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EFFECT OF TEMPERATURE AND CURING TYPE ON GEOPOLYMER CONCRETE

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ABSTRACT

Cement industry is one of the major contributors to the emission of greenhouse gasses. So, efforts are needed to make concrete more environmental friendly by using fly ash which helps in reduce global warming as well as fly ash disposal problem. This paper presents study of effect of temperature and curing type on mechanical properties of fly ash based geopolymer concrete. The study analysis is the effect of temperature and curing type on compressive strength of Geopolymer Concrete. Geopolymer concrete is manufactured by replacing cement 100% with processed fly ash which is chemically activated by alkaline solutions like sodium silicate (Na2SiO3) and sodium hydroxide (NaOH). In this study solution to fly ash ratio of 0.61 with 16 Mole concentrated sodium hydroxide solution is used. All the specimens were cured in oven at 60,90,120^{0}C for 6, 12, 18 and 24 hours, but previous research show that curing time at 18 hrs will give better result and it is observed that 18 hrs time is best. In this paper we study the different types of curing like Oven, Accelerated, Membrane and Steam Curing and various temperatures.

I. INTRODUCTION

Geopolymer is a new Material in the world of concrete in which cement is totally replaced by pozzolanic material (Fly ash) that is rich in silica and alumina and activated by alkaline liquids to act as a binder in the concrete. The demand of concrete is increasing day by day to complete the need of development of infrastructure facilities. It is well known fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases huge quantity of carbon dioxide to the atmosphere. Therefore, it is necessary to find alternatives to make the concrete environment friendly with consideration of natural resources and atmospheric pollution. [1]

II. RESEARCH REVIEW

Sandeep Hake, et al [1], the oven heat curing of geopolymer concrete has been attempted by various researchers, but for curing of geopolymer concrete is quit difficult on site by using oven, so there is scope on types of curing which makes geopolymer concrete cure easily. The oven heat curing for geopolymer concrete is mostly used. The researchers studied only for different curing temperature in oven curing, but only few of them work on steam, membrane curing and no one work on accelerated curing, as well as comparison on steam, accelerated, membrane, natural and oven curing. So there is scope on method of curing of geopolymer concrete. Also researchers studied for different curing time like 6,12,18,24 and the optimum strength obtained at 18 Hrs of

Curing. The different curing temperatures like 60^0 C, 90^0 C, 120^0C and 150^0C. The different type of curing like Oven, Accelerated, Membrane and Steam curing are need to be Study. The effect on compressive strength of Geopolymer concrete by using these parameter need to be study.

Subhash V. Patankar(2014)et al. [8] studied the effect of quantity of water, temperature duration of heating on compressive strength of fly ash based geopolymer concrete. Na_2Sio_3 solution containing Na_2O of 16.45%, SiO_2 of 34.35% and H_2O of 49.20% and sodium hydroxide solution with concentration of 13 Molar were used in geopolymer concrete as alkaline activators. Geopolymer concrete mixes were prepared with 0.35 solutions to processed fly ash ratio. Workability was measure by flow table apparatus. Geopolymer concrete cubes of 150 mm X 150 mm X 150 mm were cast. The temperature of curing was varied as 40^0C, 60^0C, 90^0C, and 120^0C for each period of 8, 12 and 24 hours of oven heating and tested after a rest period of 1, 2, 3, 7 and 28 days after demoulding the concrete cube. Test results show that the quantity of water plays important role in balancing workability but not affect on strength. While higher temperature requires less duration of heating to achieve desired strength and vice versa. Author says that the rest period of 3 days is sufficient after heating at and above 90^0C temperature.

In this study [14]have studied of effect of duration and temperature curing on compressive strength of geopolymer concrete. Geopolymer concrete is manufactured by cement fully replacing with processed fly ash which is activated by alkaline solutions like Na_2Sio_3 and NaoH. Cubes of size 150mm X 150mm X 150mm were made at solution to fly ash ratio of 0.35 with 16 Mole concentrated sodium hydroxide solution. The specimens were cured in oven at 60^0C, 90^0C and 120^0C for 6, 12, 16, 20 and 24 hour's duration. Test results show that the compressive strength increases with increase in duration and temperature of oven curingupto 24 hrs.

This paper [3], have obtained the behavior of Fly ash based Geopolymer Concrete Solid Blocks and its Durability, the size of the block were adopted was 200mm x 200mm x 400mm. The brick were cast with fly ash to river sand, M-sand and eco-sand (silica sand) with the ratio of 1:2.5 by weight. Sodium hydroxide and Sodium silicate solution were used as the alkaline activators in geopolymer concrete. The binder solution consists of a combination of NaOH and Na2SiO3 solution in the ratio of 1:2.5. The water/binder ratio is the ratio of solution (NaOH, Na_2SiO_3 and water) to fly ash. Totally 60 blocks were casted in this study under ambient curing. The blocks were cast with different types of sand with river sand, M-sand and eco-sand (silica sand). The experimental results obtained were compared with locally available Cement Solid Blocks.

III. FINALIZATION OF PARAMETER

Following parameters were fixed on the basis of various trial mix test conducted by various Authors: [5,6,7,8,9]

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
- Duration of Curing: 18 hours.

Variable Parameter:

- Temperature: 60°c, 90°c, 120°c,150°c.
- Type of curing: Oven, Steam, Accelerated, Membrane and Natural Curing.

IV. SYSTEM DEVELOPMENT

In this study, The geopolymer concrete is made up of using fly ash, fine aggregate, Coarse aggregate and alkaline liquid. The processed fly ash procured from bhusawal power plant. The alkaline liquids are Sodium hydroxide (NAOH) and Sodium Silicate (Na_2Sio_3). The sodium silicate to sodium hydroxide ratio used is 2.5 and the solution to fly ash ratio is 0.61 [14]. For preparing 16Mole solution of Sodium Hydroxide in one liter solution the following steps to be adopted. For preparation of 1M solution there is requirement of 40 gms sodium hydroxide pellets in solid form. While we mix 40 gms pellets in one liter solution then we get 1M sodium hydroxide solution. 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 contamination during the mixing of ingredients of geopolymer concrete. Similarly, we prepare 16 M solution for geopolymer concrete by adding 16 X 40 = 640 gms sodium pellets then we get 16 M one liter sodium hydroxide solution. Then all ingredients of concrete were thoroughly mixed in concrete mixer. Then, required quantity of Sodium Hydroxide solution and sodium silicate solution with proper proportion was added and mixed until homogeneous mix was formed. After making the homogeneous mix, workability test by slump cone and compaction factor is determined. Then, cubes of size 150 mm X 150 mm X 150 mm were cast in three layers as per standard process. Then after demoulding of cube these cube placed for curing of geopolymer concrete. The various methods are adopted for Oven, Steam, Accelerated and Membrane Curing at various temperatures like 60^0C, 90^0C, 120^0C. These cubes were placed at room temperature after curing up to the testing age. The testing age for cube will be assumed as 7 day which was fixed from past literature review. The effect of temperature and types of curing on geopolymer concrete are as follows.

Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Sample No	Load (KN)	Comp Strength (N/mm²)	Average (N/mm²)
60°C	18	7	O1	135	6.00	6.15
			O2	120	5.33	
			O3	160	7.11	
90°C			O4	900	40.00	40.74
			O5	930	41.33	
			O6	920	40.89	
120°C			O7	1260	56.00	59.26
			O8	1430	63.56	
			O9	1310	58.22	
150°C			O10	360	16.00	14.67
			O11	300	13.33	

			O12	330	14.67	

Table1: The temp. effect of oven cured geopolymer concrete.

Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Sample No	Load (KN)	Comp Strength (N/mm²)	Average (N/mm²)
60°C	18	7	A1	500	22.22	30.07
			A2	780	34.67	
			A3	750	33.33	
80°C			A4	1550	68.89	65.93
			A5	1420	63.11	
			A6	1480	65.78	
100°C			A7	620	27.56	33.04
			A8	860	38.22	
			A9	750	33.33	

Table2: The temp. effect of Accelerated cured geopolymer concrete.

Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Sample No	Load (KN)	Comp Strength (N/mm²)	Average (N/mm²)
60°C	18	7	M1	550	24.44	23.26
			M2	540	24.00	
			M3	480	21.33	
90°C			M4	1050	46.67	46.07
			M5	1090	48.44	
			M6	970	43.11	
120°C			M7	1120	49.78	49.93
			M8	1100	48.89	
			M9	1150	51.11	
150°C			M10	530	23.56	24.30
			M11	540	24.00	
			M12	570	25.33	

Table3: The temp. effect of Membrane cured geopolymer concrete.

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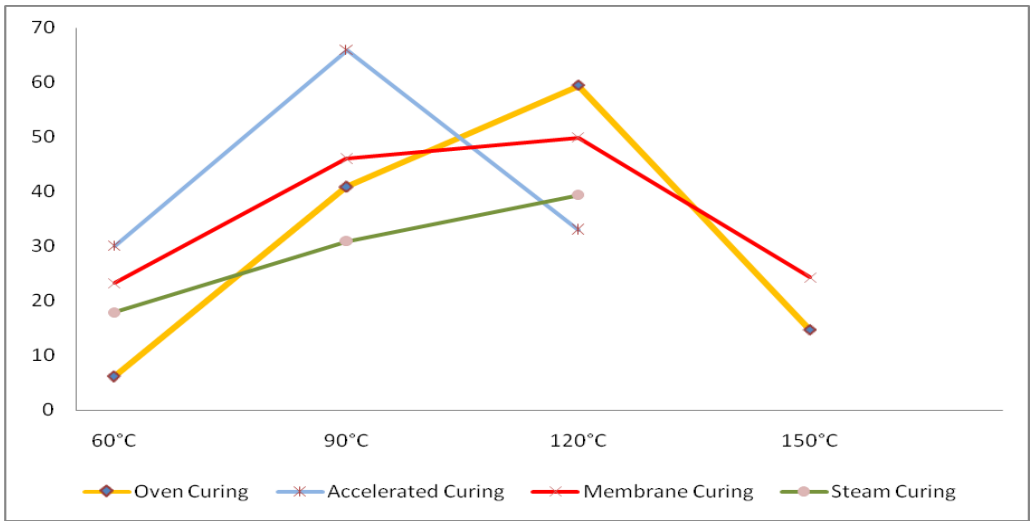
Sr.No.	Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Sample No	Load (KN)	Comp Strength (N/mm²)	Average (N/mm²)
12	60°C	18	7	S1	430	19.11	17.93
				S2	370	16.44	
				S3	410	18.22	
13	80°C			S4	730	32.44	30.96
				S5	690	30.67	
				S6	670	29.78	
14	100°C			S7	880	39.11	39.41
				S8	860	38.22	
				S9	920	40.89	

Table4: The temp. effect of Stem cured geopolymer concrete.



Graph 1 Temperature Vs Comp. strength

Fig:1 Shows the Failure pattern of cube on compression testing machine.

V. RESULT AND DISCUSSION

Table 1 show the effect of temperature variation and different type of curing on geopolymer concrete. In oven heat curing the the temperature varies from 60 ^{0} C to 150 ^{0} C the optimum result we get at 90 ^{0}C with consideration of energy for heating.

In Accelerated curing the effect of temperature on geopolymer concrete will show the optimum result at 80 ^{0}C. Also in membrane curing the effect of temperature varies from 60 ^{0} C to 150 ^{0} C the optimum result we get at 90 ^{0}C. In case of Steam curing the temperature optimize at 100^{0}C.

The fig 1 Shows the Failure pattern of cube on compression testing machine.

VI. CONCLUSION

1. In oven curing the rate of gain of strength is slow at 60^{0}C and increases at 90^{0}C and also increases at 120^{0}Cand it will sudden down at 150^{0}C and also at 150^{0}C the cracks appear on cube. If we consider electricity, at 90^{0}C we give optimum result as compare to 120^{0}C .
2. In Accelerated Curing, the optimum result we will get at 80^{0}C as compare to other temperature.
3. In case of Membrane curing the compressive strength obtained at 90^{0}C. the optimum result with consideration of electricity required is at 90^{0}C.
4. In case of steam curing the compressive strength achieved at 100^{0}C.
5. For the polymerization the heat is required to the geopolymer concrete.

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