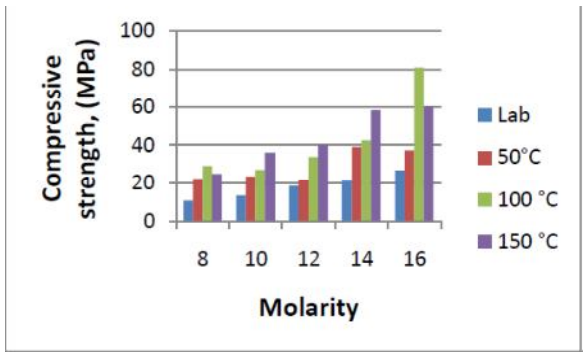


Fig.3. 28-day compressive strength of geopolymer paste samples

3.2. Ultrasonic Pulse Velocity

UPV values of geopolymer paste samples are given in Table 2 and Fig 4. Maximum UPV value was obtained from samples cured at 100°C and having 16M concentration as seen in compressive strength

results. UPC values showed that there was a close relationship between compressive strength and UPV.

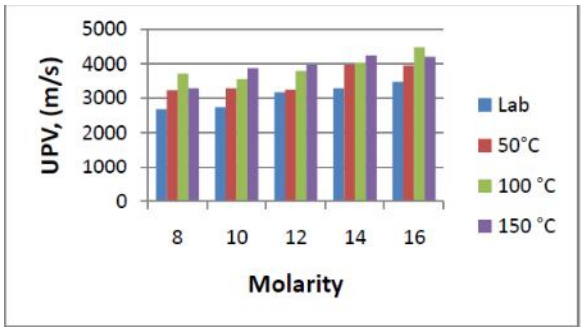


Fig.4. UPV values of geopolymer paste samples

CONCLUSIONS

This paper presents an experimental study conducted on effect of different NaOH concentrations and curing temperatures on mechanical properties of FA and Elazığ ferrochrome slag (EFS) based geopolymer pastes. The following conclusions may be derived from the experimental results:

1. In all age groups, maximum compressive strength was obtained from the samples with 100°C curing temperature and 16M activator concentrations.
2. Compressive strength of geopolymer pastes samples increased from 0 to 82.5MPa after changing activator concentrations and curing temperatures.

ACKNOWLEDGMENTS

The authors are grateful to the Inonu University for their financial support for these projects (2016/96 and 2017/818).

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