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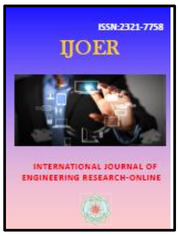
EXPERIMENTAL REPORT ON STRENGTH DEVELOPED SYNTHETIC FIBRE REINFORCED GEOPOLYMER CONCRETE

YARRA TIRUPATHI NAIDU[1], V.RAJI[2]

[1]M.Tech student,Department of Civil Engineering, Srinivasa Institute Of Engineering And Technology, Cheyyeru (V), Amalapuram, India

[2]Associate Professor, Department of Civil Engineering, Srinivasa Institute Of Engineering And Technology, Cheyyeru (V), Amalapuram, India.Email:ytnpower@gmail.com



ABSTRACT

Concrete is one of the most utilized construction materials and implemented in advanced massive construction field playing a vital role. With the advanced increment of developments in infrastructure, the demand of concrete as encouraged the advancement of cement in further optional usage. The unbalanced usage of cement has many environmental impacts. Davidovits [1988] proposed geopolymer technology. Implemented technology has advanced factor that not utilizes cement and results in no outcome of greenhouse gases. The excess usage of geopolymer concrete results in week tensile nature, to with stand these impacts synthetic fibres are recommended and used in concrete. Main scope of this investigation is utilization of synthetic fibres in geopolymer concrete. In present advanced work Class F fly ash and ground granulated blast furnace slag (GGBS) are used in similar proportions (FA_50-GGBS_50) with alkaline activator solutions. Synthetic fibres (Polypropylene and Polyester fibres) are used at fibre dosage of 0%, 0.2%, 0.25%, 0.3%, 0.35% and 0.4% respectively and various advanced mechanical properties are experimentally studied.

Key Words: Alkaline activator solution, class F Fly Ash, Ground Granulated Blast Furnace Slag, Geoplymer concrete, Synthetic Fibers

1. INTRODUCTION

Concrete's versatility durability in India utilizes about 7.3 tons of concrete per annum and due to this the cost of construction increases and causes environment pollution. In recent years, Global warming and environmental destruction have become major problems. Heightening concern about worldwide ecological issues, changeover the large scale manufacturing, mass-utilization, mass-waste, society of the past to a zero-emission society is presently seen as essential and it has has a low tensile strength, little imperviousness and limited ductility to cracking In now a day's usage of concrete occupies second place around the world other than the water.

Ordinary Portland concrete primarily consists of cement, aggregates (coarse & fine) and water. In this, cement is used as a primary binder to produce the ordinary Portland concrete. Due to increasing of developments in infrastructure, the usage of conventional concrete will be more and as well as the demand of cement would be increases in the future. Approximately it is estimated that the consumption of cement is more than 2.2 billion tons per year (Malhotra, 1999).

On the other hand, the usage of Portland cement may create the some environmental issues such as global warming, green house effect etc. Because these problems may generate due to increasing of carbon dioxide (Co_2) present in the

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environment, from the past results nearly one tone of portland cement releases equal quantity of carbon dioxide (Co_2). In order to avoid these environmental issues associated with Portland cement , there is need to use some alternatives such as fly ash, ground granulated blast furnace slag (GGBS), rise husk ash etc are as the binders to make the eco friendly concrete. The aggregates (coarse and fine) are the most important ingredient of concrete occupying almost 70-80% of its total volume and directly affect the properties of concrete. So, there is need to use some alternatives such as coal ash, furnace slag, fiberglass waste materials, rubber waste, waste plastics, work sludge pellets etc.

In this respect, Davidovits [1988] proposed an alternative binder for the concrete technology and it shows a good results. These binders are produced by an alkaline liquid reacts with the silica (Si) and aluminium (Al) present in the source materials. The technology proposed by the Davidovits is commonly called as Geo-polymers or Geo-polymer technology.

1.2 Origin of Term 'Geopolymer'

The term ''Geopolymer'' was first introduced to the world by Davidovits of France resulting in a new field of research and technology. Geopolymer also known as 'inorganic polymer' has emerged as a 'green' binder with wide potentials for manufacturing sustainable materials for environmental, refractory and construction applications.

Geopolymer concrete (GPC):

Ingredients required for creation of geopolymer binders are:

- Geopolymer source materials such as fly ash, ggbs, metakaolin, and rice husk ash, etc

- Aggregate system consisting of fine and coarse aggregate - Alkaline Activator Solution

Applications of Geopolymers

Used in industrial floor repairs.

Airfield repairs (in war zones).

Fireproof composite panels.

External repair and structural retrofit for aging infrastructure.

For storage of toxic and radioactive wastes.

Potential utilizations in Art and Decoration.

1.3 Properties of Geo-Polymer Concrete

Geopolymer are inorganic binders, which are identified by the following basic properties,

Compressive strength depends on curing time and curing temperature. As the curing time and temperature increases, the compressive strength increases.

Resistance to corrosion, since no limestone is used as a material, Geopolymer cement has excellent properties within both acid and salt environments. It is especially suitable for tough environmental conditions. Geopolymer specimens are possessing better durability and thermal stability characteristics.

1.4 Salient Features of Geo-Polymer Concrete

Geopolymer concrete reduced CO2 emissions of geopolymer cements make them a good alternative to ordinary Portland cement.

The mechanical behavior of Geo-polymer concrete is higher than nominal concrete mix.

Durability property of Geo-polymer concrete is higher than the nominal concrete mix.

Geo-polymer Concrete is Eco-Friendly.

Water absorption property is lesser than the nominal concrete.

1.5. Need for the Study

To find an alternative for the ordinary Portland cement.

To reduce CO_2 emission and produce eco-friendly concrete.

To develop a cost efficient product.

To provide high strength concrete than ordinary Portland concrete.

1.6 Objective

The research utilized fly ash (ASTM Class F), and ground granulated blast furnace slag (GGBS), as the base materials for making geopolymer concrete. As far as possible, the innovation and the hardware as of now used to make OPC concrete were utilized to make the geopolymer concrete.

The geopolymer concrete properties studied included the compressive strength, split tensile strength and flexural strength at different curing periods.

1.7 Outcome

The behaviour of geopolymers were studied by many of researchers using various types of source materials like fly ash, GGBS, rice husk ash

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etc. The present study dealt with the investigational report on the mechanical properties of geopolymer concrete adding synthetic fibers with different percentage levels of 0% to 0.4% at ambient room temperature curing.

The aims of this study were:

To measure the effects of the addition synthetic fibers (polypropelene & polyester) on the properties of a geopolymer concrete mix.

To measure the important properties of the concrete significant to its utilization in construction field, for example, compressive strength, split tensile strength and flexural strength.

Comparison of the effects of synthetic fibers in concrete mix with conventional concrete.

2. REVIEW OF LITERATURE

2.1 General

In this chapter study of geo-polymer concrete and the application of are discussed using following research articles are presented.

2.2 Geo-Polymers

In 1978, Davidovits et al proposed that an alkaline liquid could be used to react with the silicon (Si) and the aluminium (Al) in a source material of geological origin or in by- product materials such as fly ash and GGBS to produce binders.

2.3. Literatures on Geopolymer

M. J. Hasan, M. Afroz and H. M. I. Mahmud (2011) say concrete strong in compression and weak in tension to overcome this problem fibers are used in concrete. He worked on mechanical behavior of reinforced concrete with macro synthetic fibers. He prepared four mixes: one with no fibers and remaining three with three different fiber dosages 0.33, 0.42 and 0.51% respectively. He casted the concrete cubes for the determination of mechanical behavior such as tensile strength, stress-strain relationships, compressive strength and shear strength. He concluded that a macro synthetic fiber enhances the compressive strength significantly. For macro synthetic fibers at 0.33%, 0.42% and 0.51% volume fractions the ultimate shear strength was increased by at least 15, 45 and 65% respectively compared to control beams. The compressive strength was increased significantly by at least 10%, 15% and 14% for macro synthetic fibers of 0.33, 0.42 and 0.51% volume fractions respectively, compared to control specimen. However, macro synthetic fiber reinforced concrete shows more ductile behavior compared to plain concrete. Macro fibers of 0.33%, 0.42% and 0.51% volume fractions, the ultimate strain value was improved by at least 50%, 60% and 70%

According to Panada Mahabir, Biswal kishore Chandra and Dash ashis kumar Concrete is utilized generally as a part of numerous development activities. As cement is getting costlier and demand is developing more step by step, investigators have been attempting to supplant cement with different materials to save cash either by keeping up the properties utilizing waste materials or by upgrading the properties utilizing chose materials. He study the different engineering properties of a concrete made with cement supplanted by ground granulated blast furnace slag. To keep up the engineering properties, a manufactured fiber specifically Recron 3s fibers fabricated by Reliance Industry Limited, India (RIL) and generally accessible in the neighborhood retail market of India, has been utilized as a part of different proportions. The exploratory examinations incorporate essential tests for cement, and traditional tests for concrete; for example, compressive strength, flexural strength and split tensile strength have been taken up. The capilary tests and porosity tests have been additionally directed to study the impacts of concrete in respect of imperviousness to leaking or damping. It has been observed the normal consistency increments with substitution of cement by pozzolanic material, for example, GGBFS. Addition of fibers decreases the split tensile strength and compressive strength, with phenomenal change after 0.2%. Flexural strength of concrete increments with fiber addition upto 0.1 % by weight after which they decrease. Similarly the capillary absorption parameter diminishes with fiber content upto 0.1% after which the value of this parameter increases, while the porosity increments with fiber content, yet noteworthy being after 0.1-0.2%. Considering the above observations, it is concluded that inside the scope of tests led, 20% GGBFS supplanting of Portland slag concrete with 0.2% fiber addition with would enhance the damping or leaking activity of

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water in concrete other than fulfilling the other traditional criteria.

According to Kolli. Ramujee (2013), using of fibers in concrete increased during the last several years. A combination of stiffness and high strength and thermal resistance favorably characterizes the fibers. He studied the strength properties of polypropylene fiber reinforced concrete. Polypropylene, steel, glass, asbestos and polyester fibers are used in his work. The concrete samples are prepared with different fiber dosages from 0, 0.5, 1, 1.5 and 2%. He conducted split tensile strength and compressive strength for different fibers at different dosages. He concluded that if fiber content is increased slump will be decreased, especially beyond 1.5% dosage. The compressive strength and split tensile strength is increased proportionally with the increase in volume ratios of polypropylene fiber reinforced concrete to the conventional concrete mix without fibers. The split tensile strength and compressive strength was increased 40% and 34% compared to control concrete mix without fibers.

3. MATERIALS

3.1 General

In this chapter varies materials and method of conducting the test was discussed in detail and detailed methodology of the work was presented.

3.2 Materials Used

Fly ash
Ground granulated blast furnace slag (GGBS)
Synthetic fibers-Polypropelene fibers
-Polyester fibers
Chemicals
-Sodium hydroxide
-Sodium silicate
Aggregates
Fine aggregate
Coarse aggregate

3.2.1 Fly Ash

Fly ash is one of the most abundant materials on the Earth. It is also a crucial ingredient in the creation of geopolymer concrete due to its role in the geopolymerization process. A pozzolan is a material that exhibits cementitious properties when combined with calcium hydroxide. Fly ash is the main by product created from the combustion of coal in coal-fired power plants. There are two "classes" of fly ash, Class F and Class C. Each class of fly ash has its own unique properties.The chemical composition of fly ash are shown in the table 1

Table 1: Physical and Chemical Composition of Fly Ash

Particulars	Class "F" fly ash
Chemical composition	
% Silica(SiO_2)	63.4
% Alumina(Al_2O_3)	30.5
% Iron Oxide(Fe_2O_3)	3.0
% Lime(CaO)	1.0
% Magnesia(MgO)	1.0
% Titanium Oxide (TiO_2)	0.62
% Sulphur Trioxide (SO_3)	0.1
Loss on Ignition	0.24
Physical properties	
Specific gravity	2.24
Fineness (m^2/Kg)	360

3.2.2 Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag comprises mainly of calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has the same main chemical constituents as ordinary Portland cement but in different proportions. And the addition of G.G.B.S in Geo-Polymer Concrete increases the strength of the concrete and also curing of Geo-Polymer concrete at room temperature is possible.

Table 2: Physical and Chemical Composition of GGBS

Particulars	GGBS
Chemical composition	
% Silica(SiO_2)	31.41
% Alumina(Al_2O_3)	17.24
% Iron Oxide(Fe_2O_3)	0.62
% Lime(CaO)	34.48
% Magnesia(MgO)	6.79
% Titanium Oxide (TiO_2)	-

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% Sulphur Trioxide (SO_3)	1.85
Loss on Ignition	2.3
Physical properties	
Specific gravity	2.68
Fineness (m^2/Kg)	400

3.2.3 SYNTHETICFIBERREINFORCED CONCRETE

Through both research and experimental work finally introduced as an effective concrete reinforcement in the 1970s. Today an increasing rate in various applications like: RCC &PCC like lintel, beam, plastering, roads and pavements etc.

3.2.3.1 POLYPROPYLENE FIBER

It is a new era chemical fibers and are fabricated in huge scale and have fourth biggest production of acrylics and polyamides.. Polypropylene fibers were initially recommended for utilization of impact buildings implied by Engineers. Thus the polypropylene fiber has been enhanced further and is presently utilized as short discontinuous fibrillated material for creation of FRC. The strands with controlled configurations of particles can be made only utilizing special catalysts and they were earlier known as Stealthe. These are smaller scale reinforcement fibers and are 100% virgin homo polymer polypropylene graded monofilament strands and the prescribed dose rate of polypropylene strands is 0.9 kg/m^3, approximately 0.1% by volume. Monofilament polypropylene strands have much lower substance than steel fibers.

3.2.3.2 POLYESTER FIBER

Polyester however not as polypropylene filaments, polyester strands are offered by several manufacturers. The fiber groups come just in monofilament shape in lengths from 3⁄4 to 2 inches. Like polypropylene, polyester filaments are hydrophobic. In any case, they tend to deteriorate manufacturers of polyester strands coat the strands to oppose alkaline attack. Be that as it may, the long-term performance of the covered fibers has not been determined. Polyester is a classification of polymers that contain the ester functional group in their principle chain. As a particular material, it most normally refers to a sort called polyethylene terephthalate (PET). Polyesters incorporate regularly happening chemicals, for example, in the cut in of plant cuticles, and also synthetics through step-growth polymerization, for example, poly butyrate. Regular polyesters and a few engineered ones are biodegradable, however most manufactured polyesters are definitely not. Depending upon the chemical structure, polyester can be a thermoplastic or thermoset, there are likewise polyester resins cured by hardness; then again, the most well-known polyesters are thermoplastic

3.2.4 Alkaline Liquid

A combination of alkaline silicate solution and alkaline hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions.

3.2.5 Chemicals

In this project chemicals are the very important constituents. Sodium Silicate and Sodium Hydroxide liquid are obtained commercially from local suppliers in Chennai.

3.2.5.1 Sodium Hydroxide

The sodium hydroxide solids were of a laboratory grade in pellets form with 99% purity, obtained from local suppliers. The sodium hydroxide (Na OH) solution was prepared by dissolving the pellets (a small, rounded, compressed mass of a substance of sodium hydroxide) in water. The mass of sodium hydroxide solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, sodium hydroxide solution with a concentration of 8M consisted of 8x40 = 320 grams of sodium hydroxide solids (in pellet form) per liter of the solution, where 40 is the molecular weight of sodium hydroxide.

3.2.5.2 Sodium Silicate

Sodium silicate solution (water glass) obtained from local suppliers was used. The chemical composition of the sodium silicate solution was Na_2O=8%, SiO_2=28%, and water 64% by mass. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.

3.2.6 Aggregates

The aggregates are the main components of the concrete which greatly varies the strength, density and other properties of the concrete.

Different types of aggregates used are discussed below.

3.2.6.1 Fine Aggregate

The fine aggregate used in the project was locally supplied from the river Swarnamukhi, near chandragiri in chittoor district and conformed to grading zone II as per IS: 383:1970. It was first sieved through 4.75mm sieve to remove any particles greater than 4.75mm. Properties of the fine aggregate are tabulated below in Table 3.

Table 3. Properties of fine aggregates

S.No	Characteristics	Values
1.	Type	Uncrushed (natural)
2.	Specific gravity	2.54
3.	Bulk Density	1668 kg/m3
4.	Fineness modulus	2.76
5.	Grading zone	Zone II

3.2.6.2 Coarse Aggregate

Locally available coarse aggregate having the maximum size of (10 - 20mm) were used in this project. Properties of the coarse aggregate are tabulated in Table 4.

Table 4. Properties of Coarse aggregates

S.No	Characteristics	Values
1.	Type	Crushed
2.	Specific gravity	2.6
3.	Bulk Density	1765 kg/m3
4.	Fineness modulus	6.45
5.	Maximum size	20mm

4. MIX PROPORTION AND EXPERIMENTAL INVESTIGATION

4.1 Introduction

In this chapter mix design of Geo-polymer concrete and the experimental investigation carried out on the test specimen to study the strength related properties of geo-polymer concrete was discussed in detail.The experimental test for strength properties of concrete are compressive strength, split tensile strength, Flexural strength test of concrete. Based on the test procedure given in IS 516-1959 code tests were conducted on specimens.

4.2 Mix Proportion for Geo-Polymer Concrete

Most of the reported works on geo-polymer material to date were related to the properties of geo-polymer paste or mortar, measured by using small size specimens. In addition, the complete details of the mixture compositions of the geo-polymer paste were not reported.Palomo et al (1999) studied the geo-polymerization of low-calcium ASTM Class F fly ash (molar Si/Al=1.81) using four different solutions with the solution-to-fly ash ratio by mass of 0.25 to 0.40. The molar SiO_2/K_2O or SiO_2/Na_2O of the solutions was in the range of 0.63 to 1.23.

4.3 Preparation of Alkaline Activator Solution

The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.A combination of alkaline silicate solution and alkaline hydroxide solution was chosen as the alkaline liquid

Sodium-based solutions were chosen because they were cheaper than potassium-based solutions. The Alkali activator solution has to be prepared 24 hours advance before use. The Sodium hydroxide is available in small flakes and Sodium Silicate in crystal forms depending on the required solution of different morality has to be prepared.

4.4 Design of Geo-Polymer Concrete

Some of the trials carried out indicated that the workability and strength characteristics of such mixes were not satisfactory. Such a thing is possible because GPC involves more constituents in its binder (GGBS, flyash, Sodium silicate, Sodium hydroxide and water), whose interactions and final structure and chemical composition are strongly dependent on the source of the material and their production process. Therefore the formulation of the GPC mixture was done by trial and error basis. Numerous trial mixes were cast and tested for compressive strength at the end of 28 days. The ratio of AAS to binder solids and

Table 5. GPC Mix Proportions

Materials		Mass (kg/m^3)					
		0%	0.2%	0.25%	0.3%	0.35%	0.4%
Coarse Aggregate	20 mm	774	774	774	774	774	774
	10 mm	516	516	516	516	516	516

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Fine aggregate	549	549	549	549	549	549
Fly ash (Class F)	204.5	204.5	204.5	204.5	204.5	204.5
GGBS	204.5	204.5	204.5	204.5	204.5	204.5
Sodium silicate solution	102	102	102	102	102	102
Sodium hydroxide solution	41(8M)	41(8M)	41 8M)	41(8M))	41(8M))	41(8M)
Extra water	55	55	55	55	55	55
Alkaline solution/ (FA+GGBS) (by weight)	0.35	0.35	0.35	0.35	0.35	0.35
Water/ geopolymer solids (by weight)	0.29	0.29	0.29	0.29	0.29	0.29
% of fibers by volume	0	0.002	0.0025	0.003	0.0035	0.004

5. RESULTS & DISCUSSIONS

The various strength tests that are to be done listed as below.

Compressive strength

Split tensile strength

Flexural strength

Test Specimens

The test specimens for compressive strength test were made of cubes having a size of 150mm x 150mm x 150mm cast iron steel moulds were used. For each mix proportion three numbers of cubes were cast and tested at the age of 7 days, 28 days and 90 days. The test specimens for split tensile strength test were made of cylinders having a size of 100mm diameter and 300mm high cast iron moulds were used. For each mix proportion three numbers of cylinders were cast and tested at 7 days, 28 days and 90 days. The test specimens for Flexural strength test were made of prism having a size of 500mm x 100mm x 100mm cast iron steel moulds were used. For each mix proportion three numbers of prisms were cast and tested at the age of 7 days, 28 days and 90 days.

5.1 Compressive Strength Test

Compressive strength test was tested for the mixes with the various synthetic fibers replacement levels of 0%, 2%, 2.5%, 3%,3.5% &4% .The samples were tested after curing periods of 7, 28 and 90 days. Table 6 and fig 1shows the Compressive strength test of GPC mixes at different curing periods.

Table 6. Compressive strength of GPC

Compressive strength, f'_c (MPa)	7 Days	28 Days	90Days
0%	31.14	37.54	43.68
2%	32.03	42.18	45.03
2.5%	34.62	44.81	48.52
3%	35.56	46.82	52.64
3.5%	32.89	38.75	45.18
4%	30.12	37.86	44.74

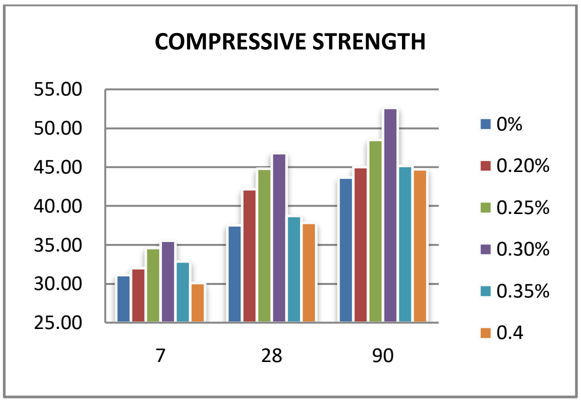

Fig 1.Variation of Compressive strength of GPC

5.2 Split Tensile Strength Test

Split tensile strength was tested for the mixes with the various synthetic fibers replacement levels of 0%, 2%, 2.5%, 3%,3.5% &4% .The samples were tested after curing periods of 7, 28 and 90 days. Table 7 and fig 2 shows the split tensile strength of GPC mixes at different curing periods.

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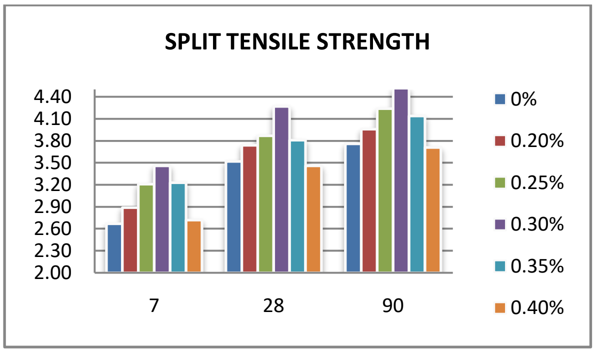
Table 7. Split tensile strength of GPC

Compressive strength, f'_c (MPa)	7 Days	28 Days	90Days
0%	2.67	3.52	3.76
2%	2.89	3.74	3.96
2.5%	3.21	3.87	4.24
3%	3.46	4.27	4.52
3.5%	3.23	3.81	4.14
4%	2.72	3.46	3.71



5.3 Flexural Strength Test

Flexural strength was tested for the mixes with the various synthetic fibers replacement levels of 0%, 2%, 2.5%, 3%,3.5% &4% .The samples were tested after curing periods of 7, 28 and 90 days. Table 8 shows and fig 3 the flexural strength of GPC mixes at different curing periods.

Table 8. Flexural Strength Test of GPC

Compressive strength, f'_c (MPa)	7 Days	28 Days	90Days
0%	3.21	3.79	4.38
2%	3.56	4.11	4.56
2.5%	3.87	4.36	4.62
3%	3.94	4.48	4.92
3.5%	3.65	3.97	4.64
4%	3.46	3.72	4.34

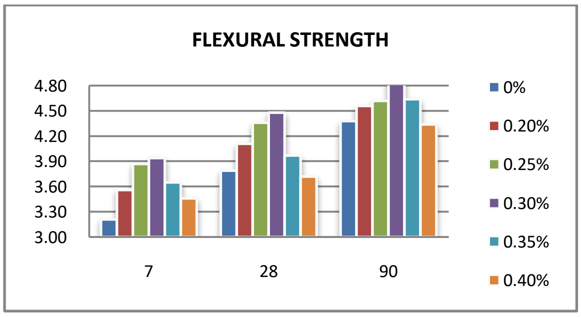


Fig 3.Variation of Flexural Strength Test of GPC

6 CONCLUSIONS AND FUTURE WORK

6.1 Conclusions

Based on the investigation, the following conclusions have been drawn.

There was a significant increase in compressive strength, split tensile strength, flexural strength with the increase in percentage synthetic fibers from 0% to 0.3% in all curing periods. The optimum percentage of synthetic fibers obtained is 0.3% of its volume of concrete.

- The maximum compressive strength of geopolymer concrete for 7days, 28days and 90 days curing period is 35.86 MPa, 46.82 MPa and 52.64 MPa respectively by partial replacement with optimum percentage of synthetic fibers of 0.3% replacement.
- The maximum Split Tensile Strength of geopolymer concrete for 7days, 28days and 90 days curing period is 3.26 MPa, 4.27 MPa and 4.52 MPa respectively by partial replacement with optimum percentage of synthetic fibers of 0.3% replacement.
- The maximum flexural strength of geopolymer concrete for 7days, 28days and 90 days curing period is 3.94 Mpa, 4.48 MPa and 4.92 MPa respectively by partial replacement with optimum percentage of synthetic fibers of 0.3% replacement.
- When the percentage of synthetic fibers was increased to 0.35% a drastic fall in compressive strength, split tensile strength and flexural strength have been evidenced.
- The drastic improvement in mechanical properties up to 0.3% synthetic fibers adding is mainly due to the blending of concrete with fibers and which fills the voids and enhance the mechanical properties.

6.2 Future work

The following suggestions are recommended for future study

- Further research is recommended to study the modulus of elasticity and bond strength between concrete and steel reinforcement.
- Further research is recommended to study the other durability properties viz. water absorption, sorptivity, acid attack and chloride penetration of GPC mixes.

- Keeping in view of the availability of natural resources and environmental aspects, it is recommended to replace some percentage of fine aggregate with quarry dust and granite slurry and coarse aggregate with demolished aggregates etc., in FA and GGBS based GPC mixes and study all GPC hardened and durability properties.
- Development of cost effective FA and GGBS based GPC mixes.
- Further research is recommended to study the mechanical and durability properties using natural fibers.

REFERENCES

[1]. IS 12089 (1987). Specifications for granulated slag for manufacture of Portland slag cement. Bureau of Indian Standards, New Delhi.

[2]. IS 2386 Part-I 1963 Indian standard methods of test for aggregates for concrete: Part-III specific gravity, density, voids, absorption and bulking, Bureau of Indian Standards, New Delhi.

[3]. IS 3812 (1981). Specifications for fly ash for use as pozzolana and admixture. Bureau of Indian Standards, New Delhi.

[4]. IS 383 (1970). Specification for coarse and fine aggregates from natural sources for concrete. Bureau of Indian Standards, New Delhi.

[5]. IS 456 (2000). Plain and reinforced concrete code for practice. Bureau of Indian Standards, New Delhi.

[6]. IS 516 (1991). Methods of tests for strength of concrete [CED 2: Cement and Concrete]. Bureau of Indian Standards, New Delhi.

[7]. IS 5816 (1999). Method of Test Splitting Tensile Strength of Concrete [CED 2: Cement and Concrete]. Bureau of Indian Standards, New Delhi.