FLEXURAL BEHAVIOUR OF HYBRID FIBRE REINFPRCED GEOPOLYMER CONCRETE BEAM USING STEEL FIBRE AND POLYPROPYLENE FIBRE

MANJUNATH M KATTI[1], ISHITHA K P[2], ABHISHEK N[3], CHANDAN H S[4], NITHESH KUMAR S[5]

Asst. professor and Students, Department Civil of Engineering, Channabasaveshwara Institute of Technology, Gubbi, Tumkur, India.

ABSTRACT –

Geopolymer concrete is one of the emerging building materials in the world. Numerous studies are conducted on the Geopolymer concrete and the engineering properties of the material have been improved drastically. A mixture of sodium hydroxide solution and sodium silicate solution of 5M is used. Geopolymer concrete is found to be relatively brittle than the normal standard concrete. To counteract this effect fibres are incorporated in to the Geopolymer concrete. During this investigation, an attempt is made to analyses behaviour of fibre reinforced geopolymer concrete by hybridization of fibres. In this investigation polypropylene and steel fibre are used in hybridization form to find the flexural performance of fibre reinforced geopolymer concrete beams. In this project work, steel fibres and polypropylene fibres are added to the Geopolymer concrete, and its influence was studied over the hardened properties of concrete such as flexural strength.

1. INTRODUCTION:

Cementations materials have low strain capability, low tensile strength, and fracture toughness property. However cementations materials have brittle property. To resist tensile and shear stresses of reinforced geopolymer concrete and to form stable and usable structural material, the reinforcements were provided as a continuous steel bars and stirrups in geopolymer concrete. For the past 5 decades, a special form of reinforcement called fibres has been used in concrete and geopolymer concrete to compensate the brittle property, named as Fibre Reinforced Geopolymer Concrete (FRGC) where discontinuous and randomly distributed fibres are imposed to produce a special type of structural material with improved strength. Geopolymer is created from waste matter like Ground Granulated Blast Furnace (GGBS) which is a byproduct of steel plant. When these alumina silicate source materials are activated with the assistance of alkali solution, polymerization reaction take place and the concrete is formed without the use of cement. The concrete that consists of GGBS (ground granulated blast furnace slag), coarse and fine aggregate, alkali solution and discontinuous discrete fibres are called Fibre Reinforced geopolymer Concrete. The fibres added in concrete are not a substitute for control reinforcement. The basic difference between steel reinforcement and discrete steel fibres is that the continual steel bars are used to increase the tensile and shear capacities of concrete whereas addition of discontinuous fibres improves the post cracking response by dominant the crack opening and propagation.

2. MATERIALS USED

2.1 GGBS:

GGBS is the slag powder obtained from the residue of the blast furnace throughout the manufacture of iron. During this work GGBS was used as the alumina silicate base material.

FIG 2.1 GGBS

2.2 AKALINE SOLUTION

A mixture of sodium hydroxide solution and sodium silicate solution was used as alkali activated solution. Commercially available sodium silicate in semi liquid gel form was used for this experimental work. Sodium hydroxide solution of 5 molarity concentration was prepared by dissolving sodium hydroxide flakes in the water. The alkali solution was prepared by mixing both sodium silicate solution and sodium hydroxide solution together at least one day prior to use, so that effective reaction of alkaline solution to takes place. Weight in grams of sodium hydroxide is 200gms for 5M (i.e.,) 5 X 40 = 200 gms, where 40 is the molecular weight of NaOH.

FIG 2.2 (a) SODIUM SILICATE

FIG 2.2(b) SODIUM HYDROXIDE

2.3 M SAND:

Manufactured sand (M-sand) is an alternative of natural sand. manufacture sand is made by crushing hard granite stone. The dimension of M-sand is less than 4.75mm.

FIG 2.3 M-SAND

2.4 COARSE AGGREGATE

Locally accessible Coarse aggregates of 20mm size was used.

2.5 POLYPROPYLENE FIBRE

Polypropylene fibres of length 12mm and aspect ratio 318 was used for the study.

FIG 2.5: POLYPROPYLENE FIBRE

2.6 STEEL FIBRE

Steel fibre is a metal reinforcement. Crimped steel fibres having diameter 0.5mm and length 30mm were used for the study.

FIG 2.6 STEEL FIBRE

2.7 : SUPERPLASTICIZER

Naphthalene based superplasticizer Conplast SP-430 was used as superplasticizer. Superplasticizer was added to improve the workability of geopolymer concrete.

FIG 2.7 SUPERPLASTICIZER

2.8 Mix Design:

The mix proportion were in the ratio of 1:1.5:2.5. These are the ratio which represent the GGBS, Fine aggregate, Coarse aggregate respectively. We had use weight batching to find the quantity of material for the size 500x100x100 mm.

2.9 PREPARING/CASTING SPECIMENS:

To start with, weighed quantity of sodium hydroxide (NaOH) in flakes form to suit 5 Molarity (5M) is dissolved in distilled water and mixed thoroughly with a glass rod, until the solution was cooled. The solution thus prepared was kept in a beaker for 24 hours. This waiting time allows the polymerization process among the alkaline solution mixed. The mix of sodium hydroxide and sodium silicate was added to the dry mix of GGBS, fibres, fine aggregate and coarse aggregate in a metallic tray. The Mix proportion of GGBS: Fine aggregate: Coarse aggregate are 1: 1.5: 2.5 was used in the present study. Water was added to the dry mix slowly as per the calculated quantity. The dry mix was thoroughly mixed for 5 minutes. Measured quantity of super plasticizer also added to the mixture for the considerable workability. Steel and Polypropylene fibres were used in the proportions 1% of the mass of GGBS. It is sprinkled uniformly throughout the concrete for uniform mix. The fresh concrete was casted into moulds immediately after mixing. The fresh concrete was casted into 500 x 100 x 100 mm prisms, to find the flexural strength. After casting, all the specimens were kept at room temperature for ambient curing and after demoulding the specimens on the next day, they were kept at ambient temperature, till the date of testing. The cast prisms, after ambient curing, were tested at 7 days, 14 days and 21 days in the flexural testing machine for its flexural strength and the results were noted.

3.0 STEP BY STEP PROCEDURE

- Material Selection
- Mix proportioning
- Preparing/ casting specimens
- Flexural test
- Results

3.1 MIX PROPORTIONING

For one Beam

- GGBS = 2.5 kg
- Fine aggregates = 3.75 kg
- Coarse aggregate = 6.25 kg
- GGBS: FA: CA = 1:1.5:2.5

TEST SETUP: -

The beams were tested under flexural testing ahine. Specimens are tested in a loading frame of 1000 kN (100 t) capacity. The load is increased in stages till the failure of the specimen was occurred. . The test setup is shown in Fig. 3.1. Following observations were made

1. First crack load
2. Kick back of needle
3. Displacement at mid span
4. Ultimate load

Fig 3.1 TEST SETUP

4 . RESULTS & DISCUSSION

4.1 Flexural strength:

Specimen	7 days curing	14 days curing	21 days curing
SFRGPC	9.31 N/mm²	11.23 N/mm²	13.0 N/mm²
PFRGPC	5.57 N/mm²	6.5 N/mm²	7.37 N/mm²
HFRGPC	6.37 N/mm²	7.23 N/mm²	8.17 N/mm²

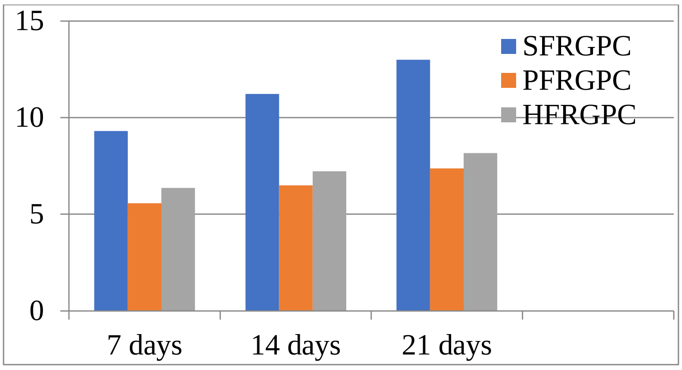

FIG 4.1 Flexural test

From the above graph 4.1 Flexural strength shows that the Mix design ratio 1:1.5:2. and the Flexural strength of

(i) SFRGPC beam

For 7 days = 9.31 N/mm², for 14 days = 11.23 N/mm², for 28 days = 13.0 N/mm²

(ii) PFRGPC beam

For 7 days = 5.57 N/mm², for 14 days = 6.5 N/mm², for 28 days = 7.37 N/mm²

(iii) HFRGPC beam

For 7 days = 6.37 N/mm², for 14 days = 7.23 N/mm², for 28 days = 8.17 N/mm²

After the flexural test, it clearly shows that the SFRGPC beam give more flexural strength at different ages of curing rather than PFRGPC, HFRGPC beams.

5. CONCLUSION

The following conclusions may be derived based on this experimental investigation into the flexural strength of hybrid fibre reinforced geopolymer concrete beams:

- The basic property of flexural strength of hybrid fiber reinforced concrete are studied.
- Addition of fiber in concrete reduce the formation of internal micro cracks.
- Workability of the geopolymer concrete decreases with increases in the fibre content irrespective of fibre utilized.

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BIOGRAPHIES

Mr. Manjunath N Katti
Asst. Professor
Depart of CivilEngineering
Channabasaveshwara
Institute of Technology, Gubbi.

Ishitha K P
BE Final year student
Civil Department
Channabasaveshwara
Institute of Technology, Gubbi

Abhishek N
BE Final year student
Civil Department
Channabasaveshwara
Institute of Technology, Gubbi

Chandan H S
BE Final year student
Civil Department
Channabasaveshwara
Institute of Technology, Gubbi

Nithesh kumar S
BE Final year student
Civil Department
Channabasaveshwara
Institute of Technology, Gubbi