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EFFECT OF DURATION AND TEMPERATURE OF CURING ON COMPRESSIVE STRENGTH OF FLY ASH BASED GEOPOLYMER CONCRETE

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ABSTRACT

The optimum temperature and duration of curing is essential in geopolymerization reaction to achieve higher strength. As such, fly ash based geopolymer concrete were prepared by varying the curing temperature of 60^0, 90^0 and 120°C, for the duration of 6,12,16 and 24 hours. The fly ash was activated by sodium silicate and sodium hydroxide solution with ratio between sodium silicate and alkaline activator was 2.5. The result show that with increase in duration and temperature of curing the compressive strength of fly ash based geopolymer concrete increase.

KEYWORDS: Geopolymer concrete, fly ash, alkaline liquids, duration and temperature of curing, compressive strength

INTRODUCTION

The global use of concrete is second only to water. As demand for concrete as a construction material increases, so also the demand for Portland cement. It is estimated that the production of cement will increase from about from 1.5 billion tons in 1995 to 1.2 billion tons in 2010.On other hand the climate change due to global warming has become a major concern. Several efforts are in progress. The use of Portland cement in concrete in order to address the global warming issue. These include the utilization of supplementary cementing materials such as fly ash, silica flume, granulated slag, rice husk ash and metakoline and the development of alternate binder of Portland cement[2]. In this respect, the geopolymer technique show considerable promising for application in concrete industries as an alternate binder to Portland cement due to high early strength, durability, eco friendly, economy and sustainable development as compared to Ordinary Portland Cement[1].

Geopolymer: Geopolymer are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in a three- dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds[1].

$$M_n\ [-(SiO_2)_z-AlO_2]_n\ .\ wH_2O$$

Where: M = the alkaline element or cation such as potassium, sodium or calcium; the symbol – indicates the presence of a bond, n is the degree of polycondensation or polymerization; z is1,2,3, or higher, up to 32.

The schematic formation of geopolymer material can be shown as described by Equations [1] and [2] ab below.

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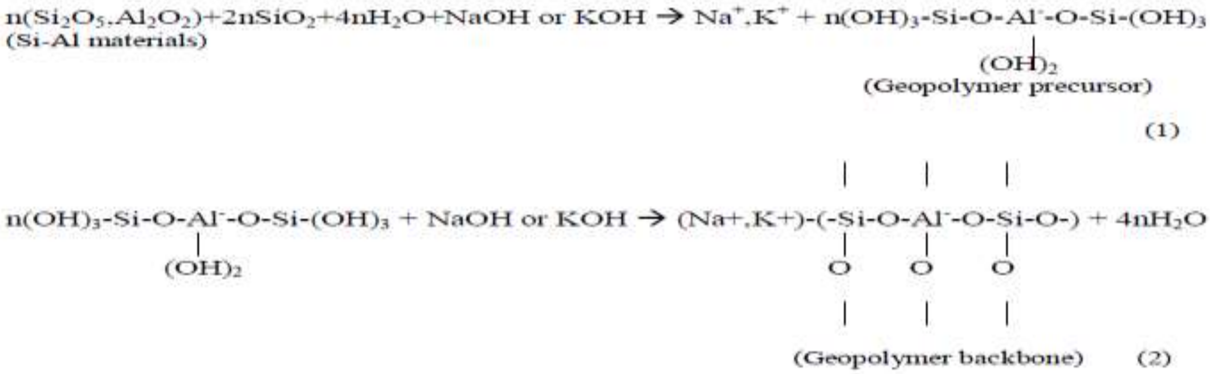

Fig. 1 Schematic formation of geopolymer concrete

MATERIALS AND METHODS

Fly ash : Low calcium fly ash ASTM class F (conforming to IS 3812-1987) specifications is used for casting the specimens. Table 1 shows the chemical composition of fly ash as per IS-3812-1981.

Table 1. composition of fly ash

Composition	Content (% by mass)	Specification as per 3812-1981
SiO_2	55	SiO_2 > 35%
Al_2O_3	22	-
Fe_2O_3	5	Total > 70%
CaO	5-7	-
MgO	3	< 5%
LOI	2	< 12%

Alkaline liquids: The alkaline liquid used for geopolymerisation is a combination of sodium hydroxide (NaOH) and sodium silicate(Na2SiO3). The sodium hydroxide (NaOH) solids were dissolved in water to make the solution. Mass of Sodium Hydroxide solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. Sodium Hydroxide solution with a concentration of 16M consisted of 16x40 = 640 grams of NaOH solids (in flake or pellet form) per litre of the solution, where 40 is the molecular weight of Sodium Hydroxide. Mass of Sodium Hydroxide solids was measured as 480 grams per kg of Sodium Hydroxide solution of 16M concentration. The sodium silicate solution having with Sio_2 to Na_2O ratio by "2" is taken. The sodium silicate and the sodium hydroxide solution were mixed together at least one day prior to use to prepare the alkaline liquid.

Fine aggregate: Good quality river sand was used as a fine aggregate. Locally available sand passed through 4.75mm IS sieve, confirming to zone II with specific gravity 2.74, water absorption 1.0% is used.

Coarse aggregates: Crushed aggregate available from local sources has been used. Coarse aggregate with a maximum size of 20 mm having specific gravity of 2.74, water absorption 0.50%.

Detail of mix proportion:

Table. 2 Mix proportion of geopolymer concrete: (Kg/m^3)

Fly ash	Fine aggregates	Coarse aggregates	Sodium silicate	Sodium hydroxide
381	554	1296	141	30

Mixing of geopolymer concrete: As there is no code provision is available for the mix-design of geopolymer concrete. The density of geopolymer concrete assumed as 2400kg/m^3. The rest of the calculation is done by considering the density of concrete. The total volume occupied by the aggregates is 70%. The conventional method used in making normal concrete is adopted to prepare geopolymer concrete. Firstly the fine aggregates, coarse aggregates and fly ash are taken according to mix design and mixed in dry condition for 3-4 minutes by hand mixing and then alkaline solutions which is the combination of sodium silicate and sodium hydroxide with ratio 2.5 is added to dry mix. The mixing is done about another 6-8 minutes for proper bonding of all materials.

Casting and curing: The fine aggregates, coarse aggregates, fly ash mixed together properly and then alkaline solution are added and mix thoroughly for proper bonding of materials. After properly mixing the cube of size 150x150x150mm are casted in layers and each layer is compacted properly. Then cubes are then placed in table vibrator for proper compaction. After proper compaction the casted cubes are kept in oven curing at specified durations and specified temperature accordance to test variable selected.At the end of curing periods, the mould were taken out from oven and allowed to cool down. The test specimen were removed from moulds and left to air dry condition at room temperature condition until tested for direct compression test at specified age of 3 and 7 days.

Fig . 2 Casting of cubes

Fig . 3 Oven curing

RESULTS AND DISCUSSION

Compressive strength test: The cube specimens were tested in a compressive testing machine having 2000kN capacity in accordance with the Bureau of Indian Standard test procedures. The compressive strength of geopolymer concrete put at different duration and temperature of curing are shown in graph below. The compressive strength is found out at 3 and 7 days.

Fig . 4 Testing of Cube under compressission testing machine

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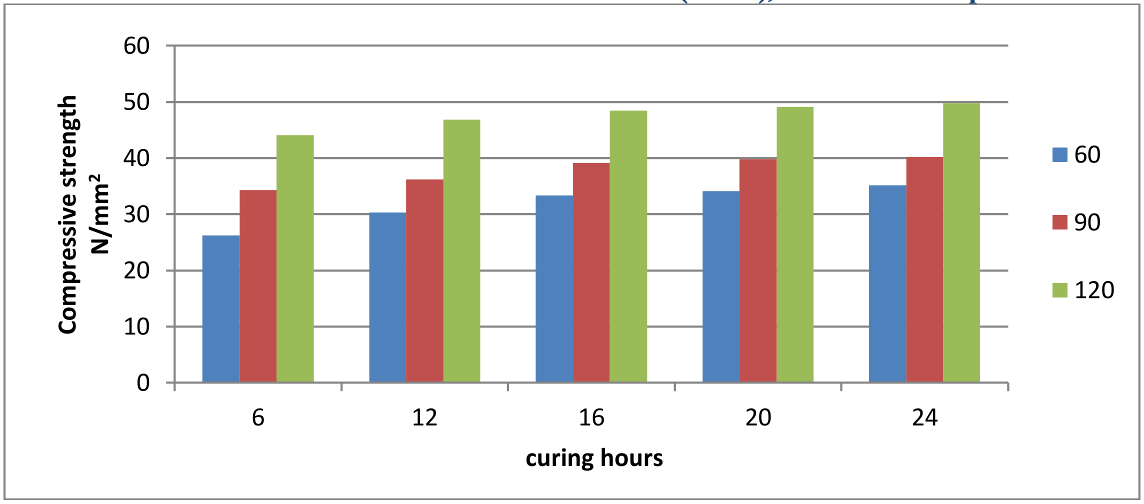

Fig 2 . 3 Days Compressive Strength for Different Duration and Different Temperature of Curing

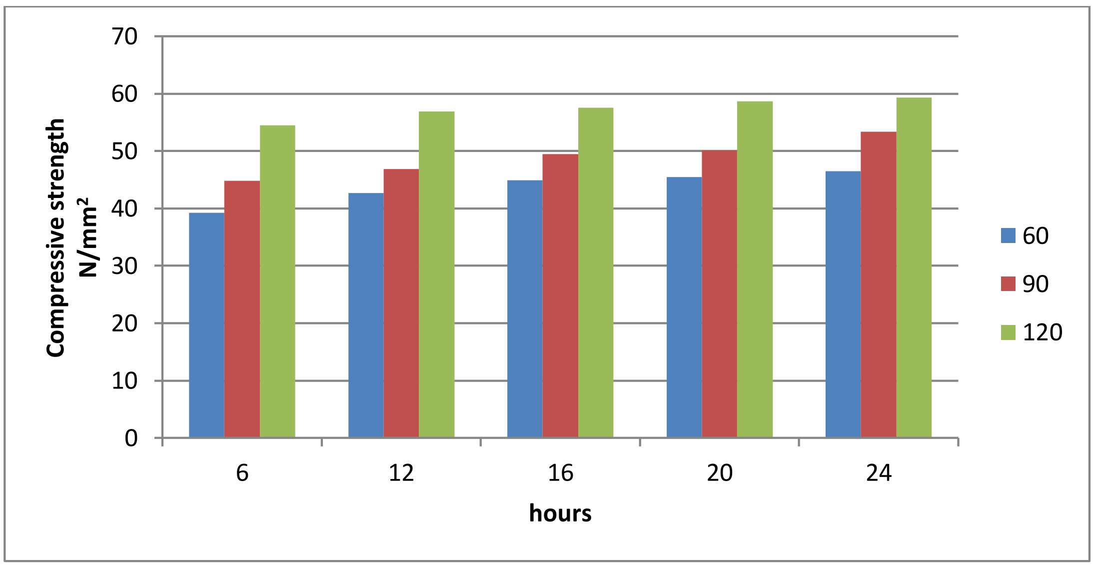

Fig 3 . 7 days 3 Days Compressive Strength for Different Duration and Different Temperature of Curing

DISCUSSION: From fig.1 and fig.2 shows the effect of duration and temperature of oven curing on compressive strength of fly ash based geopolymer concrete. It has been observed that for the same temperature of curing, compressive strength increases in with increase in duration of heating. It is also observed that, for the same duration of curing, compressive strength increases with increase in temperature of heating. At 60^0C and 90^0C the rate of gain of strength is constant up to 16 hours of duration. But beyond that strength increases with reduced rate but at 120^0C rate of gain of strength constant for all period of heating.

CONCLUSION

1. Curing temperature and its duration are also important in the activation of geopolymer concrete. Curing time, in the range of 6 to 24 hours, produces higher compressive strength. However, the increase in strength beyond 20 hours is not significant.
2. The rate of gain of strength is slow at 60°C compared to 120°C.
3. The difference between compressive strength of geopolymer concrete 16 to 20 hours is not much

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significant. So, it should be minimizes to 16 hours for saving of consumption of energy.

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