Parametric study of Geopolymer Concrete

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Abstract: The study analysis is the effect of temperature and curing time on compressive strength, split tensile strength and flexure strength. Geopolymer concrete is manufactured by replacing cement fully with processed low calcium fly ash which is chemically activated by alkaline solutions like sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH). In this study solution to fly ash ratio of 0.61 with 15 Mole concentrated sodium hydroxide solution is used and grade chosen for investigation was M30. All the specimens were cured in oven at 60^0C, 90^0C and 120^0C for 6, 12, 18 and 24 hours duration. All tests were conducted according to Indian standard code procedure. Test results for compressive strength, split tensile strength and flexure strength are tabulated and discussed in details and some important conclusions are made.

I. INTRODUCTION

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. On the other side, fly ash is the waste material of coal based thermal power plant, available abundantly but pose disposal problem. Several hectors of valuable land is acquired by thermal power plant for the disposal of fly ash. As it is light in weight and easily flies, creates severe health problems like asthma, bronchitis, etc

II. RESEARCH REVIEW

The choudhari kalyni, kute mayur,lande pravin,pardhe vasant et al, 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. Patankaret al says that, studied the Geopolymer concrete is the new development in the field of building constructions in which cement is totally replaced by pozzolanic material like fly ash and activated by alkaline solution. This paper presented the effect of concentration of sodium hydroxide, temperature, and duration of oven heating on compressive strength of fly ash-based geopolymer rmortar. Sodiumsilicate solution 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 considering solution-to-fly ash ratio of 0.35, 0.40, and 0.45. The temperature of oven curing was 111111111111maintained at 40, 60, 90, and 120^0C each for a heating period of 24 hours and tested for compressive strength at the age of 3 days as test period after specified degree of heating.

Choudhari kalyni,Kute mayur,Lande pravin,pardhe vasant et al says that, 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.

Shankar H. Sanniet et al said that, studied the Geopolymer is a class of alumina-silicate binding materials synthesized by thermal activation of solid alumina-silicate base materials such as fly ash, metakaolin, GGBS etc., with an alkali metal hydroxide and silicate solution. The geopolymer was activated with sodium hydroxide, sodium silicate and heat. This paper presents the experimental investigation done on the variation of alkaline solution on mechanical properties of geopolymer concrete. The grades chosen for the investigation were M-30, M-40, M-50 and M-60, the mixes were designed for 8 molarity. The alkaline solution used for present study was the combination of sodium silicate and sodium hydroxide solution with the varying ratio of 2, 2.50, 3 and 3.50. The test specimens were 150x150x150 mm cubes and 100x200 mm cylinders heat-cured at 60°C in an oven. The results revealed that the workable flow of geopolymer concrete was in the range of 85 to 145 and was dependent on the ratio by mass of sodium silicate and sodium hydroxide solution. The freshly prepared geopolymer mixes were cohesive and their workability increased with the increase in the ratio of alkaline solution.

Sunilaa George et al studied cement concrete is the most widely used construction material in many infrastructure projects. The development and use of mineral admixture for cement replacement is growing in construction industry mainly due to the consideration of cost saving, energy saving, environmental production and conservation of resources. Present study is aimed at replacing cement in concrete with activated fly ash. The paper highlights the chemical activation of low calcium fly ash using CaO and Na2SiO3 in the ratio 1:8 for improving the pozzolanic properties of fly ash .The investigation deals with the flexural behavior of beams using chemically activated fly ash at various cement replacement levels of 10%, 20%, 30%, 40%, 50%, and 60% with water binder ratio 0.45.The results are compared with OPC and Activated Fly ash at the same replacement levels. For a variety of reasons, the concrete construction industry is not sustainable.

Anuradha, V. Sreevidya et al studied the mix ratios for different grades of geopolymer concrete by trial and error method.Two kindsof systems were considered in this study using 100% replacement of cement by ASTM classF flyash and 100% replacement of sand by M-sand. It was analyzed from the test result that the Indian standard mix design itself can be used for the Geopolymer Concrete with some modification. From test result it was concluded that, Geopolymer concrete is an excellent alternative solution to the CO2 producing port land cement concrete.The price of fly ash-based geopolymer concrete is estimated to be about 10 to30 percent cheaper than that of Portland cement concrete.

III. FINALIZATION OF PARAMETER.

Following parameters were fixed on the basis of various trial mix test conducted by various Authors: [1, 3,4,5,6]

Fixed Parameter: The 100% cement replace with fly ash, Na_2 Sio_3 / NaoH ratio is 2.5 and solution to fly ash ratio is 0.35.

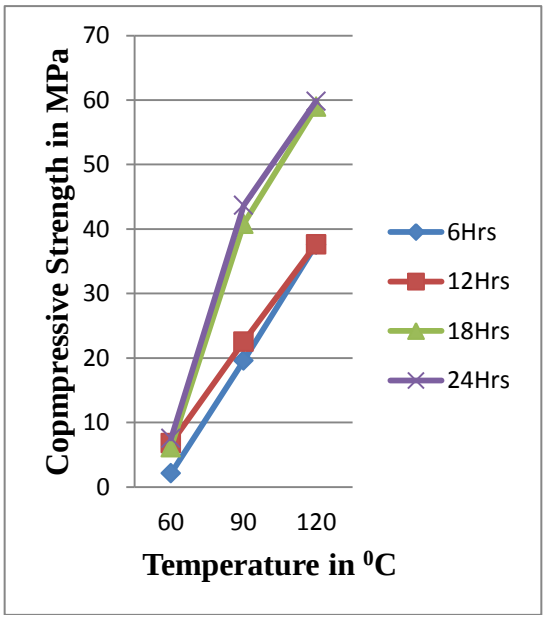
Variable Parameter: The temperature, curing time and rest period.

IV. METHODOLOGY.

In this study, the fly ash used is 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 0.35. The geopolymer concrete is made up of using fly ash, fine aggregate, Coarse aggregate and alkaline liquid. The sodium hydroxide is of 16M. for preparation of 16M solution the pallets form of NaoH is used. for one liter of 16M solution it require 640 gms of solid pallet of NaoH. 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 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 one day the demoulding of cube these cube placed for curing of geopolymer concrete. The cube were cured in oven for various temperatures like 60^{0}C, 90^{0}C, 120^{0}C and 150^{0}C. These cubes were placed at room temperature after curing up to the testing age. The after curing to the testing age of cube is assumed as rest period. The effect of temperature on geopolymer concrete are as follows.

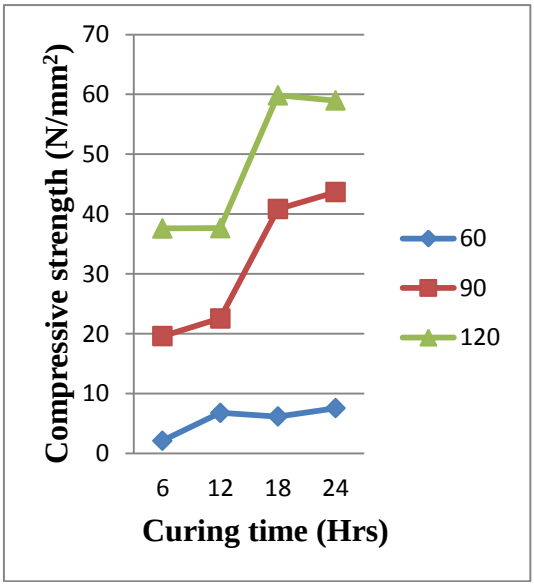
Graph shows that, the cubes were cured at various temperatures 60^{0}C, 90^{0}C, 120^{0}C for 18 hrs. These cubes were placed at room temperature for 7 days rest period. After rest period the cubes were tested on compressive testing machine. Due to the temperature variation the strength varies on stipulated time. we consider the optimum strength at 90^{0}C because as at 90^{0}C the target strength achieved, in case of 120^{0}C the strength is high but electricity

consumption is so high as compare to 90^0C. due to this reason we take optimum strength at 90^0C.

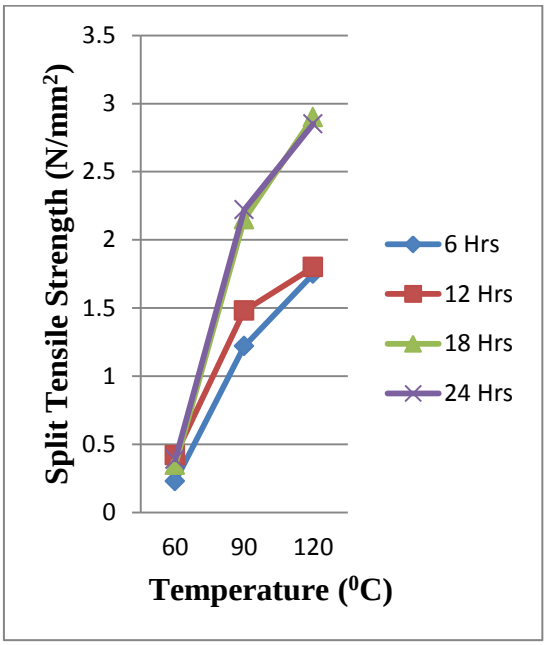


Graph1 Temperature Variation vs Compressive Strength (N/mm^2)

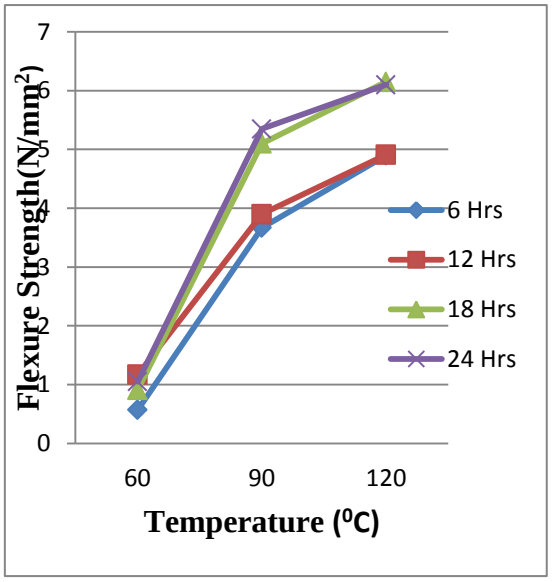
shows the effect of temperature on compressive strength of geopolymer concrete at various temperature condition at 6 hours duration of heating with all other test variables were held constant. It is observed that temperature plays vital role for polymerization of geopolymer concrete. For 60^0C the compressive strength of geopolymer concrete is less. 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 120^0C of heating. For the 90^0C temperature the rate of gain of compressive strength after 18 hours increases slightly.



Graph 2 Compressive Strength Vs Curing Time.



Graph3: Split Tensile Strength Vs Temperature.



Graph4: Flexure Strength Vs Temperature.

Graph 4 shows the Flexure Strength effect on geopolymer concrete. The flexure strength with respect temperature shown in this graph.

V. RESULT AND DISCUSSION

Temperature effect shows that the compressive strength varies with temperature. The optimum curing temperature for geopolymer concrete is 90^0 C. The curing time varies with 6,12,18,24 hours. The 90^0 C temperature shows that optimum strength in split, flexure and compressive strength in geopolymer concrete.

VI. CONCLUSION

1. The rate of gain of strength is slow at 60^0C but high at 120^0C.
2. The compressive strength for 120^0C at 6hrs and 12hrs will not be satisfactory.
3. The optimum strength achieved at 90^0C in between 18 to 24hrs duration.
4. Geopolymer concrete is more environmental friendly.

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