

# Effect of Steel Fibers on Mechanical Properties of Geo Polymer Concrete

Prateek Praveen<sup>1</sup>, Gaurav Jawale<sup>1</sup>, Vishwajeet Ghadge<sup>1</sup>, Akbar Nakedar<sup>1</sup>, Yasmeeen Tadvi<sup>1</sup>, Amit Jha<sup>1</sup>,  
Dr. N.K. Gupta<sup>2</sup>

B. E Students, Department of Civil Engineering, DYPIET, Pune, India<sup>1</sup>

Professor, Department of Civil Engineering, DYPIET, Pune, Pune, India<sup>2</sup>

**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 CO<sub>2</sub> 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 1<sup>st</sup> mix with 70% fly and 30% GGBS, 2<sup>nd</sup> 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, Geopolymerconcrete, Fly ash, GGBS, Alkaline liquids, Steel fibre.

## I. INTRODUCTION

### 1.1 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 their percentage increases more than required. The concrete manufacturing industry which releases 6% of CO<sub>2</sub> to atmosphere like one ton of Portland concrete discharges gives or takes one ton of CO<sub>2</sub> 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 pozzolanic 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-

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

polymer innovation could decrease the CO<sub>2</sub> outflow to the air created by concrete and aggregate industries by around 80% (Davidovits).

**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.

## 1.2 PROBLEM STATEMENT

In existing system cement is a key element in the construction but during the manufacturing of cement it emits some toxic gases like CO<sub>2</sub> in the excess amount. To overcome this problem scientist were done lot of research on it and finally found a compete 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

## 1.3 Scope

The scope of this project is 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 Geopolymer concrete. So in this study an attempt is made to know the strength geo-polymer concrete by adding holed steel bars in the mix.

## 1.4 Objectives

1. To overcome this problem compete 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.
2. To study 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 Geopolymer concrete.
3. To study an attempt is made to know the strength geo-polymer concrete by adding holed steel bars in the mix.
4. To test specimens will be tested for compression test, flexural test and split tensile test and finally strength of geopolymer concrete with steel fibers will be determined.

## II. LITERATURE SURVEY

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

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

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 (CO<sub>2</sub>) into the atmosphere caused by the calcination of limestone and the combustion of the fossil fuels during the process. [1]

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. 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 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. [2]

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 co<sub>2</sub> releases to the environment. [3]

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. [4]

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, Banglore. 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. [5]

Geopolymers are inorganic aluminosilicate polymeric material which cure and harden at near ambient temperatures [1]. The production of geopolymer was accompanied by much lower carbon dioxide emission compared to ordinary Portland cement since their production does not need limestone calcination and fuel combustion in the kiln. Therefore, the term ecologically friendly 'green' cement is coined on it. On the other hand, due to their improved properties such as high early strength gain, durability against chemical attack, high surface hardness, and higher fire resistance, the interest in this cementitious material is increasing and they are now seen as an alternative to conventional Portland cement [6]. However, like most ceramics, it suffers from quasi-brittle characters, deficiency of low flexural strength and sudden failure [7].

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

Geopolymers show excessive shrinkage although lesser than Portland cement materials, it is a crucial factor and need to be considered [1]. Unlike Portland cement hydration, only a small amount of water known as “interstitial or structural water” has been incorporated into the geopolymer gel production; thus, this characteristic of geopolymer has led to less demand of mixing water [4]. However, a portion of free water is demanded to make the product workable and homogenous; this water evaporates at up to 150°C [1]. The free water loss can cause a large shrinkage deformation of specimens although different curing conditions influence the rate of shrinkage rate variation. A comparison of an alkali activated fly ash and a Portland cement based mortars indicated a high shrinkage stability of the fly ash based geopolymer and its less dimensional variation under two conditions of high humidity and laboratory environment due to the stability of the main reaction [6].

Incorporation of fiber into brittle matrix is an efficient method to enhance toughening mechanisms and flexural strength due to the controlling of crack propagation under different loading or environmental effects such as shrinkage [7]. Unlike most ceramics, a wide range of fibers, including organics, can be used as reinforcement in geopolymer since the synthesis temperature of the geopolymers are near ambient temperature [1]. Fiber-reinforced geopolymer composites were first investigated by Davidovits with the aim of fabricating molding tools and patterns for the plastics processing industry [8]. Subsequently, reinforcement of geopolymers with different type of fibers were carried on through organic fiber like cotton fiber [8] and protein- based fibers [9], carbon fibers [2], steel fibers [7] and polyvinyl alcohol (PVA) fibers [2] to overcome the brittleness and catastrophic failure of the matrix.

Polypropylene fiber (PPF) have been extensively used as a reinforcement in Portland cement based materials because of its high toughness and durability; while there was a conflict about the correlation of the PPF content and the corresponding compressive strength of the concrete. Although it was stated by Building Research Establishment (2000) that incorporation of PPF reduces the compressive strength of concretes significantly, some others reported that there was no tangible reduction on compressive strength because of the PPF content [2]. This conflict was studied by A. Richardson and he was concluded because of the cement bond breaking by PPF, the compressive strength of the concrete is reduced notably [6]. Although the similar reduction in strength was expected in geopolymers by inclusion of PPF, it was reported that early compressive strength of fly ash/calcined kaolin geopolymer increased at 1 and 3 days to about 68% and 20%, respectively, by addition of 0.5 wt% PPF into matrix. Moreover, the early flexural strength of the composite including 0.75% PPF was increased about two fold for both days [7]. Why polypropylene did not have such an adverse effects, that reported by A. Richardson [6], on geopolymers was the main objective of this research. Therefore, in this study PPF is characterized firstly; then, the low and high volume of PPF (0.5%, 1%, 2%, 3%, 4%, and 5%) was incorporated in fly ash based geopolymer and mechanical properties and shrinkage of the corresponding composites were measured up to 56 days to cover the short and long term effects of the fiber. Moreover, variation of slump and setting time were determined to evaluate the fresh properties of the materials. It was observed that mechanical behavior of the composite was influenced by the adverse effect of shrinkage over time and the weak bond between PPF and geopolymer matrix. While, flexural toughness was increased and mode of failure changed from brittle to ductile in high PPF content fly ash based geopolymer composites.

Multifilament PPF was prepared from Timuran Engineering SDN BHD (Malaysia) which consisted of a straight individual fiber 12.19 mm in length, ~40 µm in diameter, 0.9 specific gravity, tensile strength of about 310 to 414 MPa and Young's modulus 345 MPa to enhance the toughening mechanism of the geopolymer matrix. Alkaline activators in the investigation consisted of sodium silicate and sodium hydroxide solutions. Sodium hydroxide (NaOH) was prepared in pellet form with 99% purity while sodium silicate ( $\text{Na}_2\text{SiO}_3$ ) was used in liquid form with about 1.5gr water per millilitre at 20°C with a modulus ratio of 2.5 ( $\text{SiO}_2/\text{Na}_2\text{O}$ ,  $\text{SiO}_2 = 30\%$  and  $\text{Na}_2\text{O} = 12\%$ ).

16 molar NaOH was mixed with  $\text{Na}_2\text{SiO}_3$  with the ratio of 0.4. The mixture was diluted with extra water in order to make the geopolymer paste workable and get a mass ratio of  $\text{Na}_2\text{SiO}_3:\text{NaOH}:\text{H}_2\text{O}$  of 2.5:1.0:0.7 after mixing with the fly ash [8]. PPF was added to the alkali activator and stirred in order to make the uniform suspension and to overcome the poor distribution. The mixture was added to the fly ash gradually with a solution to solid ratio of 0.5 and mixed for

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

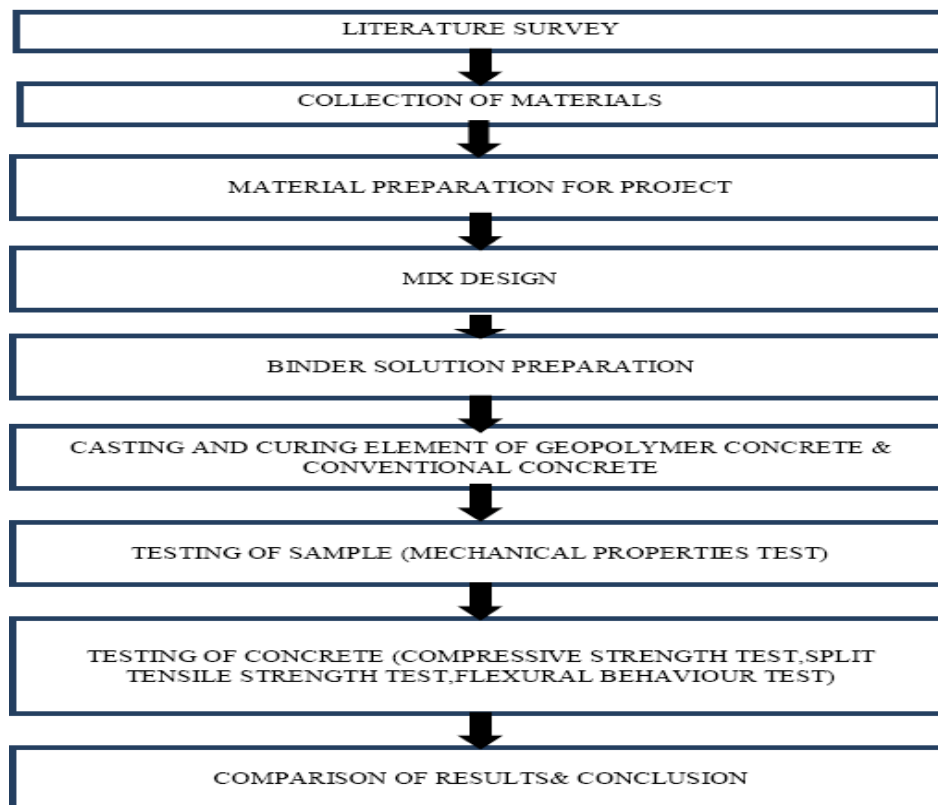
Vol. 7, Issue 5, May 2018

5 minutes; the material was immediately poured into stainless steel molds and cured in a 65°C Memmert ULM600 oven for 24 hours. Afterward, the molds were dismantled and specimens kept in ambient condition with an average temperature and humidity of 32°C and 65%, respectively, until the day of testing. It is notable that, according to our preliminary experiments, dry mixes of PPF and fly ash will result in accumulation of branch of multifilament fibers in particular place, non-uniformity and agglomeration of the matrix. The PPF content in geopolymer paste varied in the range of 0.5%, 1%, 2%, 3%, 4%, and 5%. [5]

Flow measurement test were conducted in accordance with ASTM C1437-13 in order to evaluate the workability of the geopolymer composites [9]. For this measurement, the geopolymer paste specimens were prepared by 400 g of the fly ash with the same mix design as mentioned in section 2.2. Immediately after 5 min mixing, the paste was poured into the truncated conical mold (top diameter = 70 mm, bottom diameter = 100 mm, height = 50 mm) in two equal layers and tamped 20 times for compaction. After a minute, the truncated cone was lifted up and immediately the specimen was tamped 25 times in 15 seconds. The flow (S) is the result of increase in base diameter of the paste (D), expressed as a percentage of the original based bottom diameter (D<sub>0</sub>) by the following equation

Plain cement concrete suffers from numerous drawbacks such as low tensile strength, brittleness, unstable crack propagation, and low fracture resistance. Addition of steel fibres in plain cement concrete improves its mechanical and elastic properties. Hence, steel fibre reinforced concrete has been proved as a reliable and promising composite construction material having superior performance characteristics compared to conventional concrete.

### III. METHODOLOGY



# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

## Explanation-

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.

## Strength

It is the **property of material** which opposes the deformation or breakdown of material in presence of external forces or load. Material which we finalize for our engineering product, must have suitable mechanical strength to be capable to work under different mechanical forces or loads.

## Toughness

It is the ability of material to absorb the energy and gets plastically deformed without fracturing. Its numerical value is determined by the amount of energy per unit volume. Its unit is Joule/ m<sup>3</sup>. Value of tough ness of a material can be determines by stress-strain characteristics of material. For good toughness material should have good strength as well as ductility.

For example: brittle materials, having good strength but limited ductility are not tough enough. Conversely, materials having good ductility but low strength are also not tough enough. Therefore, to be tough, material should be capable to withstand with both high stress and strain.

## Hardness

It is the ability of material to resist to permanent shape change due to external stress. There are various measure of hardness – Scratch Hardness, Indentation Hardness and Rebound Hardness.

1. Scratch Hardness Scratch Hardness is the ability of material to oppose the scratch to outer surface layer due to external force.
2. Indentation Hardness It is ability of material to oppose the dent due to punch of external had and sharp object.
3. Rebound Hardness Rebound hardness is also called as dynamic hardness. It is determined by the height of “bounce” of a diamond tipped hammer dropped from a fixed height on the material.

## Hardenability

It is the ability of a material to attain the hardness by heat treatment processing. It is determined by the depth up to which the material becomes hard. The SI unit of hardenability is meter (similar to length). Hardenability of material is inversely proportional to the weld-ability of material.

## Brittleness

Brittleness of a material indicates that how easily it gets fractured when it is subjected to a force or load. When a brittle material is subjected to a stress is observes very less energy and gets fractures without significant strain. Brittleness is converse to ductility of material. Brittleness of material is temperature depended. Some metals which are ductile at normal temperature become brittle at low temperature.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

## **Malleability**

Malleability is property of solid material which indicates that how easily a materials gets deformed under compressive stress. Malleability is often categorized by the ability of material to be formed in the form of a thin sheet by hammering or rolling. This mechanical property is an aspect of plasticity of material. Malleability of material is temperature dependent. With rise of temperature, the malleability of material increases.

## **Ductility**

Ductility is a property of a solid material which indicates that how easily a materials gets deformed under tensile stress. Ductility is often categorized by the ability of material to get stretched into a wire by pulling or drawing. This mechanical property is also an aspect of plasticity of material and temperature dependent. With rise of temperature, the ductility of material increases.

## **Creep and Slip**

Creep is the property of material which indicates the tendency of material to move slowly and deform permanently under the influence of external mechanical stress. It results due to long time exposure to large external mechanical stress with in limit of yielding. Creep is more severe in material that are subjected to heat for long time. Slip in material is a plane with high density of atoms.

## **Resilience**

Resilience is the ability of material to absorb the energy when it is deformed elastically by applying stress and release the energy when stress is removed. Proof resilience is defined as the maximum energy that can be absorbed without permanent deformation. The modulus of resilience is defined as the maximum energy that can be absorbed per unit volume without permanent deformation. It can be determined by integrating the stress-strain curve from zero to elastic limit. Its unit is joule/m<sup>3</sup>.

## **Fatigue**

Fatigue is the weakening of material caused by the repeated loading of material. When a material is subjected to cyclic loading, and loading greater than certain threshold value but much below the strength of material (ultimate tensile strength limit or yield stress limit, microscopic cracks begin to form at grain boundaries and interfaces. Eventually the crack reached to a critical size. This crack propagates suddenly and the structure gets fractured. The shape of structure effects the fatigue very much. Square holes and sharp corners lead to elevated stresses where the fatigue crack initiates.

## **IV. EXPERIMENTAL DETAILS**

**Selection of suitable mix proportion:-**As discussed from the beginning geopolymer concrete is the mixture of flyash, 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 taken like 1<sup>st</sup> combination 70% of fly ash with 30% of GGBS, and 2<sup>nd</sup> 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.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

**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).

### 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.



# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

## IV. 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 28 days of curing.

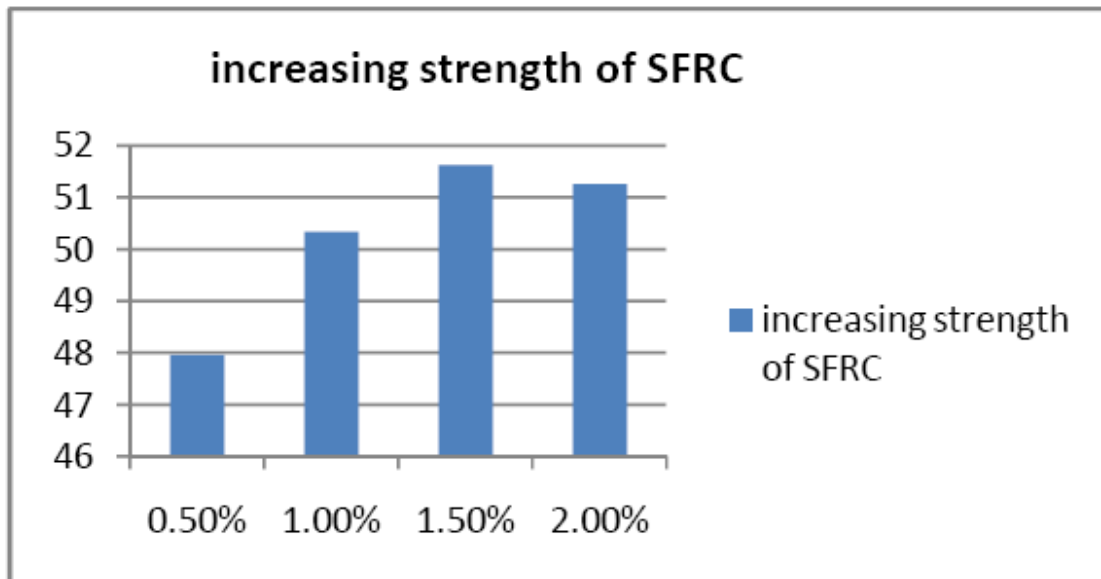


Fig. 1.0 Compression test

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

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

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

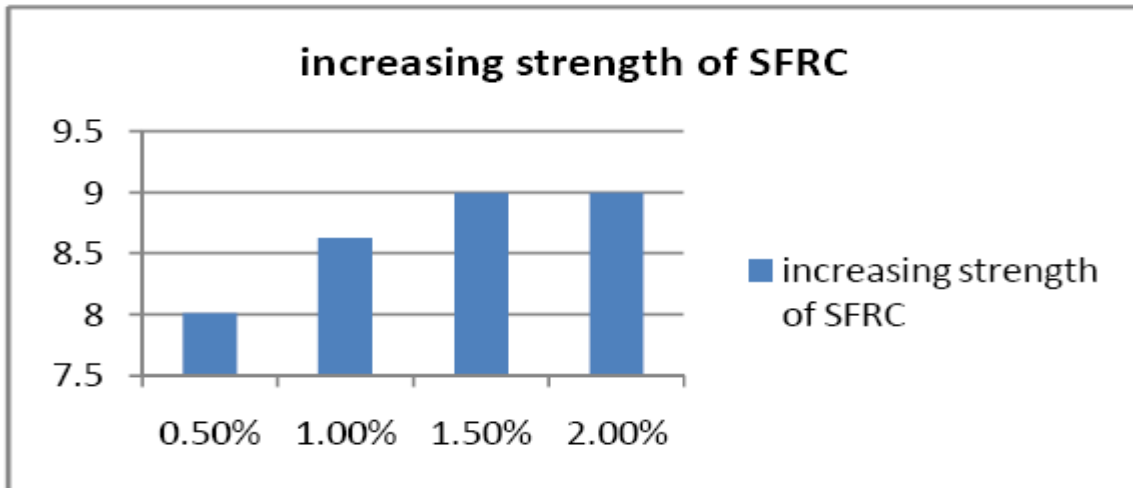


Fig.1.1 Tensile test

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:

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

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.**

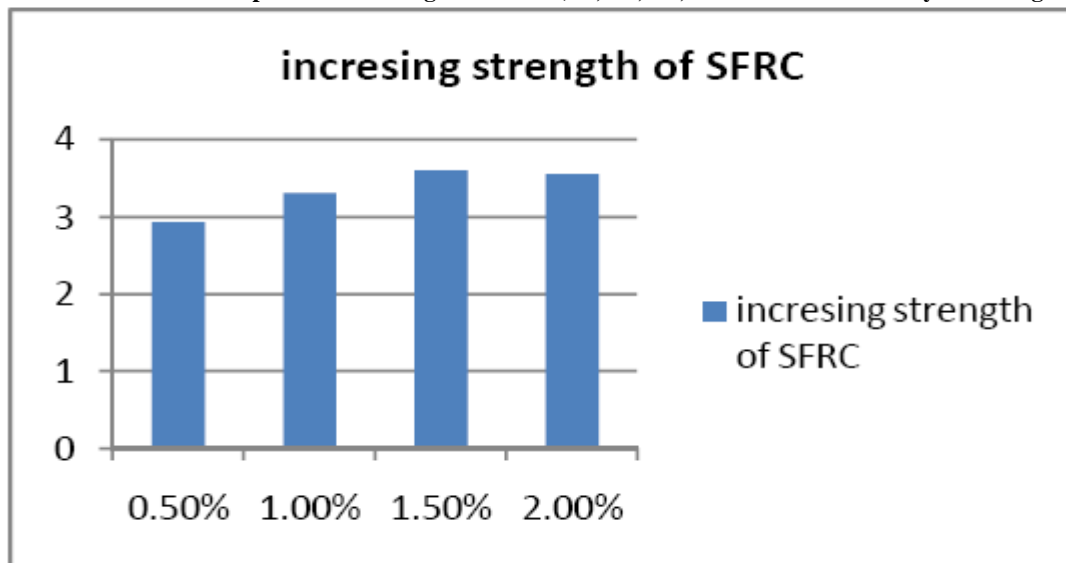


Fig. 1.3 Split tensile test

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.

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

### 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**

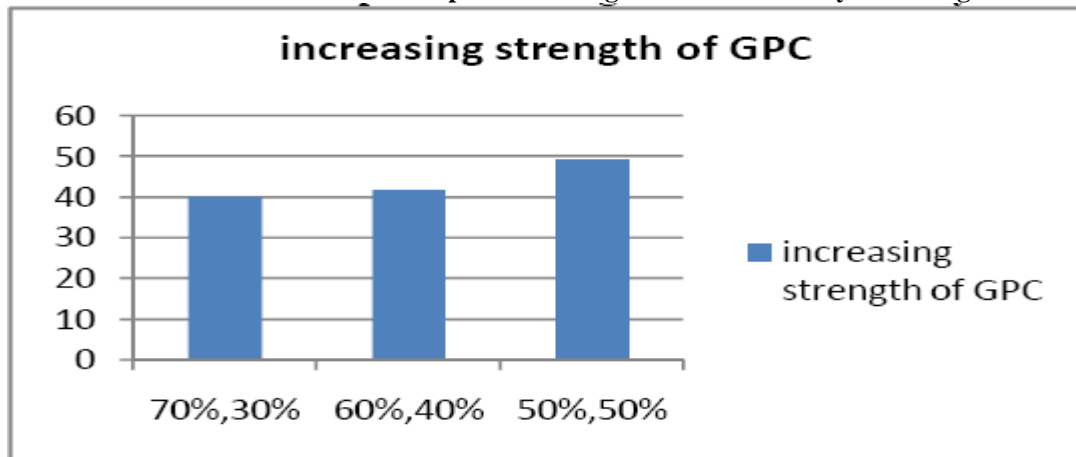


Fig. 1.4 Compression test

#### 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

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

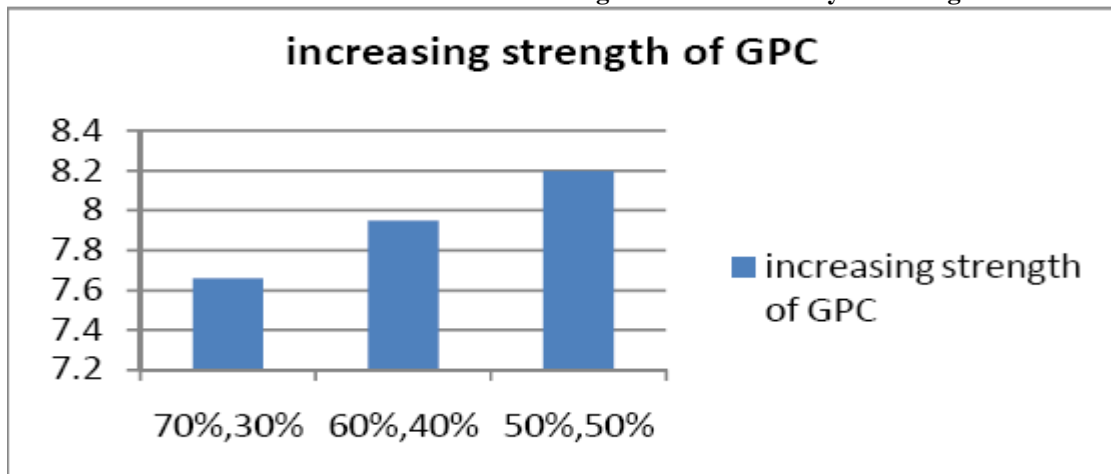


Fig.1.5 Tensile test

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

### 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.**

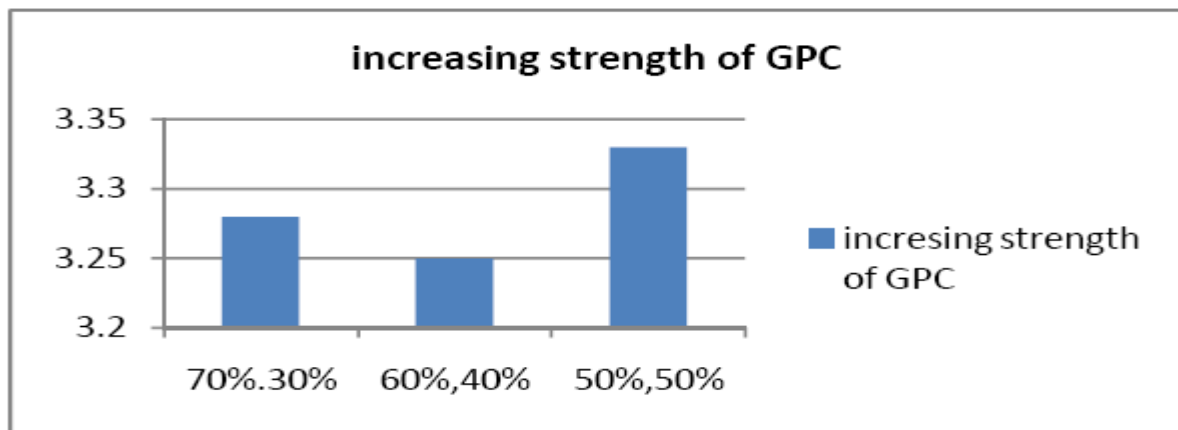


Fig. 4.6 Split Tensile test

### 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.**

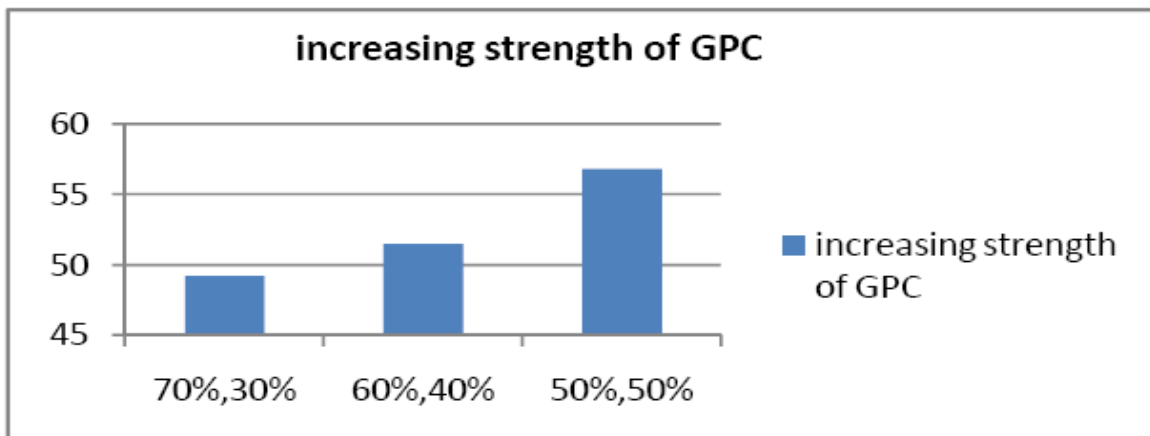


Fig. 4.7 Compression test

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

### 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 1.8 Results of Flexural strength of GPC on 28 days of curing.**

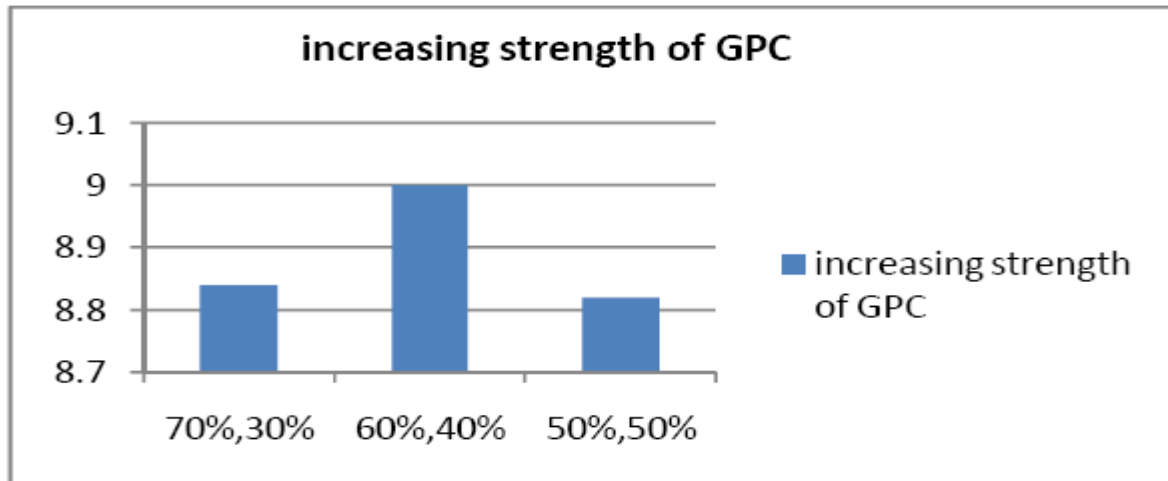


Fig. 4.8 Tensile test

### 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 1.9 Results of Flexural strength of GPC on 28 days of curing.**

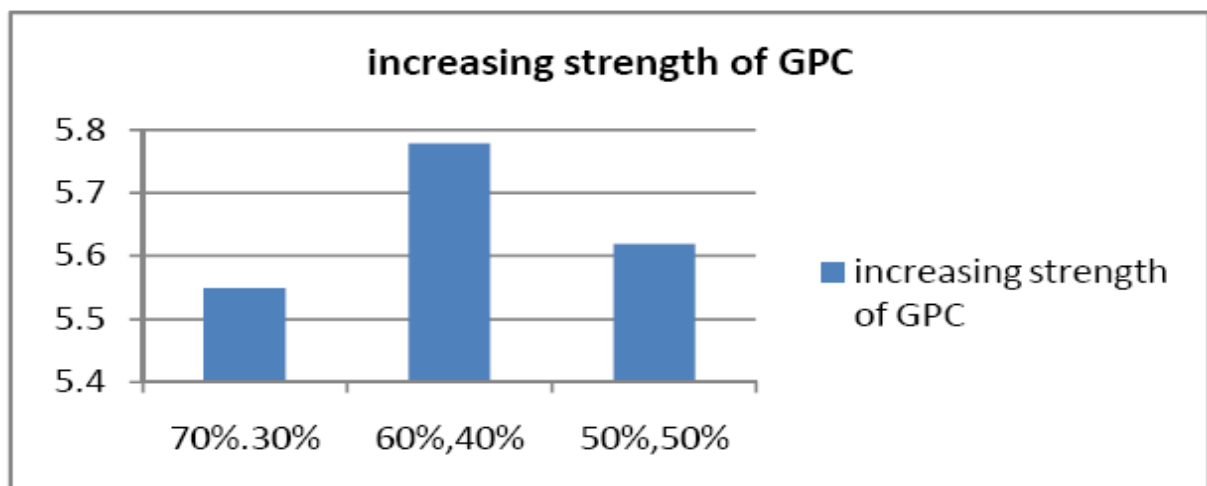


Fig. 4.9 Split Tensile test

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 5, May 2018

## V. CONCLUSIONS

1. Geo-polymer concrete is excellent alternative to Portland cement concrete.
2. Mix design was done with an assumption that the density of GPC is 2400kg/m<sup>3</sup> the total mass of the aggregate which was considered as 77% of the entire concrete mix over mass.
3. The density of GPC with and without fibres is same as that conventional concrete.
4. Hand mixing and ambient curing of GPC concrete preparation is used.
5. 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.
6. The use of water is reduced because of addition of alkaline solution, which helps in increasing in the strength of GP concrete.
7. The optimum dosage of steel fibres is 1.5% from table 4.1, the maximum compression strength at 28 days is 51.64 N/mm<sup>2</sup>.
8. 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.

## REFERENCES

- [1] Ranganath, R.V., and Mohammed Saleh. (2008) "Some optimal values in geopolymer concrete incorporating fly ash." The Indian concrete journal, pp 26-35.
- [2] Prof. Dr. Joseph Davidovits (2002), "30 Years of Successes and Failures in Geopolymer Applications. Market Trends and Potential Breakthroughs".
- [3] Hardjito . D and Rangan B.V (2005), "Development and Properties of low calcium fly ash based geopolymer concrete." Research report GC 1, Curtin University of technology Perth, Australia.
- [4] Suhodolska and L. Karavelov (2015), "Research on Cracks in Reinforced Concrete Elements by Taking Into Account the Experimentally Determined Concrete and Reinforcing Steel Mechanical Properties" Volume : 5 | Issue : 4.
- [5] Wang J.W and Cheng, T.W (2003), "Production geopolymer materials by coal fly ash." Proceedings of the 7th International Symposium on East Asian Resources Recycling Technology, Tainan, Taiwan.
- [6] Dattatreya J K , Rajamane N P, Sabitha D, Ambily P S, Nataraja M C (2011), "Flexural behaviour of reinforced Geopolymer concrete beams" Volume 2, No 1.
- [7] L. Krishnan, S. Karthikeyan, S. Nathiya, K. Suganya (2014), "Geopolymer concrete an eco-friendly construction material".
- [8] M. M. A. Abdullah, K. Hussin, M. Bnhussain, K. N. Ismail and W. M. W. Ibrahim (2011), "Mechanism and Chemical Reaction of Fly Ash Geopolymer Concrete- A Review".
- [9] Ambily.P.S, Madheswaran.C.K, Sharmila.S, Muthiah.S (2011), "Experimental and analytical investigations on shear behaviour of reinforced geopolymer concrete beams". Volume 2, No 2.
- [10] 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.
- [11] Center for Sustainable Infrastructure, School of Engineering, Faculty of Science, Engineering and Technology, Swinburne University of Technology, Melbourne, Victoria 3122, Australia.
- [12] Kushal Ghosh and Dr. Partha Ghosh (2012), "Effect of Na<sub>2</sub>O/Al<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>/Al<sub>2</sub>O<sub>3</sub> and W/B Ratio on Setting Time and Workability of Fly Ash Based Geopolymer," International Journal of Engineering Research and Applications (IJERA) ISSN.
- [13] K. Vijai, R. Kumutha, and B. G. Vishnuram, "Properties of glass fibre reinforced geopolymer concrete composite," Asian Journal of Civil Engineering, vol. 13, no. 4, pp. 511–520, 2012. View at Google Scholar
- [14] K. Vijai, R. Kumutha, and B. G. Vishnuram, "Effect of inclusion of steel fibres on the properties of geopolymer concrete composites," Asian Journal of Civil Engineering, vol. 13, no. 3, pp. 377–385, 2012. View at Google Scholar
- [15] K. Vijai, R. Kumutha, and B. G. Vishnuram, "Experimental investigations on mechanical properties of geopolymer concrete composites," Asian Journal of Civil Engineering, vol. 13, no. 1, pp. 89–96, 2012. View at Google Scholar · View at Scopus
- [16] V. Sathish Kumar, B. S. Thomas, and A. Christopher, "An environmental study on the properties of glass fibre reinforced geopolymer concrete," International Journal of Engineering Research and Applications, vol. 2, no. 6, pp. 722–726, 2012. View at Google Scholar
- [17] A. Bhowmick and S. Ghosh, "Effect of synthesizing parameters on workability and compressive strength of fly ash based geopolymer mortar," International Journal of Civil and Structural Engineering, vol. 3, no. 2, pp. 168–177, 2012. View at Google Scholar
- [18] Y. M. Ghugal and S. A. Bhalchandra, "Performance of fibre reinforced high strength silica fume concrete," Civil Engineering and Construction Review, vol. 22, pp. 32–44, 2009. View at Google Scholar IS 2770, Methods of Testing Bond Strength in Reinforced Concrete- Part I, Bureau of Indian Standards, New Delhi, India, 1997. IS 456, Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi, India, 2000.
- [19] D. J. Hannant, Fibre Cements and Fibre Concretes, John Wiley and Sons, New York, NY, USA, 1978.



ISSN(Online): 2319-8753  
ISSN(Print): 2347-6710

## International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

**Vol. 7, Issue 5, May 2018**

- [20]K. H. Tan, P. Paramasivam, and K. C. Tan, "Instantaneous and long-term deflections of steel fiber reinforced concrete beams," ACI Structural Journal, vol. 91, no. 4, pp. 384–393, 1994. View at Google Scholar · View at Scopus.
- [21]M. Kakizaki, M. Harada, T. Soshiroda, S. Kubota, T. Ikeda, and Y. Kasai, "Strength and elastic modulus of recycled aggregate concrete," in Proceedings of the 2nd International RILEM Symposium on Reuse of Demolition Waste, vol. 2, pp. 565–574, 1988.
- [22]Y. M. Ghugal, "Effects of steel fibres on various strengths of concrete," Indian Concrete Journal, vol. 4, no. 3, pp. 23–29, 2003. View at Google Scholar