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CHARACTERISTICS OF HYBRID FIBRE REINFORCED CONCRETE (HFRC)-AN EXPERIMENTAL STUDY

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ABSTRACT

Many fibres are obtained as industrial waste. For example the lathe machines produce coiled fibres, which can be used as waste steel (metallic) coiled fibres in the production of FRC. Similarly, the waste plastic is another waste material. The disposing of waste plastic is causing environmental pollution. The plastic is a non-biodegradable material, neither decays nor degenerate it either in water or in soil. In turn it pollutes the water and soil. The plastic if burnt releases many toxic gases, which are very dangerous for the health. Such plastic, which is non-biodegradable material, can be used in concrete in the form of fibres to impact some additional desirable qualities to the concrete along with the waste coiled fibres as mixed fibres. In this experimentation, an attempt is made to produce a Hybrid fibre reinforced concrete by using waste metallic coiled fibres and waste plastic fibres having different modulus of elasticity are combined together for concrete better results and to study the strength and workability properties of hybrid fibre reinforced concrete, experiments have been conducted by keeping the waste coiled steel (metallic) fibres percentage as constant at 3% and varying the percentage of waste plastic fibres such as 0%, 1%, 2%, 3%, 4%, 5% and 6%.

KEY WORDS: Metal coil, Waste plastic fibres, strength and workability characteristics

INTRODUCTION

The low tensile strength and poor fracture toughness of cement-based materials are serious shortcoming that not only impose constraints in structural design, but also affect the long-term durability of structures. In this regard, the benefits of fiber reinforcement in improving the fracture toughness, impact resistance, fatigue endurance and energy absorption capacity of concrete are well known. Fibers in concrete can also add to the tensile loading capacity of the composite system. The research has shown that the ultimate tensile strength of concrete can be increased as much as five times by adding fibers [2, 3].

The fiber reinforced concrete too has some limitations. To overcome these limitations, the hybrid fiber reinforced concrete came into existence. In hybrid fiber reinforced concrete, two or more different types of fibers are rationally combined to produce a composite that derives benefits from each of the individual fibers and exhibits a synergistic fiber and exhibits a synergistic response. The precise ways in which various fibers should be combined to produce a synergistic response, how ever, are not still understood. By using two or more different types of fibers, the fracture behaviour of concrete in both the ascending as well as the descending branch of the compression stress-strain curve can be improved[2, 3].

Broadly one can divide the hybrid composites into two categories. In the first, fibers different in sizes are combined. The idea of such dimensional hybrids follows directly from concrete itself, where particles of different sizes are combined to achieve a dense packing and dimensional stability. Typically, one would combine large macro-fibers that provide toughness at large crack opening with fine micro-fibers that reinforce the mortar phase and enhance the response prior to or just after cracking. Micro-fibers are also expected to improve the pull-out response on micro-fibers, and thus produce composites with high strength and toughness. Dimensional hybrids using steel fibers have been previously studied, but have not yet been optimized [2, 3].

The second type of hybrid composites involves combining fibers of similar sizes but different moduli. One example would be combining high modulus steel or carbon fibers with low modulus fiber, if properly bonded, would attain its optimal reinforcing capability at small to medium crack openings. The low modulus fiber, such as polypropylene, on the other hand, would develop its full reinforcement capability only at large crack openings. In combination, therefore, these fibers are expected to produce a composite with high toughness over a wide range of crack opening [2, 3].

The lathe machine shops do produce lot of coiled fibres when working with the metal pieces. These coiled fibres are considered as waste except for the recycling purposes. These coiled fibres can be used in the production of fibre reinforced concrete [4, 5].

The plastic is a non- biodegradable/non-perishable material. The plastics will neither decay nor degenerate either in water or in soil. In turn it pollutes the water and soil. The plastic if burnt releases many toxic gases, which are very dangerous for the health. Such plastic, which is a non-biodegradable/non-perishable material, can be used in concrete in the form of fibres to impart some additional desirable qualities to the concrete [1]

In this experimentation two different fibres having modulus of elasticity are combined for concrete better results, to study the strength and workability characteristics hybrid fibre reinforced concrete.

EXPERIMENTAL WORK

Experiments have been conducted by keeping the waste coiled metallic fibres percentage as constant at 3% and varying the percentage of waste plastic fibres such as 0%, 1%, 2%, 3%, 4%, 5% and 6%. The strength and workability characteristics are studied.

The commercially available ordinary port land cement (53-grade) was used in the experimentation, which satisfies the requirements of IS: 12269-1987 specifications. Locally available sand collected from the bed of river Tunga-bhadra, HARIHARA as fine aggregate. The sand used was of the type passed through set of sieves having fineness modulus 2.96 and specific gravity of 2.63 and conforming to grading zone-III of IS: 383 -1970 specifications. The crushed stone natural aggregates were collected from the local quarry. The aggregate used in the experimentation were 10mm and down size aggregates and tested as per IS: 2386-1963 and having fineness modulus of 1.9 and specific gravity2.65. The coiled steel fibre was having width of 8mm. The thickness of fibre was 1mm.The aspect ratio of the fibre adopted in the experimentation was 80. The percentage of waste coiled steel fibres used in the experimentation was 3%. The waste plastic (thermo plastic) fibres were obtained by cutting waste plastic pots. The waste plastic fibres obtained were all recycled plastics and not obtained from granules. The fibres were cut from steel wire cutter and it is labour oriented. The thickness of waste plastic fibres was 1mm and its breadth was kept 5mm.The aspect ratio adopted for the fibres were 50. The percentage of waste plastic fibre introduced in to concrete varied as 0%, 1%, 2%, 3%, 4%, 5% and 6% by weight of cement. Ordinary potable water free from organic content, turbidity and salts was used for mixing and for curing through out the experiment. To impart the additional desired properties; a super plastcizer (conplast-430) was used. Super plastcizer conplast-430 is a sulphonated Naphthalene Formaldehyde Condensate and manufactured by FOSROC chemicals (India) Ltd, Banaglore. It is a brown liquid, which is dispersible in water. It is a chloride free admixture having specific gravity 1.2 to 1.25 at 25 degree centigrade. Conplast-430 is a non–toxic and non-flammable liquid having shelf life of 12 months. It is complying with IS: 9103-1979, BS5075 Part-I and ASTM- 494 type-A.

The nominal mix proportion adopted was 1: 1.5: 3 with a w/c ratio of 0.5. The dosage of super plasticizer (Conplast-430) was 1%. All the specimens cast were water cured for 28 days. The compressive strength specimens were of dimension 150 x 150 x 150 mm tests were conducted as per IS: 516 - 1959. The tensile strength specimens were cylinder 150 mm dia and 300 mm long tests were conducted as per IS: 5816 - 1999. Flexural strength specimens were of dimensions 100 x 100 x 500mm tests were conducted as per IS: 516 - 1959.Two point loading was adopted during the testing of flexural specimens on a span of 400 mm. Impact strength test specimens were of dimensions 250 x 250 x 30 mm tests were conducted as per ACI committee 544. A steel ball weighing 1.112 kg was dropped from a height of one meter on the impact specimens, which were kept on the floor. Care was taken to see that the ball was dropped at the center point of specimen every time. The number of blows required to cause first crack and final failure were noted. The numbers of blows were converted into impact energy by the formula-

Impact energy = mghN

= w/g x g x h x N

= whN (N-m)

Where, m = mass of the ball

w = weight of the ball =1.112 kg =11.12N

g = Acceleration due to gravity

h = Height of the drop =1m

N =Average number of blows to cause the failure.

The concrete ingredients viz. Cement, sand and aggregates were weighed according to the proportion 1:1.5:3, to this, the calculated quantity of waste coiled steel fibres (3% by weight of cement) and waste plastic fibres were added and mixed dry. To this, the calculated quantity of water was added and the concrete was homogenously mixed. To this homogenous mix the calculated quantity of super plasticizer was added and the whole mix is remixed thoroughly. The prepared homogenous mix was placed in the moulds layer-by-layer and sufficient compaction was given to the specimen both by hand and table vibrator. The specimens were finished smooth. After 24 hours the specimens were demoulded and transferred to the curing tank where in they were allowed to cure for 28 days. After 28days of water curing the specimens were weighed for their density and tested for their strength. When the mix was wet the workability tests like slump test, compaction factor test, and flow test, were carried out. The tables 1 and 2 give the various test results of HFRC produced from waste coiled steel fibres and waste plastic fibres.

EXPERIMENTAL RESULTS

The various strength and workability test results of hybrid FRC produced from waste coiled steel fibres and waste plastic fibres are given in Table.1and Table 2.

The variation in strength and workability test results of hybrid FRC produced from waste coiled steel fibres and waste plastic fibres are depicted in the form of graph as shown in fig. 1, 2, 3, 4 and 5.

Table 1: Various strength test results of hybrid FRC produced from waste coiled steel fibres and waste plastic fibres

% Addition of plastic fibres	Compressive strength (MPa)	Tensile strength (MPa)	Flexural strength (MPa)	Impact strength or energy required to cause (N-m)	
				First crack	Final failure
0	29.93	3.38	3.21	29.01	47.23
1	34.01	3.65	3.35	32.72	51.29
2	40.25	4.21	3.61	39.92	70.96
3	34.73	3.61	3.15	36.32	65.45
4	34.73	3.28	3.01	32.72	43.63
5	30.22	2.73	2.94	25.41	39.92
6	26.30	2.59	2.85	25.41	36.32

Table 2 : Workability test results of hybrid FRC produced from waste coiled steel fibres and waste plastic fibres

% Addition of plastic fibres	Workability of hybrid fibre concrete through		
	Slump(mm)	Compaction factor	Percentage flow
0	29.93	3.38	3.21
1	34.01	3.65	3.35
2	40.25	4.21	3.61
3	34.73	3.61	3.15
4	34.73	3.28	3.01
5	30.22	2.73	2.94
6	26.30	2.59	2.85

Fig1: The variation of compressive strength of hybrid FRC produced from WCSF and WPF

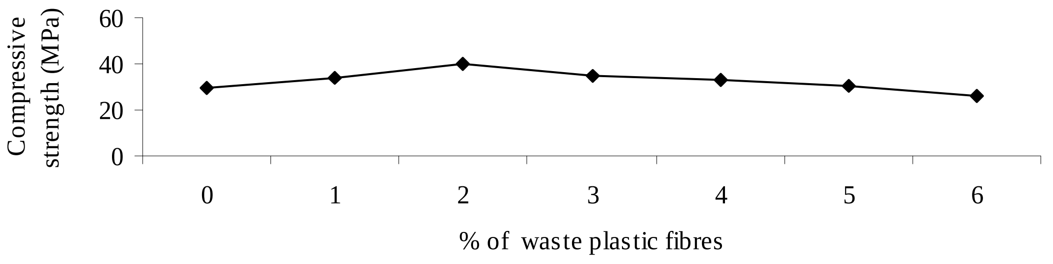
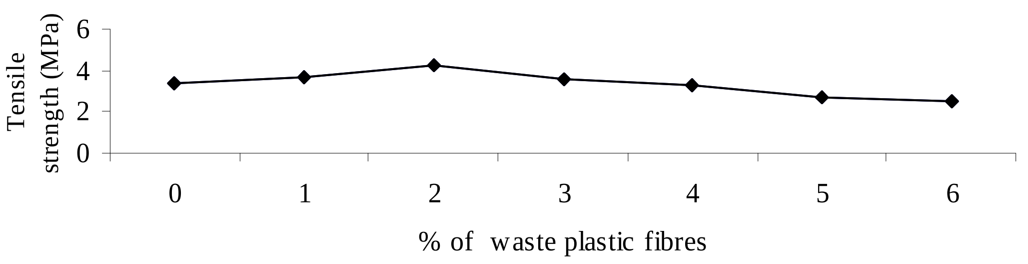
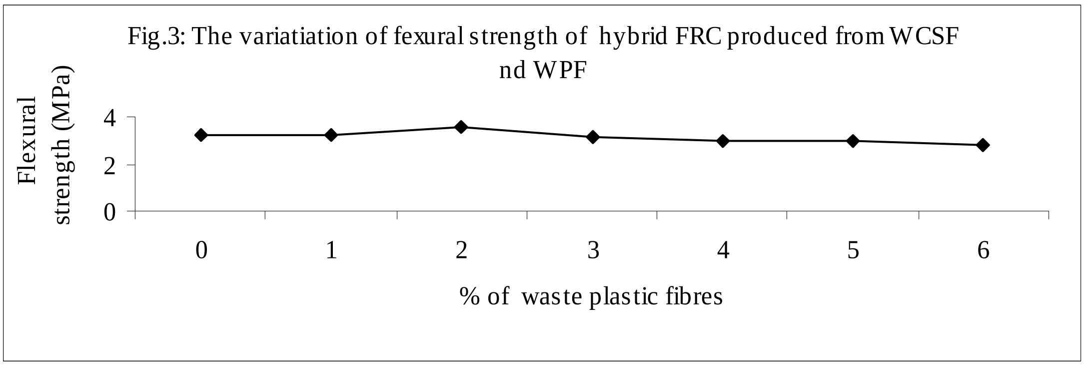
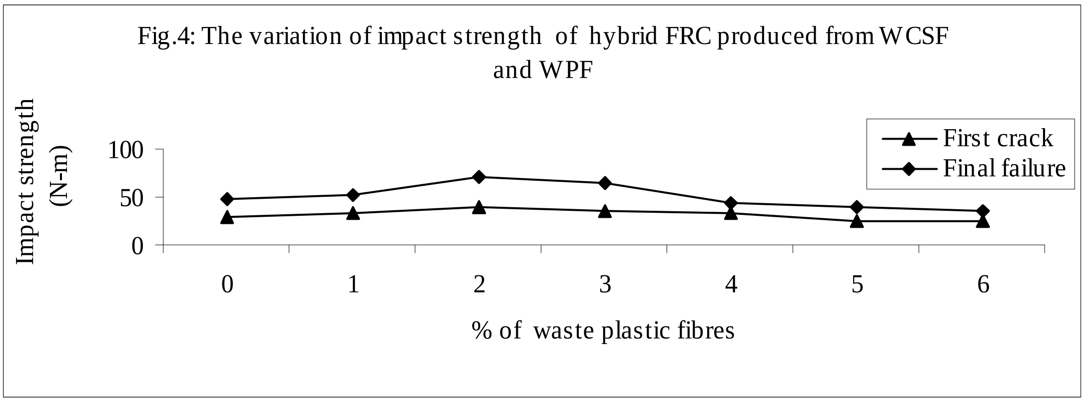
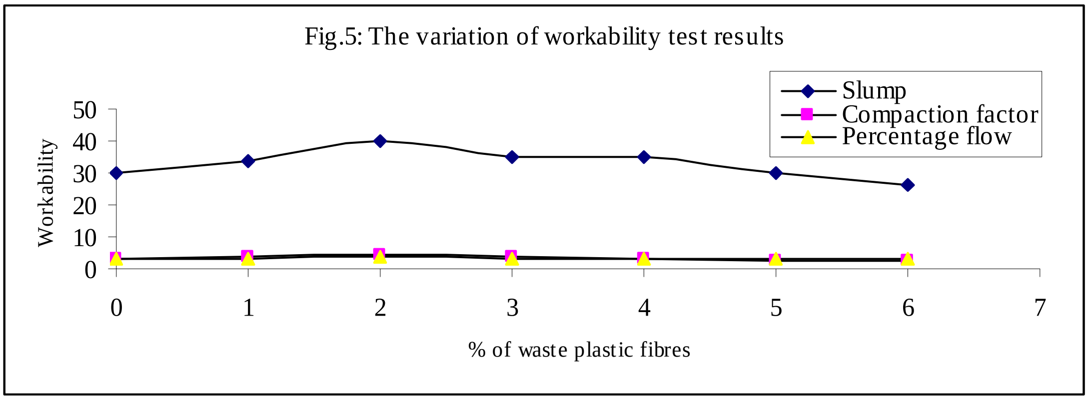


Fig.2: The variation of tensile strength of hybrid FRC produced from WCSF and WPF









CONCLUSIONS

Based on the experiments conducted, the following conclusions can be drawn.

1. The compressive, tensile, flexural and impact strength of mixed FRC produced from waste coiled steel fibres and waste plastic fibres goes on increasing up to 2% addition of waste plastic fibres. Beyond 2%, the compressive, tensile, flexural and impact strength starts decreasing i.e. the maximum compressive, tensile, flexural and impact strength is attained at 2% addition of waste plastic fibres.

More than 2% of addition of waste plastic fibres may probably affect the bond strength and may bring down the compressive, tensile, flexural, and impact strength of hybrid fibre reinforced concrete.

2. The workability of mixed FRC produced from waste coiled steel fibres and waste plastic fibres, decreases as the percentage of waste plastic fibres goes on increasing.

   This is obviously because of the abstraction caused by the fibres to the flow of concrete.

3. Thus, both the wastes viz., waste coiled steel fibres and waste plastic fibres can be used in the production of FRC as hybrid fibre reinforced concrete.

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