

Effect of Temperature and Time of Curing on Strength of Flyash based Geopolymer Concrete

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ABSTRACT: Cement industry is one of the major industries which are responsible to the production of greenhouse gasses. That is cement production consumes huge amount of virgin materials in atmosphere, which is one of cause of global warming. Around 120 million tone of fly ash get collected at the thermal power stations in India annually .Out of this, only 17 – 20% is used either in concrete or in stabilization of soil. Several hectors of valuable land is acquired by thermal power plant for the disposal of fly ash. So, efforts are needed to make concrete more environmental friendly by using fly ash which leads in reduction of global warming as well as fly ash disposal problem. Due to this the fly ash is used as ingredients in concrete which upgrade the properties of concrete and utilization of fly ash is helpful for consumption. This paper presents study of effect of time and temperature of curing on strength of fly ash based geopolymer concrete. The study analysis is the effect of time and temperature of curing on compressive strength and split tensile strength. Geopolymer concrete is casted by replacing cement fully with pozzolanic material like fly ash which is chemically activated by alkaline activators like sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH). In this study, ratio of solution to fly ash taken as 0.61 with 15 Mole concentrated sodium hydroxide solution is used. This concrete is investigated under different conditions of time and temperature so as to gain the maximum strength of concrete.

KEYWORDS: Geopolymer concrete, Fly Ash, Curing time, Temperature, strength

I. INTRODUCTION

Geopolymer concrete is a new technique in which cement is totally replaced by pozzolanic material like fly ash which is rich in silicon and aluminum and activated by alkaline solutions. The demand of concrete is increased day by day all over the world to complete the need of development of infrastructure facilities. Almost all of this concrete is currently made using OPC, leading to a massive global cement industry. Every year the production of Portland cement is increasing with the increasing demand of construction. Therefore the rate of production of carbon dioxide released to the atmosphere is also increasing. Each ton of Portland cement releases a ton of carbon dioxide into the atmosphere. The greenhouse gas emission from the production of Portland cement is about 1.35 billion tons annually, which is about 7% of the total greenhouse gas emission. Therefore, it is necessary to find alternatives to make the concrete more environment friendly.

II. LITERATURE SURVEY

S. S. Jamkar et al (April 2013) have studied the effect of fly ash fineness on the compressive strength of geopolymer concrete. Geopolymer concrete was produced by activating fly ash with a high alkaline solution of sodium silicate containing 16.45% Na_2O , 34.35% SiO_2 and 49.20% H_2O and 13 molar sodium hydroxide solutions. Concrete cubes of 150 mm were cast using five samples of fly ash with Blaine fineness of 542, 430, 367, 327, 265 m^2/kg and solution to fly ash ratio of 0.35. The specimens were cured in an oven for a duration of 4, 8, 12, 16, 20 and 24 hours at 90°C . The compressive strength results show that the fly ash fineness plays an important role in the activation of geopolymer concrete. An increase in the fineness increased both workability and Compressive strength. It was also

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discovered that finer particles resulted in increasing the rate of reaction needing less heating time to achieve a given strength.

S.V. Patankar et al (issn: 2231–5721,volume-2, issue-1,2013) have studied Geopolymer is a new invention in the world of concrete in which cement is totally replaced by pozzolanic material like fly ash and activated by alkaline liquids to act as a binder in the concrete. It was carried out to study the effect of water-to- geopolymer binder ratio on workability in terms of flow and compressive strength. After this, specimens were cured in oven at 90⁰C for 8 hours duration. Alkaline solution to fly ash ratio of 0.35 by mass was kept constant on the basis of past research. Sodium silicate solution with Na₂O = 16.37%, SiO₂ = 34.35% and H₂O = 49.28% and 13M NaOH were used as alkaline solutions. From test results it was seen that the flow of geopolymer concrete raises with raise in the water-to-geopolymer binder ratio. But the compressive strength reduces with increase in water-to- geopolymer binder ratio similar to water/cement ratio in cement concrete.

Subhash V. Patankar, Yuwaraj M. Ghugal, Sanjay S. Jamkar (May 2014)studied the Geopolymer concrete/mortar is the new development in the field of building constructions in which cement is replaced by pozzolanic material like fly ash and activated by alkaline solution. This paper introduced the effect of concentration of sodium hydroxide, temperature, and duration of oven heating on compressive strength of fly ash-based geopolymer mortar. Solution of Sodium silicate containing Na₂O of 16.45%, SiO₂ of 34.35%, and H₂O of 49.20% and sodium hydroxide solution of 2.91, 5.60, 8.10, 11.01, 13.11, and 15.08. Moles concentrations were used as alkaline activators. Geopolymer mortar mixes were prepared by taking solution to fly ash ratio of 0.35, 0.40, and 0.45. Then it is cured in oven at 40, 60, 90, and 120⁰C each for 24 hours and tested for compressive strength at the age of 3 days as test period after specified degree of heating.

Test results show that the workability and compressive strength of GC increases with increase in concentration of sodium hydroxide solution for all solution to fly ash ratios. Degree of heating also plays very important role in accelerating the strength; however there is no large change in compressive strength beyond test period of three days after specified period of oven heating. The workability as well as compressive strength of geopolymer mortar increases with increase in concentration of sodium hydroxide solution in terms of molarity. Rate of gain of strength is very slow when heat cured at 40⁰C as compared to strength at 120⁰C. But there is no considerable change in compressive strength beyond temperature of curing at 90⁰C. Similarly, duration of heating in the range of 6 to 24 hours produces higher compressive strength. However, the rise in strength beyond 12 hours is not very significant the compressive strength of geopolymer concrete increases with increase in test period up to three days. So, for the suitable composition of geopolymer mortar, 13- molar solution of sodium hydroxide is recommended on the basis of workability and compressive strength. Similarly it is also recommended that the cubes are cured in an oven at 90⁰C for 8 hours duration and tested after a test period of 3 days.

III. FINALIZATION OF PARAMETER

Following parameters were fixed on the basis of various trial mix test conducted by various Authors:

[8,10,11,12,13,14]

Fixed Parameter:

Percentage replacement of cement by fly ash: 100%

Sodium Silicate to Sodium Hydroxide Solution: 2.5

Solution to Fly ash ratio: 0.61

type of curing: Oven heat curing

Variable Parameter:

Temperature: 60⁰C, 90⁰C, 120⁰C

Duration of Curing: 6,12,18,24 hours.

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IV. SYSTEM DEVELOPMENT

In this study, The Geopolymer concrete is consisting of fly ash, fine aggregate, Coarse aggregate and alkaline liquid. The processed fly ash procured from Dirk India pvt.ltd Nashik. The alkaline liquids Sodium hydroxide (NaOH) and Sodium Silicate (Na₂Sio₃) are used. The sodium silicate to sodium hydroxide ratio used is 2.5 and the solution to fly ash ratio is 0.61[8]. The grade chosen for this experiment is M-30. The sodium hydroxide (NaOH) solids were dissolved in water to make the solution. For preparing 15M solution of Sodium Hydroxide in one liter solution the following steps to be adopted.

For preparation of 1M solution 40 gms sodium hydroxide pellets which is in solid form were dissolved in 1 liter water. Where 40 is the molecular weight of NaOH . The heat evaluation rate is so high at the time of mixing pellets into water. Due to Sodium hydroxide solution was prepared one day prior to the casting of concrete cubes to avoid any pollution during the mixing of constituents of geopolymer concrete. Similarly, we prepare 15 M solution for geopolymer concrete by adding 15 X 40 = 600 gms sodium pellets then we get 15 M one liter sodium hydroxide solution. Then all constituents of concrete were thoroughly mixed in concrete mixer. Then, required quantity of Sodium Hydroxide and sodium silicate solution with appropriate proportion was added and mixed until homogeneous mix was formed. After making the homogeneous mix, workability test by slump cone and compaction factor is carried out. Then, cubes of size 150 mm X 150 mm X 150 mm and cylinders of size 150mm diameter and 300mm height were cast in three layers as per standard process. Then after demoulding of cubes and cylinders, all the specimens were cured in oven at 60⁰C, 90⁰C and 120⁰C for 6, 12, 18 and 24 hours duration. All tests were conducted according to Indian standard code procedure. The compressive strength and split tensile strength test results are tabulated and discussed in details and some important conclusions are made.

V. RESULT AND DISCUSSION

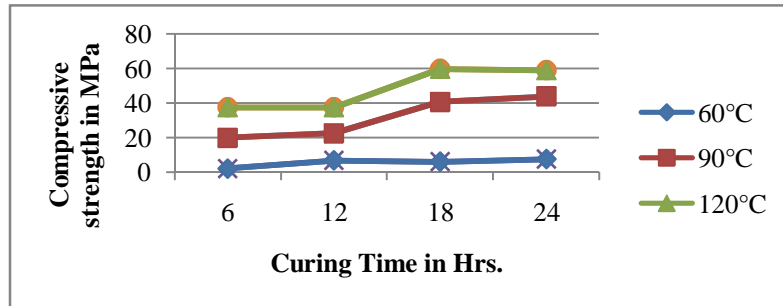
Sr.No.	Temperature (°C)	Curing Time (Hrs)	Average Compressive Strength (N/mm ²)
1.	60°C	6	2.15
		12	6.80
		18	6.18
		24	7.56
2.	90°C	6	20
		12	22.58
		18	40.85
		24	44
3.	120°C	6	37.65
		12	37.70
		18	59.80
		24	58.99

Table No. 1 Effect of duration of curing in oven on Compressive strength for processed fly ash at 60°C, 90°C and 120°C.

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Graph 1. Effect of temperature curing on compressive strength at different duration of heating for processed fly ash.

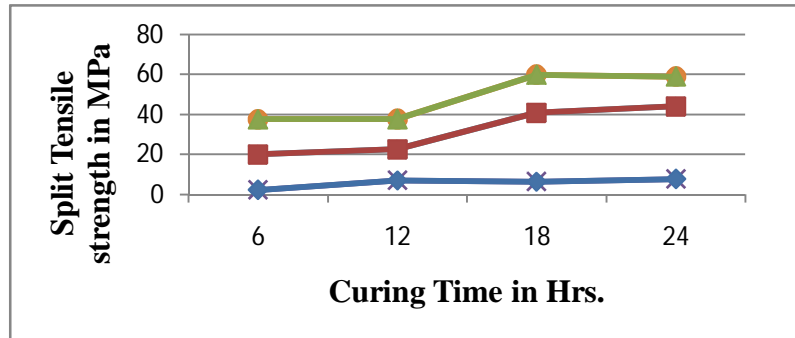


Failure pattern of Geopolymer concrete cube in compressive testing machine

Graph 1. Show the effect of temperature on compressive strength of Geopolymer concrete at various temperature conditions. It is observed that temperature plays vital role for polymerization of Geopolymer concrete. For 60°C the compressive strength of Geopolymer concrete is less compared to 120°C. As the temperature increases, strength also increases but after 18 hours duration strength will gradually increase and few cases it will decreases. Due to this the curing time is well or good in between the 18 hrs to 24hrs. It was also observed that the compressive strength of Geopolymer concrete increases with increase in duration of heating. But the rate of gain of strength is reduces after 24 hrs for 120°C of heating. For the 90°C temperature the rate of gain of compressive strength after 18 hours increases slightly.

Sr.No.	Temperature (°C)	Curing Time (Hrs)	Average Split Tensile Strength (N/mm ²)
1.	60°C	6	0.23
		12	0.42
		18	0.35
		24	0.39
2.	90°C	6	1.22
		12	1.48
		18	2.15
		24	2.22
3.	120°C	6	1.75
		12	1.80
		18	2.90
		24	2.85

Table No. 2 Effect of duration of curing in oven on Split Tensile strength for processed fly ash at 60°C, 90°C and 120°C



Graph 2. Effect of temperature curing on Split Tensile strength at different duration of heating for processed fly ash.



Failure pattern of Geopolymer concrete cylinder in compressive testing machine

Graph 2. Show the effect of temperature on split tensile strength of Geopolymer concrete at various temperature conditions. For the polymerization the 6, 12 hours is less period. The curing time increases up to 18 hours the split tensile strength will also increases but after 18 hours it will increases slowly and for 120°C the strength will decrease or sometimes it will remains same. The behavior of 120°C graph shows that the overheating reduces the strength.

VI. CONCLUSION

1. The rate of gain of strength is slow at 60°C but high at 120°C.
2. The compressive strength and split tensile strength beyond 120°C is not significant for 24 hours of curing but it is significant at 18 hrs. of curing time. The compressive strength for 120°C at 6hrs and 12hrs will not be satisfactory.
3. The rate of gain of compressive strength and split tensile strength for 60°C is not satisfactory at 6, 12, 18 and 24hrs of curing time.
4. The optimum strength achieved at 90°C in between 18 to 24hrs duration.
5. Variation in curing time as well as in temperature plays important role for polymerization in geopolymer concrete. Longer curing time improved the polymerization process resulting in higher compressive strength of Geopolymer concrete.
6. Geopolymer concrete is more environmental friendly.
7. The rate of gain of strength is slow for 60°C temperature because 60°C is not well for polymerization of geopolymer concrete at any curing time but for 90°C the rate of gain of strength is rapidly increases at various curing time.

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8. Geopolymer concrete offers several economic benefits over Portland cement concrete.

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