

Influence of Synthesizing Parameters on the Compressive Strength of Geo-Polymer Mortar

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Abstract

In the present investigation, the effect of various synthesizing parameters on the compressive strength of geo-polymer mortar is studied. Geo-polymer mortar is prepared with locally available fly ash, river sand and alkaline activators. The different parameters that are considered in the study are the molarity of Sodium hydroxide solution, the ratio of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ solution by weight, curing time and curing temperature. The experimental results revealed that compressive strength of mortar is increasing as the concentration of NaOH, curing temperature, curing time increases. Also as the ratio of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ solution by weight increases the compressive strength increases, however beyond certain stage the strength is decreasing with the increasing the value of this ratio.

Introduction

PC manufacture is significantly contributing to the green house effect. About 5% of global CO_2 emission are resulting from every ton of PC generated (Nuruddin et al. 2010). Annually about 1.35 billion tonnes of greenhouse gas emissions are resulting from global production of PC (Malhotra 2002; Hardjito et al. 2004). It is predicted that by 2020, CO_2 emissions are likely to increase by about 50% from the existing level (Naik 2005).

On the contrary Geopolymer cement is receiving increasing attention throughout the world not only due to the abundance of fly ash as its raw materials but also because its manufacture is environmentally clean, as it does not directly create CO_2 emission. The annual generation of fly ash is increasing every year whose disposal becoming another problem to environment in the form of air pollution and

contamination like leaching etc. These geopolymer cements, which have unique properties such as high early strength, low shrinkage, sulphate and corrosion resistance could become a viable alternative to conventional cement and hence substantially reduce CO_2 emission caused by the cement and concrete industries.

Materials and Methods

Fly ash: In the present study the materials are class fly ash, sand, alkaline activator. Fly ash is collected from locally available source NTPC Visakhapatnam. The physical and chemical properties of fly ash sample are shown in Table.1. Locally available sand is used.

Table.1: Properties of Fly ash (% by mass)

Binder	Sp. Gravity	Fineness(m^2/kg)	Residue on 45μ	$\text{SiO}_2 + \text{Al}_2\text{O}_3 + \text{Fe}_2\text{O}_3$	SiO_2	MgO	SO_3	LOI
Fly ash	1.91	365	30.8	94	60.78	0.94	0.12	0.88

In the preparation of alkaline activator Sodium hydroxide in pellets form with 97%-98% purity is used. Sodium silicate solution with specific gravity of 1.53 is used. The chemical constituents of sodium silicate solution are: Na_2O =13.1%, SiO_2 =28.8% and water 58% by mass.

Mixing, Compaction and Curing

About half an hour before alkaline activator solution is prepared which requires NaOH by mixing the grinded powder of NaOH pellets and sodium silicate solution. Sand and fly ash are mixed well. At this stage alkaline activator which is already prepared shall be added to these materials and mix until uniform mix is obtained. This mix is transferred to 70.6mm cubes and compacted on vibration in order to remove the entrapped air bubbles. The specimens were kept undisturbed for 30 minutes. Then the specimens are covered with plastic film to avoid the loss of water due to evaporation during the curing process. The specimens were cured in hot air oven. After curing, samples were kept in open air at room temperature until they were tested at specified age. The Parameters and their ranges considered in preparing geopolymer mortar are: Molarity of NaOH Solution: 8M to 16 M; $\text{Na}_2\text{SiO}_3/\text{NaOH}$ ratios by weight: 0.9-2.4. Curing temperature: 40°C to 90°C ; Curing Time: 24hrs-96hrs.

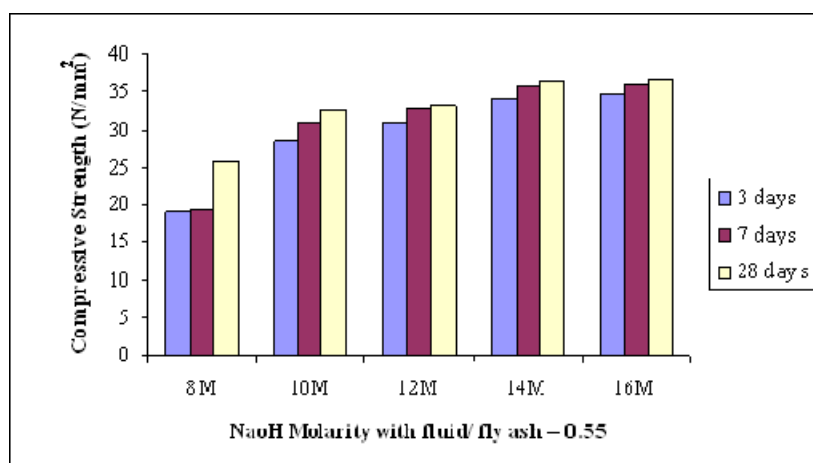
Mix proportions

For all the mixes the sand to fly ash ratio is taken as 1:1. For studying the influence of NaOH molarity, the influence of ratio of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ by weight on the compressive strength of the mortar the ratio of fluid to fly ash was kept constant as 0.55 and 0.5 respectively. The curing temperature in both these cases is maintained at 75°C and 80°C respectively. For studying the influence of curing temperature and curing time a 10M solution is taken for all mixes.

Results and Discussions

With reference to above selected parameters the compressive strength of geopolymer concrete was determined and the results were discussed in graphical form.

Influence of Concentration of NaoH Solution

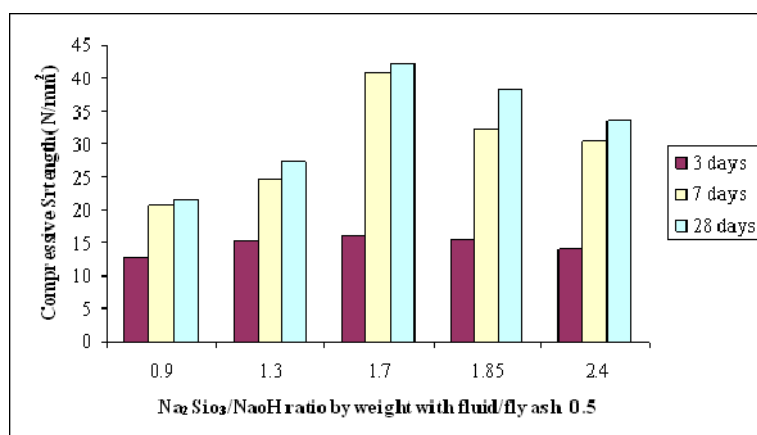


Graph 1: Variation of Compressive Strength with Variation of NaoH Molarity

From the graph it is clear that as the concentration of NaoH increases from 8 M to 16 M, the compressive strength of mortar increases at a constant fluid to fly ash ratio. Also it is observed

that the strength development in geopolymer mortars is faster than Portland cement mortar.

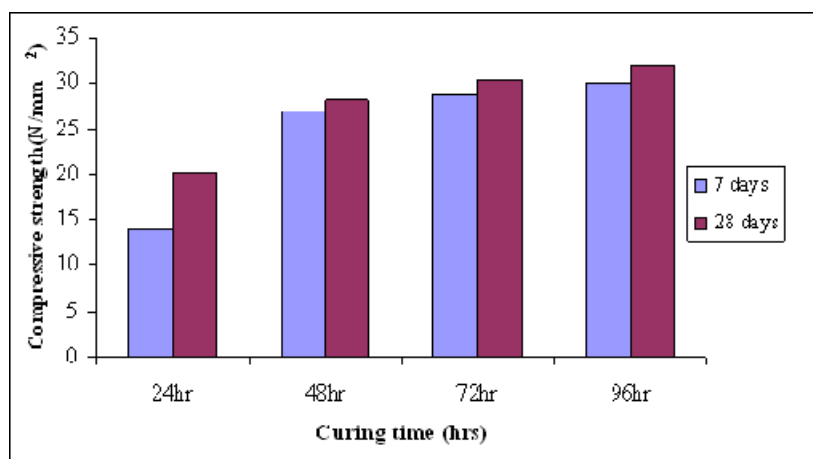
Influence of ratio of Na₂SiO₃/NaoH by weight



Graph 2: Variation of Compressive Strength with variation of ratio of Na₂SiO₃/NaoH

From graph 2 it is evident that the compressive strength of geopolymer mortar increases as the ratio of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ by weight increases from 0.9 to 1.7. After that there is some reduction in the compressive strength of the mortar with the increasing ratio of $\text{Na}_2\text{SiO}_3/\text{NaOH}$ by weight.

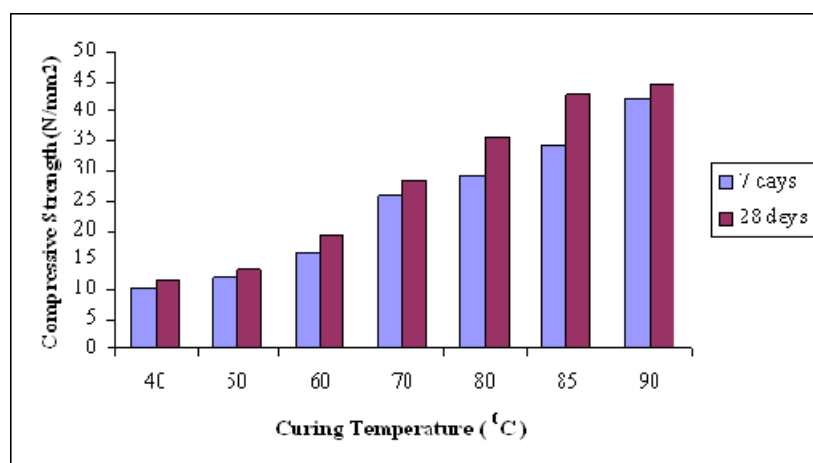
Influence of Curing Time:



Graph 3: Variation of Compressive Strength with variation of Curing Time

From graph 3 it can be concluded that the compressive strength of geopolymer mortar increases as the curing time increases. It is observed that after 48 hours there is no significant improvement in the compressive strength of geopolymer mortar.

Influence of Curing Temperature



Graph 4: Variation of Compressive Strength with variation of Curing Temperature

From graph 4 it is evident that as the curing temperature increases the compressive strength of geopolymer mortar increases. It is also clear from the graph that the optimum temperature for curing the geopolymer mortars is 85°C because of the reason that beyond this temperature there is no significant increase in the compressive strength of geopolymer mortar.

Concluding Remarks

Based on the test results and subsequent discussions, the following conclusions can be made:

- As the Na_2SiO_3 /NaOH ratio by weight increases the Compressive Strength Geopolymer mortar increases for a range of 0.9 to 1.7, however there is some reduction in compressive strength when this ratio is increased beyond 1.7.
- Compressive strength Geopolymer mortar increases with increasing concentration of NaOH Solution
- As the curing temperature increases the compressive strength of geopolymer mortar is increasing.
- It can also be concluded that optimum temperature for curing the geopolymer mortar is 85°C.
- Compressive strength of geopolymer mortar increases as the curing time increases. It can be concluded that after 48 hours there is no significant improvement in the compressive strength of geopolymer mortar.
- Geo-polymer mortar can evolve in to an eco-friendly and sustainable construction material and can be used in the precast- industry.

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