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Makale
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Effect of Thermal Curing Processes on The Properties of Geopolymer Paste

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Abstract
Today, the usage of geopolymer material with the developing technology was investigated at many studies and research. Solid alumino silicates in the production of geopolymer material were treatment together with some alkaline activators and thereby with cure processes applied to produced materials it provided strength gain a short time and quickly. Therefore, in the synthesis of geopolymer material were known to be use of pozzolans which have rich with alumina and silica. The subject of this study is to production of the geopolymer paste with usage of some alkaline activators together with fly ash (FA) which has pozzolanic properties. In accordance with different thermal curing time for the production of geopolymer paste will be done usage of pozzolans such as FA and with alkaline activators such as sodium silicate solution (water glass (SS)) and NaOH. The samples were prepared with 2.5 cm x 5 cm sizes by hydraulic manual press with 60 bars pressure. The curing processes are applied to the samples are affected the ultimate strengths in the geopolymer material synthesis. Therefore, the oven curing method as thermal curing (at certain temperature, such as 85 °C) was applied for three different curing times such as 2h, 5h and 24 h. After thermal curing processes the samples were stored 7 days, which physical and mechanical tests were done, in the laboratory environment. The end of this study; physical properties such as apparent porosity, water absorption, bulk density and apparent density with compressive strengths were determined for the geopolymer pastes.
Keywords : Geopolymer, Fly Ash, NaOH, Sodium Silicate Solution, Paste

1. INTRODUCTION

The geopolymer process is not a sintering or melting process, but a polymerization process. Geopolymer especially occurs with the formation of covalent complex polymer chains, as a result of polycondensation between the monomers containing mineral molecules such as Si-Al-Mg-Ca-P-K-Na.

Geopolymers, hydrosodalite and polisialats are alumino silicate soil materials which have the hexagonal three dimensional molecular alignment. They reach a grain structure similar to zeolite rocks by releasing the water which they contain by both chemical and physical means (dehydratation + dehydration) as a result of hydrothermal polycondensation. However, unlike zeolite crystals, they have an amorphous three-dimensional hexagonal molecular bond structure.

The geopolymerization process begins with the reaction of alkali silicate and alkali salts at low temperatures, with industrial waste such as fly ash, coal slag, blast furnace slag, silica fume, or volcanic tuff, crushed natural metamorphic rocks or soil solids with a structure of alumino-silicate such as kaolinite clay which are subjected to dehydration metakaolinite) heated at 750 ºC. Whether the end products will satisfy the physical qualities for their intended use depends on the molecular structure which varies according to raw material composition, mixture and reaction of the related chemicals at necessary molar rates, the applied thermal cure temperature or calcination temperature and time. Geopolymerization

is an exothermic chemical process involving the dissolution, transportation, orientation and polycondensation of molecules in a highly alkaline environment [1].

It is reported that Class F fly ash is a good source and that NaOH is an effective activator for the activation of fly ash in the production of geopolymer. It is also pointed out that a higher compressive strength can be achieved with the use of a combination of Sodium silicate solution and NaOH in samples [2]. The reason behind this is the fact that the water glass used will increase the reaction products with Si during geopolymerization and then bring in more mechanical strength [3]. Hence, studies in which fly ash is used in the production of geopolymer can be found in the literature [4-8]. In this study, fly ash-based geopolymer paste production was carried out under a certain pressure and variations in the samples depending on the applied curing time were examined.

2.MATERIAL AND METHOD

2.1. Materials

Fly ash obtained from Kütahya Seyitömer Thermal Power Plant was used in the preparation of the samples. The laser particle size analysis is given in Figure 1 and the chemical properties are given in Table 1. According to chemical analyses, class F fly ash was used in the study [9].

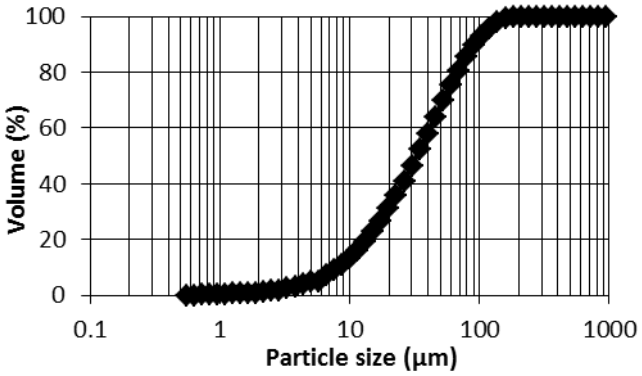

Figure 1. Laser particle size analysis of the fly ash.

NaOH and SS were used as alkaline activators in the preparation of the geopolymer paste samples, and their properties are presented in Table 2.

Table 1. Chemical composition of the fly ash.

Composition	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	SO_3	CaO	LOI	Total
%	48.90	19.63	11.56	4.31	0.73	2.06	1.65	6.06	2.32	97.22

Table 2. Chemical materials and their properties.

Sodium Silicate Solution (SS) (Water glass)	**Sodium Hydroxide (NaOH)**
Na_2O : 7.5 – 8.5 %, SiO_2 : 25.5 – 28.5 %	M: 40 g/mol
Density (20 °C) 1.296 – 1.396 g/ml, Fe ≤ 0.005 %	NaOH ≥ 97,0
Heavy metals: (as Pb) ≤ 0.005 % [10]	

2.2. Method

9M NaOH solution was prepared 24 hours prior to the production of the samples. NaOH/SS liquid ratio was established as 0.5 during the preparation of the pastes. Then a mixture was prepared using 180 g of UK and 80 ml of liquid during the preparation of the geopolymer pastes. Afterwards, cylindrical samples

in 2.5 x 5 cm size were prepared using a laboratory-type hydraulic hand press at 60 bar of pressure. Finally, the samples were subjected to thermal curing processes at 85 ^{o}C for 2, 5 and 24 h.

After the completion of the thermal curing, the samples were stored in the laboratory environment until the day of the tests. 7-day geopolymer pastes were used in the tests. The mean values of three samples from each of the sample groups were taken for the physical tests and the compressive strength tests. The apparent porosity, unit weight and apparent density values of the samples were determined according to TS EN 772-4 [11] and their water absorption values were determined according to TS EN 771-1 [12]. The mechanical properties of the geopolymer pastes were determined according to TS EN 196-1 [13].

3. RESULTS

According to the data obtained from the geopolymer pastes, the porosity and water absorption values of the samples decreased with an increase in the curing time. The porosity values of the samples varied between 42.3% and 44.1% (Fig. 2). The water absorption rates obtained from the samples decreased with an increase in the curing time, just as the porosity rates. The water absorption rates varied between 35.6% and 38.7% (Fig. 3).

Fig. 3 shows the density values of the geopolymer paste samples. The unit weight and apparent density values of the samples peaked at the end of the 24-hour curing times. Although the values obtained from the samples cured for 2 and 5h were close to each other, the lowest intensity values were obtained from the samples cured for 5h. The unit weight and apparent density values of the geopolymer pastes were 1135.6 – 1186.6 kg/m^3 and 2014.7 – 2056.5 kg/m^3, respectively.

The compressive strength values of the geopolymer pastes varied between 9.7 and 15.9 MPa (Fig. 4). Fig. 4 indicates that the 2 and 24h curing processes of the geopolymer pastes revealed similar strength gains while the 5h curing process elicited the highest strength gain.

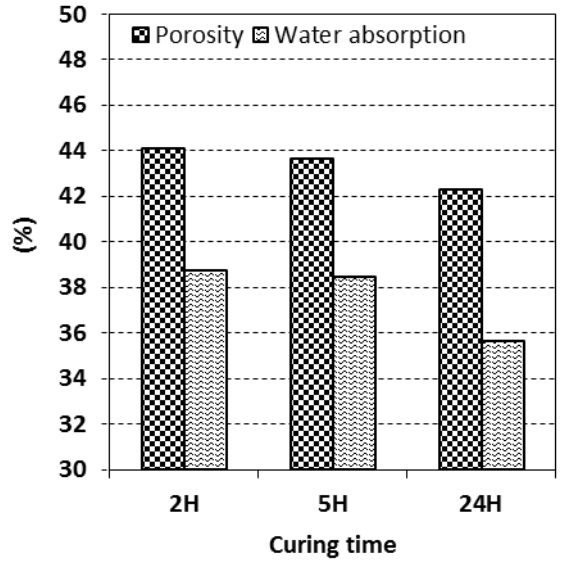

Figure 2. Porosity and water absorption rates of the geopolymer pastes.

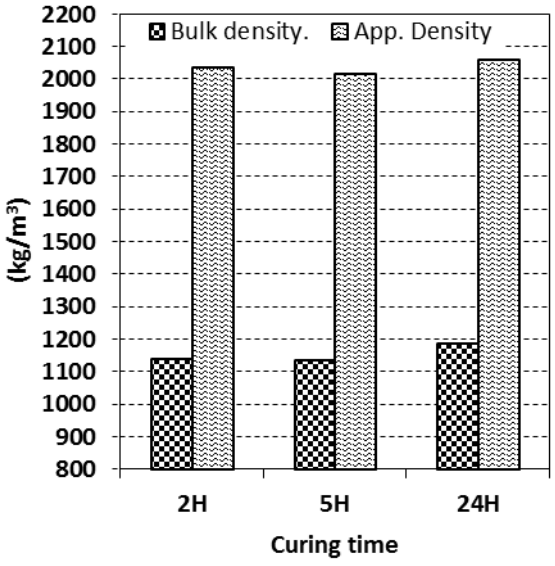

Figure 3. The density values of the geopolymer pastes.

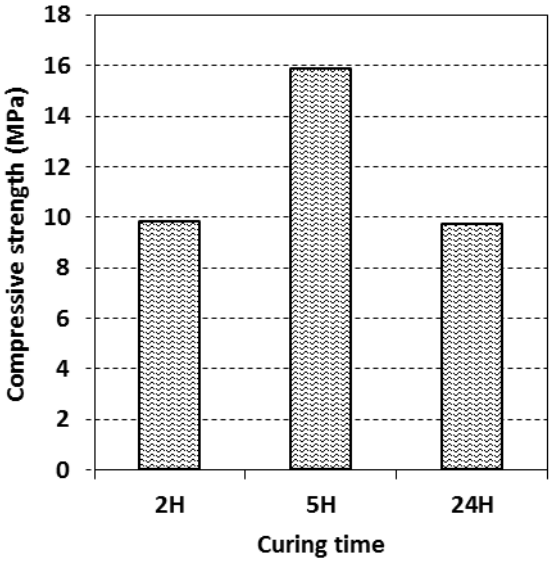

Figure 4. The compressive strength values of the geopolymer pastes

4. DISCUSSION

Curing time and temperature are important factors which affect compressive strength as well as materials used in geopolymers [14]. However, it is also stated that when sodium silicate solution and NaOH are used in combination, they contribute to the strength of the samples at an early age, while they do not have a significant effect during long periods [2]. The geopolymer pastes produced in this study also revealed similar results and a 5h curing time was found to give the best results in terms of compressive strength values.

In light of all the data, in terms of material properties and compressive strength, a 5h curing time was determined to be the ideal thermal curing time at different curing times for geopolymer pastes activated with 9M NaOH and shaped at 60 bar of pressure.

ACKNOWLEDGEMENTS

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5. KAYNAKLAR

1. Zeybek, O., 2009, "Uçucu Kül Esaslı Geopolimer Tuğla Üretimi", Yüksek Lisans Tezi, İnş. Müh. A.B.D., Anadolu Üniversitesi, Fen Bilimleri Enstitüsü.

2. Fernandez-Jimenez, A., Palomo, J. G., Puertas, F., 1999, "Alkali-activated slag mortars: Mechanical strength behaviour", Cement and Concrete Research, 29, 1313-1321.

3. Criado M, Palomo A, Fernandez-Jimenez A. Alkali activation of fly ashes. Part 1: Effect of curing conditions on the carbonation of the reaction products. Fuel 2005;84:2048–54.

4. Li, Q., Xu, H., Li, F., Li, P., Shen, L., Zhai, J., 2012, Synthesis of geopolymer composites from blends of CFBC fly and bottom ashes, Fuel 97 (2012) 366–372

5. Swanepoel, J. C., Strydom,C. A., "Utilisation of fly ash in a geopolymeric material", Applied Geochemistry, 17, 1143-1148.

6. Wu, H. C., Sun, P., 2007, New building materials from fly ash-based lightweight inorganic polymer, Construction and Building Materials 21 (2007) 211–217

7. Provis, J. L., Yong, C. Z., Duxson, P., van Deventer, J. S. J., Correlating mechanical and thermal properties of sodium silicate-fly ash geopolymers, Colloids and Surfaces A: Physicochem. Eng. Aspects 336 (2009) 57–63

8. Van Jaarsveld, J. G. S., van Deventer, J. S. J., Lukey, G. C., The characterisation of source materials in fly ash-based geopolymers, Materials Letters 57 (2003) 1272–1280.

9. ASTM C 618, 2000, Standart Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete, Annual Book of ASTM Standart, No. 04.02.

10. http://erenkimya.com, 03.05.2013

11. TS EN 772-4, 2000, "Methods of test for masonry units – Part 4: Determination of real and bulk density and of total and open porosity for natural stone masonry units",TSE, Ankara-Turkey.

12. TS EN 771-1, 2005, "Specification for masonry units – Part 1: Clay masonry units",TSE, Ankara-Turkey.

13. TS EN 196-1, 2002, "Methods of testing cement – Part 1: Determination of strength",TSE, Ankara – Turkey.