Effect of inclusion of steel fiber & polypropylene fiber on mechanical properties of geopolymer concrete

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ABSTRACT

Environmental pollution is one of the major problem in the world today. In the construction industry mainly the production of Portland cement causes emission of pollutants which results in environmental pollution. We can reduce this pollution effect on environment, by increasing the usage of industrial by-products in our construction industry. Geo-polymer concrete is one such eco friendly material which is used as alternative to ordinary Portland cement (OPC). GPC result from polymerization process of fly ash and GGBS as a binding material and alkaline liquid. Alkaline solution is sodium silicate Na_2SiO_3 and Sodium Hydroxide NaOH.

This paper presents data on the engineering properties of geopolymer concrete with varying Molarity & different percentage of polypropylene fibers & steel fiber (0.2%,0.4%,0.6%,0.8%,1%). Ratio of Na_2SiO_3 / NaOH is 2 & Na_2O / SiO_2 is 2.25. The paper demonstrates that this particular geopolymer concrete complies with relevant performance requirement and thus provides engineer with viable alternative to Portland cement based concrete allowing greatly reduced the embodied energy and carbon dioxide footprint.

Keyword: *Geopolymer Concrete, Fly ash, Alkaline Liquid, Polypropylene fiber , steel fiber.*

1. INTRODUCTION

Utilization of concrete as a major construction material is a worldwide phenomenon and the concrete industry is the largest user of natural resources in the world. This use of concrete is driving the massive global production of cement, estimated at over 2.8 billion tonnes according to recent industry data. Associated with this is the inevitable carbon dioxide emissions estimated to be responsible for 5to 7% of the total global production of carbon dioxide. Significant increases in cement production have been observed and were anticipated to increase due to the massive increase in infrastructure and industrialization in India, China and South America .Demand for concrete as construction material is on the increase and so is the production of cement. In order to address environmental effects associated with Portland cement, there is need to develop alternative binders to make concrete. The development and application of high volume Geopolymer concrete, which enabled the replacement of OPC up to 60% by mass is a significant development. Because of the load & Environment changes, a micro crack appears in cement products. Therefore cement based materials have low tensile strength and cause brittle failure. The weakness in tension can be overcome by the use of sufficient volume fraction of certain fibers. In order to improve the mechanical properties of concrete it is good to mix cement with fiber which have good tensile strength. Incorporation of steel & polypropylene materials in concrete significantly improve its bleeding, plastic settlement, thermal and shrinkage strains and stress concentration imposed by external restraints. Under an applied load, distributed micro cracks propagate to produce macro cracks.

2. LITERATURE REVIEW

Ganapati Naidu. P, A.S.S.N.Prasad reported in this paper that an attempt is made to study strength properties of geopolymer concrete using low calcium fly ash replacing with slag in 5 different percentages. Higher concentrations of G.G.B.S (Slag) result in higher compressive strength of geopolymer concrete.90% of compressive strength was achieved in 14 days

M. Tamil Selvi1* ,Dr. T.S. Thandavamoorthy studied strength of concrete cubes, cylinders and prisms cast using M30 grade concrete and reinforced with steel and polypropylene fibres. The steel, polypropylene and hybrid polypropylene and steel (crimped) fibres of various proportion i.e., 4% of steel fibre, 4% of polypropylene fibre and 4% of hybrid polypropylene and

steel (crimped) fibres each of 2% by volume of cement were used in concrete mixes. Besides cubes, cylinders of 150 mm x 300 mm of M30 grade concrete were cast with 4% of steel fibre and polypropylene fibre, respectively, by volume of cement. The test results show that use of steel fibre reinforced concrete improves compressive strength and split tensile strength

A. S. Sayyad and S. V. Patankar studied the effect of steel fiber and low calcium fly ash on mechanical and elastic properties of geopolymer concrete composite. Tests were conducted on fresh concrete like flow table test, wet density and dry density. And they also analyzed the effect of steel fibre and low calcium fly ash on hard concrete like compressive strength, flexural split tensile strength and bond strength of geopolymer concrete composite. The test result shows that the workability of geopolymer concrete including steel fiber reduces with increases in fiber content and inclusion of steel fiber increases the density of geopolymer concrete. Also Authors reported that optimal fiber content for maximum value of various strength of geopolymer concrete is 0.2%.

S. S. Patil and A. A. Patil studied mechanical properties of Polypropylene Fibre Reinforced Geopolymer Concrete (PFRGPC) which contains fly ash, alkaline liquids, fine & course aggregates & polypropylene fibers. The effects of inclusion of polypropylene fibers on compressive strength, split up tensile strength & flexural strength of hardened geopolymer concrete (GPC) composite was studied. Polypropylene fibers were added to the mix in two different lengths of 12mm and 20mm and also the hybridization of both polypropylene fibers was mixed in volume of concrete. Based on the test results, it was observed that the PFRGPC have relatively higher strength than GPC & OPC concrete

3. OBJECTIVE OF STUDY

The objective of the current research is to study the mechanical properties of M30 grade of concrete with molarity 12M,13M,14M. After getting result of different molarity, One Molarity to be selected which has good results. Steel & polypropylene fibers are added with different percentage to evaluate their strength & find Optimum percentage of Fibers & respective Split tensile Strength & Flexural strength.

4. MATERIALS & METHODOLOGY

4.1 Fly ash

In the present experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash obtained from the dirk India pvt. Limited, Nasik was used as the base material. Fly ash (Pozzocrete 63) is a high efficiency class F pozzolanic material confirming to BS 3892, obtained by selection and processing of power station fly ashes resulting from the combustion of pulverized coal. Pozzocrete 63 is subjected to strict quality control. Fineness of fly ash used is 320 kg / m^2.For research work Fly ash procured from Dirk India pvt. Limited,Nashik.

4.2 Fine aggregate

River sand was used as fine aggregate having specific gravity 2.65.

4.3 Coarse aggregate

Crushed angular metal of 20mm size (65% of total coarse aggregate) & 12 mm size (35% of total coarse aggregate) was used as coarse aggregate

4.4 Water

Portable water should use for casting of all specimens of this investigation

4.5 Polypropylene fiber

Polypropylene fiber having diameter 10um & length 18 mm was used for study. Density of polypropylene fiber is 0.91 gm/cc. Polypropylene fibers procured from Dolphin Float Pvt.Limited, Pune.

3.6 Steel fiber

Crimped type steel fiber having diameter 0.5 mm & length 35 mm was used. Aspect ratio is defined as ratio of length to diameter.70 Aspect ratio was used for study. Tensile strength of fiber used is 1120 Mpa & Density is 7.98 gm/cc. Steel fibre procured from Steewols steel Pvt limited, Nagpur.

3.7 Alkaline Liquid

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

3.7.1 Sodium Hydroxide

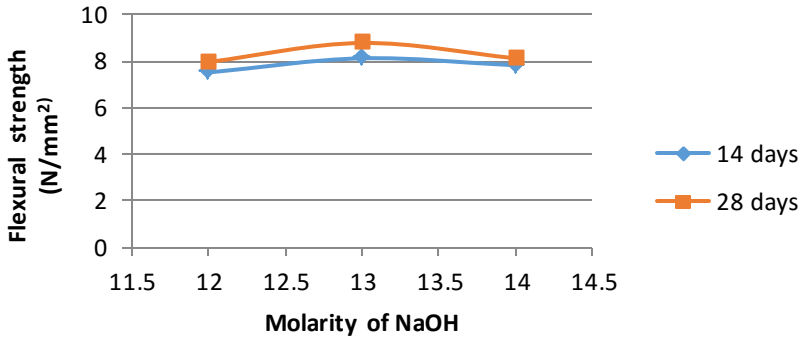
Generally the Sodium Hydroxides are available in solid state by means of pellets and flakes. The cost of the Sodium Hydroxide is mainly varied according to the purity of the substance. The sodium hydroxide (NaOH) solution was prepared by dissolving the flakes in water. The mass of NaOH solids in a solution varied depending on the concentration of the solution expressed in terms of molar (M). Sodium Hydroxide was procured from Abhay chemicals, Ahmednagar.
For example: 13M = (13X40) = 520 gms NaOH flex/lit water, where 40 is the molecular weight of NaOH.

3.7.2 Sodium Silicate

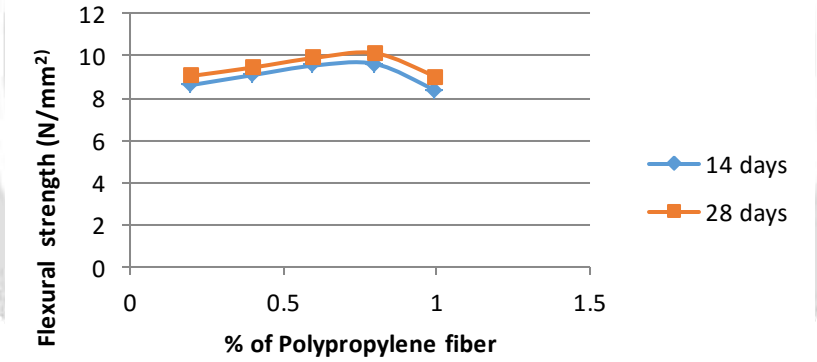
Sodium Silicate also known as water glass or liquid glass is available in liquid (gel) form. Sodium Silicate is used for the making of Geopolymer Concrete. The chemical composition of the sodium silicate solution is approximately Na_2O=15.06 %, SiO_2=34.01 % & H_2O =50.93% by mass. The other characteristics of the sodium silicate solution is approximately specific gravity=1.53 g/cc and viscosity at 20°C=400 cp. Sodium silicate procured from Shanti chemicals, Belgoan.

5 EXPERIMENTAL PROGRAM & DISCUSSION OF RESULT

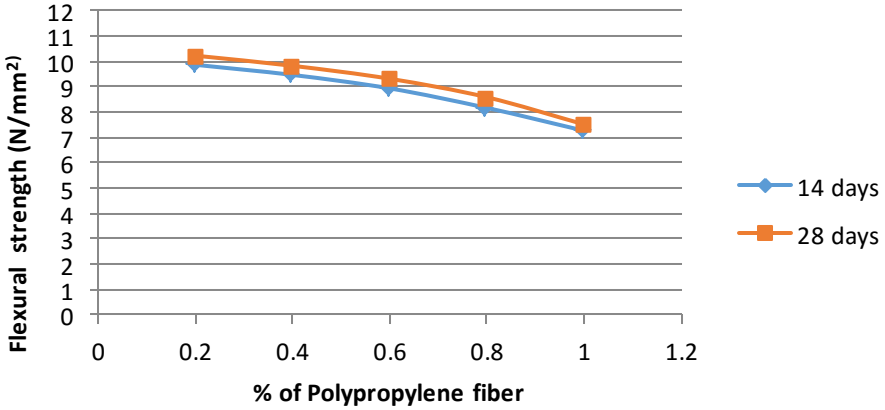
5.1 Flexural test result



Graph no 1: Flexural strength Results of varying Molarity

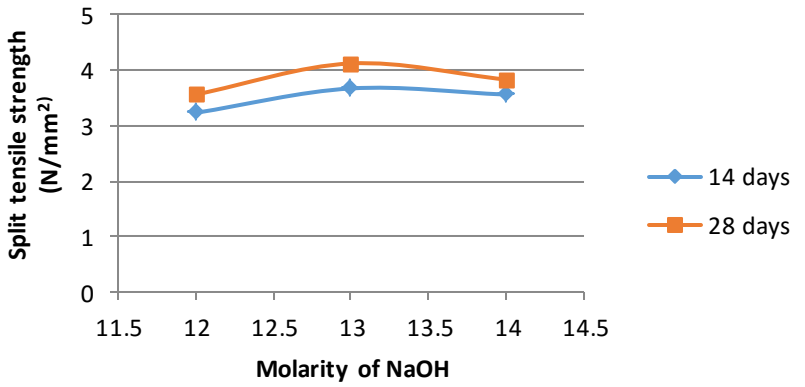


Graph No-2 : Flexural strength Result of Steel fiber for 13M

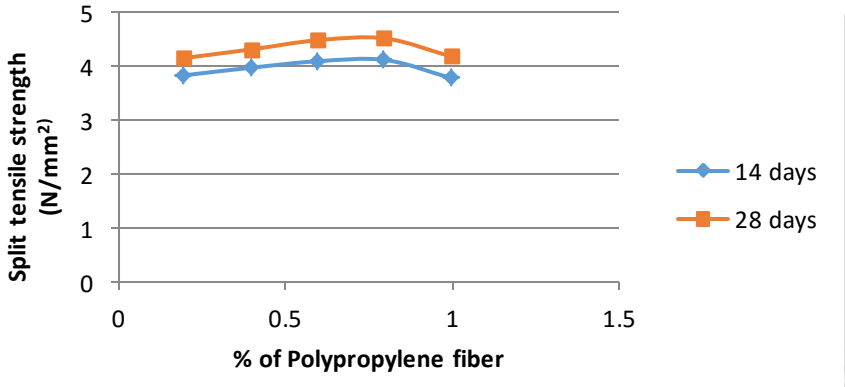


Graph no 3: Flexural strength Result of Polypropylene fiber for 13M

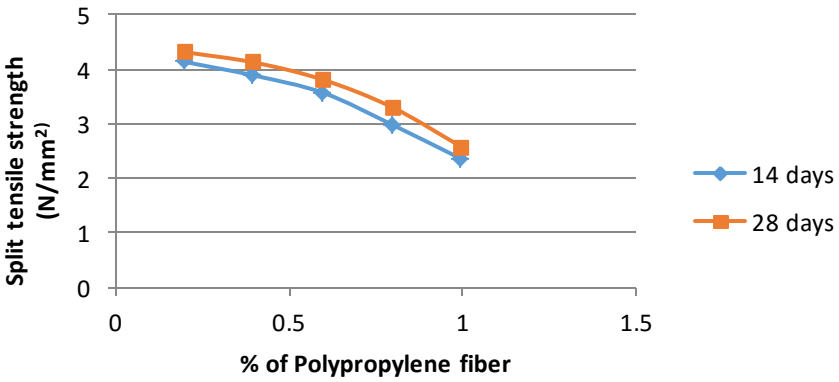
5.2 Split tensile test result



Graph no4.7: Split tensile test Results of varying Molarity



Graph no 4.8 :Split tensile test Result of Steel fiber for 13M



Graph no4.9: Split tensile test Result of Polypropylene fiber for 13M

.CONCLUSION

- Flexural strength increases with increase in Molarity of NaOH up to 13M. It gives percentage increase of 15.26%. Beyond 13M Flexural strength decrease .It gives percentage decrease of 8.12%
- The increase in Flexural strength of steel fibre reinforced geopolymer concrete was found to be increased as compared to geopolymer concrete. The maximum Flexural strength is achieved with 0.8 % of mass of steel fibres by mass of geopolymer concrete. It gives % strength increase of 16.40 %.
- Flexural strength of Geopolymer concrete with polypropylene fiber increased with addition of polypropylene fiber with 0.2% of mass of Geopolymer concrete. It gives % strength increase of 15.26%.
- Split tensile strength increases with increase in Molarity of NaOH up to 13M. It gives percentage increase of 9.70%. Beyond 13M Split tensile strength decrease .It gives percentage decrease of 4.61%

- The increase in Split tensile strength of steel fibre reinforced geopolymer concrete was found to be increased as compared to geopolymer concrete. The maximum Split tensile strength is achieved with 0.8 % of mass of steel fibres by mass of geopolymer concrete. It gives % strength increase of 9.70 %.
- Split tensile strength of Geopolymer concrete with polypropylene fiber increased with addition of polypropylene fiber with 0.2% of mass of Geopolymer concrete. It gives % strength increase of 4.61 %.

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