Percentage Replacement of Cement in Geopolymer Concrete

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Abstract: A recent article in the newspaper reported an increase in the demand of cement by 3% to 5% for the year 2016-2017. Also the demand of concrete for the development of infrastructure is increasing rapidly where the primary binder is cement. Being aware of the adverse environmental issues caused by the production of cement has now emerged a need of new binders thereby replacing cement. Geopolymer has been in the popular research topics with an urge to overcome the demerits and adverse environmental issues caused by conventional concrete. This paper emphasis on an effort to achieve the designed strength of Geopolymer concrete by replacing Fly Ash with cement and opting wet curing. In this experimental investigation Geopolymer concrete is produced for two different grades with fly ash as the binding material, Sodium Hydroxide and Sodium Silicate as the activators with morality as 16M, aggregates and fine sand being similar as in conventional concrete, replacing cement for various percentages. Specimens casted with the mention specifications will be opted for wet curing.

Keywords: Cement, Fly Ash, Geopolymer concrete, Wet Curing.

I. INTRODUCTION

To reduce the environmental degradation, safeguarding our environment and maintaining healthy environment surrounding and conditions has now become a responsibility of every individual residing on the Earth. For safe survival of human instincts it is a must that our actions intend towards a pollution free environment. The depletion of ozone layer is one of the crucial matters; humans are dealing with and the main cause of it being the emission of CO_2. The source of emission of CO_2 is of equal importance too. One of the major sources of CO_2 emission for the last few years gaining attention is the production of Cement. The Cement industries have now considered responsible for major source of CO_2 emission by the production of PPC. Statistically about 1ton of cement production emits the same amount of CO_2 in the environment thereby degrading the quality of our environment.

Now the challenge amongst the researchers is the finding an appropriate alternative for eliminating the environmental hazard caused due to production of cement. A very prominent research by Davidovits in 1978, was the invention of Geopolymer concrete which was a cement free concrete. This attracted a lot of attentions where fly ash replaced cement for 100%. It had its own identity and left a remarkable impression in the research studies. Geopolymer exhibits similar properties to that of conventional concrete the only difference being its cement free-100%. But challenging human tendency of having blind faith for the years, over cement for its strength and durability is an uprising challenge. Building faith and trust for the use of Geopolymer Concrete over conventional concrete is a huge task and requires testing of Geopolymer concrete against conventional concrete. Not only the elimination of CO_2 emission can be avoided there are lot many reasons for Geopolymer Concrete to be eco-friendly.

The most eye catching reason being the use of Fly Ash which has its own which had its own dumping issues earlier and was of scarce uses. Previous investigations on Geopolymer concrete have succeeded to achieve the desired strength but with the curing done at elevated temperatures, setting its applications and uses limited with no practical use on site. With replacement of optimum percentage of cement an additional amount of heat will be produced, when mixed with water the reaction being exothermic that can be used as an alternative for the elevated curing temperatures, thereby achieving

the desired strength by wet curing giving it a wide scope and various practical applications and uses.

II. LITERATURE REVIEW

Sourav Kr. Das et.al [1] investigated that, with a higher Na_2SiO_3 gives a higher strength, and generally with a ratio of 2.5.Heat cures geopolymer concrete gives higher strength. The rate of increase of strength is rapid in the initial 24 hours of curing beyond that the gain of strength was moderate so the specimens should be cured for 24 hours only which will be sufficient enough. Geopolymer concrete has excellent properties as discussed earlier so it can be very useful for rehabilitation and retrofitting works.

Subhash V. Patankar et.al [2] investigated that, the desired compressive strength was achieved by fixing the solution-to-fly ash ratio of 0.35for the Mix Design of Fly Ash Based Geopolymer Concrete on the basis of various parameters such as quantity and fineness of fly ash, quantity of water and grading of fine aggregate.

Subhash V. Patankar et.al [3] investigated that, the rate of gain of strength is slow when heat cured at 40°C as compared to strength at 120°C. But there is no appreciable change in compressive strength beyond curing temperature of 90°C. Similarly, duration of heating in the range of 6 to 24 hours produces higher compressive strength. However, the increase in strength beyond 12 hours is not very significant. It is also observed that the compressive strength of geopolymer concrete increases with increase in test period up to three days.

S.S. Jamkar et.al [4] investigated that, the compressive strength results show that the fly ash fineness plays a vital role in the activation of geopolymer concrete. An increase in the fineness increased both workability and compressive strength. It was also observed that finer particles resulted in increasing the rate of reaction needing less heating time to achieve a given strength.

III. MATERIALS AND SPECIFICATIONS

1. ***Fly Ash***: Fly ash used in this study is low calcium class F processed fly ash from Dirk India private limited under the name of the product Pozzocrete 60. Chemical compositions of the fly ash used along with the specifications are given in Table1. The specific gravity of the Fly Ash used is 2.26. The residue of fly ash retained on 45μm IS sieve was reported as 16.84%. The fineness of the Fly Ash by Blen's method is 360m^2/kg.
2. ***Alkaline solution:*** The alkaline liquid used was a combination of sodium hydroxide and sodium silicate solution. Sodium hydroxide (NaOH) in flakes form with 98% purity purchased from local chemical supplier was used and Sodium silicate solution (Na_2O = 16.84%, SiO_2 = 35.01% and water = 46.37% by mass) was used as alkaline liquid. Sodium hydroxide solution is prepared by dissolving the flakes in water. Tap water available in laboratory was used to prepare NaOH solution. The activator solution was prepared at least one day prior to its use. Molarity of the solution to be used is 16M.
3. ***Aggregates:*** Locally available 12.5 mm and 20 mm crushed aggregates to be used as coarse aggregates having specific gravity 2.65. Locally available river sand is to be used as fine aggregate in the concrete mixes having specific gravity 2.5.
4. ***Cement:*** The cement used in the study is ordinary Portland cement (53 Grade) conforming to IS 12269: 1987.
5. ***Water:*** Water used for portable water conforming IS 456-2000.
6. ***Sample mould:*** Mould of size 150mm X 150mm X 150mm was used to cast specimens for conducting compression test.

IV. EXPERIMENTAL WORK

The mixing procedure used for preparing geopolymer concrete is very similar to that of conventional concrete. Mixing of all the materials have been done in the laboratory at room temperature. Fly ash and aggregate (65%-CA-I-35%-CA-II) weighed according to the mix design, were mixed together in a concrete mixer. This mixing was allowed to continue for about 3 to 4 minutes. After ensuring proper mixing weighed quantity of Cement was added in the mixer and allowed to mix for the next 2 minutes. NaOH solution which was prepared one day prior to the casting was then mixed with Na_2SiO_3 and the extra water; all weighed as per the mix design

were stirred thoroughly to ensure proper mixing. This alkaline solution prepared was then added to the mix in the concrete mixer in three stages to ensure proper mixing. After the liquid was introduced to the mixture the mixing was continued for about 2 minutes. The fresh geopolymer concrete thus prepared was casted into the moulds immediately. For compaction, specimens were vibrated using vibration table for another 10 to 15 seconds. After the casting, the moulds were left at room temperature for 24 hours. Then, the moulds were demoulded and cured to the required temperature in an oven for the specified time. In this experimental program specimens were casted for compression test of two grades i.e. M30 & M45. For wet Curing the specimens were kept in water for specified curing days. The specimens were tested under a compression machine of capacity 3000KN after the completion of specified curing period.

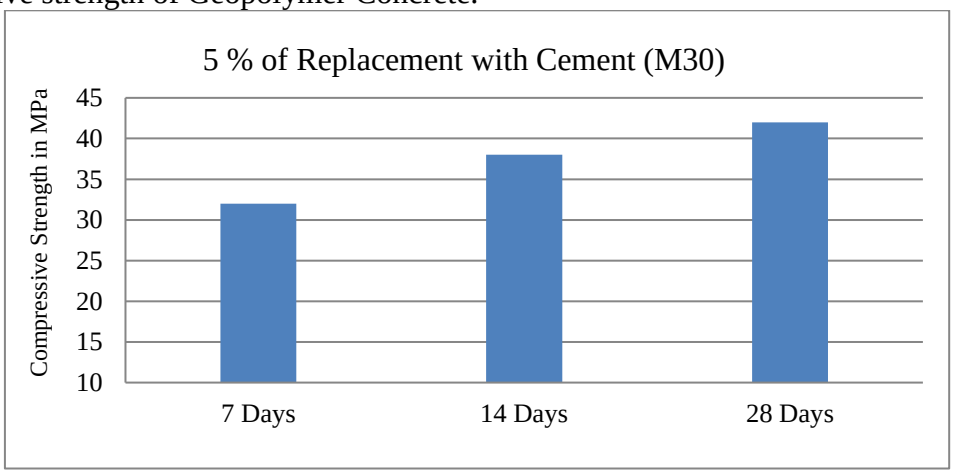
a. Specimens casted for replacement with cement

b. Specimens kept for wet curing

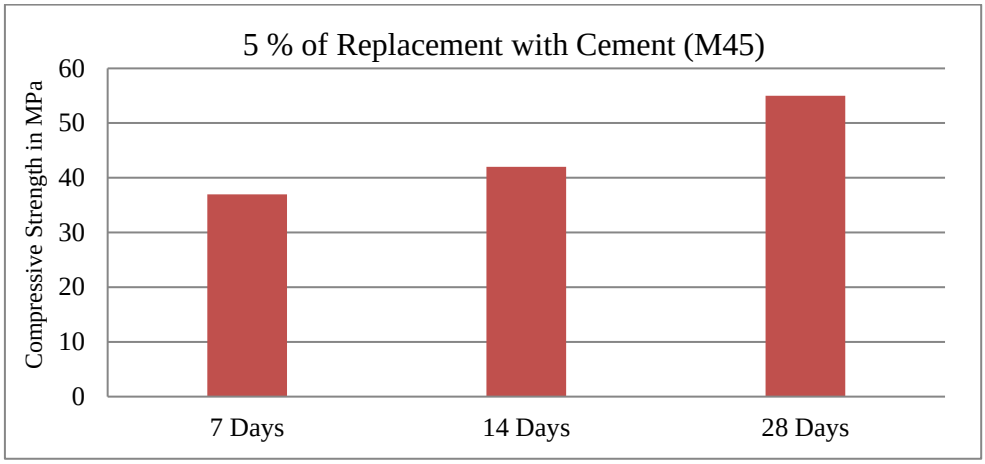
c. specimen tested for compression

V. RESULTS

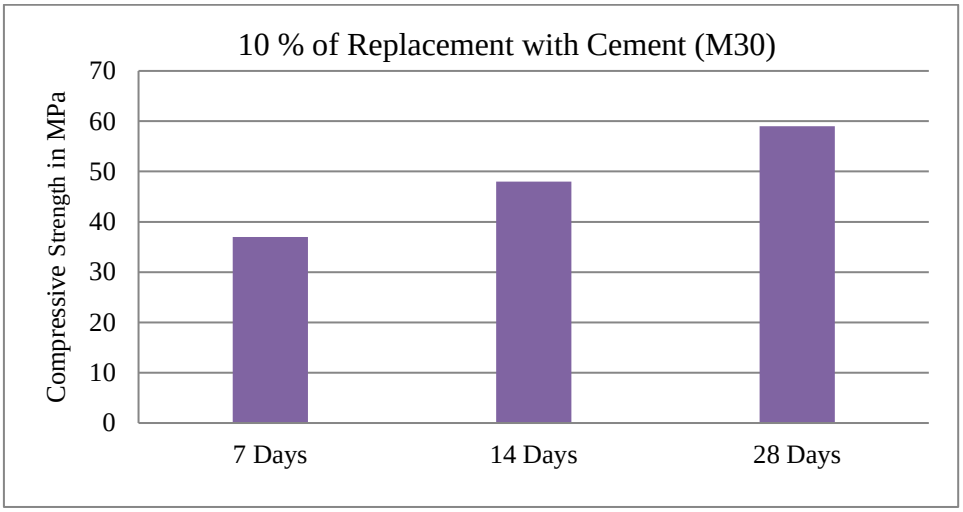
Compression Testing: Specimens were casted of size 150mm x 150mm x 150mm of grade M30 & M45 having alkaline solution ratio as 2.5 where various percentages of Fly ash was replaced with Cement by weight. These specimens were opted for wet curing for varied curing time of 07,14 and 28 days and with a rest period of 01 day after the completion of the specified curing period after which the specimens were tested for compression on a compression testing machine of capacity 3000KN. The readings were recorded, to know the optimum percentage of replacement with cement and its effect on the compressive strength of Geopolymer Concrete.



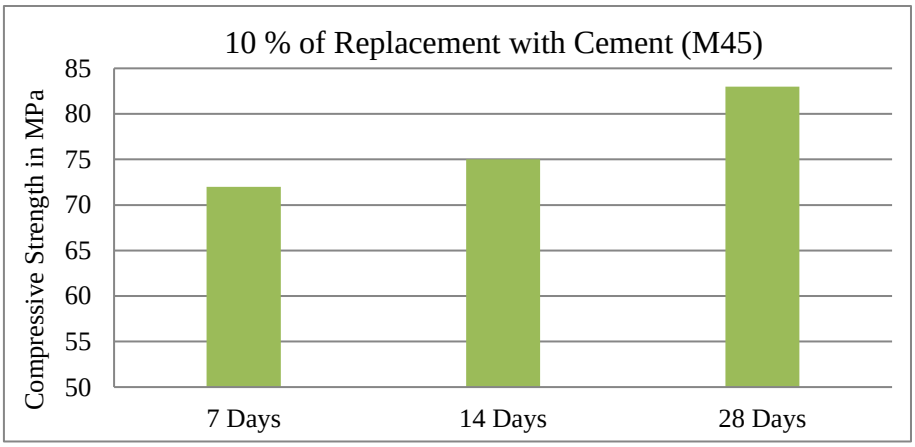
Graph 1. 5% replacement with cement with varied curing days for wet curing (M30)



Graph 2. 5% replacement with cement with varied curing days for wet curing (M45)



Graph 3. 10% replacement with cement with varied curing days for wet curing (M30)



Graph 4. 10% replacement with cement with varied curing days for wet curing (M45)

VI. CONCLUSION

1. Compressive strength can be achieved for both the grade of GPC i.e. M30 & M45 by replacing Fly ash with Cement for various percentages i.e. 5% & 10% by opting wet curing.
2. The compressive strength goes on increasing with the increase in replacement percentage with cement in M30 & M45 grade of GPC by opting wet curing where maximum can be achieved by replacing 10% with cement.

3. The increase in the curing days increases the compressive strength of Geopolymer concrete for M30 & M45 grade of concrete for 5% and 10% replacement with cement where maximum compressive strength is achieved after 28days of curing.

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