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Experimental Investigation on Concrete Blocks Using Foundry Sand and Hybrid Fibres

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***Abstract*: An attempt has been made to use waste foundry sand (WFS) in concrete. Glass fibres are added to the concrete forming fibre-reinforced concrete (FRC), to improve its ability to absorb energy and deformation before failure, and behave as a ductile material. Glass fibres with an aspect ratio of 60 need to be used for improving the impact resistance of the concrete. Plant-based natural fibres are low cost renewable materials which can be found in abundance in many countries. Studies have shown that hybridisation of natural fibres with synthetic fibres helps in improving the properties of concrete. Hybrid fibre reinforced concrete (HFRC) need to be manufactured by maintaining a constant dosage (1%) of glass fibre and by varying the proportions (0%, 0.2%, 0.4% & 0.6%) of coir fibre. The present work started by determining the basic properties of materials and mix design for M25 was carried out. Mechanical properties of HFRC with WFS have to be studied and optimum dosage of hybrid fibres has to be found. For that optimum dosage, performance evaluation of beam need to be studied.**

***Keywords*: Glass fibre, Waste foundry sand, Hybrid fibre reinforced Concrete Beams.**

1. Introduction

Disposal of industrial by-products into the environment may cause major issues and this can be overcome by utilising industrial wastes in the construction industry, thereby protecting the environment. Waste foundry sand (WFS) is a by-product from the ferrous and non-ferrous metal casting industries, which can be beneficially used to reduce the cost and over-exploitation of river sand. Large volume of waste foundry sand is also used in geotechnical applications such as road construction and embankments. Use of natural fibres has been gaining momentum due to lower cost, easy availability and non-hazardous nature. Glass fibre is increasing confinement and arresting cracks.

In case of seismic vulnerable zone, adding fibres to concrete helps in improving the ductility of the structure by absorbing energy and also acts as a solution for controlling crack extension. The production of fibre reinforced concrete (FRC) helps in combining the mechanical properties of two or more different fibres and take advantage of each individual fibre properties. This project focuses on the production of fibre reinforced concrete using glass fibre and waste foundry sand and it helps to compare the strength properties of FRC with conventional concrete. The flexural behavior of the FRC has to be studied.

2. Materials

Following are the basic materials used for the preparation of Hybrid fibre reinforced concrete beam.

1) Waste foundry sand
2) Fine Aggregates
3) Coarse aggregate
4) Coconut fibre
5) Glass fibres
6) Water
7) Super plasticizer

1) Waste foundry sand

Waste foundry sand (WFS) is a by-product from the ferrous and non-ferrous metal casting industries. It is also known as spent foundry sand (SFS) or Used foundry sand (UFS). It is high quality silica sand which is easily available, inexpensive and resistance to heat damage and used for moulding and casting operations in foundries. During casting process, moulding sands are repeatedly recycled and reused, until it degrades and become unsuitable for further recycling. Then the sand is discarded from the industry and that discarded sand is termed as waste foundry sand.

2) Fine aggregate

Locally available river sand is used as fine aggregate. The sieve analysis is conducted. The fine aggregate test conforms to Zone-II as per IS: 383-1970. Fineness modules and Specific gravity of fine aggregate were 2.61 and 2.64, respectively.

3) Coarse aggregate

Locally available crushed(angular) granite coarse aggregate passing through 12.5 mm sieve size and retained on 10 mm sieve are used. The Coarse aggregate tested confirms to the size of 12.5 mm graded aggregate of nominal size as per IS 383 – 1970 code of practice. Specific gravity and water absorption of the aggregates were 2.62 and 0.3%, respectively.

4) Coconut fibre

In this project, coconut fibre with an aspect ratio of 133 is used. The various properties of coconut fibre length 6 to 8 inches, diameter 16 micron, density 1.4 g/cc, swelling in water 5% in diameter.

5) Glass fibre

In this project, glass fibre with an aspect ratio of 60 is used.

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The various properties of glass fibre are poisson's Ratio 0.21, Shear Modulus 35 Gpa, Young's Modulus 86 Gpa, Tensile strength 4700 MPa.

6) Water

Mixing water quality is required in accordance with the quality standards of drinking water. Fresh and clean water is used to determine the material properties.

7) Super plasticizers

Superplasticizer used in this project is Fosroc Conplast Sp430. It is a chloride free superplasticizing admixture based on sulphonated napthalene polymers. It reduces water content upto 30 percent and improves cohesion and durability of concrete. Specific gravity of superplasticizer is taken from vendor specification sheet and it properties are Specific gravity 1.18, Appearance is Brown liquid, Chloride content Nil to BS 5075/BS:EN934, Air entrainment is Less than 2% additional air entrained at normal dosages.

3. Experimental Procedure

` In this project, an experimental study will be carried out on FRC concrete using waste foundry sand. Material properties like specific gravity, fineness modulus, setting time will be studied for cement, river sand, waste foundry sand and coarse aggregate.

According to Indian standards, cubes (150 mm x 150 mm x 150 mm) will be prepared for fibre reinforced concrete mix (M25) with 20% replacement of fine aggregate with WFS.

In this FRC mix, 1% of coconut fibres and different percentages of glass fibres such as 0.2%, 0.4% & 0.6% is used. The companion specimens will be casted and then vibrated upon a vibrating table. It will be demoulded 24 hours after casting and then cured in normal laboratory condition. Various tests will be carried out to find the mechanical properties of FRC using WFS and the optimum dosage of fibres will be found.

1) Compressive strength

For whole mixtures maintaining constant ratio 20% of WFS and 1% of SF, except mix id (CC). When river sand is replaced with 20% of WFS, compressive strength has increased up to 13.39% when compared with conventional concrete (CC). Concrete containing 1% volume fraction of coir fibre with 20% of WFS shows better performance with 14.68% increase in compressive strength. Addition of 0.2% volume fraction of glass and 1% volume fraction of coir fibre with 20% WFS shows slight increase in strength of concrete. From table 1, it can be understood that further increase in volume fraction of glass fibre shows marginal increase in strength up to 0.2% and decreases from 0.3%.

2) Flexural strength test

For whole mixtures maintaining constant ratio 20% of WFS and 1% of SF, except mix id (CC). 10.30% increase in flexural strength is observed in concrete containing 20% of WFS when compared with CC. HFRC-FS1 showed higher flexural strength with 39.95% increase. HFRC-FS3 with 0.2% volume fraction of glass fibre and 1% volume fraction of coir fibre with 20% of WFS increases the flexural strength up to 41.71% when compared to CC

Table 1
Compressive strength Result

Mix id	% of SiF	Compressive strength 7 days (MPa)	Compressive strength 28 days (MPa)
CC	-	22.11	31.75
FS	-	25.1	36
HFRC-FS1	0	25.82	36.41
HFRC-FS2	0.1	25.87	36.81
HFRC-FS3	0.2	25.98	36.83
HFRC-FS4	0.3	25.66	36.74

Table 2
Flexural strength Result

Mix id	% of SiF	Compressive strength 7 days (MPa)	Compressive strength 28 days (MPa)
CC	-	2.68	3.98
FS	-	2.89	4.39
HFRC-FS1	0	3.77	5.57
HFRC-FS2	0.1	3.84	5.62
HFRC-FS3	0.2	3.92	5.64
HFRC-FS4	0.3	3.88	5.61

3) Discussion of companion specimens

From the above test results, compressive strength, split tensile strength and flexural strength is maximum for HFRC-FS3 containing 20% of WFS with 1% volume fraction of coir fibre and 0.2% volume fraction of glass fibre. Thus, the beams were casted according to the optimum value and the various properties of HFRC beams were studied.

4) Flexural behaviour of beam

All beams were tested under two-point static loading at a load increment of 5 kN. The corresponding deflections were noted. Two-point loading system is used at L/3 distance in order to get pure bending. The deflection value increases when compared to conventional beam due to the ductile behaviour of coir fibres.

5) First crack load and ultimate load

In conventional beam, initiation of crack take place at a load of 15 kN. For FS and HFRC-FS3 beams, initiation of crack took place at a load of 20 kN and 30 kN This shows the ductile behaviour of HFRC-FS3 beam. All the beams were loaded upto their ultimate load. It was noted that HFRC-FS3 beam has the higher load carrying capacity compared to the Conventional beam and FS beam. In conventional specimen, ultimate failure took place at a load of 50 kN whereas, in FS and HFRC-FS3 beams it is 55 kN and 70 kN. 40% increase in ultimate load was observed in HFRC-FS3 beam when compared with the conventional beam. Comparison chart for first crack and ultimate load was given in Fig. 1.

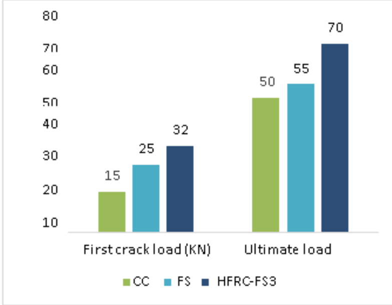

Fig. 1. First crack load and Ultimate load

4. Conclusion

Following conclusions were drawn from this experimental study,

- HFRC-FS3 containing 20% of WFS with 1% volume fraction of coir fibre and 0.2% volume fraction of glass fibre is found to be optimum.
- Initial crack of HFRC-FS3 beam was delayed due to its ductile behavior.
- Ultimate load of HFRC-FS3 beam is 40% higher than conventional beams.
- Natural fibres can be used in concrete because of their compatibility with the environment, low cost & better durability.
- Incorporation of hybrid fibres into the concrete along with waste foundry sand increased the overall performance of the concrete.
- An optimum percentage of WFS can be partially replaced for river sand to overcome the environmental issues and to reduce the depletion of natural river sand leading to sustainable environment.

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