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Experimental Study on Strength Properties of Steel Fibre Reinforced Concrete

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Abstract:

This paper is a part of an experimental research to determine the properties of steel fibre reinforced concrete by using fibres. Fibres impart energy absorption, toughness and impact resistance properties to fibre reinforced concrete material and these characteristics in turn improve the fracture and fatigue properties of fibre reinforced concrete research in glass fibre reinforced. In the present experimental investigation the alkali resistance glass fibres has been used to study the effect on compressive, split tensile and flexural strength on different grades of concrete.

INTRODUCTION:

Plain concrete which is strong in compressive strength possesses a very low tensile strength, limited ductility and little resistance to cracking. The low resistance to tensile crack propagation intern results in low fracture toughness, limited resistance to impact and explosive loading. Internal micro cracks are inherently present in the concrete due to drying, shrinkage and poor tensile strength, eventually leading to brittle fracture of concrete. Hence fibers are added to concrete to overcome these disadvantages.

FIBRE REINFORCED CONCRETE (FRC):

Fiber reinforced concrete (FRC) is a concrete composite of cement, fine and coarse aggregate and fibers with different proportions.

TYPES OF FIBRE:

The fibers can be broadly classified into two groups
1. Low modulus, high elongation fibers
2. High Strength, high modulus fibers

LOW MODULUS, HIGH ELONGATION FIBERS:

Nylon, polypropylene, plastic are some of the low modulus high elongation fibers which are capable of large energy absorption characteristics. They do not lead to strength improvement but impart toughness, resistance to impact and explosive loading.

HIGH STRENGTH, HIGH MODULUS FIBERS:

High Strength, high modulus fibers are Glass, Carbon and Steel. These fibers impart primary characteristics of strength and stiffness to composite and varying degrees of dynamic properties.

Fibre Material	Tensile Strength (10^3N/mm^2)	Young's Modulus (10^3N/mm^2)	Specific Gravity
Steel	275-2758	200	7.86
Glass	1034-3792	69	2.5
Asbestos	551-965	89-138	3.2
Nylon	758-827	4.31	1.1
Polypropylene	551-758	3.45	0.90

Table 1: Types of Fibers and its properties.

STEEL FIBERS:

Out of all types of fibers, Steel Fibers are mostly used because steel has high modulus of elasticity, high elongation, high tensile strength and the bond between steel and the fiber is enormous. Different types of steel fibers being shown in figure 1.2.

Rounded, straight steel fibers are produced by cutting or chopping wire, typically having diameter between 0.25mm and 1.0mm. Flat, straight steel fibers having typical cross sections ranging from 0.15mm to 0.41mm thickness by 0.25mm to 1.14mm width are produced by shearing sheet or flattening wire.

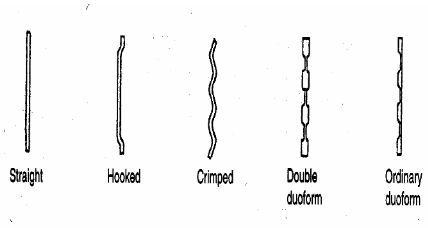

Fig 1.2 Types of steel fibers

ORIENTATION OF FIBERS:

One of the differences between conventional reinforcement and fiber reinforcement is that in conventional reinforcement, steel bars are oriented in the direction desired while fibers are randomly oriented.The fibers alignment parallel to the applied load gives more tensile strength and toughness than randomly distributed or perpendicular fibers.

FIBERS:

Locally available Mild Steel binding wire is cut into smaller lengths based on the required Aspect Ratio.
Diameter of the binding wire was determined by using Digital Screw Gauge.
Its value was found to be 0.91mm
Aspect Ratio = L/d (where, dia of wire = 0.91mm)
For l/d = 60, L = 5.46 cm
For l/d = 50, L = 4.55 cm
The tensile strength of steel fiber is 461.42 N/mm2, determined by using Tensometer (Fig 3.1)

Fig 3.2 Steel Fiber

SAMPLE CALCULATIONS FOR MIX TYPE 1

Table 4.1 Sample Calculations for MIX 1

S. NO	Material	Vol of 50 kg cement bag in cu.m	Material for cu.m of concrete (kg)
1	Cement	50/(3.0.7*1000) =0.01628	50/0.13163=379.85
2	Water	(50*0.4)/1000 =0.0200	(50*0.4)/0.13163 =151.94
3	Coarse Agg	(50*5*0.6)/(1000*2.65) =0.05660	(50*5*0.6)/0.13163 =1139.55
4	Fine Agg	(50*5*0.4)/1000*2.58 =0.03875	(50*5*0.4)/0.13163 =759.70
5	Total	0.13163	

Quantities required for 3 cubes, 3 cylinders and 3 beams:
Volume of concrete required for 3 cubes = 3×0.15×0.15×0.15 = 0.010125cu.m
Volume of concrete required for 3 cylinders = = 0.015904 cu.m
Volume of concrete required for 3 beams = 0.1×0.1×0.5×3 = 0.015 cu.m
Total volume of concrete = 0.041029 cu.m
Quantity of coarse aggregate required for 0.041029cu.m of concrete = 0.041029×1139.55 = 46.75 kg
Quantity of fine aggregate required for 0.041029cu.m of concrete = 0.041029×759.70 = 31.17 kg
Quantity of fiber required for 0.75 % of volume = 0.041029×7850 = 2.4155 kg
Quantity of fiber required for 1% of volume = 0.01×0.041029×7850 = 3.22 kg
Quantity of cement required for 0.041029cu.m of concrete = 0.041029×379.85=15.58 kg
Quantity of water required for 0.041029cu.m of concrete = 0.041029×151.94 = 6.23 kg
Quantity of fiber required for 1.5% of volume = 0.015×0.041029×7850 = 4.83 kg

4.2 CASTING :

Following sizes of moulds were used for casting cubes, beams & cylinders
Cubes of 150X150X150mm.
Cylinders of 150mm diameter and 300mm height.
Flexural beams of 500X100X100mm.

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TEST RESULTS OF THE SFRC

S. NO	ID MARK	W/C RATIO	L/D RATIO	A/C RATIO	% FIBRE	COMPACTION FACTOR	AVERAGE COMPRESSIVE STRENGTH N/MM²	SPLIT TENSILE STRENGTH N/MM²	FLEXRURAL STRENGTH N/MM²
01	P1	0.40	50	5	0	0.873	31.550	2.050	3.500
02	F1				0.75	0.817	36.440	2.9	3.765
03	F2				1.0	0.787	35.105	3.110	3.820
04	F3				1.5	0.781	38.440	3.460	4.440
05	P2	0.45	50	5	0	0.903	30.215	1.620	2.980
06	F4				0.75	0.898	32.98	2.82	3.170
07	F5				1.0	0.867	34.98	3.030	3.670
08	F6				1.5	0.825	37.99	3.320	3.450
09	P3	0.50	50	5	0	0.940	25.215	1.200	2.590
10	F7				0.75	0.894	29.770	2.750	3.670
11	F8				1.0	0.840	29.550	2.820	3.980
12	F9				1.5	0.813	30.440	2.90	3.860
13	P1	0.4	60	5	0	0.873	31.550	2.050	3.500
14	E1				0.75	0.872	34.220	2.960	3.760
15	E2				1.0	0.842	40.220	3.320	3.770
16	E3				1.5	0.774	42.44	4.170	4.180
17	P2	0.45	60	5	0	0.903	30.215	1.620	2.980
18	E4				0.75	0.873	31.55	2.61	3.4
19	E5				1.0	0.849	35.33	3.26	3.82
20	E6				1.5	0.788	37.99	3.54	4.04
21	P3	0.5	60	5	0	0.940	25.215	1.200	2.590
22	E7				0.75	0.874	27.1	2.82	3.5
23	E8				1.0	0.865	30.22	3.03	3.57
24	E9				1.5	0.848	29.33	3.36	3.79

CONCLUSIONS:

Under the limitation of the experimental work, the following conclusions are made

SFRC MIXES WITH ASPECT RATIO 50 AND AGG-CEM RATIO 5:

1.Maximum increase in compressive strength obtained at 0.45 w/c ratio with 1.5% of fiber is 37.99 N/mm2 which is 25.73% more than the reference mix.

2.Maximum increase in split tensile strength obtained at 0.5 w/c ratio with 1.5% of fiber is 2.9 N/mm2 which is 141.67% more than the reference mix.

3.Maximum increase in flexural strength obtained at 0.5 w/c ratio with 1.5% of fibers is 3.86 N/mm2 which is 49.03% more than the reference mix.

SFRC MIXES WITH ASPECT RATIO 60 AND AGG-CEM RATIO 5:

1.Maximum increase in compressive strength obtained at 0.45 w/c ratio with 1.5% of fiber is 42.44 N/mm2 which is 34.516% more than the reference mix.

2.Maximum increase in split tensile strength obtained at 0.5 w/c ratio with 1.5% of fiber is 3.36 N/mm2 which is 180% more than the reference mix.

3.Maximum increase in flexural strength obtained at 0.5 w/c ratio with 1.5% of fibers is 3.79 N/mm2 which is 46.33% more than the reference mix.

The increase in volume of % of fibers increases compressive, split tensile and flexural strength in the ranges tested, however with the increase in fiber volume, the workability of mix decreases.The relation between strength parameters, w/c ratio, % of fibers of SFRC is non-linear.

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