EFFECT ON STRENGTH OF GEOPOLYMER CONCRETE WITH ADDITION OF LIME AND METHOD OF CURING

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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 on an increasing rate where the primary binder for which 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 experimental investigation emphasizes on an effort to achieve the desired strength of Geopolymer concrete at normal room temperature and also by wet curing with an addition and replacement with optimum percentage of Lime powder and Cement respectively. In this experimental investigation Geopolymer concrete is produced for one different grades with fly ash as the binding material, Sodium Hydroxide and Sodium silicate as the activators having morality as 16M, aggregates and fine sand being similar as in conventional concrete, adding Lime powder and replacing cement for an optimum percentage. Specimens casted with the mention specifications will be cured at a temperature from 40°C to 120°C, at normal room temperature and these will also be opted for wet curing. The optimum results will be calculated and specimens will be then casted for observing flexural and split tensile behavior of Geopolymer concrete.**

Keywords: Geopolymer, Curing, Fly ash, Hydrated Lime.

I. INTRODUCTION

A very prominent research by Davidovitts 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%. Basically, alkali metal (Na or K) silicate or hydroxide is often used as an activator for synthesis of the metakaolin based or fly ash-based geo-polymers. The most eye catching reason being the use of Fly Ash which has its own which has its own dumping issues earlier and was of scarce uses. Previous investigations on Geopolymer concrete have succeeded to achieve the desired strength but where the curing done at elevated temperatures, setting its applications and uses limited with no practical use on site. With an addition and replacement of optimum percentage of Lime and cement respectively an additional amount of heat will be produced, when mixed with water the reaction being exothermic can be used as an alternative for the elevated curing temperatures, thereby achieving the desired strength at normal room temperature and by wet curing giving it a wide scope and various practical applications and uses. Debabrata Dutta et.al [1] studied the Pore sizes get reduction after addition of Lime stone dust into geopolymer paste sample. Subhash V. Patankar et.al [2] studied that desired compressive strength was achieved by fixing the solution-to-fly ash ratio of 0.35 for 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. S.S. Jamkar et.al [3] studied that the compressive strength results shows 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. S. Kumaravel [4] investigated that at atmospheric temperature and pressure, setting time increases of the geopolymer concrete by addition of slag as a part of fly ash binder. The geopolymer concrete possesses good compressive strength and well suited to manufacture precast concrete products. Low calcium fly ash-based geopolymer concrete has excellent compressive strength and is suitable for structural applications. B. Siva Konda Reddy et.al [5] studied the strength and workability of fly ash based geopolymer concrete. As alkaline liquid sodium hydroxide and sodium silicate was used.Procedure for Paper Submission

A. Materials

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 Table

1. 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.

TABLE 1
COMPOSITION OF CLASS F FLY ASH (P60)

Chemical Composition	Percentage
Sio2	57.30%
Al2O3	27.13%
Fe3O3	8.06%
MgO	2.13%
SO3	1.06%
Na2O	0.73%
CaO	0.03%
LOI	1.60%

The Lime stone dust is a solid composite having specific gravity 2.7, bulk density 1425 kg/m3.It has an average particle size of 25 micron while particle size varies between ranges of 10µ to 70µ.

TABLE 2
COMPOSITION OF LIME

Chemical Composition	Percentage
CaO	51.01%
MgO	0.28%
Fe3O3	0.38%
Al2O3	2.74%
SiO2	3.92%
K2O	0.04%
Na2O	NIL
TiO2	0.09%
LIO	41.56%

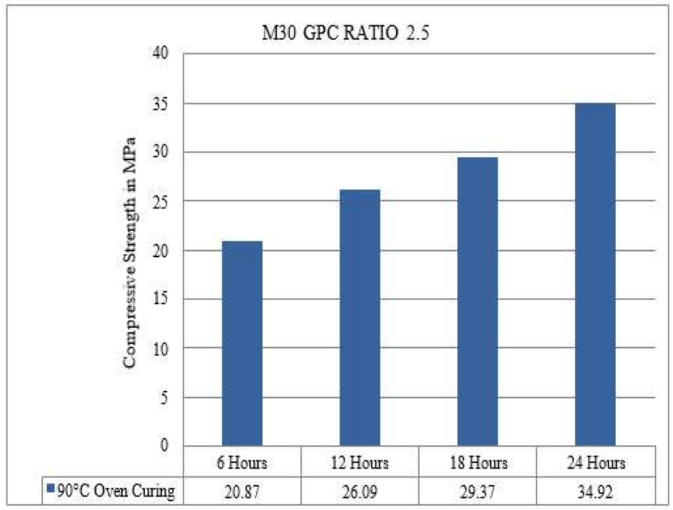
B. Sample Preparation

In this report, the grade of geopolymer concrete is considered as M30. For this grade M30, cubes of different compositions are made by hand mix having temperature above 90 º C at normal room temperature. Compositions are vary from 5% of Lime to 25% of Lime & strength is measured by CTM. The compressive strength test is carried out on the cubes of different grades, Flexural test is conducted on the beams of the optimum value of strength which is obtained in compressive strength in case of cubes, whereas split tensile test is carried out on the cylinder of M30 grade.

II. RESULTS AND DISCUSSION

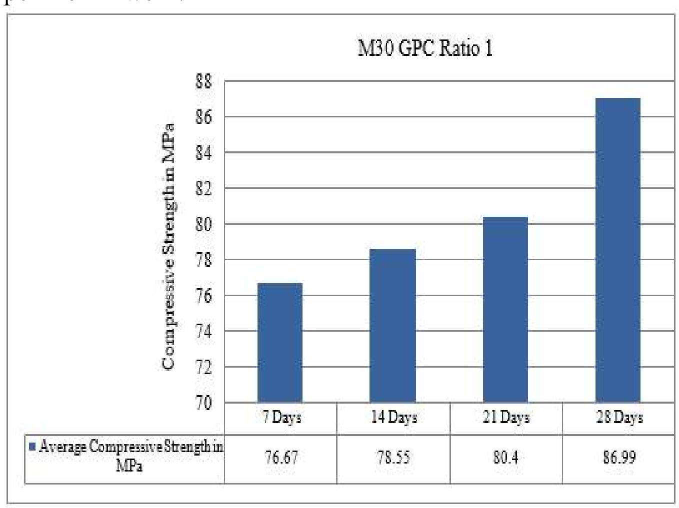
A. Compressive strength

The compressive test is carried out on the specimen having dimensions of 150mm * 150mm * 150mm of M30 Grade of geopolymer concrete having the ratio alkaline liquid of 2.5 of and 1 cured at 90 º C.



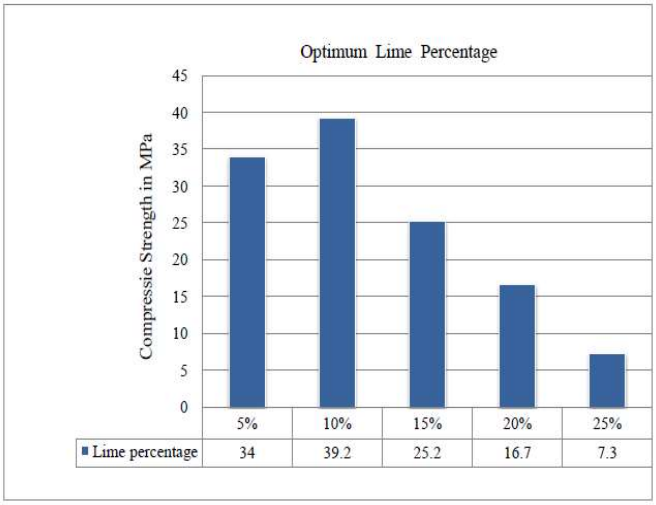
Graph 1. Effect of Curing Hours on GPC M30 at 90°C Oven Curing for Ratio 2.5

The graph 1 represents the maximum compressive strength was achieved at 24hrs. Thus, the Optimum curing hours observed here is 24hours.The trial mix for M30 gives desired results at 24hours. Hence it can be used for further experimental work.



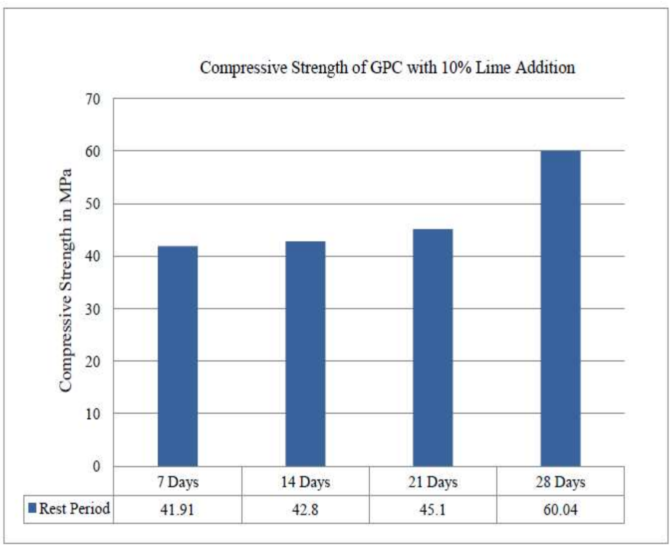
Graph 2. Alkaline Ratio 1 for M30 Grade of Geopolymer Concrete

The graph represents the increase in the strength of geopolymer concrete of grade M30 with alkaline ratio as 1, with the increase in the rest period oven cured at a temperature of 90°C. Thus, the maximum strength achieved was at a rest period of 28days.



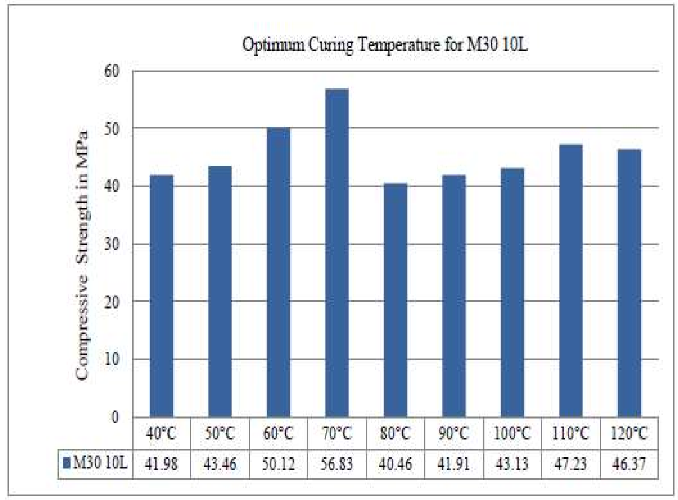
Graph 3. Lime Percentage for M30 at 90°C Oven Curing

The graph represents the variation in the strength of geopolymer concrete of grade M30 with the addition of lime percentage cured for 24hours at a temperature of 90°C. The rest period for the cured specimens was 07 days. The maximum compressive strength was achieved with addition 10%. Thus, the Optimum percentage of Lime addition observed here is 10%.



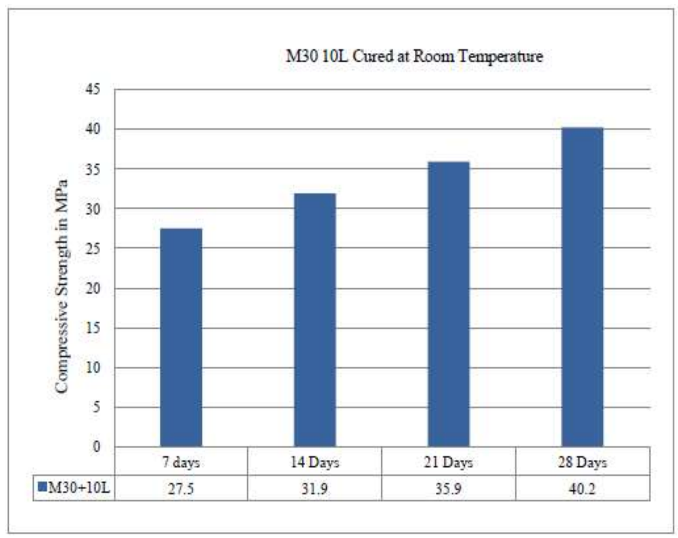
Graph 4. Effect of Rest Period on Compressive Strength of Geopolymer Concrete with 10% Lime Addition

The graph represents the increase in the strength of geopolymer concrete of grade M30+10 with the increase in the rest period at a temperature of 90°C. The maximum compressive strength was achieved at 28 days. But, at 7 days the strength achieved was more than the designed strength. Thus, the Optimum rest period observed here is 7days the project work being time bound.



Graph 5. Effect of Curing Temperature for GPC M30 10L

The graph represents the variation in the strength of geopolymer concrete of grade M30 with the addition of 10% lime cured for 24hours at varied temperatures. The rest period for the cured specimens was 07 days. The graph depicts the decrease in strength at higher temperatures. The maximum compressive strength was achieved with addition 10% at 70°C. Thus, the Optimum temperature with 10% Lime addition observed here is 70°C.

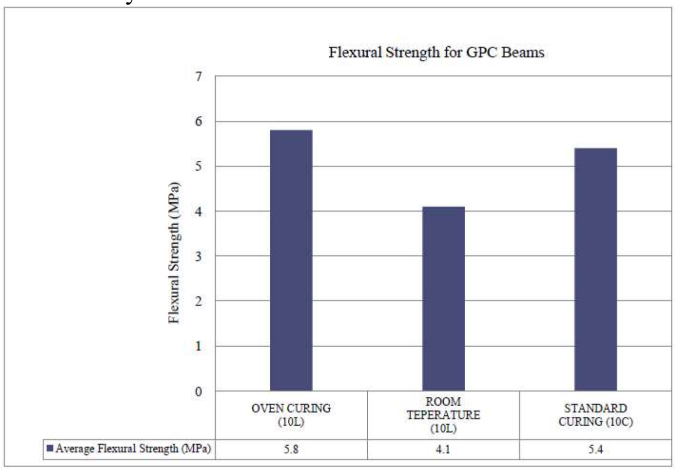


Graph 6. Compressive Strength of M30+10l Cured at Normal Room Temperature.

The graph represents the increase in the strength of geopolymer concrete of grade M30+10L with the increase in the rest period at a normal room temperature. The normal room temperature on an average was recorded as 28°C (Temperature in the morning was recorded as 27°C and in the evening it was recorded as 29°C). The strength observed at the rest period of 7 days was achieved more than 70% unlike conventional cement concrete. The maximum compressive strength was achieved at 28 days which is more than the designed strength. Thus, Geopolymer concrete of Grade M30 with 10% Lime addition by weight of Fly ash does achieve strength more than designed at normal room temperature.

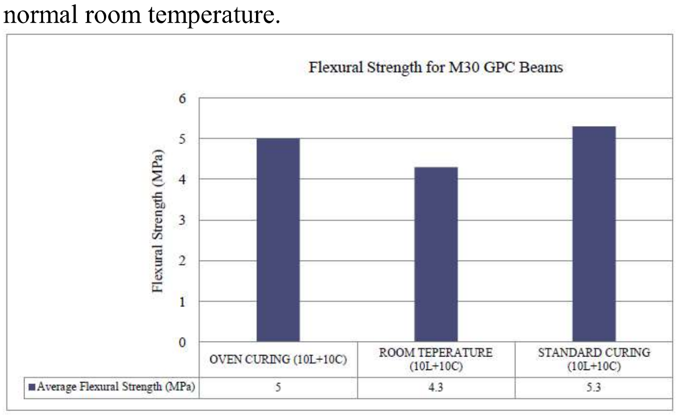
B. Flexural Strength

Determination of flexural strength is essential to estimate the loads at which concrete members may crack. The axis of the specimen was carefully aligned with the axis of the loading devise. The load was applied without shock and increasing continuously. The failure load was noted.



Graph 7. Flexural Strength of GPC for Grade M30 with Addition of Lime and Replacement with Cement

The graph represents the Flexural strength for M45 geopolymer concrete at a rest period of 28days with an addition of 10% lime cured in oven at 70°C and cured at normal room temperature (Temperature in the morning was recorded as 27°C and during the evening it was recorded as 28.5°C) and 10% replacement with cement with wet curing. The Flexural strength achieved by wet curing was observed to be 32% more than the flexural strength achieved by curing at normal room temperature. Whereas, the maximum flexural strength was achieved by 10% addition of Lime and by opting oven curing. This was observed to be 7.5% more than wet curing and 41.5% more than the flexural strength achieved at normal room temperature.

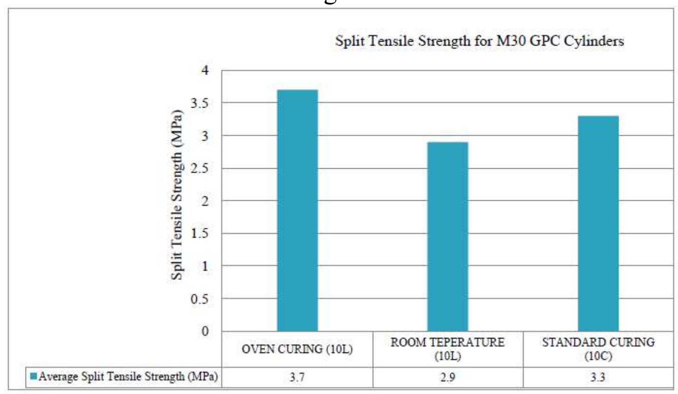


Graph 8. Flexural Strength of Geopolymer Concrete of Grade M30 for 10% Lime Addition and For 10% Replacement with Cement

The graph represents the Flexural strength for M30 geopolymer concrete at a rest period of 28days with an addition of 10% lime and 10% replacement with cement. (Temperature in the morning was recorded as 27°C and during the evening it was recorded as 28.5°C). The flexural strength achieved by oven curing was observed to be 17% more than the flexural strength achieved by curing done at normal room temperature. Whereas, the maximum flexural strength was observed by opting wet curing. This was observed to be 7% more than oven curing and 24% more than the flexural strength achieved at normal room temperature.

C. Split Tensile Strength

These tests were carried out in accordance with IS 5816-1999 standards conducted on geopolymer concrete cylinders of 150 mm diameter and 300 mm length.



Graph 8. Split Tensile Strength of GPC for Grade M30 with Addition of Lime

The graph represents the split tensile strength for M30 geopolymer concrete at a rest period of 28days with an addition of 10% lime cured in oven at 70°C and cured at normal room temperature (Temperature in the morning was recorded as 27°C and during the evening it was recorded as 28.5°C). The split tensile strength achieved by wet curing was observed to be 15% more than the split tensile strength achieved by curing done at normal room temperature. Whereas, the maximum split tensile strength was achieved by 10% addition of Lime and by opting oven curing. This was observed to be 12% more than wet curing and 28% more than the split tensile strength achieved at normal room temperature.

III. CONCLUSION

From the above experimental investigations following conclusions were drawn:

1. The compressive strength increases with the increase in the curing time, and the maximum is achieved at 24 hours of oven curing.
2. When 5% of Fly ash was replaced by Lime by weight the mixture observed was deficient of the binder i.e. Fly ash, thereby decreasing the compressive strength of the geopolymer concrete making it necessary to add Lime rather than replace Lime in the preparation of geopolymer concrete.
3. The compressive strength of geopolymer concrete of grade M30 goes on increasing with the addition of 5% and 10% of Lime, where maximum can be achieved by addition of 10% of Lime.
4. The compressive strength goes on increasing for M30 grade of geopolymer concrete with 10% Lime addition, as the rest period increases; where the maximum strength is achieved at the completion of 28 days of rest period.

5. The compressive strength achieved by grade M30 of geopolymer concrete cured at normal room temperature at a rest period of 7days is higher than the compressive strength achieved by ordinary concrete for similar rest period.
6. Flexural strength achieved by M30 by opting oven curing (70°C), curing done at normal temperature for 10% Lime addition and by wet curing for 10% replacement with cement at a rest period of 28 days is higher than the flexural strength achieved by ordinary concrete where; maximum is achieved by opting oven curing(M30 10L).

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