A Study on Potential of Low Corbon Concrete And Utilization Technologies For The Production of Sustainable Concrete

B Dev Kumar, K Urmila Devi
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *The usage of cement is increasing day by day for satisfying the need of development of infrastructure facilities. As the emission of carbon dioxide during the production of cement is more and thus causes serious problems to degradation of environment. In view of this, there is a significant expectation on the researchers to reduce co2 emission. 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 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, nano silicaand GGBS 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 GGBS based geopolymer concrete. . The strength tests of these geopolymer concrete specimens are tested at 7days, 14days and 28 days.*

Keywords- Nano silica, GGBS, Sodium Hydroxide (NaOH), Sodium Silicate (Na2SiO3), Compressive strength, split tensile strength test, flexural strength test.

I. INTRODUCTION

The quest for the development of high strength and high performance concretes has increased considerably in recent times because of the demands from the construction industry. In the last three decades, supplementary cementitious materials such as GGBS, 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. GGBS addition proves most economical among these choices, even though addition of GGBS 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. GGBS and Nano silica can be effectively used in concrete as a cementitious material because of their high content of silica and pozzolanic properties which plays an important role in achieving high strength and durability in concrete. To Substitute the cement we can utilize GGBS and Nano silica that is accessible as a waste material delivered by power plants.

Rapid industrial expansion produces severe difficulties all around the world, including as the depletion of natural resources and the creation of vast amounts of waste materials throughout the manufacturing, construction, and demolition stages; one option to mitigate this problem is to utilize wastes. The impact of carbon dioxide emission due to production of Portland cement can be reduced by partial replacement of cement with supplementary cementitious materials. GGBS could be a by-product of the thermal power industries, the disposal of this material is already inflicting environmental issues round the industrial factories. As the emission of carbon dioxide during the production of cement is more and thus causes serious problems to degradation of environment. In view of this, there is a significant expectation on the researchers to reduce CO2 emission. In order to reduce the usage of ordinary Portland cement, there is a need to find the alternate material to the cement.

The main objective of the present study is to know the influence of GGBSand nano silica 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 GGBS, nano silicaetc. 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 Nano silicain Association with Super Plasticizer. Nano silicaseems to be an auspicious additional cementitious material for superior cement. Properties of cement with nano silicaare for the most part favoured added substances in superior cement. The nano silicaconsolidations increment the quality of the concrete specimens. In this work, the impact of various contents of Nano silicaincluded 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 nano silicareplacing the cement have been evaluated for M30 grade. The outcomes have been contrasted and those for the control test and practicality of adding nano silicato concrete has been examined. It was watched that up to 15% of concrete can be supplanted with nano silicablended 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 GGBS , 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 GGBS (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. GGBS
5. Nano silica.
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. GGBS

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel industry. Blast furnace slag is defined as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron ina blast furnace." In the production of iron, blast furnaces are loaded with iron ore, fluxing agents, and coke. When the iron ore, which is made up of iron oxides, silica, and alumina, comes together with the fluxing agents, molten slag and iron are produced.

V. Nano silica

Advance cement made by the investigation of concrete at Nano scale have demonstrated Nano silica superior to anything silica utilized in traditional cement, however engineering investigations demonstrates that likewise with silicon powder, additionally bring two issues, from one perspective is the cohesiveness increment of cement to development cause certain issue.

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 GGBS, 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

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 GGBS and nano silicaare 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 GGBS and nano silica.

TABLE 5.1 shows the Variation of Slump Values

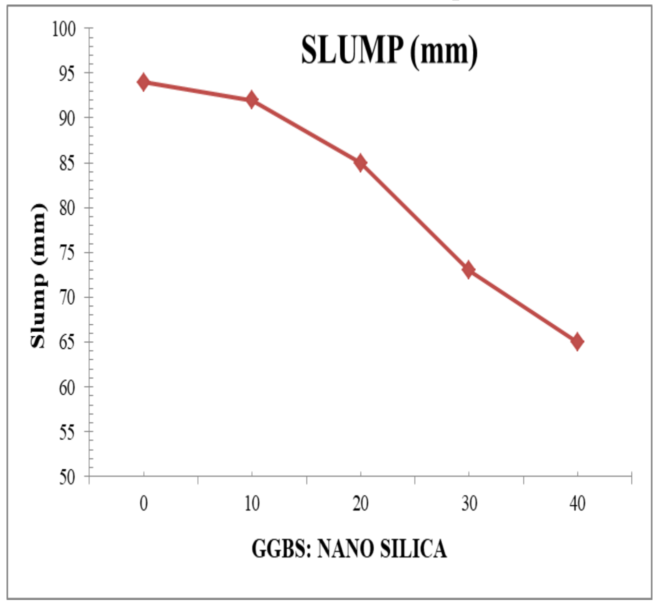

Fig 5.1: Plot shows the Variation of Slump Values for different proportions of GGBS + Nano silica

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.

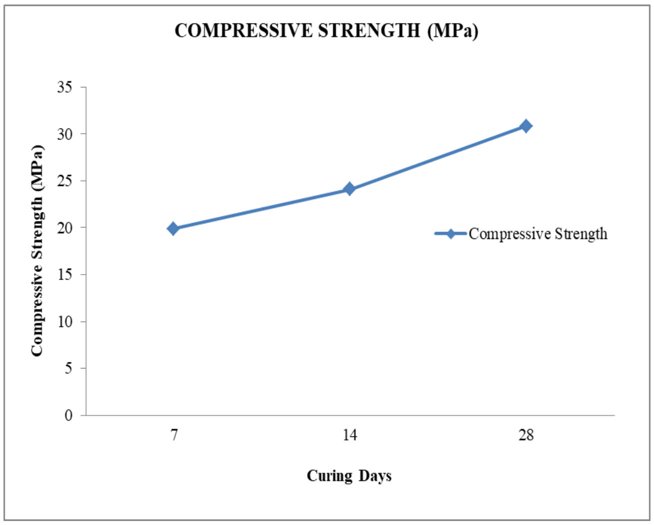

Fig 6.1: Plot shows the Compressive Strength results of normal concrete for M30

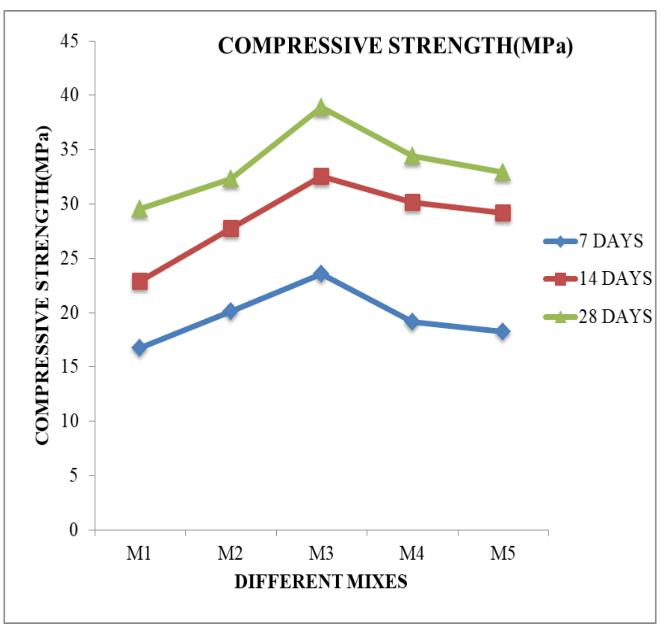

Fig 6.2: Plot shows the Compressive Strength results of GGBS + Nano silicaat molarities of 10M

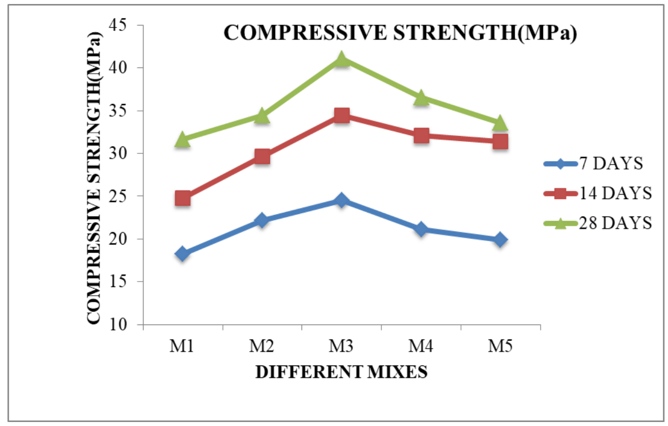

Fig 6.3: Plot shows the Compressive Strength results of GGBS + Nano silicaat molarities of 12M

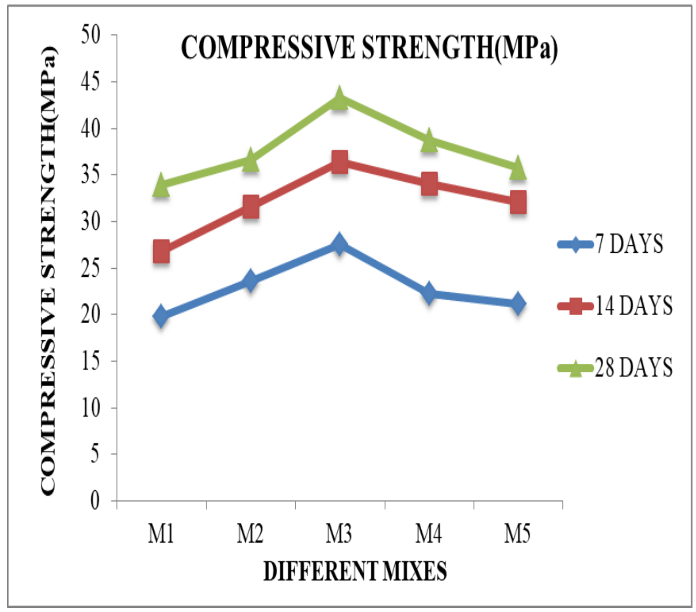

Fig 6.3: Plot shows the Compressive Strength results of GGBS + Nano silicaat molarities of 14M

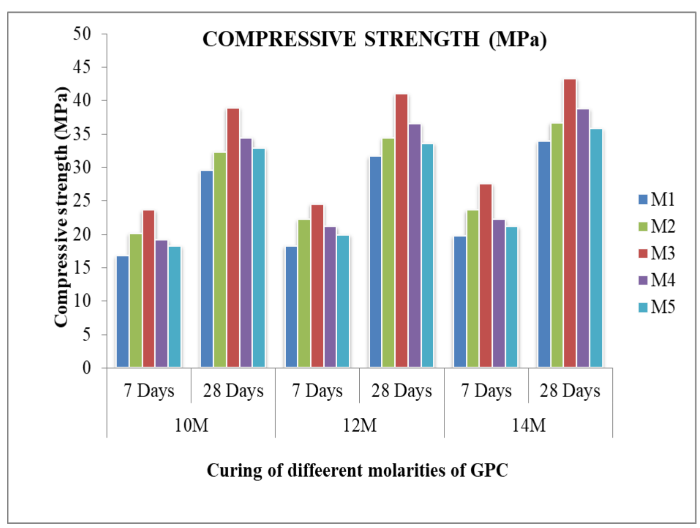

Fig 6.4: Plot shows the Compressive Strength results of GGBS + Nano silicaat molarities of 10M, 12M and 14M

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.

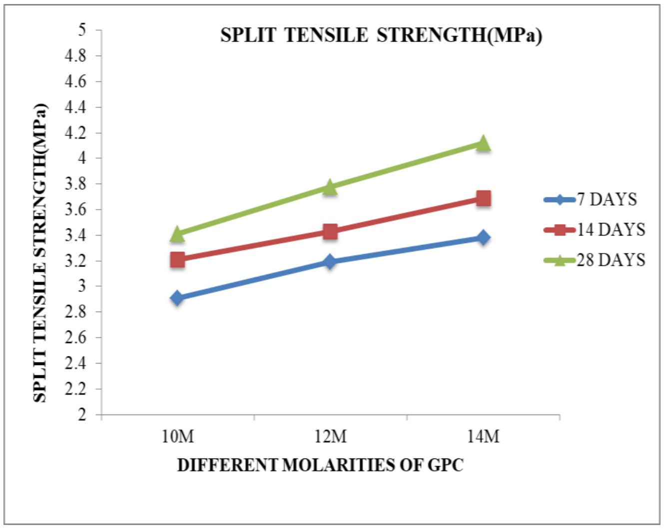

Fig 6.5: Plot shows the Split tensile Strength results of GGBS + Nano silicafor Different molaritiesof 10M, 12M and 14M.

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.

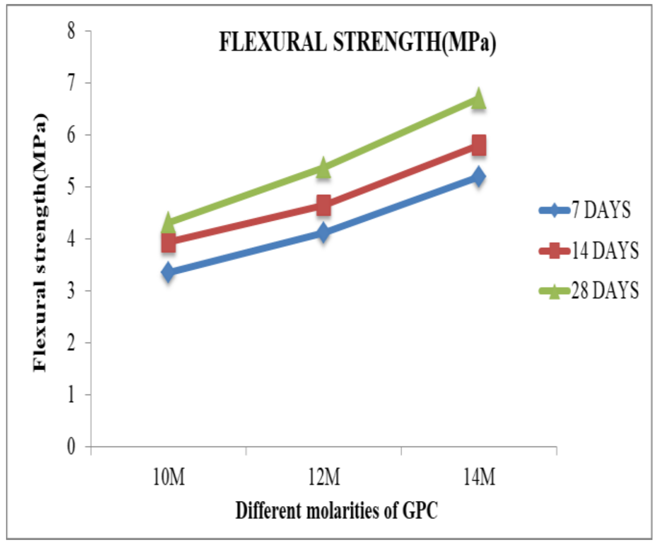

Fig 6.6: Plot shows the flexural Strength results of GGBS + Nano silicafor Different molaritiesof 10M, 12M and 14M

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 GGBS and nano silicain concrete production was studied and after the research work is done, the following conclusions were made:

- It is observed that workability of geopolymer concrete decreases linearly with increase of % Nano silica replacing by GGBS. For every 10 % replacement of GGBS with Nano silica.
- It is observed that compressive strength of geopolymer concrete increases with increase in % Nano silica replacing GGBS up to 20 %, and then decreases beyond. Hence, it concluded that 20 % Nano silica is optimum for M30 grade concrete.
- The highest compressive strength of ambient cured 14 M mix is 43.16 N/mm^2 at 28 days ambient curing.
- It is evidenced that with increasing in percentage of Nano silica in GGBS with alkaline solution, there is an increase in split tensile strength and it is observed that at 20% replacement of Nano silica the split tensile strength is more.
- In the ambient cured specimens 14 M got the highest splitting tensile strength is 4.21 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 Nano silica in GGBS with alkaline solution, there is an

increase in flexural strength at 20% replacement of GGBS by Nano silica. The highest strength of oven-cured specimens of 14 M mix is 6.74 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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