A Study on Effect of Different Molarities of Alkaline Activtor on Flyash And Metakaolin Based Geopolymer Concrete

K. Kalyan[1], R. Saiteja[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *Concrete is one of the most extensively used construction material, it is commonly related with Portland cement as an essential constituent for making concrete. The usage of cement is increasing day by day for satisfying the need of development of infrastructure facilities. Production of cement depletes significant amount of natural resources and releases large volume of carbon dioxide add to the pollution of environment. In order to reduce the usage of ordinary Portland cement, there is a need to find the alternate material to the cement.Geopolymer concrete is a new generation concrete and it uses GGBS, flyash, alccofine etc. and alkaline solution as the binding materials. As there is no alternative building material which totally replaces the cement, the search for any such material, which can be used as an alternative or as a supplementary for cement, should lead to global sustainable development and lowest possible environmental impact. Hence, in this project, metakaolin and fly ash is used as substitute for cement and an experimental study is carried out. In this study for the polymerization process alkaline liquids used are Sodium Hydroxide (NaOH) and Sodium Silicate (Na2SiO3). Different molarities of sodium hydroxide solution i.e. 10M, 12M and 14M are taken to prepare different mixes and the compressive strength is calculated for each of the mix.. M30 grade of geopolymer concrete with different molarities i.e; 10M, 12M and 14M were chosen. Compressive strength, flexural strength and tensile strength tests were conducted on fly ash based geopolymer concrete. . The strength tests of these geopolymer concrete specimens are tested at 7days, 14days and 28 days.*

Keywords- Metakaolin (MK), Fly ash (FA), Sodium Hydroxide (NaOH), Sodium Silicate (Na_2SiO_3), Compressive strength, split tensile strength test, flexural strength test.

I. INTRODUCTION

In the construction field, Cement is the main ingredient for the production of concrete. But the production of cement requires large amount of raw material. During the production of cement burning of lime stone take place which results in emission of carbon dioxide (CO2) gas into the atmosphere. There are two different sources of CO2 emission during cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of burning limestone.

In the last three decades, supplementary cementitious materials such as fly ash, silica fume and ground granulated blast furnace slag have been judiciously utilized as cement replacement materials as these can significantly enhance the strength and durability characteristics of concrete in comparison with ordinary Portland cement (OPC) alone, provided there is adequate curing. Fly ash addition proves most economical among these choices, even though addition of fly ash may lead to slower concrete hardening. However when high strength is desired use of silica fume is more useful however, this product is rather expensive.

Metakaolin (MK) or calcined kaolin or other type of pozzolan produced by calcination has the capability to replace silica fume as an alternative material.At present the market price of MK in the country is about 3 - 4 times that of cement. Therefore the use of metakaolin proves economical over that of silica fume. Previously, research findings have shown a lot of interest in MK as it has been found to possess both pozzolanic and micro filler characteristics. It has also been used successfully for the development of high strength concrete using mathematical modeling. However limited test data are available regarding the performance of the commercially available MK and Indian cements in the case of high strength concrete in the country.

New sort of concrete comprised of source material like fly ash, ground granulated blast furnace slag (GGBS), rice husk ash, metakaolin and alccofine and so on and a solution called alkaline activator or alkaline solution arranged by utilizing sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) of appropriate fixation. Rather than sodium silicate and sodium hydroxide we can even utilize potassium hydroxide (KOH) and potassium silicate (K_2SiO_3) yet numerous scientists proposed to utilize sodium based alkaline activators to reduce off cost of the alkaline solution and to improve solution which can upgrade the limiting property of the source material taken to get ready geopolymer concrete.

The main objective of the present study is to know the influence of fly ash and metakaolin mixes at different molarities of alkaline solutions on properties of geopolymer concrete and detecting workability, compressive strength, flexural and tensile strength on comparison with conventional concrete.

II. REVIEW OF LITERATURE

This part of the study deals with the review of several research papers related to compressive strength and workability of geopolymer concrete poised by employing various source materials such as fly ash, metakaolin etc. But considering availability of material and cost considerations many researchers studied various properties of geopolymer concrete are given below.

AnasShahidMultani, A K Nigam (2017) Investigated on Partial Replacement of Cement with Metakaolin in Association with Super Plasticizer. Metakaolin seems to be an auspicious additional cementitious material for superior cement. Properties of cement with metakaolin are for the most part favoured added substances in superior cement. The metakaolin consolidations increment the quality of the concrete specimens. In this work, the impact of various contents of Metakaolin included to concrete containing super plasticizer its compressive quality strength and workability has been contemplated. Samples with 0%, 5%, 10%, 15%, 20% and 25% content of metakaolin replacing the cement have been evaluated for M30 grade. The outcomes have been contrasted and those for the control test and practicality of adding metakaolin to concrete has been examined. It was watched that up to 15% of concrete can be supplanted with metakaolin blended with superplasticizer.15% substitution is the ideal rate at which expanded quality of test sample is seen from the base sample test.

Saxena, S. K., Kumar, M., & Singh, N. B. (2018) compared the results of geopolymer cement with opcinterms of compressive strength , durability test by using sulphuric acid. The geopolymer cement was made by using fly ash , Alkaline Solution (14M NaOH) and Silicate solution (Sodium silicate solution) And also he used alccofine powder which has have similar properties of silica fume. Finally he concluded that compared to OPC this designed mix (geopolymer mix) giving better reliable results than OPC in terms of durability, Compressive strength.

Junaid, M. T., Kayali, O., Khennane, A., and Black, J. (2015) In this paper he decided the mix proportions geopolymer concrete (GPC) by utilizing Calcium Class F Flay Ash and Alkaline solutions of sodium silicates and sodium hydroxide. For the distinctive mix plans he discovered ideal substance of alkaline fluid to fly ash (AL/FA) proportion, water to geopolymer concrete (W/GPS) proportion and Alkaline to water (AL/W) proportion.

Sangeetha,P.S.Joanna (2014) studied the structuralbehavior of RC beams with GGBS concrete. The results obtained from experiments statesthat the ultimate moment capacity of GGBS was less than the controlled beam when tested at 28 days, but it increases by 21% at 56 day. The measuredcrack width at service loadranged between 0.17 to 0.20mm and is within the limits (IS456-2000). The structuralbehavior of RC beam with GGBS resulted the typicalbehavior of RCC beamsand there increase in loadcarryingcapacity of GGBS beams with age. The structuralbehavior of Reinforced concrete beams with GGBS resembles the typicalbehavior of Reinforced cement concrete beamsand there is increase in loadcarryingcapacity of GGBS beams with age. Hence results of this investigation suggest that concrete with 40% GGBS replacement for cement could be used for RC beams. Having cementing properties, which can be added in cement concrete aspartialreplacement of cement, without compromising on its strength anddurability, which will result in decrease of cement production thus reduction in emission in greenhousegasses, in addition to sustainablemanagement of waste.

III. MATERIALS AND METHODS

The experimental investigation work is started with various tests on the constituent materials. The constituent materials are given below.

1. Cement
2. Coarse aggregate
3. Water
4. Fly ash
5. Metakaolin.
6. Super plasticizer

I. Cement

Ordinary Portland Cement (OPC) was used in the experimental work which is conforming to I.S 4031-1988.The O.P.C is classified into three grades, those are 33grade, 43grade and 53 grade, depending upon the strength of the cement in this experiment 43grade cement is used.

II. Fine Aggregate

Fractions from 4.75 mm to 150 microns are termed as fine aggregate. Locally available river sand passed through 4.75mm IS sieve is applied as fine aggregate conforming to the requirements of IS 383:1970.

III. Coarse Aggregate

The crushed aggregates used were of 20mm nominal maximum size.Aggregate most of which is retained on 4.75-mmIS Sieve and containing only so much finer material as is permitted for the various types described in this standard.

IV. Fly ash

Class f and low calcium type of fly ash is used in this study as major source material of geopolymer concrete and it was obtained from National Thermal Power Corporation Ramagundam.

V. Metakaolin

Metakaolin is the unpurified thermally activated ordinary clay and kaolin clay. Metakaolin is not highly reactive pozzolanic material, but it shows high pozzolanic reactivity after removing unreactive impurities by water process. The colour of metakaolin is white or cream. With metakaolin, cement paste undergoes distinct densification and it helps to increases the strength and decreases the permeability.

VI. Superplasticizer

Naphthalene based super plasticizer namely Fosroc Conplast SP430 is a chloride free, super plasticizing admixture based on sulphonated naphthalene polymer is used to upgrade or boost the workability as well as strength of geopolymer concrete. The dosage is raging from 1.00 to 3.00 litres per 100 kg of cementitious material such as fly ash, GGBS and alccofine etc.

IV. MIX DESIGN

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance. Percentage dosage of super plasticizer was fixed as per the mix design method described in IS 10262- 2009. Mix proportion was arrived through various trial mixes. The grade of concrete prepared for the experimental study was M30.

V. TESTS ON FRESH CONCRETE

5.1 WORKABILITY OF CONCRETE

Workability of GPC with variable proportions is determined utilizing slump cone test. It is seen that decline in the slump an incentive as expansion in both molarity of alkaline solution and proportion of fly ash and metakaolin are flaky in nature and high molar solution has greater viscosity when contrasted with water. Slump test was carried out to measure the workability of various mixes. The workability of various mixes was assessed as per the IS 1199:1959 specification.Figure 5.1shows that the variation of slump values with different proportions of fly ash and metakaolin.

TABLE 5.1 shows the Variation of Slump Values

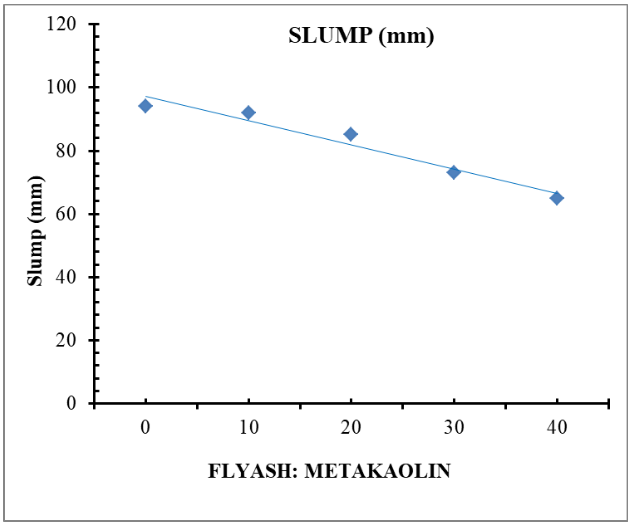

Fig 5.1: Plot shows the Variation of Slump Values for different proportions of Fly ash + Metakaolin

VI. TESTS ON HARDENED CONCRETE

6.1 VARIATION OF COMPRESSIVE STRENGTH FOR DIFFERENT MIXES

It is noticed that Na_2SiO_3/NaOH proportion of 2.5 the outcomes acquired are generally more.The test is done on geopolymer concrete cubes in compressive testing machine to determine its compressive strength after the age of 7 days, 14 days and 28 days. The compressive strength results obtained are shown in figure 6.1.

In order to compare the Compressive Strength of Geopolymer Concrete with the Compressive Strength of Normal Concrete, normal concrete cubes were also casted and its strength is measured at the age of 7 days, 14 days and 28 days.

From experimental Results of normal Concrete and geopolymer Concrete obtained, we can conclude that, the rate of gain of strength of geopolymer Concrete is more than the normal Concrete. Also the maximum Compressive Strength of geopolymer Concrete is higher than the maximum comp. strength of normal Concrete at the age of 7 days, 14 days and 28 days.

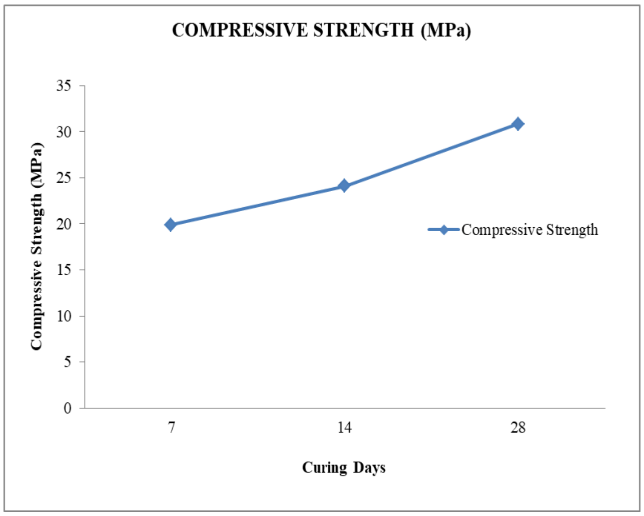

Fig 6.1: Plot shows the Compressive Strength results of normal concrete for M30

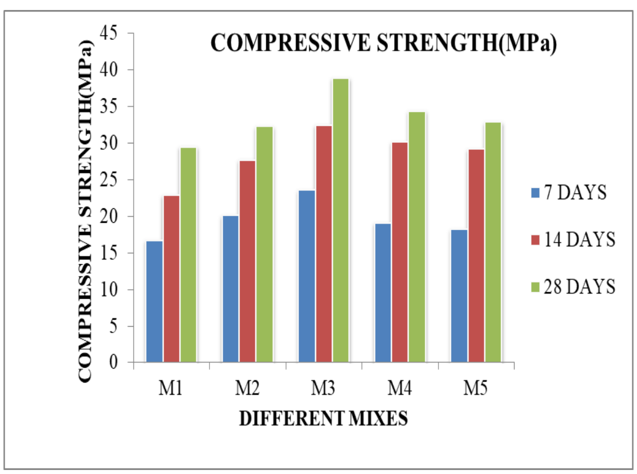

Fig 6.2: Plot shows the Compressive Strength results of Fly ash + Metakaolin at molarities of 10M

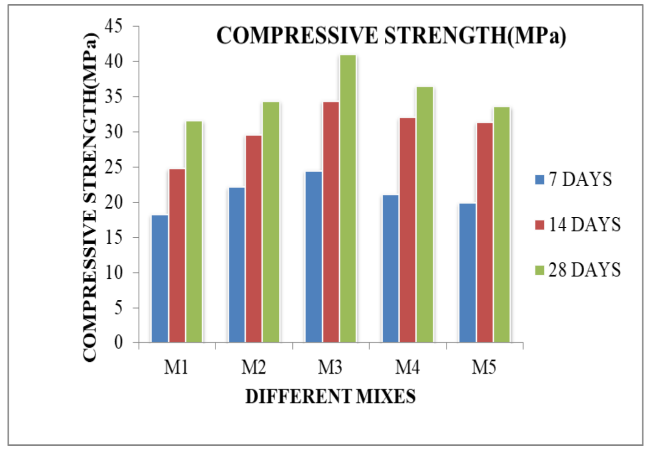

Fig 6.3: Plot shows the Compressive Strength results of Fly ash + Metakaolin at molarities of 12M

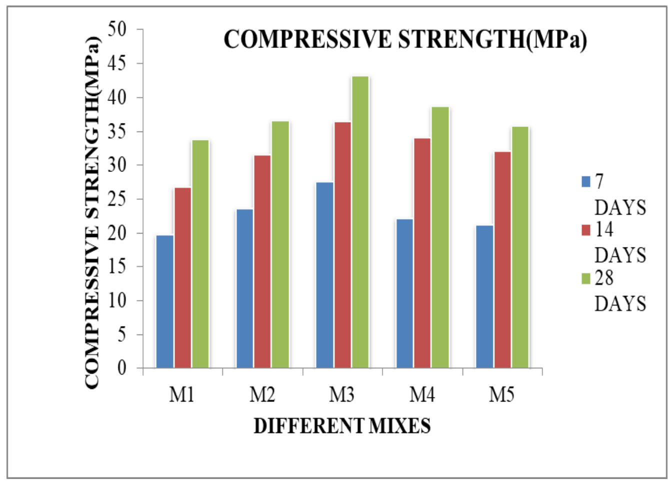

Fig 6.3: Plot shows the Compressive Strength results of Fly ash + Metakaolin at molarities of 14M

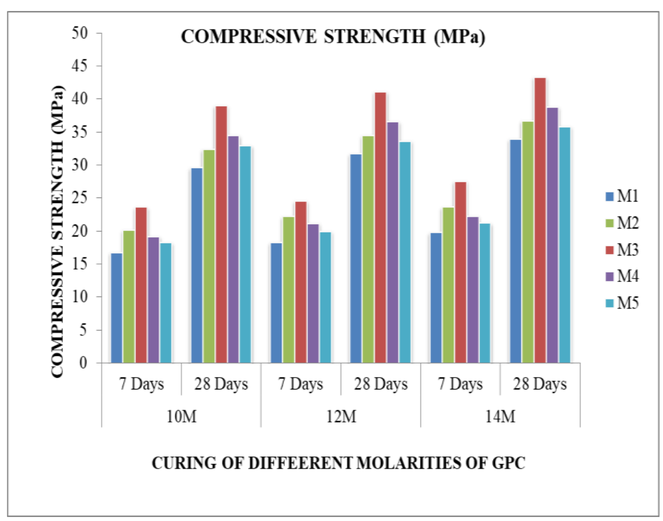

Fig 6.4: Plot shows the Compressive Strength results of Fly ash + Metakaolin at molarities of 10M, 12M and 14M

6.2 VARIATION OF SPLIT TENSILESTRENGTH FOR DIFFERENT MIXES

The variation of split tensile strength at the age of 7 and 28 days were given below. From the test results, it was observed that with the increase in concentration of sodium hydroxide, the split tensile strength of geopolymer concrete increases for all cases.

It is seen that with expanding molarity of alkaline solution, split tensile strength esteems are expanding. The maximum tensile strength of geopolymer concrete was observed in M4 at 28 days.

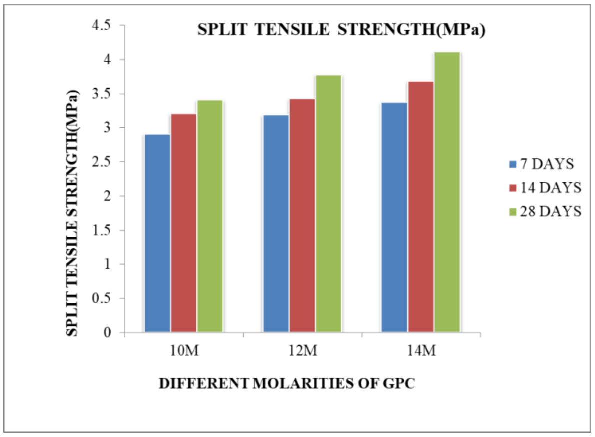

Fig 6.5: Plot shows the Split tensile Strength results of Fly ash + Metakaolin for Different molaritiesof 10M, 12M and 14M.

6.3 VARIATION OF FLEXURAL STRENGTH FOR DIFFERENT MIXES

The variation of flexural strength at the age of 7 and 28 days were given below. From the test results, it was observed that with the increase in concentration of sodium hydroxide, the flexural strength of geopolymer concrete increases for all cases.

It is seen that with expanding molarity of alkaline solution, flexural strength esteems are expanding. The maximum flexural strength of geopolymer concrete was observed in M4 at 28 days.

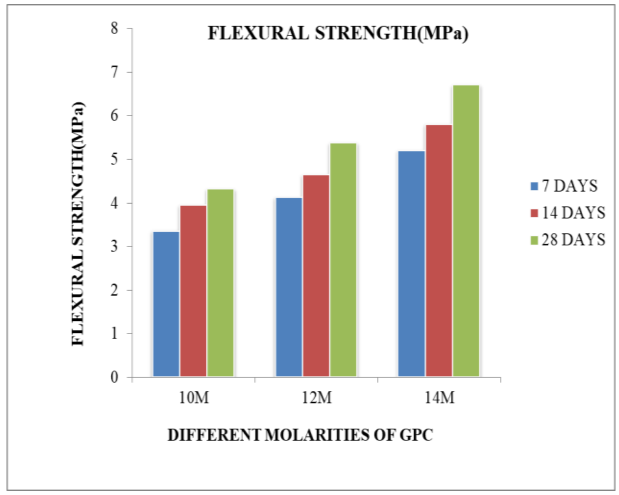

Fig 6.6: Plot shows the flexural Strength results of Fly ash + Metakaolin for Different molaritiesof 10M, 12M and 14M

VII. CONCLUSIONS

The conclusion drained through the testing of the various mix designs specimens in the form of cube cylinder and prism molds by the destructive testing of ambient-cured in which the molarity of NaOH and Na2SiO3/NaOH varying in the design mix of GPC and the use of fly ash and metakaolinin concrete production was studied and after the research work is done, the following conclusions were made:

- It is observed that workability of geopolymer concretedecreases linearly with increase of % metakaolin replacing by fly ash. For every 10 % replacement of fly ash with metakaolin.
- It is observed that compressive strength of geopolymer concrete increases with increase in % fly ash replacing metakaolin up to 20 %, and then decreases beyond. Hence, it concluded that 20 % metakaolin is optimum for M30 grade concrete.
- The highest compressive strength of ambient cured 14 M mix is 36.41 N/mm^2 at 28 days ambient curing.
- It is evidenced that with increasing in percentage of metakaolin in fly ash with alkaline solution, there is an increase in split tensile strength and it is observed that at 20% replacement of metakaolin the split tensile strength is more.
- In the ambient cured specimens 14 M got the highest splitting tensile strength is 4.12 N/mm^2 at 28 days.
- Similarly, the ambient-cured geopolymer concrete specimens got more flexural strength as compared to the normal concrete under water curing.
- It is noted that with increasing in percentage of metakaolin in fly ash with alkaline solution, there is an increase in flexural strength at 20% replacement of fly ash

by metakaolin. The highest strength of oven-cured specimensof 14 M mix is6.71 N/mm^2 at 28 days.

- Molarity of alkaline solution shows a great impact on strength, increasing concentration of solution improved the strength but decreased workability and cost of preparation of geopolymer concrete is also increased.

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