EXPERIMENTAL STUDY AND INVESTIGATION ON BEHAVIOUR OF POLYPROPYLENE AND CRIMPED STEEL FIBER IN CONCRETE

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ABSTRACT

Both steel and polymeric fibers have been used to reinforced concrete and consequently increase its toughness and crack resistance. Fiber reinforced concrete can be used in some structural applications with a reduced amount or even without any conventional reinforcement. One of the application for fibers is to increase the load-carrying capacity of concrete subjected to shear. Several design methods have been proposed to increase the shear strength due to fibers. Each of the methods accounts for the fiber contribution by means of an index based on the toughness of the material. However, each formula uses a different index, obtained from different types of test configurations. Thus the application of the design methods can be difficult. Moreover, most of the design methods and test procedures have been developed only for the evaluation of steel fiber reinforced concrete.

Keywords— Reinforced concrete, Crimped steel fiber, Polypropylene fiber, Strength and Durability, Application.

I. INTRODUCTION

Concrete mixture design is vast and generally based on performance criteria. The wet mixture used was prepared first without the fibers. The slump of the concrete before fiber addition should be (50 to 76 mm) greater than the final slump desired. Normally, the mixture would be prepared using the water-cement ratio found to give the best results and meeting the specifications of the research. The use of high-range water-reducing admixture can be advantageous, but was not essential. With the mixes operating at normal charging speed, add the individual fibers, ball-free to the mixer.

After all the required fibers were introduced into the mixer, the mixer should be slowed to the rated mixing speed and mixed for approximately 10 to 15 revolutions to obtain the uniform concrete mix.

II LITERATURE SURVEY

WAI HOE KWAN [1]investigated the "Flexural strength and impact resistance study of fiber reinforced concrete in simulated aggressive environment" They concluded that it is a new method of measuring impact energy absorption of FRC panels. Ductile and high tensile strength properties of BF have contributed to the highest degree of improvements on flexural and impact resistance performance of concrete compared with coconut fiber and glass fiber.

SOON POH YA [2] discussed about the "Flexural toughness characteristics of steel–polypropylene hybrid fiber-reinforced oil palm shell concrete" They concluded that the addition of 1% steel fiber and 0.9% steel and 0.1% PP hybrid fibers enhanced the compressive and tensile strengths of the OPSFRC significantly splitting tensile and flexural strengths showed an improvement by up to 83% and 34% for the mixes with 0.9% steel fiber and 0.1% PP hybrid fiber.

NEMKUMAR BANTHIA [3] investigated the "Sustainable fiber reinforced concrete for repair applications" They concluded that it is able to bond properly with the old concrete and restore structural integrity and it is durable and is able to withstand severe climatic conditions and then, it has chemical, electrochemical, permeability and dimensional compatibility with the old substrate being repaired.

GONZALO RUANO [4] discussed about the "Shear retrofitting of reinforced concrete beams with steel-fiber reinforced concrete" They concluded that the fiber reinforced concrete improves structural properties, and moreover, the compatibility between the base and the retrofitting materials but thinner cracking pattern, prevents the income of aggressive agents increasing the durability of the reinforcement.

FLORES MEDINA.N [5] investigated the "Enhancement of durability of concrete composites containing natural pozzolans blended cement through the use of Polypropylene fibers" They concluded that PPF showed early age cracking control ability, reducing the total cracked area and the length of cracks. The maximum cracking control ability among the fiber VF tested was measured for mixtures with 600 g/m3of PPF (0.07% fiber VF).Larger amounts of PPF did not improve cracking 2ontrollability and the reduction of cracked area measured at the exposed concrete surface has been more decisive than the internal porous structure.

CUENCA.E [6] reported the "Shear behavior of prestressed precast beams made of self-compacting fiber reinforced concrete" They concluded that Steel fibers positively interact with traditional transverse reinforcement (additive effect).These results are in agreement with the fact that the flange factor in shear (k_f) does not vary for b_f> 400 mm, according to RILEM.

CHEN G.M [7] investigated the "Compressive behavior of steel fiber reinforced recycled aggregate concrete after exposure to elevated temperatures" They concluded that the normal concrete (NC), color change was observed on the surface of RAC specimens after exposure to 200C, 400C and 600C due to chemical and physical changes and then theeffects of elevated temperature on the degradation mechanism of steel fiber reinforced RAC (SFRAC) and how the inclusion of the steel fiber contributes to alleviate the degradation should be further studied by examining the change in the microstructures of concrete in the future.

Advantages of Polypropylene Fibers

- Increases abrasion resistance by over 40% thereby increasing life of roads.
- Reduces pitting of floor.
- Improved long-term serviceability of the structure or product.
- High ductility.
- Prevents the occurrence of large crack widths.
- Increases matrix tensile strength at high volume percentages of fibers.
  Results in saving of expansive mortar, cement and sand.

Advantages of Crimped Steel Fibers

- Target Crimped Steel Fiber Concrete can give comparable performance at a lower cost or improved performance at a slight increase in cost when compared to conventionally reinforced concrete.
- Concrete volume requirements may be reduced.
- Improved toughness.
- Greatly improved impact, fatigue, and spall resistance.
- Resistance to salt scaling equal to or better than that of regular concrete.
- Increased flexural strengths.

III MIX DESIGN

In this experimental investigation 0.4,0.7 and 1.0 percentage of fiber volume fraction is used in M25 mix.

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Fiber Reinforced Concrete Mixture

Concrete mixture design is vast and generally based on performance criteria. Based on the information given above, some simple guidelines for the design of fiber reinforced concrete.

The wet mixture used was prepared first without the fibers. The slump of the concrete before fiber addition should be (50 to 76 mm) greater than the final slump desired. Normally, the mixture would be prepared using the water-cement ratio found to give the best results and meeting the specifications of the research. The use of high-range water-reducing admixture can be advantageous, but was not essential. With the mixes operating at normal charging speed, add the individual fibers, ball-free to the mixer. After all the required fibers were introduced into the mixer, the mixer should be slowed to the rated mixing speed and mixed for approximately 10 to 15 revolutions to obtain the uniform concrete mix.

Mixture Proportion

Mixture proportions of fiber reinforced concrete with and without ferrous and non-ferrous fibers with the design compressive strength of M25 Mpais used in this investigation. OPC conforming to IS 4031-1998was used. The bulk density of cement was taken as 1440 Kg/m^3. No industrial by-product was incorporated. The combined aggregate was selected to match the standard grading curves used in the design of Ordinary Portland Cement concrete mixtures. For instance, the aggregate may comprise 817.13 Kg/m^3 (60%) of 20mm aggregates, 544.75 Kg/m^3 (40%) of 12.5mm aggregates and 425.7 Kg/m^3 of fine aggregate to meet the requirement of standard grading curves. The water-cement ratio was 0.45. Initially (0.4%,0.7 % and 1.0%)percentage of fiber volume fraction was incorporated in cubes, cylinders and prisms.

IV STRENGTH TEST

Cube Compressive Strength Test

Sl.no	Design mix	Type of fibers added	Percentage of fibers added	Avg. compressive strength @ 7 days	Avg. compressive strength @ 28 days
1.	M25	Nil	Nil	17.44	26.05
2.	M25	CSF	0.4	18.47	27.61
3.	M25	PF	0.4	18.16	27.50
4.	M25	CSF	0.7	20.84	30.72
5.	M25	PF	0.7	20.38	30.17
6.	M25	CSF	1.0	17.48	28.95
7.	M25	PF	1.0	16.90	26.43

Experimental set up of Compressive Strength Test

Tensile Strength Test

Experimental set up of Split Tensile Strength Test

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Sl.no	Design mix	Type of fibers added	Percentage of fibers added	Avg. tensile strength in Mpa @ 7 days	Avg. tensile strength in Mpa @ 28 days
1.	M25	Nil	Nil	1.96	2.94
2.	M25	CSF	0.4	2.43	3.42
3.	M25	PF	0.4	2.21	3.08
4.	M25	CSF	0.7	2.54	3.59
5.	M25	PF	0.7	2.49	3.45
6.	M25	CSF	1.0	2.28	3.39
7.	M25	PF	1.0	2.16	3.26

Flexural Strength Test

Sl.no	Design mix	Type of fibers added	Percentage of fibers added	Avg. flexural strength in Mpa @ 7 days	Avg. flexural strength in Mpa @ 28 days
1.	M25	Nil	Nil	2.08	3.56
2.	M25	CSF	0.4	2.72	4.2
3.	M25	PF	0.4	2.16	3.71
4.	M25	CSF	0.7	2.96	4.91
5.	M25	PF	0.7	2.76	4.72
6.	M25	CSF	1.0	2.26	3.92
7.	M25	PF	1.0	2.00	3.64

Flexural strength test on prism

V TEST RESULTS AND DISCUSSIONS

The structural-scale beams were tested under shear loading through the two-point load configuration, with a shear span to depth ratio equal to 2.67. The smaller anchorage length provided for the longitudinal reinforcement did not allow the development of arch effect, which caused failure by debonding of the flexural reinforcement in the case of beams without conventional shear reinforcement.

The typical load-deflection responses, where the shear ductility increase induced by fiber action is appreciable. In SFRC beams, the maximum load is higher by approximately 40% of that of RCC Beam with minimum stirrups, with increase the deflection at maximum load. An increase of ductility under shear loading can be clearly observed for all FRCs with respect to RCC Beam with minimum stirrups, indicated by the significant increase in the deformability of the elements at maximum load.

Nevertheless, the load carrying capacity of beams reinforced with fibers is always lower than that of the beams with the same volume of steel in the form of stirrups. This is attributed to the distributed nature of the fiber reinforcement where only some fibers are favorably oriented to resist cracking, whereas all the stirrups actively prevent crack opening.

Load and Displacement values for SFRC beam.

Sl.no.	Load in KN	Displacement in mm (at point 1)	Displacement in mm (at centre)	Displacement in mm (at point 2)
1.	8.24	0.36	0.37	0.36
2.	16.45	0.82	0.84	0.78
3.	24.67	1.07	1.12	1.03
4.	32.94	1.75	1.90	1.70
5.	41.00	2.29	2.50	2.22
6.	49.30	2.94	3.20	2.85
7.	57.40	3.81	4.25	3.68
8.	65.15	4.55	5.07	4.39
9.	72.73	5.55	6.20	5.40
10.	70.00	6.28	7.10	6.25
11.	68.50	8.00	10.25	8.25

Load and Displacement values for PFRC beam

Sl.no.	Load in KN	Displacement in mm (at point 1)	Displacement in mm (at centre)	Displacement in mm (at point 2)
1.	8.24	0.45	0.54	0.39
2.	16.45	0.86	0.82	0.72
3.	24.67	1.09	1.09	1.04
4.	32.94	1.89	2.0	1.76
5.	41.00	2.23	2.43	2.11
6.	49.30	2.60	2.90	2.51

7.	57.40	3.60	4.04	3.51
8.	65.15	4.32	4.87	4.24
9.	63.00	5.20	6.70	5.60
10.	61.50	8.60	9.80	8.80

VI CONCLUSION

It has been observed that the incorporation of fibers to the mix increases the material toughness both in tension and compression, as represented by the toughness indexes of the ASTM and JSCE standards.

COMPRESSIVE STRENGTH

- Compressive strength concrete increased at 28days as compared with control mix.
- There is an increase of 17.5% using CSF (0.7%) with control mix and also there is an increase in 15.8% strength using PF (0.7%).

SPLIT TENSILE STRENGTH

- Increase in the split tensile strength is observed up to 22% using CSF (0.7%) and 17.3% using PF (0.7%)compared to normal concrete.

FLEXURAL STRENGTH

- The Flexural strength results for concretes is also increased as below
  - 38% using CSF (0.7%)
  - 32.5% using PF (0.7%)
- First crack occurs earlier in PFRC when compared to SFRC.
- In SFRC beams, the maximum load increased by approximately 20% of the plain concrete.
- The length and width of the crack is reduced due to the incorporation of fibers in the concrete.

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