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Strength Characteristics of Concrete using Solid Waste an Experimental Investigation

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ABSTRACT: Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. Solid waste disposal i.e. water bottles, polythene bags, disposable glasses, cement bags, cool drink bottles etc. was creating lot of environmental problems. An attempt has been made in this study by using solid waste (non-biodegradable) material in the concrete. Fiber Reinforced Concrete (FRC) is an emerging field in the area of Concrete Technology. This study mainly focused on the use of cement bags waste (High Density Polyethylene (HDPE)) in concrete. Concrete having compressive strength of 30 N/mm^2 was used for this study. Cubes, cylinders and beams are casted with 0 to 6% of fiber with 0.5% increment. Samples were tested for the compressive strength, split tensile strength and Flexural strength and comparison analysis was made for the conventional concrete and modified concrete. It has been found that, increase in the compressive strength, split tensile strength and flexural strength of concrete by using the fibers up to some extent.

KEY WORDS: Solid waste, Fiber reinforced concrete, High Density Polyethylene, Strength.

INTRODUCTION

The ingredients of concrete are cement, sand, coarse aggregate and water. These ingredients are mixed in a desired proportion depends on the strength of concrete. As every researcher knows that the concrete is very weak in tensile strength as compared to compressive strength. The main aim of researchers or concrete technologist is how to improve the tensile strength of concrete. One of the solution is by providing the reinforcement in the concrete so that the tensile stresses can be taken by this reinforcement. The reinforcement means it can be any material so that it will take the tensile stresses. Most commonly steel is used as the reinforcement in the concrete. In the present study, fibers have been used as the reinforced material in place of steel. From the literature, the addition of fibers in concrete would act as crack inhibitors and substantially improve the tensile strength, cracking resistance, impact strength, wear and tear, fatigue resistance and ductility of concrete.

Fiber reinforced concrete is one of the major research areas in the field of concrete research. There is lot of research is going on in this area past three to four decades and its continuing. In the early ages the steel fibers are used as reinforcing material. Fiber reinforced concrete (FRC) is primarily used for the rigid pavements. At present FRC is using in all the areas including bridges, water retaining structures, retaining walls, Manhole covers and prestressed concrete etc. Hybrid reinforcing materials in the concrete i.e. steel and glass fibers are giving the good results in load carrying capacity, ductility and serviceability [1]. Vasudevan et al [2] investigated by using solid waste material in the concrete pavements. Solid waste means waste tyres, plastic waste, municipal solid waste etc. Stone aggregate is coated with the molten waste plastics. The coating of plastics reduces the porosity, absorption of moisture and improves soundness. The polymer coated aggregate bitumen mix forms better material for flexible pavement construction as the mix shows higher Marshall Stability value and suitable Marshall Coefficient. Ali R. Khaloo and Majid Afshari Influence of length and volumetric percentage of steel fibers on energy absorption of concrete slabs with various concrete strengths is investigated by testing 28 small steel fiber reinforced concrete (SFRC) slabs under flexure. Test results indicate that generally longer fibers and higher fiber content provide higher energy absorption [3]. Avinash and suresh [4] tested steel fiber reinforced concrete beams for bending, shear and torsion without web reinforcement. Mechanical properties of fiber reinforced light weight concrete composites studied by perez-pena and mobasher [5]. They have used Polyvinyl Chloride (PVC), Polypropylene (PP) and alkali resistant glass is used as fibers in the concrete. They found that the significant improvement in the cracking strength and load carrying capacity by using the fibers in concrete. Alsayed, Al-Salloum and Almusallam [6] studied the performance of glass fiber reinforced plastic bars as reinforcing materials for concrete. The flexural strength of modified concrete is more compared to conventional concrete. Karim et al., [7] studied the structural behavior of polymer concrete beams using polyethylene terephthalate (PET) fibers in the concrete. They found that the beams exhibited higher strength and more ductility than conventional concrete beams. M_{30} concrete is used for the present study. Modified concrete is prepared with 0.5% increment of HDPE fibers starting from 0 to 6% by volume. Cubes, cylinders and beams are prepared for finding the compressive, split tensile and flexural

strengths of both conventional and modified concretes at the ages of 7 and 28days.

Cement: In these experimental investigations ordinary Portland cement 43 grade used. The chemical composition and physical properties of cement is given in the below table.

Table 1 Properties of cement

Properties	Test Results	Limits as per IS8112-1989
Fineness (M^2/Kg) (Specific Surface)	262	225 minimum
Setting Time (Initial)	58	30
Setting Time (Final)	296	600
Sound Ness By Lechatelier By Auto Clave	 3.3 0.1	 10mm 0.8%
Compressive strength 3 days 7 days 28 days	 28.6 39.8 50.7	 23MPa 33MPa 43MPa

Fine Aggregate: The size of the aggregate is below 4.75mm. The most important function of the fine aggregate is to assist in producing workability and uniformity. In this investigation locally available river sand is used which is free from organic impurities. The specific gravity of this fine aggregate was found to be 2.65 and the fineness modulus was 2.87. The percentage of passing is within the limits as per IS383-1970 [8] and IS 2386-1963[9]. Sand is confirming to zone II.

Table 2 Sieve analysis of Fine aggregate

IS Sieve	Weight retained	%of weight retained	Cumulative %of weight retained	% of passing
10	0	0	0	100
4.75	54	5.4	5.4	94.6
2.36	87	8.7	14.1	85.9
1.18	121	12.1	26.2	73.8
600	286	28.6	54.8	75.2
300	325	32.5	87.3	12.7
150	123	12.3	99.6	0.4
Total cumulative % of weight retained			287.4	

Coarse Aggregate: The coarse aggregate used here is 20mm in size, crushed angular shape and free from dust. The specific gravity and fineness modulus was found to be 2.82 and 7.03 respectively. The percentage of passing is within the limits as per IS383-1970[8] and IS 2386-1963[9].

Table 3 Sieve analysis of Coarse aggregate

IS Sieve	Weight retained	%of weight retained	Cumulative % of weight retained	% of passing
40	0	0	0	100
20	1850	18.5	18.5	81.5
10	6590	65.9	84.4	15.6
4.75	1560	15.6	100	-
2.36	-	-	100	-
1.18	-	-	100	-
600µ	-	-	100	-
300µ	-	-	100	-
150µ	-	-	100	-
Total cumulative % of weight retained			702.9	

Water: water to be used in the concrete work should be free from oils, acids, alkalies and other organic and inorganic impurities.

Table 4 Properties of Water

S. No	Parameter	Results	Limits IS: 456[12]
1	pH	6.92	6.5 – 8.5
2	Chlorides	52 mg/l	2000 mg/l (PCC) 500 mg/l (RCC)
3	Alkalinity	7 ml	< 25ml
4	Sulphates	128 mg/l	400 mg/l
5	Florides	0.04 mg/l	1.5 mg/l
6	Organic Solids	56 mg/l	200 mg/l
7	Inorganic Solids	129 mg/l	3000 mg/l

High density Polyethylene Fiber (HDPE): HDPE is a linear polymer with the chemical composition of polyethylene and defined by ASTM D1248-84 [10] as a product of ethylene polymerization with a bulk density of 0.96gm/cm^3 or higher.

Table 5 Properties of HDPE Fiber

S. No	Test	Result
1	Tensile breaking load at yield	66.89Kg
2	Tensile breaking load at break	2.87Kg
3	Tensile elongation at break	25.86%
4	Identification	High Density Polyethylene

MIX PROPORTIONS

The concrete mix is designed as per IS 10262 – 1982 [11], IS 456-2000 [12] and SP23 [13] for the normal concrete. Finally 0 to 6% of HDPE fibers will be adding the concrete. The water cement ratio is 0.42. The mix proportions of M30 concrete are 1:2.05:3.38.

MIXING AND CASTING

By using pan mixer, mix all the ingredients of concrete. Care should be taken while mixing of the fibers so that the uniform dispersion of fibers and prevent the segregation or balling of the fibers. The present experimental investigation of HDPE fiber includes testing of specimens for compressive, split tensile and flexural strengths. Specimens are prepared using design mix with HDPE percentages starting from 0 to 6% with an increment of 0.5 by volume of concrete. Cubes 150 X 150 X 150 mm, cylinders with 150φ X 300mm and beams of size 100X100X500 mm are prepared. The samples are kept in a sump for curing.

RESULTS AND DISCUSSIONS

Compaction factor test has been used for finding the workability of the concrete. This test has conducted in the room temperature. In this test compaction factor is gradually increasing. At 2% fiber maximum compaction factor attained for HDPE fiber. The results are shown in fig.1.

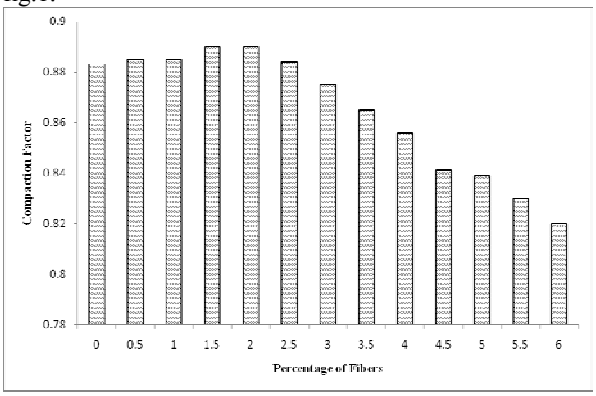

Fig. 1 Compaction Factor test results

The compressive strength and split tensile strength of concrete at the age of 7 and 28 days with percentages of fiber varying from 0 to 6%. The compressive strength and split tensile strength of concrete is increasing as the fiber content increases up to 3.5% and the strength is decreasing as the fiber content increases from 3.5 to 6%. The results are presented in the fig. 2 and 3.

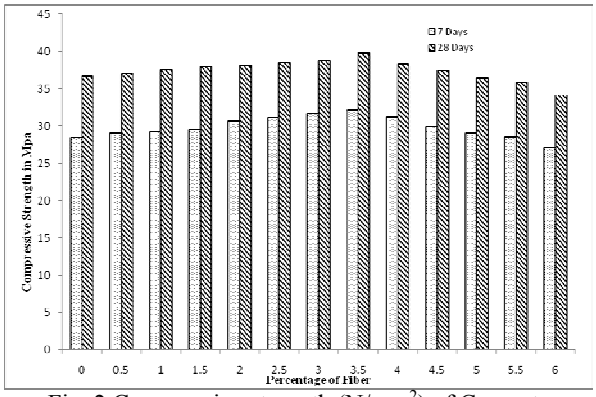

Fig. 2 Compressive strength (N/mm^2) of Concrete

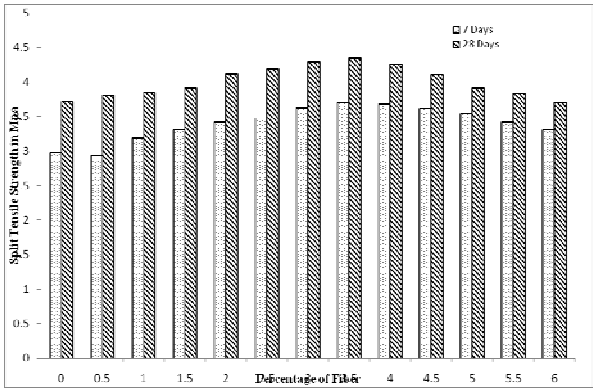

Fig. 3 Split Tensile strength (N/mm^2) of Concrete.

The experimental setup for the Flexural strength of concrete is shown in the fig.4. Concrete beam has tested using 40KNcapcity load frame.

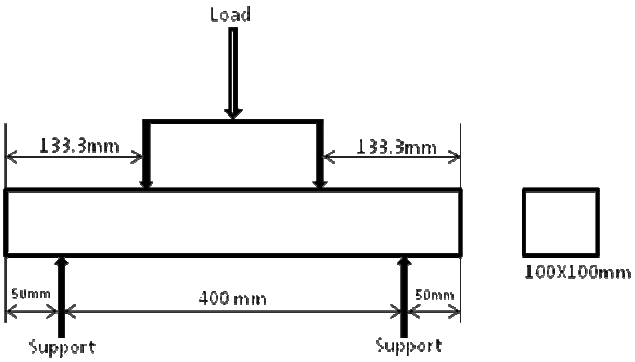

Fig. 4 Experimental setup for the flexural test

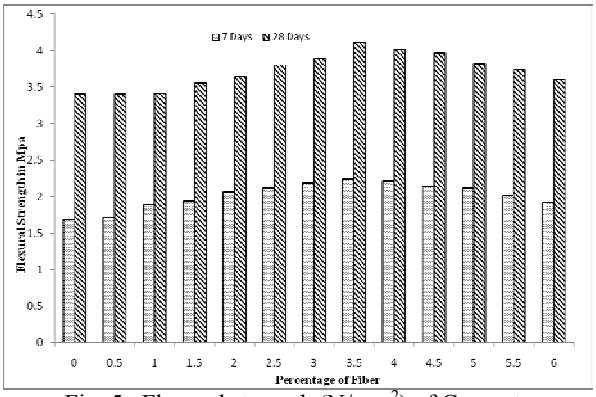

Fig. 5. Flexural strength (N/mm^2) of Concrete

Similarly as the percentage of fiber increases the load carrying capacity in flexure is increases up to 3.5%. Beyond this flexural strength is reducing. The maximum flexural strength of concrete at 3.5% of fiber is 4.12N/mm^{2}at the age of 28 days. The results are shown in fig.5.

CONCLUSIONS

From the experimental investigation, solid waste can be used in the concrete for the strength and disposal point of view. The load carrying capacity of the concrete is increased by using solid waste fibers. Maximum of 2% of fibers can be used for the strength purpose and up to 6% of fibers can be used for disposal purpose. Maximum compressive strength, split tensile strength and flexural strength are 39.85, 4.35 and 4.12 M Pa respectively.

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