

An Experimental Study on Mechanical Properties of Steel Fibers in Geo-Polymer Concrete

Santhosh. GK¹, Laxmi.G.G²M.Tech Structures, Department of Civil Engg, ACS College of Engineering, Karnataka, India¹Asst. Professor, Department of Civil Engg, ACS College of Engineering, Karnataka, India²

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, GGBS, Alkaline liquids, Steel fibre.

I. INTRODUCTION

Concrete is the widely used constituent for construction all over the globe, which is also one of the key constituent for the development of the country. Portland cement is normally used for the production concrete.

As the concrete is used much more in quantity for rapid growth of the country but there are some ill effects from the concrete to the environment also. Atmosphere consists of an number of gases some are necessary for the survival of the mankind and some gases are hazard's if there percentage increases more than required. The concrete manufacturing industry which releases 6% of CO₂ to atmosphere like one ton of Portland concrete discharges gives or takes one ton of CO₂ into the environment. To overcome this issue a substitute can be used in the place of Portland cement which can improve workability, sturdiness and compressive strength.

The fly ash, from the practical perspective point, common Portland concrete is referred to be more extravagant as its generation is profoundly energy serious. Then again, concretizations pozzolonic material preparing obliges practically zero immediate energy related expenses, henceforth less expensive than Portland concrete. This thusly outlines that a huge substitution of Portland concrete by concretizations material is a financially savvy intends to deliver mortar or paste. As far as diminishing the dangerous atmospheric devotion, the geo-polymer innovation could decrease the CO₂ outflow to the air created by concrete and aggregate industries by around 80% (Davidovits).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Geopolymer Concrete:- The geo-polymer concrete was invented by Davidovits in 1978, by using the inorganic fasteners by synthetic structure like zeolites and with a formless microstructure. Not at all like standard Portland/pozzolonic concretes, geo-polymers don't system C S H aimed at formwork solution & strength, however use of poly-condensation of Si & Al antecedents to accomplish auxiliary strength. The materials on alumino-silicate thought to be rich in Si and Al. Geo-polymers are likewise extraordinary in correlation to other Al and Si materials. The convergence of solids in geo-polymerisation is greater than in Al and Si union.

Application of geo-polymer technology: As per Davidovits, geo-polymeric materials have an massive variety of uses in the field of commercial enterprises, for example, in the car and aviation and structural designing and plastic manufacturing industry. The utilization of geopolymer in composite layers to reinforce solid structures and used as covering to secure the transportation foundations. The introduction of geopolymers is superior to the natural polymer as far as adherence to fire, solidness under ultra violet light, and did not include any lethal. The assembling of fly slag based geopolymer solid rail lines. The designing exhibitions of the items were magnificent, and the drying shrinkage was little.

Workability of geopolymer concrete: Water is the most essential part in both geopolymer concrete and conventional concrete. As the utilized of water in geopolymer is to improve the workability, and also to permeable in solid since it is dissipation of liquid amid curing procedure at lifted temperature. Increase in sodium hydroxide and sodium silicate fixation will decrease the stream of concrete furthermore it will help the geopolymer concrete to improve compressive strength. Workability of concrete superplasticiser or additional water can be included. Be that as it may, the utilization of superplasticiser to improve the more than 4% had an unfriendly impact on the strength of geopolymer. As being what is indicated, additional water will gives higher strength than expansion of superplasticiser.

II. EXPERIMENTAL DETAILS

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 gropolymer 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.

Casting: The fresh concrete after mixing was cast into moulds of size 150mmX150mmX150mm immediately after mixing to find the compressive strength. Compaction of the specimen is achieved by giving sixty manual strokes for three layers by using tamping rod.

Curing:- After casting all the specimens were kept without demoulding at room temperature for a rest period. The term 'Rest Period' demonstrates the time taken from the finishing of casting of test specimen to the beginning of curing at room temperature. It was found that delaying the curing for period of time causes an increment in the compressive strength. After the completion of the rest period, the demoulding procedure was done. The entire test specimen was tested on seventh from the date of casting.

Tests on Geopolymer concrete:

The basic test on concrete as per the Indian standard code was conducted to study the behaviour of the concrete. The compression test on cube specimens were conducted as per the IS: 516-1959(reaffirmed 1999).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Tests and discussion on fresh geopolymer concrete:

The fresh geopolymer concrete was dark in color and the mixes were generally gives good bonding between the aggregates. The workability is measured by using slump cone test. The slump results for 8 molarity are tabulated in table 3.10 All the tests are carried out according to the IS 1199-1999 code guidelines. From the test results we can see that slump value decreases with increase in binder content and it decreases with increase in molarity of NaOH solution. The fresh geopolymer concrete is more cohesive compared to the ordinary Portland concrete cement and it is bit difficult to handle.

Tests and discussion on hardened geopolymer concrete:

The tests conducted on the harden geopolymer concrete are

1. Compressive Strength Test.
2. Split Tensile Strength Test.
3. Flexural Strength.

Compressive strength test: For compressive strength test, cube specimens with M40 grade of concrete with dimensions 150 x 150 x 150 mm were casted. Super plasticizer (0.2% to 0.6% by weight of cement) was added to this. 1.5% of fibre is filled in the moulds. Using table vibrator air voids were removed in the moulds. The specimen top surface is levelled and finished. The moulds were kept for curing after 24 hours the specimens were remoulded and they were allowed to cure for 14days, 28 days. After 14 days, 28 days curing, these cubes were tested on digital compression testing machine as per I.S. 516-1959. Cubes were tested and there values are reported and failure load is noted.

Flexural strength test: For flexural strength test beam specimens of dimension 100x100x500 mm were cast. After 24 hrs specimens were remoulded and were kept into the ambient curing and allowing the specimens to cure for 14days and 28 days. The specimens over an effective span of 400mm which are used for flexural strength test were tested under two point loading as per I.S. 516-1959, on Flexural testing machine. Failure loads and corresponding failure deflections were noted. Three beams were used and their average value in the test is reported.

Split Tensile strength test: For Split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were kept into the ambient curing where in they were allowed to cure for 14days,28 days. Three cylinders were used for testing compression test and their average value is reported.

III. RESULTS AND DISCUSSIONS

1 Compressive strength of conventional concrete:

As per IS 516-1959, Cubes of size 150 x 150 x 150mm were cast to evaluate the compressive strength of concrete.

Aspect ratio (l/d) 60

Compressive strength = load/area

Table 1.1 Results of compressive strength of SFRC (0.5, 1.0, 1.5,2.0% of fibers on 28days of curing.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

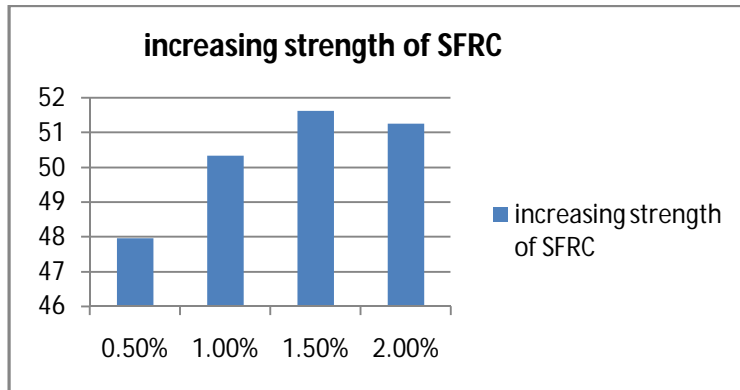


Fig. 1.0 Compression test

In the above chart X- axis represents % of steel fibre used and Y- axis represents Compressive load and it is observed that the cubes made with 1.5% of steel fibres gives better results compared to other % of steel fibre.

Flexural strength of conventional concrete:

The flexural strength were obtained as follows.

$$\text{Flexural strength (MPa)} = (P \times L) / (b \times d^2)$$

Where, P = Failure load, L = Centre to centre distance between the support = 400 mm, b = width of specimen=100 mm, d = depth of specimen= 100 mm

Table 1.2 Results of Flexural strength of SFRC (0.5, 1.0, 1.5,2.0% of fibers on 28 days of curing.

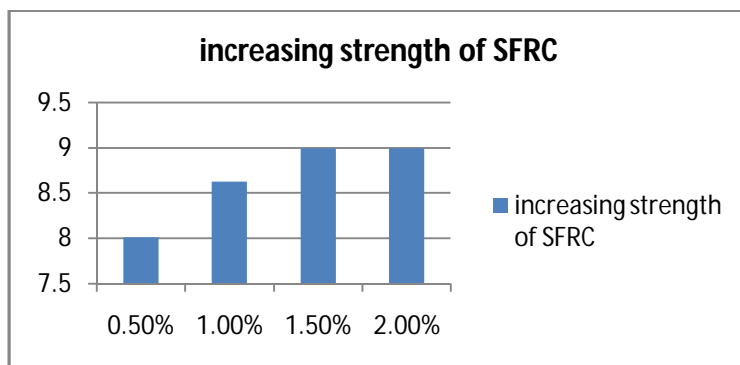


Fig. 1.1 Tenile test

In the above chart X- axis represents % of steel fibre used and Y- axis represents Flexural load and it is observed that the cubes made with 1.5% of steel fibres gives better results compared to other % of steel fibre.

Split tensile strength of conventional concrete:

Split Tensile strength were obtained as follows as split tensile strength:

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

Where, P = failure load,

D = diameter of cylinder, L = length of cylinder

Table 1.3 Results of Split Tensile strength of SFRC (0.5, 1.0, 1.5,2.0% of fibers on 28 days of curing.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

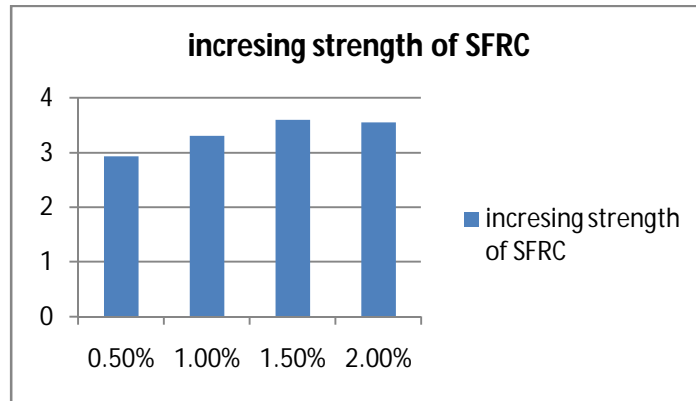


Fig. 1.2 Split tensile test

In the above chart X- axis represents % of steel fibre used and Y- axis represents Split tensile load and it is observed that the cubes made with 1.5% of steel fibres gives better results compared to other % of steel fibre.

14 days 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

Table 1.4 Results of Compressive strength of GPC on 14 days of curing.

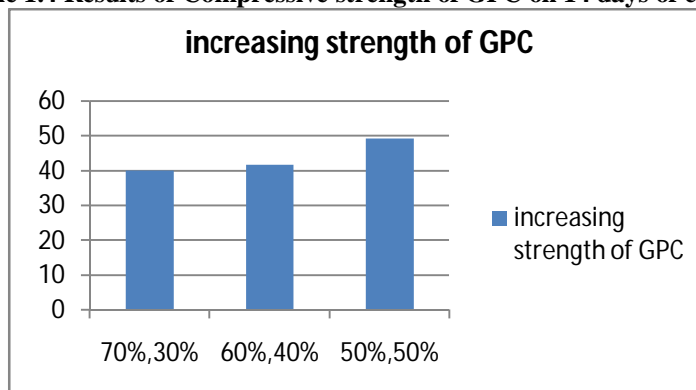


Fig. 1.3 Compression test

Flexural strength:

Parameter:

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

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Table 1.5 Results of Flexural strength of GPC on 14 days of curing.

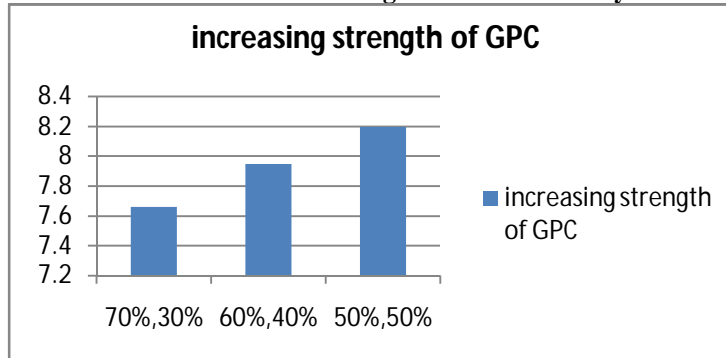


Fig. 1.4 Tensile test

Split Tensile strength:

Parameter:

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

Table 1.6 Results of Flexural strength of GPC on 14 days of curing.

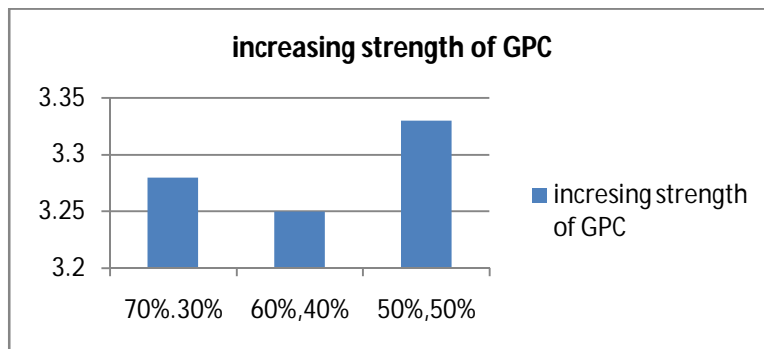


Fig. 4.6 Split Tensile test

28 days Strength of Geo-polymer concrete:

1. 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

Table 1.7 Results of Compressive strength of GPC on 28 days of curing.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

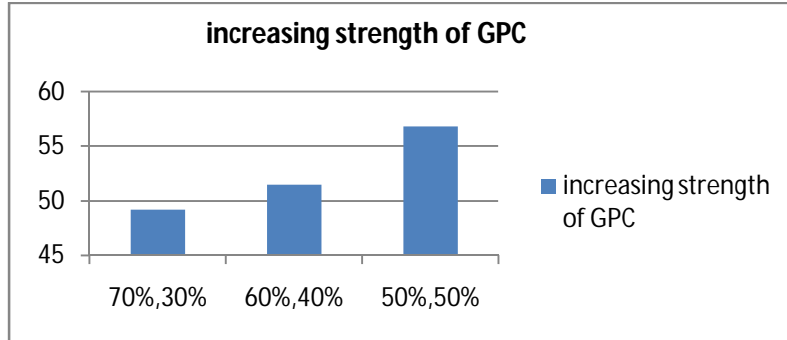


Fig. 4.7 Compression test

2. Flexural 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

Table 1.7 Results of Flexural strength of GPC on 28 days of curing.

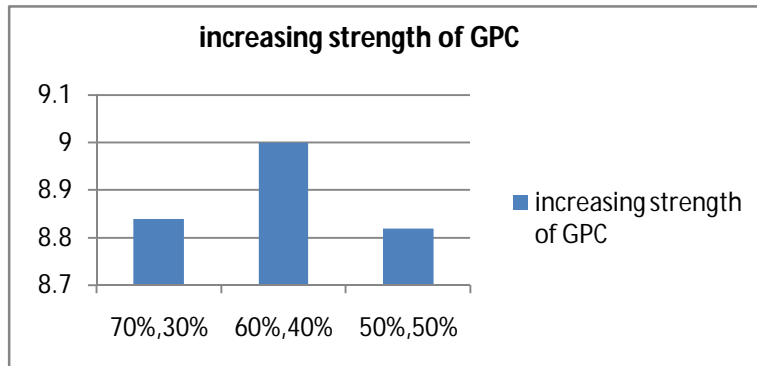


Fig. 4.8 Tensile test

3.Split Tensile 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

Table 1.8 Results of Flexural strength of GPC on 28 days of curing.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

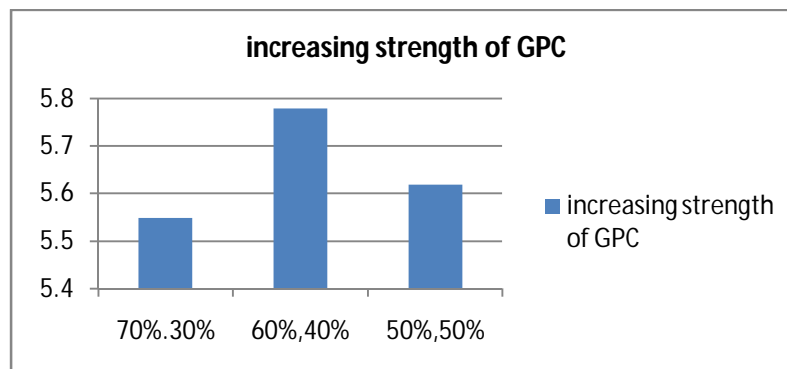


Fig. 4.9 Split Tensile test

IV. CONCLUSIONS

- Geo-polymer concrete is excellent alternative to Portland cement concrete.
- Mix design was done with an assumption that the density of GPC is 2400kg/m³ the total mass of the aggregate which was considered as 77% of the entire concrete mix over mass.
- The density of GPC with and without fibres is same as that conventional concrete.
- Hand mixing and ambient curing of GPC concrete preparation is used.
- Additional of steel fibres in GPCC effects workability of steel fibre reinforced GPC decrease the % volume fraction of steel fibres increases to enhance the workability super plasticizer is used.
- The use of water is reduced because of addition of alkaline solution, which helps in increasing in the strength of GP concrete.
- The optimum dosage of steel fibres is 1.5% from table 4.1, the maximum compression strength at 28 days is 51.64 N/mm².
- The maximum compressive strength, flexural strength and split tensile strength at 14 days is 49.41, 8.20, 3.33 respectively. From these results it can be concluded that the SFGPC for non strength is achieved at 14 days under ambient curing when compared with conventional concrete.

ACKNOWLEDGEMENTS

I am thankful to Mrs ,Laxmi,G,G,Dept of Civil Engineering, Principal of ACS College of Engineering, Bangalore, Karnataka, India. My students and my beloved friends for their timely help rendered and the immense support extended for the submission of this paper.

REFERENCES

1. WATILE R. K, MHAISANE R. J (2015), "Development and application of geopolymer concrete: A sustainable approach". IJPRET, Volume 3 (8): 535-545.
2. Pradip Nath, Prabir Kumar Sarker (2014), —Effect of GGBFS on setting, workability and early strength properties of fly ash geopolymer concrete cured in ambient condition. | Department of Civil Engineering, Curtin University, GPO Box U1987, Perth, WA 6845, Australia.
3. Jeyaseela.J, Dr. B.G. Vishnuram(2015), —Study on workability and durability characteristics of self-compacting geopolymer concrete, | International Journal of Advanced Technology in Engineering and Science.
4. Aminul Islam Laskar and Rajan Bhattacharjee(2012), —Effect of Plasticizer and Superplasticizer on Workability of Fly Ash Based Geopolymer Concrete, | Proceedings of International Conference on Advances in Architecture and Civil Engineering (AARC 2012), 21st – 23rd June 2012 974 Paper ID SAM134, Vol. 2.
5. Anupam Bhowmick, Somnath Ghosh (2012), —Effect of synthesizing parameters on workability and compressive strength of Fly ash based Geopolymer mortar, | INTERNATIONAL JOURNAL OF CIVIL AND STRUCTURAL ENGINEERING.