

Study on Mechanical Properties of Geo-Polymer Concrete Using M-Sand and Steel Fibers

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ABSTRACT: There is rapid development in construction industry, which is also one of the important sources for the revenue of the country. Construction industry provides employment opportunity, and also improves standard of living of the people in the country. Although there is a benefit from the construction industry but also there is disadvantage because of excess usage of cement in the construction. As the cement is a key element in the construction but during the manufacturing of cement it emits some toxic gases like CO₂ in the excess amount.

To overcome this problem scientist were done lot of research on it and finally a French scientist Davidovits found a complete cement replacing agent called GEO-POLYMER concrete. Geo-polymer is a concrete where there is no cement is used instead Fly ash and GGBS is used as the binding elements.

Fly ash which is residue from the coal manufacturing industry and blast furnace slag are the key constituents for preparing geo-polymer concrete. And also fine aggregates, coarse aggregates and finally water is added to make a Geo-polymer concrete.

So in this study an attempt is made to know the strength geo-polymer concrete by adding holed steel bars in the mix. By making 3 mixes with varying proportion of fly ash and GGBS like 1st mix with 70% fly and 30% GGBS, 2nd mix with 50% fly ash and 50% GGBS and finally 60% fly ash and 40% GGBS. For all the 3 mixes hooked steel fiber were added and from this cubes of size 150mm x 150mm x 150mm and 24 in number were casted. And 24 cylinders with size 150mm dia and 300mm height and beams of size 100mm x 100mm x 400mm 24 in number were casted.

And all the test specimens were tested for compression test, flexural test and split tensile test. And finally strength of geopolymer concrete with steel fibers was determined.

KEYWORDS: CONVENTIONAL CONCRETE, WORKABILITY, GEOPOLYMER CONCRETE, FLY ASH, ALKALINE LIQUIDS, STEEL FIBRE.

I. INTRODUCTION

Concrete is using widely as constituent for construction in the globe and is also a key constituent for development of the country. Portland cement is generally used for the production concrete. Green building has become an ever-growing concept in Construction industry given how production of new material affects the environment. Companies are becoming more conscientious about the amount of new materials that must be used during a construction project and have turned to the use of recycled materials and efficiency during construction to help reduce the amount of materials that must be expended throughout the lifetime of any structure. One way in which construction negatively affects the environment is through cement production, a required product in the manufacture of concrete.

Cement production throughout the world has increased over the years, with 3.6 billion tons of cement having been produced in 2011. A side-effect of cement production is the release of carbon dioxide (CO₂) into the atmosphere caused by the calcination of limestone and the combustion of the fossil fuels during the process. The production cement of one ton contributes about one ton carbon dioxide into the atmosphere (Malhotra 1999). With the demand for cement growing annually, researchers have found ways to reduce the amount of cement required in the production of concrete.

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The use of recycled materials and admixtures into concrete has been an area of research which has found methods of using less cement in a concrete mix while still retaining the favourable characteristics of concrete. One such admixture which has been used in concrete to replace a significant amount of cement in a mix is fly ash.

Geo-polymer

Geo-polymer concrete was first invented by Davidovits (in 1978), by using inorganic fasteners by synthetic structure like as zeolites and with a formless microstructure. Use of poly-condensation of Si and Al antecedents accomplish auxiliary strength. Alumina-silicate is rich in Si and Al. Geo-polymers are very good in correlation to other Al and Si materials. Al and Si union is less than convergence of solids in geo-polymerisation

History of Geo-polymer

French scientist Davidovits did innovation for geo-polymer using salt materials and alumina silicates and it is known as alkaline base actuated concrete and in worldwide as a inorganic polymer geo polymer reduces greenhouse effect substance resistance of expanded flame more even waste can be utilized. Now a day's use of geo-polymer a late advance concrete because of natural ecological and specialized advantages in same cast European geo-polymer creation modern geo-polymer application takes a large portion. In 2nd world war Soviet Union first trailed geo-polymers solid applications and later various structures were developed. Now a days construction is one of the most improving fields in all over the world so yearly increase in the construction of buildings for the construction lime material and also there is an adverse effect on the environment because of manufacturing of concrete. Amount of concrete releases equal to the amount of CO₂ releases to the environment.

Necessity of Geo-polymer concrete

Construction is one of the very fast developing fields around the world. According to the present world situation, there is a need of around 2, 60, 00, 00,000 Tons of Concrete. However for the next decade it will be expanded 25%. Since the Lime stone is the principle component material which is used for the manufacturing of conventional Portland concrete and there is an intense lack of limestone may come following 25 to 50 years. And there is adverse effect on the atmosphere since manufacturing of one ton concrete releases roughly one ton of carbon dioxide to the environment.

Properties of Geo-polymer concrete (GPC)

- Higher compressive, Tensile and flexural strength
- Elasticity modulus
- Higher durability
- Bleeding free and non-toxic
- Impermeable
- Higher resist all inorganic chemicals and resist to heat
- Higher resistance against chemical attack
- Higher resistance against acidic solutions
- More workability

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II. MATERIAL USED

Fly ash

For this case study, the main material (fly ash) is collected from power plant raichur . The chemical and physical composition of main material (fly ash) was determined as per IS: 3812 Table2. It is classified into 2 classes:

- Class F- fly ash: it has good pozzolonic properties and it produced by burning of bituminous coal and it as less than 5% of calcium oxide.
- Class C- fly ash: it is produced by burning of lignite/ sub standards of bituminous coal. This type of Fly ash may have calcium oxide content in excess of 10% addition to its pozzolonic and concretionous properties.



Fig a. Fly ash

Ground granulated blast furnace Ash (GGBS)

GGBS is a by product of the Iron and steel making in the molten stage. Slag is essentially comprised of silica (35%), alumina (13%), calcium oxide (40%), and magnesia (8%). Different components like manganese, iron, sulphur, and follow measures of different components make up about other 5% of slag. Slag is precisely amassing components of different some what depending on where and how the slag is created. Around 30% by mass of binder was replaced with GGBS. The GGBS which is used in this work is brought from Ultratech RMC plant, Kanakapura, Bangalore. Ground Granulated Blast Furnace Ash is partially replaced with concrete in geo polymer concrete. GGBS gives better workability without increase in water content, and decreases heat of hydration. After concrete get hardens durability and ultimate strength will increase. The tests on granulated blast furnace slag were carried out as per IS: 383-1970.

Fine aggregate

1 M-sand

The manufactured sand from Ultra-tech RMC plant, yelahanka, Bengaluru was collected for present study. The tests are conducted on manufactured sand. The Sieve analysis results are given below and conforming to I.S. – 383-1970.

Tablea: physical properties of manufactured sand

S n	physical properties	value
01	specific gravity	3.28
02	water absorption (%)	1

Fineness modulus of M-sand = $328.0/100 = 3.28$

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4 Fibre

Hooked-end steel fibres made with low carbon steel has a length of 15mm and a Dia of 0.3 mm thus giving an Aspect ratio of 50 were used and they are shown in Figure. These fibres have adensity of 3925 kg/m³, modulus of elasticity of 2x10⁵ MPa and yield strength of 650 MPa (Source: Manufacturer's data).

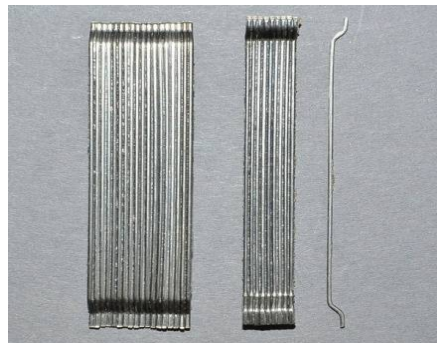


Fig b. Hooked Fibres

Water

Clean portable water is utilized for mixing process meant for the work. The Water which is available in campus is of the portable water which is having PH value 7 is utilized.

Alkaline Liquid

In this study, Sodium hydroxide(NaOH) and sodium silicate combine to prepare Alkaline liquid. Sodium solutions are used because they are more economical than potassium solutions. For this study we using concentration of 8M of alkaline liquid. Sodium hydroxide pellets and flakes are available in market.

Coarse Aggregates:

The coarse aggregates selected from size 12.5mm down used from the crushed aggregate available from the local source is considered and conforming to IS 383-1970.

Super Plasticizer

In this work we used sulphonated naphthalene based super plasticizer i.e., conplast SP430 DIS by FOSROC chemicals which is used to increase the workability of fresh GPC.

III. RELATED WORK

Selection of suitable mix proportion:-

As discussed from the beginning geopolymer concrete is the mixture of fly ash, GGBS, 70% of aggregates and water and where complete replacement of ordinary Portland cement has done. In this research geopolymer concrete mix is prepared with different percentages of both Fly ash and GGBS as these two are key elements in the concrete. Firstly 3 combinations of different percentage of fly ash and GGBS are takes like 1st combination 70% of fly ash with 30% of GGBS, and 2nd combination where both fly ash and GGBS are taken equally that is 50% - 50%, and finally the third combination where fly ash is used is 60 and GGBS is 40%. With these 3 combinations of geopolymer mix hooked steel fibres were added. When the hooked steel fibres were added in ordinary concrete the 1.5% showed the best results so the same percentage can be used in the geopolymer concrete as well.

After the geopolymer concrete mix prepared with 1.5% of hooked steel fibres test specimens were casted like cubes of size 150mm x 150mm x 150mm in size, and cylinders with length 300mm and diameter 150mm, and finally beams of size 100 x 100mm x 400mm each specimens that is cubes, cylinders and beams each of 24 in number were casted. After that the test specimens were kept for ambient curing and different tests like compressive test, tensile test and split test were carried for a period of 7days and 28 days.

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Mix proportion per cubic meter

Combined aggregate	1848kg
Fine aggregate	552kg
Coarse aggregate	1294kg
NaOH	41kg
Sodium silicate	103kg
Fly ash + GGBS (70%&30%)	408kg
Hooked Steel Fiber	118

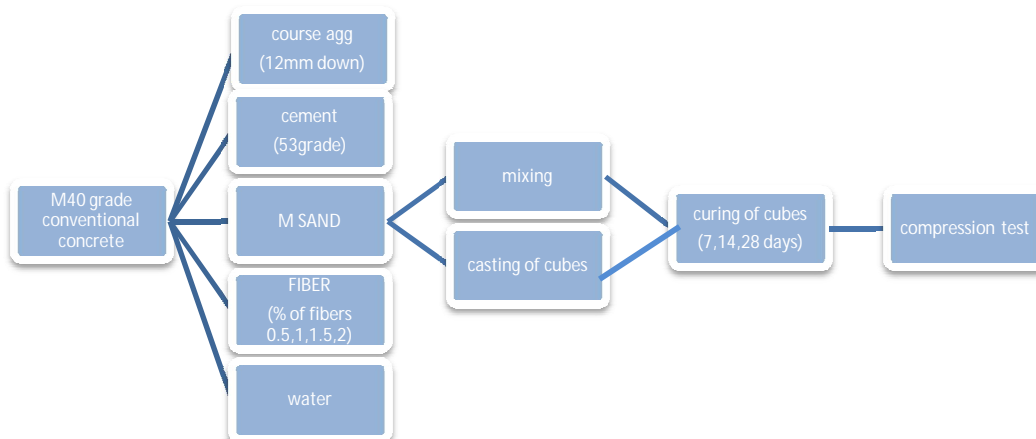


Fig a: Flow chart on preparation and testing of cubes

IV. EXPERIMENTAL RESULTS

This chapter will present the results of the carried out experimental program on these reinforced Conventional concrete along with reinforced geo-polymer concrete. This behaviour of load characteristics is presented in this chapter.

- Compressive strength
- Flexural strength
- Split Tensile strength

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Aspect ratio (l/d) 50

Compressive strength of conventional concrete

As per Indian standards 516-1959, size of standard cubes 0.15m x 0.15m x 0.15m were cast to evaluate the compressive strength of concrete.

$$\text{Compressive strength} = \text{load/area}$$

Flexural strength of conventional concrete

It was calculated by using.

$$F_s = (P \times L) / (b \times d^2),$$

Where, P = Failure load, L = 400 mm, b = 100 mm, d = 100 mm.

Split tensile strength of conventional concrete

It was calculated by

$$\text{Split Tensile strength} = 2P / \pi DL(\text{Mpa}),$$

Results of SFRC (0.5, 1.0, 1.5, and 2.0% of fibres on 28days of curing).

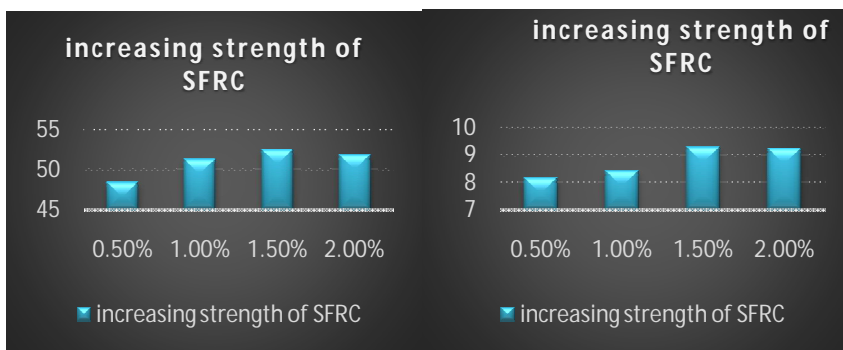


Fig a: Compression test

Fig b: Flexure test

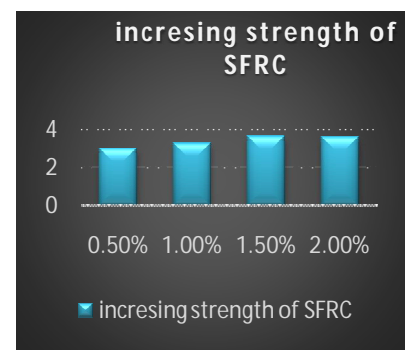


Fig c: Split tensile test

14 days Compressive strength of Geo-polymer concrete

Compressive strength

Parameter

- 70% Fly ash & 30% GGBS, 60% Fly ash 40%GGBS and 50%Flyash & 50% GGBS
- 8 Molarities
- 1.5% of Steel Fiber
- 14 days of curing

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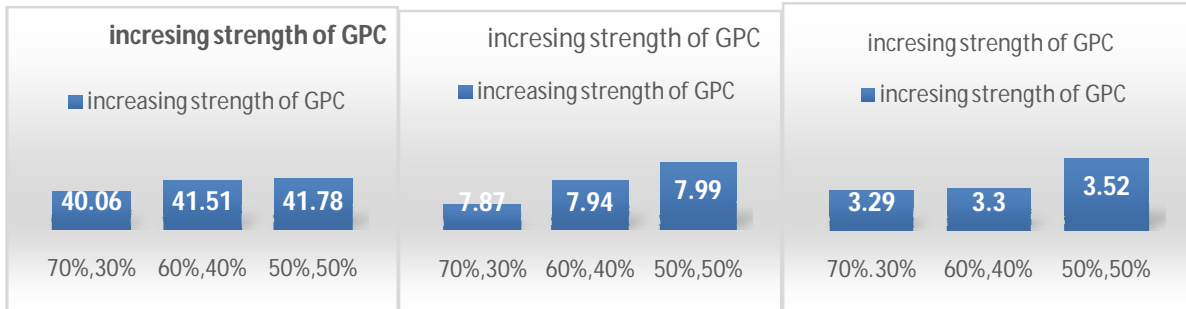


Fig d : Compression test

Fig e : Flexural test Fig f : Split Tensile test

28 days Compressive strength of Geo-polymer concrete

Compressive strength

Parameter:

- 70% Flyash & 30% GGBS, 60% Flyash & 40% GGBS and 50% Flyash & 50% GGBS
- 8 Molarities
- 1.5% of Steel Fiber
- 28 days of curing

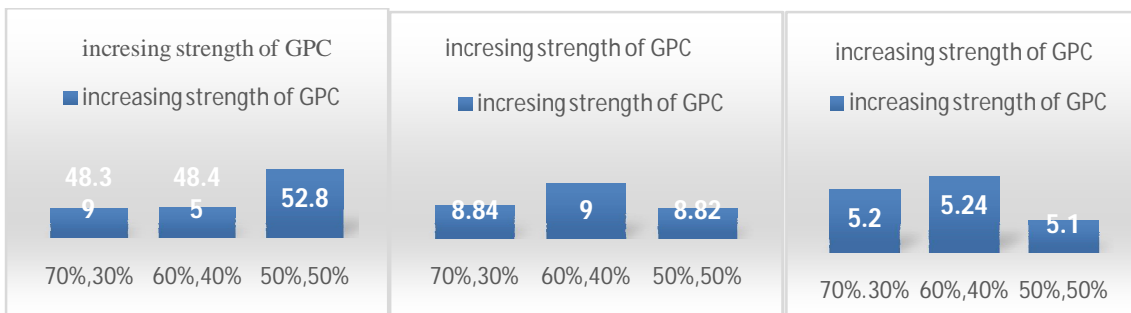


Fig g. Compression test

Fig h. Flexural test

Fig i. Split Tensile test

V. CONCLUSION

- The optimum dosage of steel fibres for an aspect ratio of 50 is 1.5% by volume of concrete.
- Workability of the GPC mix diminished with addition of steel fibres.
- It observed that addition of Super plasticizer will improve the workability as long as total water to GPC solid ratio is within 0.35.
- The maximum compressive, split tensile, and flexure strength of GPC with 8M and 1.5% steel fibres is 41.78, 3.52 and 7.99 respectively after 14 days curing.
- The maximum compressive, split tensile, and flexure strength of GPC with 8M and 1.5% steel fibres is 52.80, 5.24 and 9.10 respectively after 28 days of curing.

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- The maximum strength of GPC with 8M and 1.5% steel fibres was obtained with 50% of fly ash and 50% of GGBS after 14 days curing.
- The maximum compressive strength of GPC with 8M and 1.5% steel fibers was obtained with 50% of fly ash and 50% of GGBS after 28 days curing.
- The maximum strength (flexure and split tensile) of GPC with 8M and 1.5% steel fibers was obtained with 60% of fly ash and 40% of GGBS after 28 days curing.
- No necessity of exposing geopolymer concrete to high temperature for achieving of high strength .

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