Effect of Varying Concentration of NaOH on Geopolymer Concrete

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Abstract- *Various experiments were conducted on infusing of fly ash mixed with NaOH solution and on mixing procedure for preparing geopolymer. Infusing of SiO2 and Al2O3 was investigated by mixing fly ash with NaOH solution for different time intervals and leachates were analyzed in terms of silica and alumina contents. In the separate mixing process of mortar, sodium hydroxide solution is mixed with fly ash for the first 10 min; after that sodium silicate solution is added into the mortar or concrete mixture. In normal mixing, fly ash, NaOH and sodium silicate solutions were fused and mixed at the same time. The geopolymers are cured at 65 C for 48 h. The experimental results have proven that the solubility of fly ash depends on concentration of sodium hydroxide and also duration of mixing with NaOH. For the mixing procedure, separate mixing will give slightly better strength for mortar than normal mixing. Comparatively High strength geopolymer mortar mix of 70 to 75 MPa is obtained when the mixture is formed by using 10 M NaOH.*

Keywords: Infusing Waste processing, Industrial minerals Cementation

1. INTRODUCTION

Portland cement is generally replaced by industrial waste Fly Ash for making concrete. However, it can only partially replace Portland cement since SiO_2 and Al_2O_3 in fly ash still need $Ca(OH)_2$ from Portland cement hydration for its pozzolanic reaction to pro-duce calcium silicate hydrate and calcium aluminate hydrate. Recently, another form of cementitious materials called geopolymer has been developed. This geopolymer is usually made of fly ash activated with alkaline solution at low temperature and it is sometimes called alkaliactivated fly ash. Geopolymers having good mechanical properties like, very high compressive strength and stability at temperature up to 1300–1500 C can be synthesized at comparatively low temperature using similar techniques to that of zeolites. Geopolymerization is based on alumino-silica chain. Industrial Fly Ash generally contains high amount of amorphous silica and alumina, hence it is used as a source material for making geopolymer. Industrial Fly Ash is mostly mixed with alkali solution to get alumina and silica precursors. When it comes into contact with alkali solution, dissolution of silicate species starts the dissolution of fly ash is affected by the type and concentration of used alkali solution. Leaching of Al^{3+} and Si^{4+} ions are generally high with sodium hydroxide solution compared to potassium hydroxide solution (Van Jaarsveld and Van Deventer, 1999; Xu and Van Deventer; 1999). Hence, alkali concentration proves to be a significant factor in controlling the infusing of alumina and silica with fly ash particles, also the geopolymerization and mechanical properties of hardened geopolymer.

The varios studies are carried out to investigate alumina and silica in the form of Al^{3+} and Si^{4+} ions infused out from the fly ash particles after mixing with sodium hydroxide at different alkali concentrations and leaching times before forming geopolymer with silicate solution. The mixing procedures is also being investigated by the authorities. The knowledge will be able to help understand the reaction and strength development of geopolymer and to better utilize it in the future.

2. LITERATURE REVIEW

[1] Sir Chindaprasirt (2006) use of fly ash in concrete increases its ultimate compressive strength.. But still, when high amount of fly ash replacement is used (50 to 55 %), the compressive strength of concrete will start to decrease. Industrial Fly Ash have effect on compressive strength of concrete due to a process known as the close packing of tiny fly ash particles. Physical properties of industrial fly ash such as uniformity, sphericity and fineness of particles influences the effects on rapid packing of concrete. Because of these physical properties of fly ash, most of the voids or airspaces will be filled with tiny particles which will increase the density of concrete. Along with this, pozzolanic reaction improves which will result in increasing the compressive strength.

[2] Xiaolu Guo et al. (2013) investigated the effectiveness of using geopolymers based on class C fly ash to self-solidify heavy industrial metal wastes. The formulated leaching concentrations of all the heavy metals in geopolymers are much lower than the maximum concentration limits applied.

[3] Wang et al. (2005) have proven experimentally that the compressive strength, along with the apparent density and content of the amorphous phase of metakaolinite-based geopolymer, increase with the increase in amount NaOH concentration within the range 4–15 mol/L. Main cause of this is the effective dissolution of the metakaolinite particulates and hence the accelerated condensation of the used monomers in the clear presence of higher sodium hydroxide concentrations.

[4] Prakash R. Vora . (2012) The universal demand of concrete is soaring day by day for satisfying the need of development of infrastructure facilities. It is very well known fact that the production of Ordinary Portland Cement not only consumes much high amount of natural resources and energy but also releases substantially large quantity of carbon dioxide to the atmosphere. Hence, it is very essential to find alternatives to make the concrete environment friendly. Geopolymer is an inorganic alumino-silicate compound, infused with industrial waste fly ash.

3. MATERIALS AND METHODS

3.1 Materials

Fly ash from the local store in Pune with a mean particle size of 19 lm, NaOH and sodium silicate solu- tion (water glass) with SiO2:Na2O weight ratio of 3.2, NaOH is abtained by dissolving Sodium hydroxide pellet (AR grade) in deionized water Polyethylene containers to avoid silica contamination. River sand passing No. 16 sieve (1.18 mm opening) and retaining on No. 100 sieve (150 lm opening) with fineness modulus of 2.8 and specific gravity of 2.65 for making mortar specimen.

3.2 Infusing test of fly ash

Three NaOH concentrations of 5, 10, and 15 M with fly ash/NaOH ratio of 3:1 by weight will be used to dissolve silica and alumina from fly ash particles. Fly ash will be mixed with NaOH solution in a mixer at 120 rpm for 5, 10, 20, and 30 min. Longer period of time (more than 30 min) will not be performed since the mixture would become very sticky with formations of Si(OH)4 and Al(OH)3 gel.

3.3 Geopolymer paste

To allow leaching of ions mix fly ash with solution separately for 10 minutes.Add Sodium silicate solution then to the mixture and mix for 1 min. Only short mixing time is required here since the mixes are relatively fluid.

3.4 Geopolymer mortar

Add sand to make mortar to paste mixture at sand to fly ash ratio by weight of 2.75 and mix for one more minute. The mixture will be cast into 50 mm cubic mould and wrapped with cling-film to avoid moisture evaporation during heat curing. Samples will then be cured in oven at 65 C for 48 h to complete geopolymer-ization reaction.

4. TESTING AND DISCUSSION

4.1 Compressive strength

The compressive strength is tested in two ways i.e.cube strength and split cylinder test. According to various experiments use of 10M and 15M NaOH solutions give high values compared to low concentration 5 M NaOH geopolymer mix. For high concentrations of 10 M and 14 M NaOH mixes, the effects were not highly considerable. The obtained strengths of 5 M sodium hydroxide geopolymer with low G/N of 0.5 and 1.0 were only 13.0 and 22.0 MPa, compared to the strengths of 10 M and 15 M NaOH geopolymer were much higher at around 62 MPa. For comparatively high G to N ratio of 1.4 and 2.5, the strengths of 5M NaOH geopolymer were much better at slightly less than 56.0 MPa compared to 62.0–68.0 MPa of 10 M and 15 M NaOH geopolymer concrete mortars.

4.2 Setting time

The Setting of concrete is defined as the on-set of rigidity in fresh concrete. Although, the specific events are defined, i.e. initial and final setting. Ordinary Portland cement is the principal active ingredient in concrete that causes setting. Industrial fly ash generally has a tendency to retard the time of setting of cement relative to similar concrete made without fly ash. .

4.3 Workability and requirement of water

The requirement of water for constant workability is generally lower for fly ash containing mixtures, but the amount of water reduction varies among fly ashes. For various conventional replacement levels, Class C fly ashes tend to affect greater water reduction than the Class F fly ashes.

4.4 Curing

Various experimental strength-development studies show that the concrete containing fly ash require much longer moist curing than pure cement concrete.

4.5 Physical characteristics

Various physical characteristics of fly ash like particle shape and size, fineness, density and colour mainly depend on the type of collection system and the combusting temperature of the used pulverised coal. The main physical properties of fly ash have a great influence on the performance of fresh concrete such as workability, segregation, bleeding etc. The fineness modulus of the fly ash influences pozzolanic activity and workability of concrete. From various experiments it is observed that the fineness modulus of fly ash is the most significant parameter influencing the suitability of fly ash for the applications in concrete.

4.6 Data required for concrete mix design :

I. Concrete ingredient data

a. Specific gravity of cement used: 3.10
b. Specific gravity of fine aggregate (FA): 2.52
c. Specific gravity of coarse aggregate (CA): 2.71

II. Data required for concrete

a.Characteristic compressive strength at 28-day grade designation: M20
b. Nominal size of aggregates (maximum): 20 mm
c. Shape of coarse aggregate used: Circular
d. Workability requirement (slump): 40-70 mm
e. Quality control checking : as per IS:456
f. Environmental exposure: Mild (as per IS: 456)
g. Type of cement: OPC grade 43
h. Method of concrete placing: by hand

5. CONCLUSIONS

The collective results of the study of various experiments shows an satisfying construction material industrial waste, which entire that the flyash based geopolymer can be used instead of cement mortar, and the properties of the geopolymer with similar to that of the cement mortar.

The amount of leaching was dependent on NaOH concentration and leaching time. The results indicated that leaching time of 5–10 min was sufficient. The mixing of fly ash with 10 M NaOH for 10 min was, therefore, appropriate for synthesis of geopolymer when economy and practicality were taken into consideration.

Geopolymer concrete with high molarity mix of NaOH solution shows high strength compared to low molarity solution mix.

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