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Fibers Study On Properties Of Geopolymerconcrete With Polypropylene

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Abstract:- Fly Ash is one of the major waste materials available from thermal power plants. Its treatment and disposal was a problem in the early stages. Researchers found out a useful method of replacing fly ash for cement in calculated qualities. Presently the percentage of replacement has been increasing.

Here an experiment has been conducted to study the performance of concrete using fly ash as the major binding material without of cement. Low calcium fly ash is preferred as a source material than High calcium fly ash because of to reducing more carbon di oxide emission

Alkaline liquid Sodium hydroxide and Sodium silicate solution are used in this project as binders. It is used in Geo polymerization process. Reactions occur at high rate when the alkaline liquid contains soluble silicate, either sodium or potassium silicate compared to the use of only alkaline hydroxides.

A mix proportion for Geopolymer concrete was designed and carried out tests for different grade of concrete. The tensile strength and compressive strength of Geopolymer concrete have been studied and compared with OPC.

Polypropylene is one of the cheapest & abundantly available polymers. Polypropylene fibers are resistant to most of the chemicals & it would be cementations matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degree centigrade).So that a working temp (about 100 degree centigrade). Polypropylene is one of the cheapest & abundantly available polymers. Polypropylene fibers are resistant to most of the chemicals & it would be cementations matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degree centigrade).So that a working temp is about 100 degree centigrade.

Keywords:- Polypropylene fibers,Geopolymer, Alkaline liquid Sodium hydroxide , Sodium silicate.

I. INTRODUCTION

1.1 General

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcinations of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum. On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete.

In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminum in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymers. Palomo et al (1999) suggested that pozzolans such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of OPC in concrete. In this scheme, the main contents to be activated are silicon and calcium in the blast furnace slag. The main binder produced is a C-S-H gel, as the result of the hydration process.

1.2 Fly ash-based Geopolymer concrete

In this work, low-calcium (ASTM Class F) fly ash-based geopolymer is used as the binder, instead of Portland or other hydraulic cement paste to produce concrete. The fly ash based geopolymer paste binds the loose coarse aggregates, fine aggregate sand other un-reacted materials together to form the geopolymer concrete, with or without the presence of admixtures. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. As in the case of OPC concrete, the aggregates occupy about 75-80 % by mass, in geopolymer concrete. The silicon and the aluminum in the low-calcium (ASTM Class F) fly ash react with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geopolymer paste that binds the aggregates and other un-reacted materials.

1.3 Aim of the study

The aims of our study are:

1. To develop a mixture proportioning process to manufacture low-calcium fly ash based Geopolymer concrete.
2. To identify and study the effect of salient parameters that affects the properties of Low-calcium fly ash-based geopolymer concrete.
3. To study the short-term engineering properties of fresh and hardened low calcium Fly ash- based geopolymer concrete.
4. To study the properties and polypropylene fibers mixed geopolymer concrete

II. LITERATURE REVIEW

2.1 General

This chapter presents an overview of literatures collected from various journals. The most worthy of them which are relevant to the current study are being reviewed.

2.2 Literatures

H. Mohammed et al. (2010) Compressive strength is an essential property for all concrete where it also depends on curing time and curing temperature. When the curing time and temperature increase, the compressive strength also increases. With curing temperature in range of 60 to 90ºC, within time in24 to 72 h, the compressive strength of concrete can be obtained about400 to 500 kg/cm2 (Chanh et al., 2008). In addition, the compressive strength of geopolymers also mainly depended on the content of fly ash fine particles (smaller than 43 μm).The compressive strength was increase when the finess of fly ash increase. Hence the nature and the concentration of the activators were dominant factors in the reaction of alkali activation. The highest compressive strength was obtained using a solution of sodium silicates and activator (n = 1.5; 10% Na2O). Sodium silicate is the most suitable as alkaline activator because it contains dissolved and partially polymerized silicon which reacts easily, incorporates into the reaction products and significantly contributes to improving the mortar characteristics.

S. Mandal et al. (2009) Based on the present experimental investigation it can be concluded that concentration of activator fluid and the fluid to fly ash ratio has a great effect on the compressive strength at higher concentration (in terms of molarity) and at fluid to fly as ratio, the strength of the mortar seems to be maximum. As the curing temperature in the range of 250Cto 900C increases, the compressive strength of the mortar also increases even strength increases with the longer curing period, however increase in strength beyond 48years is not significant. Finally, alkali activation of fly ash produces a material with excellent material properties in terms of compressive strength.

S.Thokchom et al. (2010) Exposure solutions recorded considerable increase in pH value which can be attributed to migration of alkalis from specimen to solution. Maximum increase in pH occurred in solution containing specimen with highest Na2O content which suggests that more alkalis migrated from these specimens. Geopolymer mortar specimen gains weight during exposure to magnesium sulphate solution and such gain are related to Na2Ocontent of the specimen. Specimen recorded extremely low gain in weight, the maximum gain being noticed in the specimen with minimum Na2O content. Residual compressive strength showed some fluctuations during the period of exposure. After 24 weeks of exposure, specimen with highest Na2O content retained maximum strength of 89.7%.Geopolymer mortar specimen manufactured with higher alkali content performed better than those manufactured with lower alkali content.

K.Naveen Kumar Reddy et al. (2010)found that geopolymer concrete prepared from low lime based fly-ash and a mixed alkali activator of sodium hydroxide and sodium silicate solution are investigated. An increase in compressive strength of these concrete samples is observed with increased molarity of NaOH solution. The workability of concrete decreases when the molarity of NaOH solution is increased for the samples cured at 60°C.

The workability of geopolymer concrete is reduced with higher concentrations of sodium hydroxide (in the range of 10 M to16 M) solution which results in a higher Compressive strength .There is a slight increase in the compressive strength with age of the concrete for a defined concentration of NaOH solution. The addition of high-range water reducing admixture with 1.5% of fly-ash(by mass) resulted no much impact on thecompressive strength of the hardened concrete, but improved workability of fresh geopolymer concrete.

Fareed Ahmed Memon et al. (2011) Longer curing time improves the geo polymerization process resulting in higher compressive strength. Increase in compressive strength was observed with increase in curing time. The compressive strength was highest when the specimens were cured for a period of 96 hours however; the increase in strength after 48 hours was not significant. Compressive strength of concrete increased with the increase in curing temperature from 60°C to 70°C; however an increase in the curing temperature beyond70°C decreased the compressive strength of self compactinggeopolymer concrete.

R. Anuradha et al. (2005) showed that experimental study was conducted to assess the Acid resistance of fly ash based geopolymer mortar specimens of size 50x50x50mm with a ratio of fly ash to sand as 1:3.The ratio between solution(Sodium hydroxide and Sodium silicate solution) to fly ash were 0.376,0.386,0.396 and 0.416. After casting the specimens were subjected to both ambient curing and heat curing. In heat curing the specimens were kept continuously at60oC for 24 hrs. Durability of specimens was assessed by immersing them in 5% of sulfuric acid and 5%hydrochloric acid for a period of 14 weeks. Evaluation of its resistance in terms of change in weight, compressive strength and visual appearance at regular intervals was carried out. After exposure in the acid solutions for 14 weeks, the samples showed very low weight loss. Results obtained from the present study indicate that Geopolymers are highly resistance to sulfuric acid and hydrochloric acid.

B. VijayaRangan et al. (2006) found that Heat-cured low-calcium fly ash-based geopolymer concrete offers many advantages such as excellent structural properties, low creep, very little drying shrinkage, excellent resistance to sulfate attack, and good acid resistant. It is cheaper than Portland cement concrete, energy efficient, and environmentally friendly. The paper presents the results of tests conducted on reinforced geopolymer concrete beams and columns to demonstrate the structural applications of geopolymer concrete.

R.Kumuta. (2011) Geopolymer Concrete (GPC mix) has two limitations such as delay in setting time and necessity of heat curing to gain strength. These two limitations of GPC mix was eliminated by replacing 10% of fly ash by OPC which results in Geopolymer Concrete Composite (GPCC mix). Replacement of 10% of fly ash by OPC in GPC mix resulted in an enhanced compressive strength, split tensile strength and flexural strength by 73%, 128% and 17%respectively with reference to GPC mix. Addition of steel fibers in Geopolymer concrete composites enhanced its mechanical properties. Compressive strength, split tensile strength and flexural strength of steel fiber reinforced Geopolymer concrete composites increases with respect to the increase in the percentage volume fraction from 0.25 to 0.75. Addition of 0.25% volume fraction of steel fibers resulted in an enhanced compressive strength.

Dang Van Tuan et al. (2008) As the curing temperature in the range of 60oC to 90oC increases, the compressive strength of fly ash-based geopolymer concrete also increases. Longer curing time, in the range of 24 to 72 hours (4 days), produces higher compressive Strength of fly ash-based geopolymer concrete. However, the increase in strength beyond48 hours is not significant.The slump value of the fresh fly-ash-based geopolymer concrete increases with the increase of extra water added to the mixture. The compressive strength of heat-cured fly ash-based geopolymer concrete does not depend on age. Geopolymer concrete has excellent properties within both acid and salt environments. Comparing to Portland cement, the production of geopolymers has a relative higher strength, excellent volume stability, better durability

III. METHODOLOGY

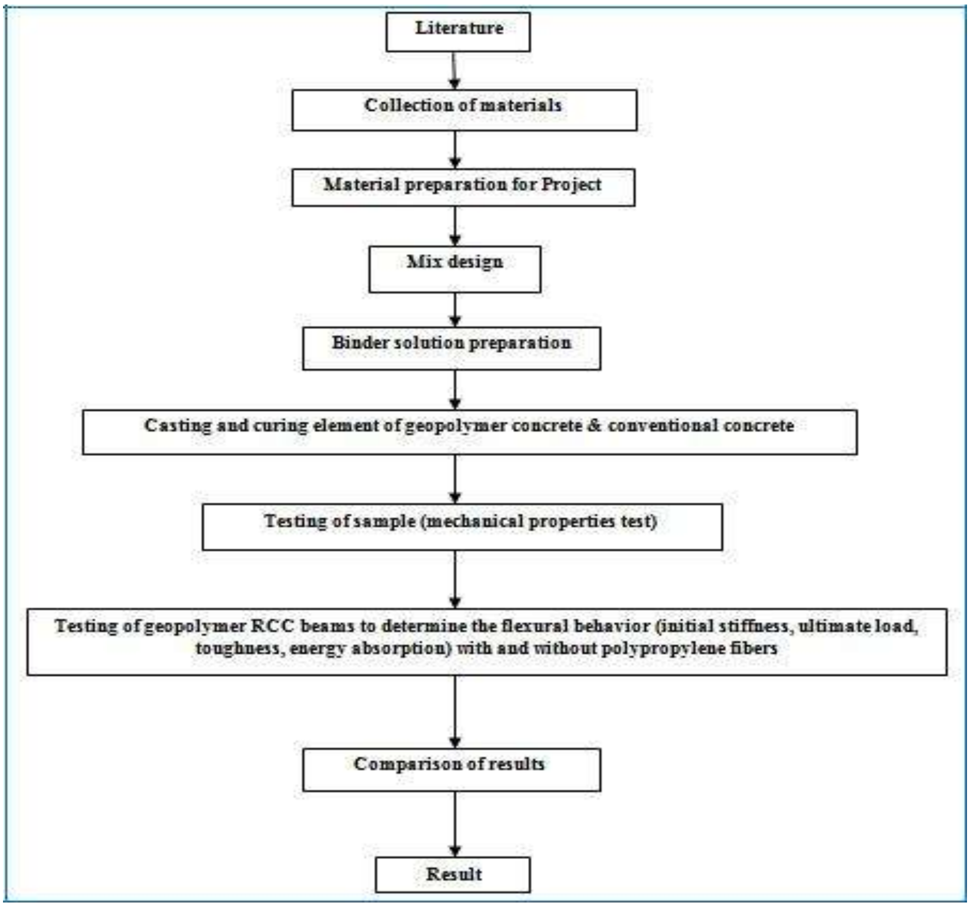


Figure 3.1 Methodology

3.1 Ingredients used in Geopolymer with Polypropylene Fibers

- Fly ash
- Fine aggregate : Natural river sand
- Coarse aggregate
- Water: Ordinary portable water
- Polypropylene fibers
- Mineral admixtures: sodium hydroxide and sodium silicate solution.

3.2 Fly ash

The fly ash is should be used having high fineness, low carbon content and good reactivity .The characteristics of fly ash such as specific gravity, grain size, compaction characteristics permeability coefficient, shear strength parameters and consolidation parameters are the same as those for natural soils .The procedure for determination of these parameter are also similar to those soils .the quality of fly ash was found to satisfy the requirement of fly ash.

Table: 3.1 Properties of fly ash

Fly ash	values
Specific gravity	2.2
Fineness m^3/kg	310
Bulk density kg/m^3	0.55%

3.3 Water

Portable water was used for casting of all specimens of this investigation

3.4 Fine aggregate

Sand is either round or angular grain and is often found mixed in various grading of fineness at different zones. Fine aggregate properties are evaluated as per the IS2386 methods. The four zones of river sand are used for the preparation of mortar cubes. Though it contains impurities it has to cleaned and well sieved so that the mortar will not affect the structure. Fine aggregate properties.

Table: 3.2 Properties of fine aggregate

Fine aggregate	**values**
size	Passing through 4.75mm sieve
Fineness modulus	3.5
Specific gravity	2.6
Water absorption	1.0%

3.5 Coarse aggregate

The coarse aggregate used was broken crushed stone and it was free from clay lambs weeds and other organic matters are non-porous .the water absorption capacity is less than 1%.the size of which passes through 26 mm sieve and retained on 19mm sieve the properties of the coarse aggregate.(From IS: 383-1970 this is Zone)

Table: 3.3 Properties of Coarse aggregate

Coarse aggregate	**Values**
Size	12mm
Fineness modulus	7.3
Specific gravity	2.6
Water absorption	0.55%

3.6 Sodium Hydroxide

Generally the Sodium Hydroxides are available in solid state by means of pellets and flakes. The cost of the Sodium Hydroxide is mainly varied according to the purity of the substance. Since our Polypropylene Fibre Reinforced Geopolymer Concrete is homogeneous material and its main process to activate the Sodium Silicate so it is recommended to use the lowest cost i.e. up to 94% to 96% purity. In this investigation the Sodium Hydroxide pellets were used. Whose chemical property and physical property are given by manufacturer are as follows for solid Sodium Hydroxide.

Figure: 3.2 Sodium Hydroxide pellets

Table: 3.4. Physical Properties of Sodium Hydroxide

Colour	Colour less
Specific gravity	2.13
pH	14

Table: 3.5 Chemical Properties of Sodium Hydroxide

Assay	**97%**	**Min**
Carbonate(Na2co3)	2%	Max
Chloride(Cl)	0.01%	Max
Sulphate(so2)	0.05%	Max
Lead(pb)	0.001%	Max
Iron(Fe)	0.001%	Max
Potassium(K)	0.01%	Max
Zinc(Zn)	0.02%	Max

3.7 Sodium Silicate

Sodium Silicate also known as water glass or liquid glass, available in liquid (gel) form. In this Sodium Silicate is used for the making of Polypropylene Fiber Reinforced Geopolymer Concrete. The Chemical Properties and the Physical Properties of the Silicates are given the manufacture as follows.

Figure: 3.3 Sodium Silicate gel

Table No: 3.6. Physical and Chemical Properties of Sodium Silicate

Chemical formula	**Na2O x SiO2 Colour less**
Na2O	15.9%
Sio2	31.4%
H2O	52.7%
Appearance	Liquid(gel)
Boiling point	102 C for 40% acqeous solution
Molecular weight	184.04
Specific gravity	1.6

3.8 Polypropylene fibre

In this investigation, polypropylene fibers are used an average diameter of 10 μm, a length of 18mm

Figure: 3.4. Polypropylene Fiber

Table: 3.7. Properties of Polypropylene Fibers

Specification	**Values**
Aspect ratio	1800
Tensile strength (Mpa)	2.5x103
Elasticity modulus (Mpa)	8x103
Specific gravity (g/cm3)	8

3.9 Mixing, Casting and Curing

The solids constituents of the fly ash-based geopolymer concrete, i.e. the aggregate sand the fly ash, were dry mixed about three minutes. The liquid part of the mixture, i.e., the sodium silicate solution, the sodium hydroxide solution, added water (if any).The fresh fly ash-based geopolymer concrete was dark in color and shiny in appearance. The workability of the fresh concrete was measured by means of the conventional slump test .Compaction of fresh concrete in the cylinder steel moulds was achieved by applying twenty five manual strokes per layer in three equal layers.

IV. EXPERIMENTAL INVESTIGATIONS

4.1 Introduction

In order to develop the fly ash based geopolymers concrete technology, therefore, a rigorous trail-and-error process was used. The focus of the study was to identify the salient parameters that influence the mixture proportions and the properties of low calcium fly ash-based geopolymers concrete. In order to simplify the development process, the compressive strength was selected as the benchmark parameter. This is not unusual because compressive strength has an intrinsic importance in the structural design of concrete structures. Also as in the case of OPC the aggregates occupied 75-80 % of the total mass of concrete. In order to minimize the effect of the properties of the aggregates on the properties of fly ash based geopolymers.

4.2 Materials

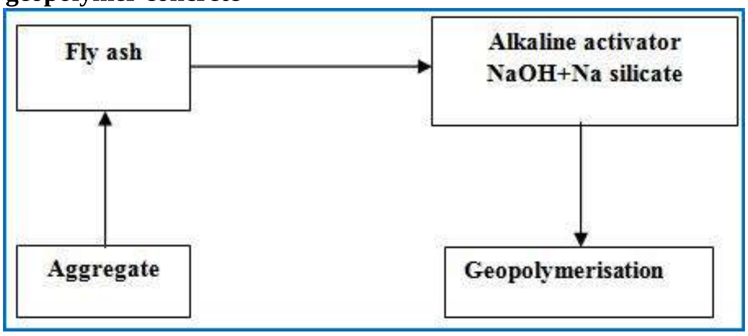
4.2.1 Fly ash

In the present experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash obtained from the silos of Mettur thermal Power Station was used as the base material. The chemical compositions of the fly ash from all batches, as determined by X-Ray Fluorescence (XRF) .Fly ash contained a very low percentage of carbon as indicated by the low Loss on Ignition (LOI) values. The molar Si-to-Al ratio was about calcium oxide content was very low. The iron oxide (Fe2O3) contents from all batches are relatively high; Specific Surface Area was 1.29m2/cc

4.2.2 ConstituentsofGeopolymer concrete

• Source materials :
Alumina-silicate
• Alkaline liquids
Combination of sodium hydroxide (NaOH) sodium silicate.

4.2.3 Preparation of geopolymer concrete



4.3 Mix proporation

4.3.1 Alkaline liquid

- The Ratio of sodium silicate solution to sodium hydroxide solution, by mass of 0.4 to 2.5. This ratio was fixed at 2.5 for most of the mixtures because the sodium silicate solution is considerably cheaper than the sodium hydroxide solution.
- Molarities of sodium hydroxide (NaOH) solution in the range of 8M to 16M.
- Ratio of activator solution fly ash, by mass, in the range of 0.3 and 0.4.
- Course and fine aggregate of approximately 75 to 80% of the entire mixture by mass.
- Extra water (if necessary).

V. RESULTS AND DISCUSSION

5.1 General

For M 25 grade conventional concrete and geopolymer concrete the compressive strength, tensile strength and load deflection test results are conducted. GPC values are higher than conventional concrete higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of fly ash-based geopolymer concrete.

5.2 Compressive Strength

Compressive strength is one of the important properties of concrete. Concrete cubes of size 150mmx150mmx150mm were cast with and without of fly ash. After 24 hours, the specimens were demoulded and subjected to water curing. After 28 days of curing specimens were taken and allowed to dry and tested in compressive strength testing machine .

Table :5.1 Compressive strength test results conventional concrete & GPC (with out fibers)

Mix ratio	Compressive strength (N/mm^2)	
	Conventional concrete	GPC
M25	31.33	35.6
	32.56	36.1
	31.78	34.14

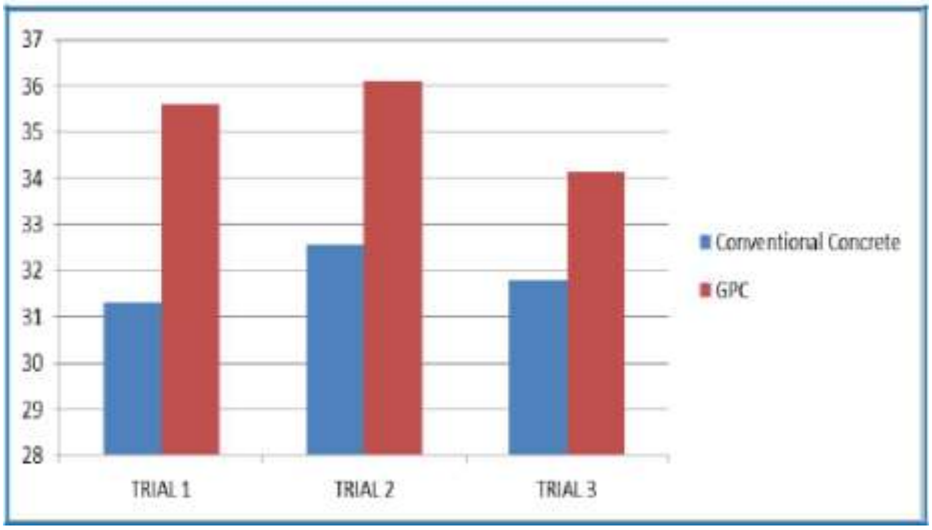


Figure 5.1 Comparison of Compressive strength 28 days conventional concrete &GPC(without fibers)

Table: 5.2 Compressive strength test results conventional concrete & GPC (with fibers)

Mix ratio	Compressive strength (N/mm^2)	
	Conventional concrete	GPC
M25	34.42	38.6
	36.68	40.21
	33.48	37.28

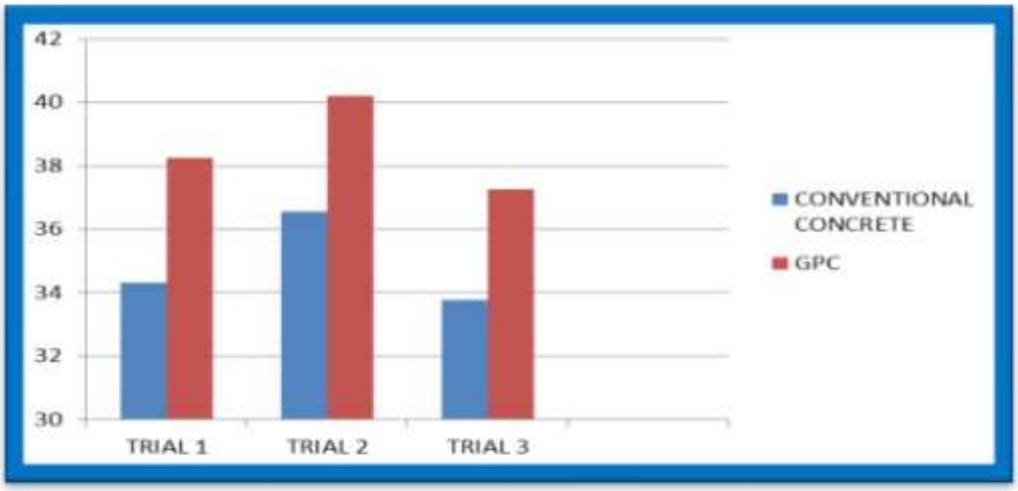


Figure 5.2. Comparison of compressive strength 28 days conventional concrete & GPC (with fibers)

5.3 Split Tensile Strength

Split tensile strength is indirect way of finding the tensile strength of concrete by subjecting the cylinder to a lateral compressive force. Cylinders of size 150mm diameter and 300mm long were cast with and without fly ash. After 24 hours the specimen were demoulded and subjected to water curing. After 28 days of curing of specimens were taken and allowed to dry and tested in universal testing machine by placing the specimen horizontal.

Split tensile strength, fsp = $2P/\pi bd$

Where, P = Load applied to the specimen in
N b = Breadth of the specimen in mm
d = Depth of the specimen in mm

Table:5.3 Split Tensile Strength Results conventional concrete & GPC (without fibers)

Mix ratio	Tensile strength (N/mm^2)	
	Conventional concrete	GPC
M25	3.63	3.82
	3.43	3.94
	3.56	4.1

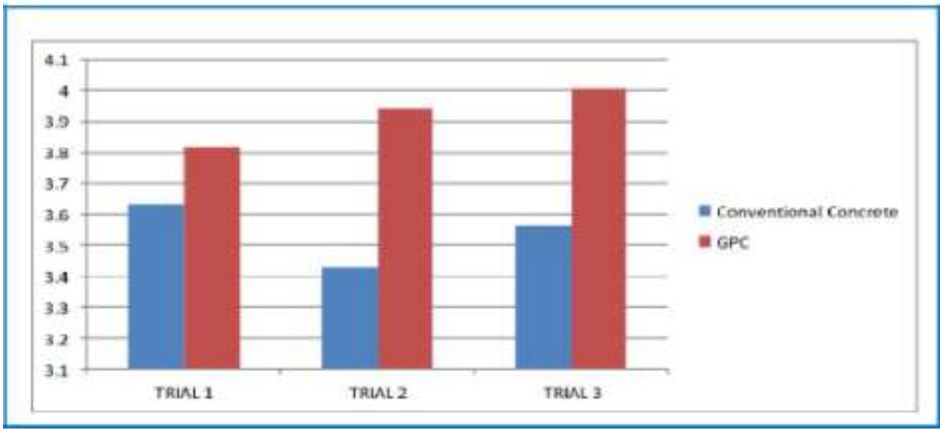


Figure 5.3. Comparison of Split Tensile strength 28 days conventional concrete & GPC (without fibers)

Table :5.4 Split Tensile strength results conventional concrete & GPC (with fibers)

Mix ratio	Tensile strength (N/mm^2)	
	Conventional concrete	GPC
M25	4.63	5.22
	4.45	5.02
	4.58	5.28

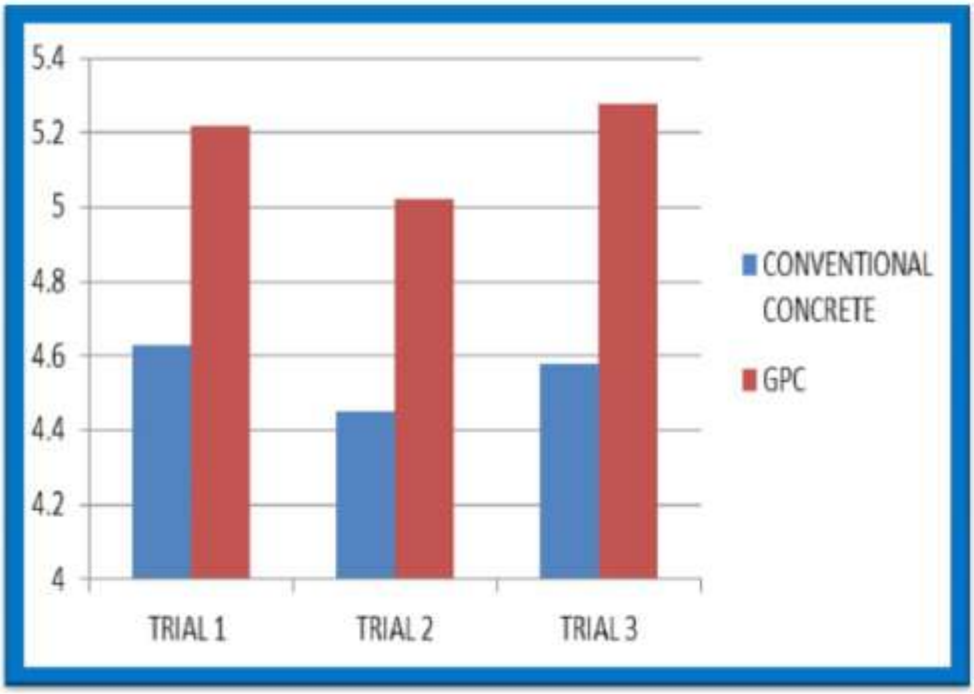


Figure 5.4. Comparison of Split Tensile strength 28 days conventional concrete & GPC (with fibers)

5.4 Load Deflection Test

5.4.1 Deflection values for specimens

The extreme fiber stress calculated at the failure of specimen is called Modulus of rupture. It is also an indirect measure to predict the tensile strength of concrete. RCC beams test was conducted on 150 mm X 230mm X 1000 mm beam. The size of main bar is 10mm ϕ dia two number rod, distribution bar size 10mm ϕ two number rod, strips 8mm ϕ, cover is 25 mm..

Load and deflection tests were carried out for different trail mix and RCC beam specimens with addition of 1 % polypropylene fibers by weight. The first crack load, yield load and ultimate load and their corresponding deflections were found out

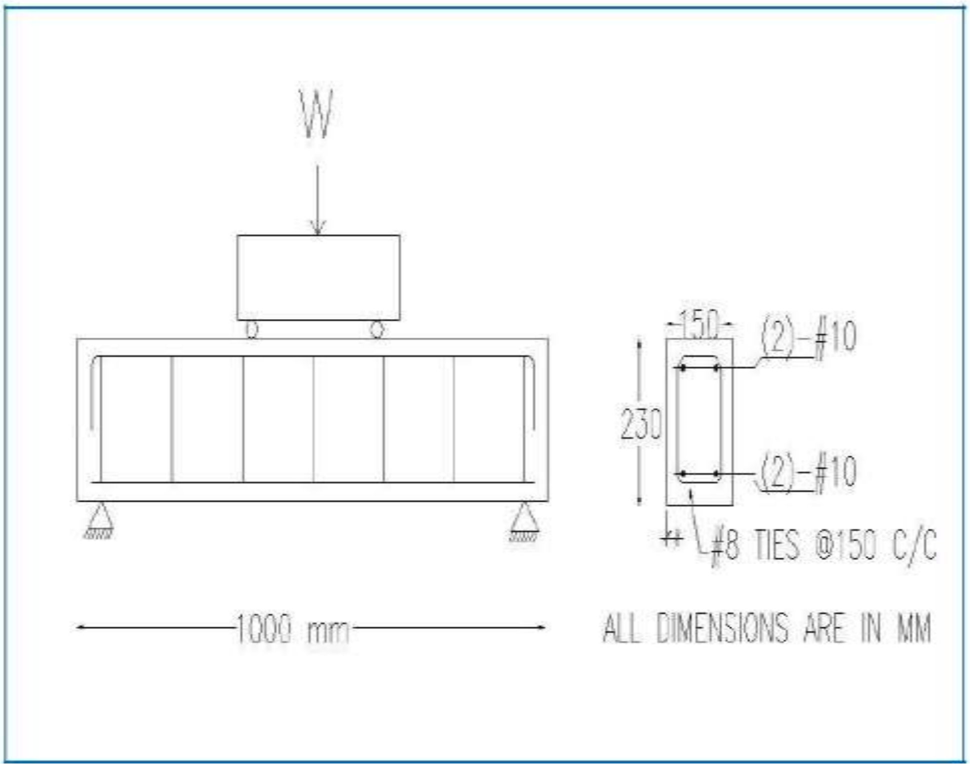


Figure: 5.5 Beam Reinforcement Details

Table: 5.5 Load deflection test values for RCC conventional concrete beam (without fibers)

S.No	Load in KN	Deflection	
		Division	mm
1	10	0	0
2	20	25	0.25
3	30	90	0.9
4	40	165	1.65
5	50	220	2.2
6	60	290	2.9
7	70	360	3.6
8	80	445	4.45
9	90	680	6.80
10	100	1020	10.20

Table : 5.6 Load deflection test values for with GPC beam (without fibers)

S.No	Load in KN	Deflection	
		Division	mm
1	10	0	0
2	20	33	0.33
3	30	105	1.05
4	40	210	2.10
5	50	240	2.40
6	60	314	3.14
7	70	389	3.89
8	80	468	4.68
9	90	728	7.28
10	100	1082	10.82

mm

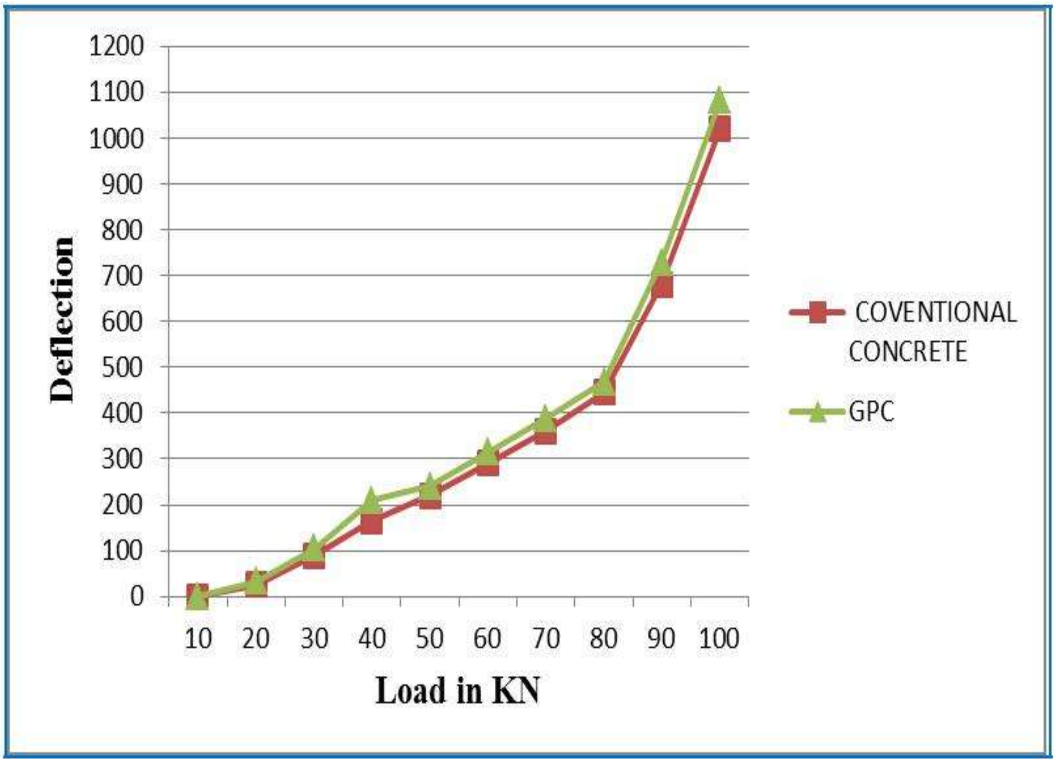


Figure 5.6: Comparison of load deflection test 28 days conventional concrete & GPC (without fibers)

Table:5.7 Load deflection test values for with conventional concrete beam(with fibers)

S.No	Load in KN	Deflection	
		Division	mm
1	10	0	0
2	20	28	0.28
3	30	94	0,94
4	40	173	1.73
5	50	226	2.26
6	60	299	2.99
7	70	364	3.64
8	80	451	4.51
9	90	685	6.85
10	100	1028	10.28

Table : 5.8 load deflection test values for with GPC beam(with fibers)

S.No	Load in KN	Deflection	
		Division	mm
1	10	0	0
2	20	36	0.36
3	30	109	10.9
4	40	215	2.15
5	50	247	2.47
6	60	319	3.19
7	70	394	3.64
8	80	473	4.73
9	90	734	7.34
10	100	1086	10.86

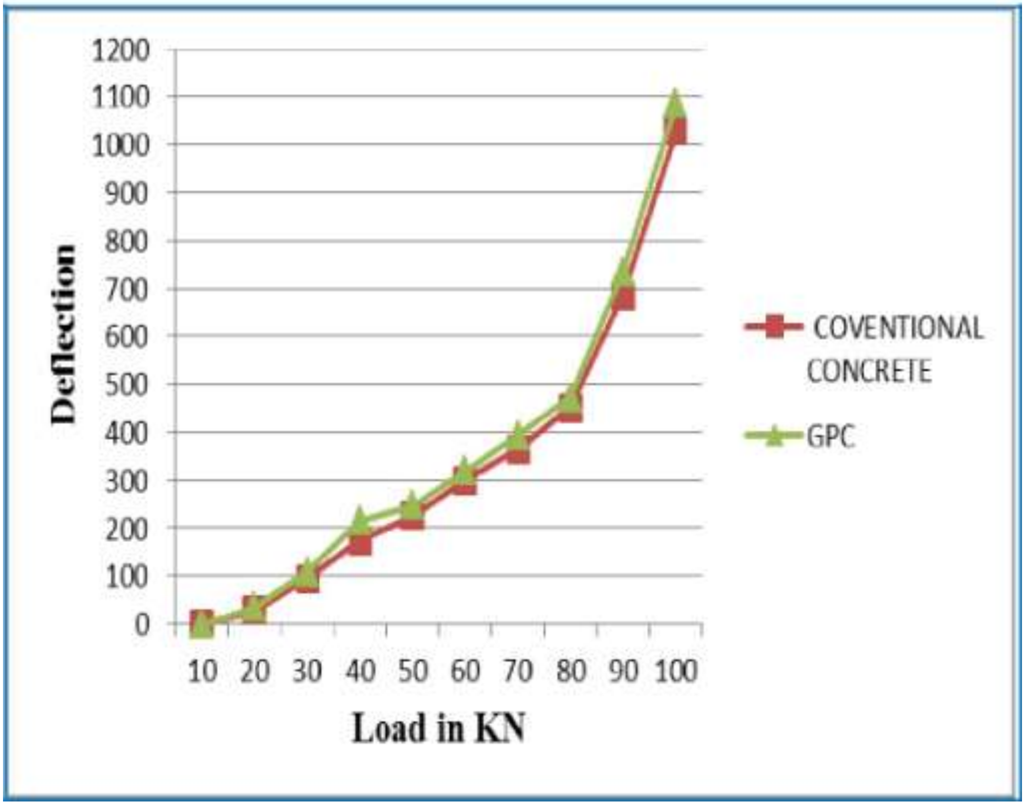


Figure 5.7. Comparison of load deflection test 28 days conventional concrete & GPC (with fibers)

5.4.2 Load deflection test parameters
5.4.2.1 Determination of ultimate load

The ultimate load of RCC beams test was conducted on 230 mm X 150mm X 1000 mm beam cast M 25.grade. The reinforcements were designed and detailed in table the beam was tested for its ultimate load applying two point load

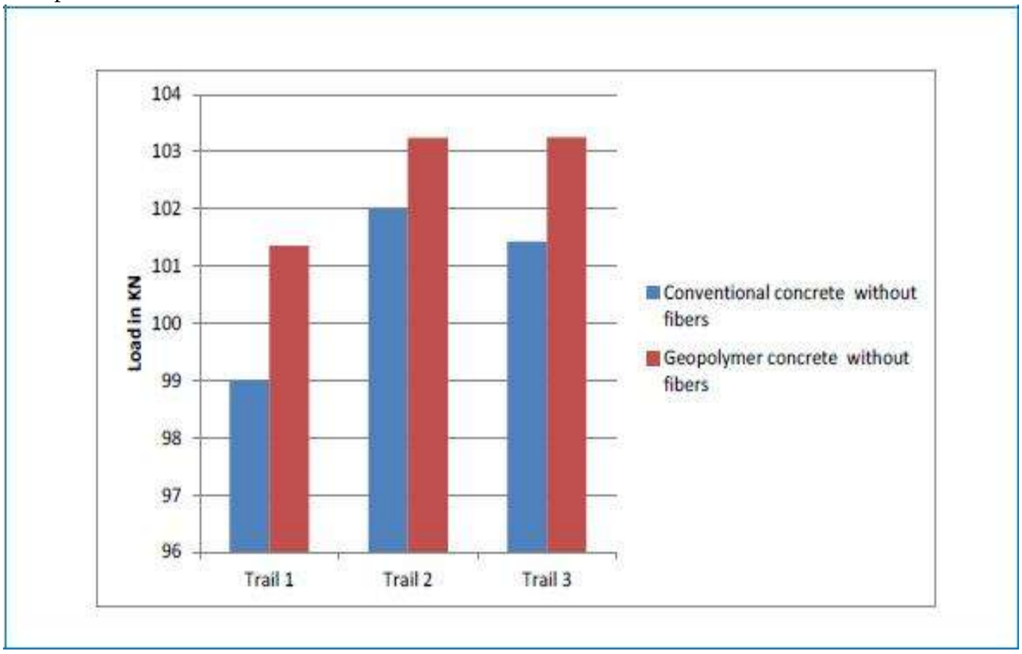


Figure 5,8. Test results of Ultimate load without fibers

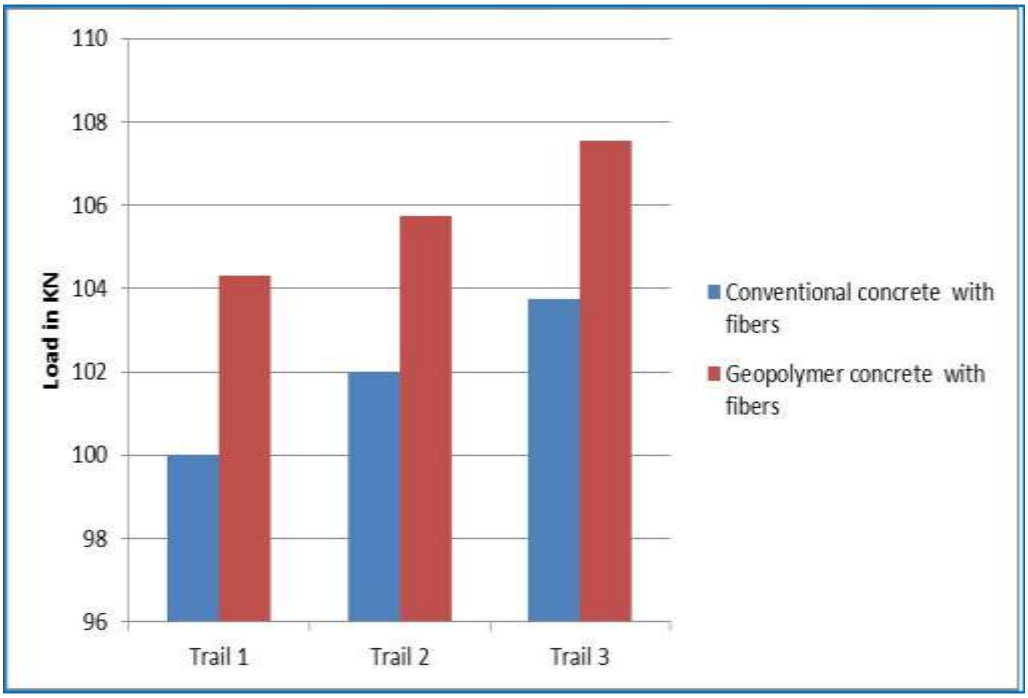


Figure 5.9: Test results of Ultimate load with fibers

5.4.2.2 Determination of energy absorption.

The energy absorption capacity of RCC beams was found out from the measurement, load-deflection curves were drawn and the sum of the area under the cure up to the ultimate load gave the total energy absorption capacity of concrete.

Energy absorption capacity = Sum of the area below the load-deflection curve up to the ultimate load point

A=46.25+212.2+370 =629.33 KN mm

5.4.2.3 Determination of Toughness Indices

As per ASTM C1018 the toughness indices were calculated respectively as ratios of the area of the load-deflection curve up to deflections of 3 and 5.5 times the first crack deflection divide by the area of the load-deflection curve up to first crack deflection (first crack toughness).These indices give information on the approximate shape of the post cracking load deflection response. They have minimum value of unity for elastic-brittle behavior and values of 5 and 10 respectively for ideal elastic-plastic behavior.

5.4.2.5 Determination of Initial Stiffness

The first tangent was drawn for the load-deflection curves and the slope of the tangent gave the initial stiffness of concrete member.

Initial stiffness = Slope of first tangent of load-Deflection curve.

= 20/ 0.25 =80 KN mm

Table : 5.9 load deflection test parameters calculations

Description	Energy absorption KN mm	Tough ness indices Nmm	Ductility factor	Initial stiffness KN mm
Conventional concrete(without fibers)	629.33	680000	4.636	80
GPC(without fibers)	632.48	710000	6.283	89
%Increases	0.50	4.41	35.64	11.25
Conventional concrete(with fibers)	653.62	725000	6.82	91
GPC(with fibers)	728.63	743000	7.912	89
%Increases	11.47	2.48	15.94	-2.19

VI. CONCLUSION

- Compressive strength of the Geopolymer concrete without fibers has increased by 10.63%, then Conventional concrete.
- Split tensile strength of the Geopolymer concrete without fibers have increased by 11.58%, then Conventional concrete.
- Compressive strength of the Geopolymer concrete with fibers has increased by 10.70%, then Conventional concrete.
- Split tensile strength of Geopolymer concrete with fibers has increased by 13.62%, then Conventional concrete.
- Geopolymer concrete produces a substance that is comparable to or better than traditional cements with their properties.
- Low-calcium fly ash-based geopolymer concrete has excellent compressive strength and is suitable for Structural applications.
- As per load deflection test, strain energy absorbed, ductility factor and, toughness index, are considerably increases in GPC with addition of polypropylene fibers.
- Due to geopolymer concrete the consumption of cement, emission of carbon di -oxide and greenhouse effect are reduced.

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