MECHANICAL PROPERTIES OF FLY ASH BASED GEO POLYMER CONCRETE

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ABSTRACT

The major problem that the world facing today is global warming. The cement industry is one of the major reasons for emission of greenhouse gases, such as CO_2 which causes global warming. A lot of energy and natural resources are consumed in production of Ordinary Portland Cement (OPC). Geopolymer Concrete (GPC) is one of the processes that reduces cement usage and increases the usage of industrial byproducts in concrete. In the present study, OPC is fully replaced by pozzolanic materials (Fly Ash) and alkaline liquids such as Sodium hydroxide (NaOH) and Sodium silicate (Na2SiO3) to produce the Geopolymer concrete.

This chapter describes the Mechanical Properties (Compressive strength, Split tensile strength and flexural strength) of GPC at ambient room temperature curing. The above all strengths are also based on different molarities like 4M, 6M, 8M & 10M.

KEYWORDS: Fly Ash, Sodium hydroxide, Sodium silicate, Compressive strength, Split tensile strength and flexural strength.

1. INTRODUCTION

Now a day‘s usage of concrete occupies second place round the world nevertheless the water. Ordinary Portland concrete primarily consists of cement, aggregates (coarse & fine) and water. In this, cement is employed as a primary binder to provide the normal Portland concrete. Around it's calculable that the consumption of cement is quite 2.2 billion tons each year [1].Due to increasing of developments in infrastructure, the usage of typical concrete are going to be additional and furthermore because the demand of cement would be will increase within the future

On the opposite hand, the usage of cement could produce some environmental problems equivalent to heating, inexperienced house impact etc. As a result of these issues could generate because of increasing of CO_2 present with in the surroundings, from the past results nearly one tone of cement releases equal amount of CO_2[2]. So as to avoid these environmental problems related to cement, there's have to be compelled to use some alternatives equivalent to fly ash, rise husk fly ash etc. Area unit because the binders to create the eco-friendly concrete. During this respect, Davidovits [1988] planned another binder for the concrete technology and it shows an honest results. These binders area unit created by associate degree base-forming liquid reacts with the oxide (Si) and Aluminium (Al) present within the source. The technology planned by the Davidovits is often referred to as Geo-polymers or Geo-polymer technology.

1.1 Geo-polymers

In general the source and alkaline liquids area unit treated as major materials within the Geo-polymers. By mixing the two solutions, named caustic soda (NaOH) associate degreed soluble glass (Na_2SO_3) we will prepare an alkaline liquid that is employed in geo-polymers. The reaction takes place by caustic soda and soluble glass solutions is treated because the geo-polymerization method for our convenience. And conjointly we've got to think about that oxide (Si) and Aluminium (Al) area unit key components in geo-polymers. The proportion of Aluminium and silicon area unit to be taken into consideration within the materials that area unit used. The source like fly ash, oxide fume, slag, rice husk-fly ash etc. Area unit to be used. The supply materials choice is additionally economical.

1.2 Advantages of Geo polymers

Geo polymer concrete is additional immune to corrosion and hearth, has compressive and tensile strengths, gains its full strength quickly (cures totally faster), low creep, no shrinkage, sensible acid resistance, low porousness, immune to sulphate attack and sturdy finishes.

2. LITERATURE REVIEW

This chapter presents the Historical review of the geo chemical compound concrete, language and Chemistry of the geo polymers. The study of literature survey adore the geo chemical compound concrete technology has exhausted this chapter.

2.1 Historical Review

The phenomenal sturdiness of ancient concretes and mortars compared to those being employed in trendy time prompted analysis into the character of those ancient compounds. Results from varied studies, summarized by Davidovits, [6] verified that there's of course an awfully distinct distinction between ancient mortars and also the cement based mostly building materials in use these days.

The ancient merchandise appear to be not solely physically additional sturdy, however conjointly additional immune to acid attack and freeze-thaw-cycles. Initially it was thought that this distinction is that the consequence of atomic number 20 salt hydrates (of the C-S-H-gel type) that represent the most a part of cement. Later, however, it absolutely was discovered that these ancient concretes conjointly contain amounts of C-S-H gel and consequently researchers turned their attention to the big amounts of zeolitic phases conjointly found within the ancient merchandise [6]. It absolutely was later terminated that the future sturdiness of ancient mortars is that the results of high levels of zeolitic and amorphous compounds in their integrative make-up.

The use of pozzolanic materials within the manufacture of concrete features a long, victorious history. In fact, their use pre-dates the invention of contemporary day cement by nearly two hundred years. Today, most concrete producers worldwide acknowledge the worth of pozzolanic enhancements to their merchandise and, wherever they are available; they're turning into a basic concrete ingredient. Mineral admixtures akin to fly ash and oxide fume area unit usually employed in concrete as a result of they improve sturdiness cut back consistence and improve the interface with the mixture.

2.2 Terminology and Chemistry

Davidovits, [7-9] created and applied the term Geo polymer. For the chemical designation of geo polymers supported silicon-aluminates, "Poly (sialate)" was prompt. Sialate is associate abbreviation for silicon-oxo-aluminate.

Polysialates area unit chain and ring polymers with Si4+ and Al3+ in IV-fold coordination with, gas and vary from amorphous to semi-crystalline. Additionally positive ions comparable to Na^{2+}, Ca^{2+}, K^{2+} and alternative aluminiferous cat ions should be present in framework cavities to balance the charge of Al^{3+}.

2.3 Literature Survey on Geo polymer Concrete

Rangan (2008) has reportable on the fly ash-based Geo polymer concrete. He study the results of salient factors that influence the short and future properties of the Geo polymer concrete within the recent and hardened states. He describes the applications and economic deserves of Geo polymer concrete within the industry. He finally finished that the low-calcium fly ash-based Geo polymer concrete has wonderful compressive strength and is appropriate for structural applications. The salient factors that influence the short and future properties of the recent concrete and hardened concrete area unit known.

Lloyd and Rangan (2010) have reportable on the Geo polymer concrete with fly ash. They in depth studies conducted on the mechanical properties of fly ash-based Geo polymer concrete. He determined the silent options that result the properties of the Geo polymer concrete with fly ash. The report describes the transient details of fly ash-based Geo polymer concrete associated an easy methodology to style Geo polymer concrete mixtures has been represented and illustrated by an example.

Sumajouw and Rangan (2006) have reportable on the low-calcium fly ash-based Geo polymer concrete: reinforced beams and columns. This analysis Report describes the behaviour and strength of bolstered low-calcium fly ash-based Geo polymer concrete structural beams and columns, the event, the mixture proportions, the short properties, and therefore the semi-permanent properties of low-calcium fly ash-based Geo polymer concrete. Heat-cured low-calcium fly ash-based Geo polymer concrete has wonderful compressive strength, suffers little or no drying shrinkage and low creep, wonderful resistance to sulphate attack, and sensible acid resistance.

Vijaya Rangan (2008) has applied a study to research the factors that influence the recent and hardened fly ash based mostly Geo polymer concrete and additionally studied the long and short term properties of Geo polymer concrete. During this present investigation the mixture of aggregates (coarse and fine) and low calcium fly as his employed. An alkaline activator of sodium hydroxide and sodium silicate is used as a binder solution. Furthermore, the alkaline/fly ash quantitative relation and therefore the metallic element silicate/sodium hydroxide quantitative relation (by mass) for the binder were 0.3-0.45 and 2.5 respectively. The specimens were cured on each dry and stream temperature and therefore the results area unit studied. it's determined that the compressive check results were high just in case of dry hardening condition as compare to the stream hardening.

Cheng and Chiu (2003) reportable the investigation of constructing incombustible Geo polymer mistreatment slag combined with metakaolinite. The mixture of pot fly ash (KOH) and glass (Na_2So_3) was used alkaline liquids.

Supraja and Kanta Rao (2011) have investigated the Geo polymer concrete is absolutely replaced with alkaline liquids area unit used for the binding of materials. Totally different molarities of the hydroxide solution i.e. 3M, 5M, 7M and 9M area unit taken to arrange totally different mixes and studied the mechanical properties of Geo polymer concrete. Two totally different hardening area unit carried i.e. kitchen appliance hardening at 500-degree centigrade and hardening directly by inserting the specimens to direct daylight. He determined that the compressive strength is accrued with the rise within the molarities of hydroxide. The kitchen appliance cured specimens gave best results as compared to specimens cured by direct daylight, kitchen appliance cured specimens provides the upper compressive strength. He counselled that daylight hardening is convenient for sensible conditions.

Sekhar et al. (2014) have studied the Strength Studies on fly ash mixed Geo polymer concrete. During this present investigation, the result of fly ash (class F) on the mechanical properties of Geo polymer concrete (GPC) at totally different replacement levels area unit to be found. Glass (Na_2SiO_3) associated hydroxide (NaOH) solution has been used as an alkaline matter. Within the present investigation, it's planned to review the mechanical properties viz. compressive strength once 7, 14 and 28 days and split durability once 28 days of close temperature hardening.

Pavan (2012) reportable that the result of fly ash (class F) on the mechanical properties of Geo polymer concrete at totally different replacement levels area unit to be found. Glass (Na_2SiO_3) associated hydroxide (NaOH) solution has been used as an alkaline matter. Within the present investigation, it's planned to review the mechanical properties viz. compressive strength once 7, 14 and 28 days and split durability once 28 days of close temperature hardening. From the results, it's finished that the accrued level of fly ash accrued the compressive strength of GPC in the least hardening periods and split durability once twenty eight days of hardening. Results discovered that fly ash mixed GPC mixes have earned increased mechanical properties in the least hardening periods. Additionally during this study, the mechanical properties of GPC (FA100) were compared to M25 grade of standard concrete (CC).

Sudarsan (2013) has reportable on performance of fourteen M based mostly geo polymer mortar with fly ash. He studied the flow on totally different binder composition, compressive strength of geo polymer mortar at totally different ages like 1, 3, 7 days and additionally study the microstructure properties of geo polymer mortar. From the results, it's finished that the compressive strength is accrued with increase in fly ash content and it shows most compressive strength F/B =0.5 and so decreases. From SEM pictures it's finished that microstructure is densified with age. This densified microstructure is chargeable for higher strength of the mortar.

3. MATERIALS AND METHODOLOGY

3.1 General

This Chapter presents the small print of development of the method of constructing low metal (ASTM class F) fly ash primarily based Geo polymer concrete and during this investigation traditional fine aggregate has been taken. First, the materials, mix proportions, manufacturing and curing of the test specimens are explained.

The physical and chemical properties of fly ash, aggregate and water utilized in the investigation were analysed supported commonplace experimental procedures arranged down in IS, ASTM and BS codes. The experiments conducted on coarse aggregate square measure relative density and water absorption, Bulk density & Sieve analysis by victimization individual codes. The experiments conducted on fine aggregates square measure relative density, wet content, sieve analysis and bulking of fine aggregate victimization volume technique. The tests conducted on Geo polymer concrete square measure Compressive strength, Split strength, Flexural strength square measure as per the individual IS, BS and ASTM codes.

3.2 Materials

3.2.1 Fly ash

According to ASTM C 618 (2003) the fly ash are often divided into 2 sorts supported quantity of metal present within the fly ash. The classified Fly ashes square measure class F (low-calcium) and sophistication C (high-calcium). Within the present investigation class F fly ash made from Rayalaseema Thermal station (RTPP), Muddanur, and A.P was used. The chemical and physical properties square measure conferred within the Table 3.1.

Table 3.1. Chemical and Physical Properties of Class F Fly Ash

Particulars	**Class “F” fly ash**	**ASTM C 618 Class “F” fly ash**
Chemical composition		
% Silica(SiO_2)	65.6	
% Alumina(Al_2O_3)	28.0	
% Iron Oxide(Fe_2O_3)	3.0	SiO_2+ Al_2O_3+ Fe_2O_3>70
% Lime(CaO)	1.0	
% Magnesia(MgO)	1.0	
% Titanium Oxide (TiO_2)	0.5	
% Sulphur Trioxide (SO_3)	0.2	Max. 5.0
Loss on Ignition	0.29	Max. 6.0
Physical properties		
Specific gravity	2.24	
Fineness (m^2/Kg)	360	Min.225 m^2/kg

3.2.2 Coarse aggregate

Coarse aggregate of size 20 mm and 10 mm are to be used. The bulk specific gravity in oven dry condition and water absorption of the coarse aggregate 20 mm and 10mm as per IS code were 2.58 and 0.3% respectively.

3.2.3 Fine aggregate

The slag used throughout the experimental work was obtained from the Lanko industries near Srikalahasthi in Chittoor district. The bulk specific gravity in oven dry condition and water absorption of the slag as per IS code were 2.62 and 1% respectively.

3.2.4 Alkaline Liquid

The alkaline liquid used was a mixture of water glass solution and hydroxide solution. The water glass solution (Na_2O= 13.7%, SiO_2=29.4%, and water=55.9% by mass) was purchased from an area provider. The hydroxide (NaOH) in flakes or pellets from with 97%-98% purity was conjointly purchased from an area provider. The hydroxide (NaOH) solution was ready by dissolving either the flakes or the pellets in needed amount of water. The mass of NaOH solids in an exceedingly solution varied betting on the concentration of the solution expressed in terms of concentration, M. Let's say, NaOH solution with a amount of 8M consisted of 8x40 = 320 grams of NaOH solids (in flake or pellet form) per metric capacity unit of the solution, where, 40 is that the relative molecular mass of hydroxide (NaOH) pellets or flakes.

3.3 Mixture Proportions

Based on the restricted past analysis on GPC (Hardjito & Rangan, 2005), the subsequent proportions were selected for the constituents of the mixtures

- The combined mass of coarse and fine aggregates square measure taken as 77% of the mass of concrete.
- Alkaline liquid as given in Section 3.2.5.
- Ratio of matter solution-to-fly ash and slag, by mass, within the range of0.3 and 0.4. This magnitude relation was fastened at 0.35.
- Class F fly ash (FA100)
- Ratio of water glass solution-to-sodium hydroxide solution, by mass, of 0.4 to 2.5. For the foremost of the cases the magnitude relation was fixed at 2.5, as a result of the water glass solution is significantly cheaper than the hydroxide solution.
- Concentration of hydroxide (NaOH) solution was unbroken at 4M, 6M, 8M &10M
- Calculate water-to-geo polymer solids.
- Extra water, when added, in mass.

The following state of affairs describes the GPC combine style of this study:

Assume that normal-density aggregates in SSD (Saturated surface Dry) condition square measure to be used and also the unit-weight of concrete is 2400 kg/m^3. During this study, take the mass of combined aggregates as 77% of the overall mass of concrete, i.e. 0.77x2400=1848 kg/m^3. The coarse and fine aggregates is also elite to match the quality grading curves utilized in the look of Portland cement concrete mixtures.

For instance, the coarse aggregates (70%) might comprise 776 kg/m^3 (60%) of 20mm aggregates, 518 kg/m^3 (40%) of 10 mm aggregates, and 554 kg/m3 (30%) of fine aggregate to fulfil the necessities of ordinary grading curves. The adjusted values of coarse and fine aggregates square measure 774 kg/m3 of 20 mm aggregates, 516 kg/m3 of 10 mm aggregates and 549 kg/m^3 (30%) of fine aggregate, when considering the water absorption values of coarse and fine aggregates.

The mass of geo polymer binders (fly ash) and the alkaline liquid = 2400 – 1848 = 552 kg/m^3. Take the alkaline liquid-to-fly ash ratio by mass as 0.35; the mass of fly ash = 552/ (1+0.35) = 409 kg/m^3 and the mass of alkaline liquid = 552 – 409 = 143 kg/m^3. Take the ratio of sodium silicate (Na2SiO3) solution-to-sodium hydroxide (NaOH) solution by mass as 2.5; the mass of sodium hydroxide (NaOH) solution = 144/ (1+2.5) = 41 kg/m^3; the mass of sodium silicate solution = 143 – 41 =102 kg/m^3.

The sodium hydroxide solid (NaOH) is mixed with water to make a solution with a concentration of 4M, 6M, 8M &10M. This solution comprises 40% of NaOH solids and 60% water, by mass.

For the trial mixture, water-to-geo polymer solids ratio by mass is calculated as follows:

In sodium silicate solution, Water = 0.559x102 = 57 kg, and solids = 102 – 57 = 45 kg.

In sodium hydroxide solution, solids = 0.40x41 = 16 kg, and water = 41 – 16 = 25 kg.

Therefore, total mass of water = 57+25 = 82 kg, and the mass of geo polymer solids = 409 (i.e. mass of fly ash) + 45 + 16 = 470 kg.

Hence, the water-to-geo polymer solids ratio by mass = 82/470 = 0.17.

3.3 Methodology

3.3.1 General

In the course of investigation, traditional fine mixture for the study of varied properties, completely different specimens are solid and tested. The physical and chemical properties of fly ash, scoria and water utilized in the investigation were analysed supported customary experimental procedures arranged down in IS ASTM and BS codes. The tests conducted on Geo chemical compound concrete area unit Compressive strength, Split enduringness, and Flexural strength as per the various IS, BS and ASTM codes.

3.3.2 Compressive Strength test

Compression check is one in all the foremost common check conducted on hardened concrete, part as a result of its most vital and it's straightforward to perform additional most of the fascinating characteristic properties of concrete area unit qualitatively concerning its strength.

The compression check is dispensed on specimens like cuboidal or cylindrical in form generally prisms are used. The tip components of beam area unit left intact when failure in flexure and since of the square cross section of the beam this a part of the beam may well be well accustomed determine the compressive strength. The compressive strength of concrete is that the most vital and helpful property of Concrete. The compression check was dispensed mistreatment 2000 KN compression testing machine.

Figure 3.1. Testing of cubes for compressive strength

The compressive strength of the GPC was conducted on the cubical specimens for all the mixes after 7, 28 and 90 days of curing as per code. 9 No's of 150 mm cube specimen were made for each mix and 3 samples in each were cast and tested for 7 days, 28 days and 90 days respectively. The average value of these 3 specimens was taken for study. The compressive strength (f'_c) of the specimen was calculated by dividing the maximum load applied to the specimen by the cross-sectional area of the specimen as given below.

$$f'_c = P / A$$

Where, f'c= Compressive strength of the concrete (in N/mm^2)

P = Maximum load applied to the specimen (in Newton)

A = Cross-sectional area of the specimen (in mm^2)

3.3.3 Split Tensile Strength test

Splitting Tensile Strength (STS) test was conducted on the specimens for all the mixes after 28 days of curing as per code. Three cylindrical specimens of size 150 mm x 300 mm were cast and tested for each age and each mix. The load was applied gradually till the failure of the specimen occurs. The maximum load applied was then noted. Length and cross-section of the specimen was measured. The splitting tensile strength (f_{ct}) was calculated as follows:

$$f_{ct} = 2P / (\Pi\, l\, d)$$

Where, f_{ct} = Splitting tensile strength of concrete (in N/mm^2)

P = Maximum load applied to the specimen (in Newton)

l = Length of the specimen (in mm)

d = cross-sectional diameter of the specimen (in mm)

Figure 3.2. Testing of cylinders for Split tensile strength

3.3.4 Flexure Strength test

Flexural strength test was conducted on the specimens for all the mixes at different curing periods as per code. Three concrete beam specimens of size 100 mm x 100 mm x 500 mm were cast and tested for each age and each mix. The load was applied gradually till the failure of the specimen occurs. The maximum load applied was then noted. The distance between the line of fracture and the near support 'a' was measured. The flexural strength (f_{cr}) was calculated as follows:

When '*a*' is greater than 13.3 cm for 10 cm specimen, f_{cr} is

$$f_{cr} = (P \text{ x } l) / (\text{b x } d^2)$$

When '*a*' is less than 13.3 cm but greater than 11.0 cm for 10 cm specimen, f_{cr} is

$$f_{cr} = (3 \text{ x } P \text{ x } a) / (\text{b x } d^2)$$

Where, fcr = Flexural strength of concrete (in N/mm^2)

P = Maximum load applied to the specimen (in Newton)

b = measured width of the specimen (in mm)

d = measured depth of the specimen at the point of failure (in mm)

l = Length of the specimen on which the specimen was supported (in mm)

Figure 3.3. Testing of prisms for Flexural strength

4. RESULTS AND DISCUSSION

4.1 Introduction

This chapter describes the Compressive strength, Split tensile strength and flexural strength of GPC at ambient room temperature curing. The compressive strength values of GPC mixes were measured after 7, 14, 28, 56 and 112 days of curing. The split tensile strength values of GPC mixes were measured after 28, 56 and 112 days of curing. The flexural strength values of GPC mixes were measured at 28, 56 and 112 days of curing. The above all strengths are also based on different molarities like 4M, 6M, 8M and 10M.

4.2 Compressive Strength

Table 4.1. Compressive strength of GPC

Age (days)	Mix type				
	M25	**4M**	**6M**	**8M**	**10M**
7	10.8	9.9	21	28.5	38.5
14	22.5	15.1	26.8	37.2	44.8
28	30.6	18.7	32.5	43.4	51.3
56	36.1	28.2	36.2	49.2	57.2
112	38.9	25.3	39.4	52.7	59.5

The compressive strength of GPC mixes with fly ash (FA100) at different molarities like 4M, 6M, 8M and 10M as shown in the above table. In the table we also noticed that the average strengths test specimens are calculated for 7days, 14days, 28days, 56days and also 112days. From the table we also noticed that the strengths are going to increase whenever the molarities are increased. So, Molarity of solution gives further strength to the sample after curing.

It was observed that there was a significant increase in compressive strength in the percent Fly ash 100% in all curing periods as shown in Figure 4.1. The GPC with 100% fly ash sample exhibited compressive strength values of 9.9 MPa, 21 MPa, 28.5 MPa and 38.5MPa in 4M, 6M, 8M and 10M condition for 7days. Usually 15.1 MPa, 26.8 MPa,37.2MPa, 44.8MPa in 4M, 6M, 8M and 10M conditions after 14days Similarly 18.7MPa, 32.5MPa, 43.4 MPa and 51.3 MPa strengths are attained in 4M, 6M, 8M and 10M after 28days. Similarly, for

56days the strengths are as follows 28.2 MPa, 36.2MPa, 49.2 MPa and 57.2MPa in 4M, 6M, 8M and 10M situations and similarly 25.3MPa, 39.4 MPa, 52.7 MPa and 59.5 MPa strengths are gained in 4M, 6M, 8M and 10M conditions after 112 days of curing respectively at ambient room temperature.

4.3 Split Tensile Strength

Table 4.2 shows the split tensile strength of GPC mixes with fly ash (FA100) at different molarities like 4M, 6M, 8M and 10M at different curing periods. The tensile strengths are increased slightly based on the increasing level of molarities. The simple thing that we have to observe here is we no need to consider 7days, 14days.

Table 4.2. Split tensile strength of GPC

Age (days)	M25	Mix type			
		4M	6M	8M	10M
28	3.72	2.31	3.88	4.86	5.49
56	3.94	2.42	4.02	5.23	5.98
112	4.32	2.64	4.38	5.7	6.48

It was observed that there was a significant increase in splitting tensile strength with the percentage of 100% Fly ash in all curing periods as shown in Figure 4.2. The GPC with 100% Fly ash sample exhibited splitting tensile strength values of 2.31 MPa, 3.88 MPa, 4.86 MPa and 5.49MPa after 28days. And 2.42MPa, 4.02MPa, 5.23 MPa and 5.98 MPa strengths after 56days and 2.64MPa, 4.38MPa, 5.7MPa &6.48MPa strengths after 112 days of curing respectively at 4M, 6M,8M and 10M conditions at ambient room temperature.

4.4 Flexural strength

Table 4.3 shows the flexural strength of GPC mixes with fly ash (FA100) at different curing periods.

Table 4.3. Flexural strength of GPC

Age (days)	M25	Mix type			
		4M	6M	8M	10M
28	5.72	4.52	5.92	7.46	8.82
56	6.34	4.58	6.45	7.94	9.62
112	6.94	4.72	6.94	8.4	9.94

It was observed that there was a significant increase in flexural strength with the Fly ash as 100% in all curing periods as shown in Figure 4.2.The GPC with 100% fly ash sample exhibited splitting tensile strength values of 4.52MPa, 5.92MPa, 7.46MPa and 8.82MPa after 28days. The strengths like 4.58MPa, 6.45MPa, 7.94MPa and 9.62MPa after 56days. Similarly the strengths 4.72MPa, 6.94MPa, 8.4MPa and 9.94MPa are after 112days of curing respectively at 4M, 6M, 8M and 10M condition at ambient room temperature

From the results it is revealed that FA blended GPC mixes attained enhanced mechanical properties at ambient room temperature curing itself without the need of heat curing as in the case of only FA based GPC mixes Siddique (2007).

5. CONCLUSIONS AND SCOPE OF FUTURE WORK

5.1 Conclusions

The primary aim of this analysis was to develop GPC with the fine aggregate and study the mechanical properties of GPC mixes at close temperature. Supported the investigation, the subsequent conclusions are drawn.

1. There was a big increase in compressive strength whereas increasing in concentration.
2. The grade of M 25 is reminiscent of 6M.
3. Split tensile strength and flexure strength also increased while increasing in molarity.
4. From 8M strength properties area unit drastically decreases by using 4M and 6M.
5. Eco-friendly edges area unit there whereas mistreatment fly ash and slag materials.

5.2 Scope of future work

The following suggestions are recommended for future study-

1. Further analysis is suggested to review the bond strength between concrete and steel reinforcement.
2. Further analysis is suggested to review the opposite sturdiness properties viz. water absorption, chloride penetration of GPC mixes.
3. Keeping visible of the supply of natural resources and environmental aspects, it's

suggested to switch some share of scoria with in FA based GPC mixes and study all GPC hardened and sturdiness properties.

4. Development of cost effective FA and primarily based GPC mixes.

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