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EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE BY USING GLASS FIBRES

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ABSTRACT

Global release of CO2 from all sources is estimated as 23 billion tons per year and the Portland cement production accounts for about 7% of total CO2 emissions. So finding any other alternative for cement was needed to reduce pollution done during production of cement. Geopolymer concrete is the best innovation which able to replace the use of cement in concrete. Geopolymer is a type of formless alumino-silicate product that shows the ideal properties of rock-forming element i.e. hardness, chemical stability and strength etc. properties of geopolymer includes high early strength, low shrinkage, sulphate resistance etc. Geopolymer concrete is the composite material of fly ash and alkaline liquid like sodium silicate & sodium hydroxide. Fly ash is by product of coal obtained from thermal power plant is plenty available worldwide. Fly ash is rich in silica and alumina reacted with alkaline solution produced aluminosilicate gel that acted as the binding material for the concrete. The curing method for geopolymer concrete is heat curing which help to achieve strength to the concrete. It was observed that geopolymeric cement generates 5-6 times less CO2 than the Portland cement. Therefore the use of geopolymer concrete not only significantly reduces the CO2 emission as compared to cement industries, but also utilizes the industrial wastes or by-products used in composition. The polymerization process happens in the geopolymer concrete caused to gain strength for that providing heat is major issue.

I INTRODUCTION

Geopolymer concrete is the best innovation which able to replace the use of cement in concrete. Geopolymer is a type of formless alumino-silicate product that shows the ideal properties of rock-forming element i.e. hardness, chemical stability and strength etc. properties of geopolymer includes high early strength, low shrinkage, sulphate resistance etc. Geopolymer concrete is the composite material of fly ash and alkaline liquid like sodium silicate & sodium hydroxide. Fly ash is by product of coal obtained from thermal power plant is plenty available worldwide. Fly ash is rich in silica and alumina reacted with alkaline solution produced aluminosilicate gel that acted as the binding material for the concrete. The curing method for geopolymer concrete is heat curing which help to achieve strength to the concrete. It was observed that geopolymeric cement generates 5-6 times less CO2 than the Portland cement. Therefore the use of geopolymer concrete not only significantly reduces the CO2 emission as compared to cement industries, but also utilizes the industrial wastes or by-products used in composition. The polymerization process happens in the geopolymer concrete caused to gain strength for that providing heat is major issue. Giving oven curing or heat curing is one of the important part of geopolymer concrete that limitation can neglect by adding lime or cement in partial replacement of fly ash. The heat produced by lime and cement help to gain strength to

geopolymer concrete but effect of these material in geopolymer concrete is slightly different in present study both material replaced by fly ash to study the effect of each. Also the concept of adding fibres as reinforced in concrete is not new for enhance the strength of concrete. From the 1960's steel, glass and synthetic fibre were used in concrete and research into new fibre reinforced concrete continues today. Concerning with structural applications fibre concrete possesses many advantages compared to the traditional structural concrete such as increase in compressive, flexural and spilt tensile strength also durability and other properties positively affect. Geopolymer is a type of concrete with amorphous, alumino-silicate product that exhibits the ideal properties of rock forming properties i.e. hardness, chemical stability and longevity. The properties of geopolymer concrete include high early strength, low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance. However, geopolymer concrete does not utilize any Portland cement in it and the binder is produced by the reaction of an alkaline liquid with a source of material which is rich in silica and alumina. Geopolymer concrete is an innovative and eco-friendly construction material and an alternative to Portland cement concrete. Use of geopolymer reduces the demand of Portland cement which is responsible for high CO_2 emission. Geopolymer was the name given by Daidovits in 1978 to materials which are characterized by chains or networks or inorganic molecules. Geopolymer cement concrete is made from utilization of waste materials such as fly ash . Fly ash is the waste product generated from thermal power plant. Fly ash are processed by appropriate technology and used for concrete works in the form of geopolymer concrete. The use of this concrete helps to reduce the stock of wastes and also reduces carbon emission by reducing Portland cement demand.

Glass fibres are available in continuous or chopped lengths. Glass fibres have large tensile strength and elastic modulus but have brittle stressstrain characteristics and low creep at room temperature. Glass fibres are usually are usually round and straight with diameters from 0.005 mm to 0.015 mm. They can be also bonded together to produce the bundle of glass fibres with diameter up to 1.3 mm. The production of one ton of cement emits approximately one ton of carbon dioxide to the atmosphere which leads to global warming conditions. A need of present status is, should we build additional cement manufacturing plants or find alternative binder systems to make concrete? On the other scenario huge quantity of fly ash are generated around the globe from thermal power plants and generally used as a filler material in low level areas. Alternative binder system with fly ash to produce concrete eliminating cement is called "Geopolymer concrete"

Fig 1. Geopolymer concrete building

The present study deals with the manufacture and the mechanical properties of low-calcium fly ash and glass fibre based Geopolymer concrete (GPC). The aims of the study wereTo understand the manufacturing process of Fly-ash and glass fibre based Geopolymer concrete. To ascertain it's suitability as an alternative to conventional cement concrete.To calculate the compressive and tensile strength of concrete. To produce Eco-friendly concrete with high strength

II RESULTS AND DISCUSSIONS

Concrete mixture design process is vast and generally based on performance criteria. The aggregates and the fly ash are mixed dry in a pan mixer for about 4 minutes. At the end of this dry mixing, the activator solution (prepared one day prior to casting), the super plasticiser, and the extra water (if any) are mixed together, and then added to the solid particles and the mixing continued for another 3 to 5 minutes. The fresh concrete is expected to have a stiff consistency and was glossy in appearance. The fresh concrete mixture was then cast in moulds in three layers and vibrated for 10 seconds on a vibrating table. The previous studies on Geopolymer concrete revealed that geopolymer concrete did not attain any strength at room temperature or by water curing. The Geopolymer concrete will harden at steam curing or hot air curing and the minimum curing period shall be 24 hours. After casting the specimens, they were kept in rest period in room temperature for 2 days. The term 'Rest Period' was coined to indicate the time taken from the completion of casting of test specimen to the start of curing at an elevated temperature. The geopolymer concrete was demoulded and then placed in an autoclave for steam curing for 24 hours at a temperature of 60o C. The cubes were then allowed to cool in room temperature for 24 hours The prepared solution of sodium hydroxide of 12M concentration was mixed with sodium silicate solution one day before mixing of concrete to get the desired alkalinity in the alkaline activator solution. Initially coarse aggregate, fine aggregate, cement, fly ash, and GGBS were dry mixed for three minutes in the mixer. Now add the calculated amount of glass fibres into the concrete mixer after separating the fibres into pieces. After dry mixing, alkaline activator solution was added to the dry mix and wet mix was done for 4 minutes. Finally, extra water along with super plasticizer was added. The mixing of total mass was continued until the binding paste covered all the aggregates and mixture become homogeneous and uniform in color. Each specimen was cast in three layers by compacting manually as well as by using vibrating table. Each layer received 25 strokes of compaction by standard compaction rod for concrete, followed by further compaction on the vibrating table. The specimens were removed from the mould immediately after 24 hours since they set in a similar fashion as of conventional concrete. All the specimens were left at room temperature in ambient curing till the date of testing. The ideal concrete is the one which is workable in all conditions i.e, can prepared easily placed, compacted and moulded. In this chapter, the workability is assessed by two methods as follows:

III SLUMP CONE TEST

The test was conducted for fresh concrete prepared before the moulding process. concrete mixes are prepared at different times. Workability Results obtained from slump cone test for M40 grade of concrete is shown in below given table .

Table 1 : workability of the given specimen

S NO	Specimen	Slump Values
1	0% Glass Fibre	43 mm
2	1% Glass Fibre	41 mm
3	2% Glass Fibre	38 mm
4	3% Glass Fibre	34 mm
5	4% Glass fibre	32 mm

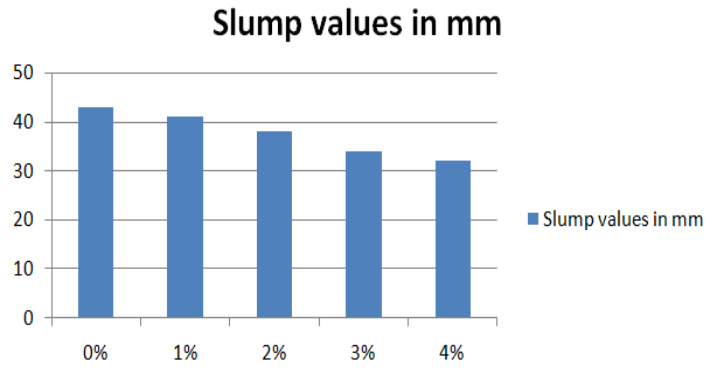

Fig 2 : slump values in mm

Test Results of Compressive Strength for M40 Grade Concrete The casted cubes were tested for their compressive strengths at 7days, 14days, 28days respectively and the results are tabulated as follows. Geopolymer concrete is designated as GPC The tests was done as per IS 516-1959. The cubes of standard size of 150×150×150mm were used to find compressive strength. Cubes were placed on the surface of UTM, and apply a uniform rate of loading till the failure of cube. The maximum load was noted and

Table 2: Compressive strength of Geopolymer concrete by using Glass fibres

S NO	Sample	% of Glass fibre	Compressive strength in N/mm2	Compressive strength in N/mm2	Compressive strength in N/mm2
			7 Days	14 Days	28 Days
1	S1	0	13.14	22.29	39.16
2	S2	1	13.21	24.14	39.55
3	S3	2	13.66	25.28	40.15
4	S4	4	14.02	26.45	41.17
5	S5	5	13.40	26.11	4.83

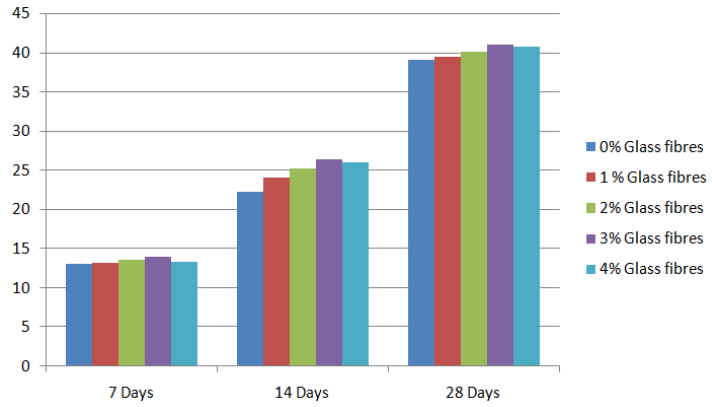

Fig 3: Compressive strength of Geopolymer concrete by using Glass fibres

Result: It is seen from the Graph that the goepolymer concrete with glass fibre given Maximum Compressive strength at 4 % of glass fibre which is 41.17 N/M2

IV SPLIT TENSILE STRENGTH

The split tensile test used to determine tensile strength of concrete. The split tensile test conducted on cylinders of 150mm dia.x300mm height. Split tensile strength of cylinder specimens is determined by placing between the two plates of Compression Testing Machine. This test was done as per IS 5816-1970. The cylinder of standard size of 150mm dia and 300 mm height was placed on the UTM with the horizontal diameter. At the bottom and at the top two strips of wood were placed to avoid concrete crushing at the points where bearing surface of CTM and cylinder specimen meets. The maximum load was noted down.

Table 3 : Split tensile strength of Geopolymer concrete by using Glass fibres

S NO	Sample	% of Glass fibres	Split tensile strength in N/mm2	Split tensile strength in N/mm2	Split tensile strength in N/mm2
			7 Days	14 Days	28 Days
1	S1	0	3.21	3.89	4.87
2	S2	1	3.30	4.67	5.08
3	S3	2	3.69	4.89	5.76
4	S4	3	3.98	5.55	6.12
5	S5	4	3.83	4.93	5.90

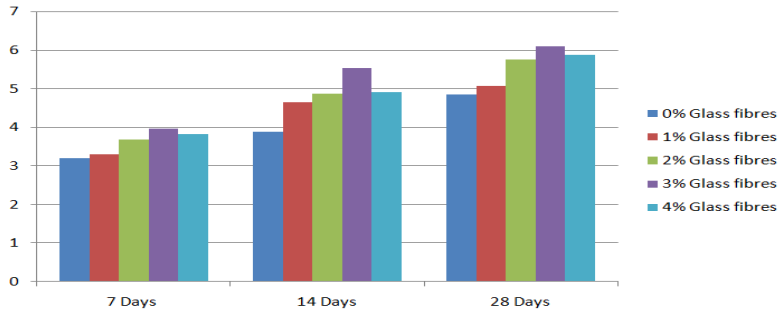

Fig 4 : Split tensile strength of Geopolymer concrete by using Glass fibres

Result: It is seen from the Graph that the goepolymer concrete with glass fibre given Maximum tensile strength at 4% of glass fibre which is 6.12 N/mm2

V FLEXURAL STRENGTH

The flexural test on glass fibre geopolymer concrete is taken on the standard beam specimen of size 100x100x500 mm were supported symmetrically over a span of 400 mm. The average flexural strength of Glass fibre Geopolymer concrete at age 28 days with adding lime and cement. This test was performed by the procedure given in ASTM C-78, Center loading was performed on this test in UTM study the flexural strength. Standard cast iron moulds were used for casting the test specimens. Before casting, machine oil was smeared on the inner surfaces of moulds. Geopolymer concrete with glass fibres was mixed using a horizontal pan mixer machine and was poured into the moulds in layers. Each layer of concrete was compacted using a table vibrator.

Table 4 : Flexural Strength of Geopolymer concrete by using Glass fibre

S NO	Sample	% of Glass fibre	Flexural strength in N/mm2	Flexural strength in N/mm2	Flexural strength in N/mm2
			7 Days	14 Days	28 Days
1	S1	0	2.98	3.36	4.69
2	S2	1	3.36	3.98	5.33
3	S3	2	3.87	4.32	5.96
4	S4	3	4.11	5.46	6.32
5	S5	4	4.05	5.04	6.28

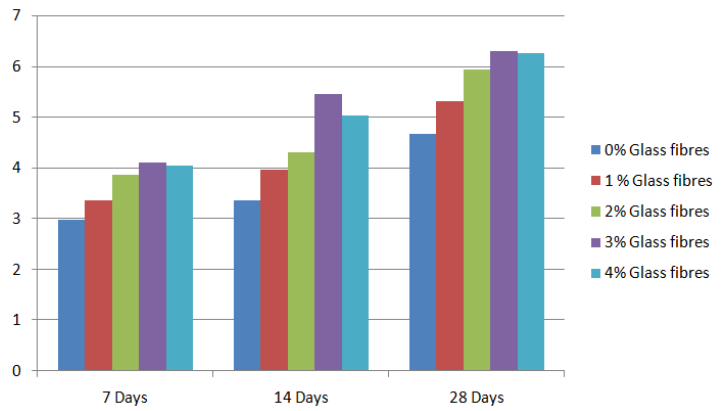

Fig 5 : Flexural strength of Geopolymer concrete by using Glass fibres

Result: It is seen from the Graph that the goepolymer concrete with glass fibre given flexural strength at 4 % of glass fibre which is 6.32 N/mm2

V CONCLUSIONS

Based on the results obtained in this investigation, the following conclusions are drawn Workability of Geopolymer concrete by using Glass fibres decreases due to the addition of glass fibres. During the mixing of geopolymer concrete, the increase of glass fibre content seems to decrease its workability Fly ash based Geopolymer

Concrete had exhibited good compression strength as per the mix desired and is suitable for structural applications. Resistance to Sulphuric acid attack of Geopolymer concrete was observed to be twice that of conventional cement concrete at all ages of testing. Similarly, resistance to Sodium Sulphate attack of Geopolymer concrete was observed to be more than twice that of conventional cement concrete at all ages of testing. It can thus be said that Geopolymer concrete possesses excellent mechanical properties and durability for aggressive environment compared to Convention Cement Concrete. The cost of chemicals used in geopolymer concrete had made it a bit expensive compared to Portland cement concrete. But taking into consideration, the fact that geopolymer concrete needs no separate water curing and reduced maintenance charges in the long run, Fly ash based Geopolymer concrete can be conveniently employed as a replacement of Cement concrete. The results from the present experimental work, which dealt with acid and sulphate resistance criteria, place Geopolymer concrete as a promising alternative to conventional cement concrete. Geopolymer concrete is an excellent alternative to Portland cement concrete. Density of Geopolymer concrete is similar to that of ordinary Portland cement concrete. Low calcium fly ash based Geopolymer concrete has excellent compressive strength within short period (3 days) & suitable for structural applications. Inclusion of glass fibres in Geopolymer concrete shows considerable increase in compressive, & flexural strength of GPCC with respect to GPC without fibres. Compressive strength, Split tensile strength & Flexural strength of glass fibre reinforced geopolymer concrete increases with respect to increase in percentage volume fraction of glass fibres from 0%, 1%, 2%, 3%, 4%, .Addition of 4% volume fraction of glass fibres shows maximum increase in Compressive strength, Split tensile strength & Flexural strength.

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