FLEXURAL FATIGUE BEHAVIOR OF RECRON FIBER REINFORCED CONCRETE

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ABSTRACT

This paper presents the experimental investigation carried on Recron Fiber Reinforced Concrete subjected to flexural fatigue failure. The beam specimen of size 700mm x 150mm x 150mm is used Recron fibers of size 12mm length in 0.5%,1%,1.5%,2%,2.5%,3%,3.5%,4%,4.5% ,5%and 6% volume are used in M25 grade concrete.

I. INTRODUCTION

The mechanics of fatigue failure of brittle materials, such as concrete and mortar, is a complex process. A fatigue failure mechanism for concrete or mortar develops in three stages. The first comprises of initiation of flaws or cracks followed by second stage of slow growth of flaws or cracks to a critical size. In the last stage, rapid propagation of the flaws or cracks of a critical size takes place. In a large volume of concrete or mortar all the three stages would be active at any instant of time; however, for a sufficiently small volume the above three stages are sequential.

Fiber reinforced concrete is a relatively new structural material developed through extensive research and development during the last three decades. It has already found a wide range of practical application and has proved a reliable structural material having superior performance characteristics compared to conventional concrete. Due to this benefit, the use of FRC has steadily increased during the last two decades and its current field of application includes: airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, bridge deck overlays, hydraulic structures, etc. Concrete is one of the most versatile building materials. It can be cast to fit any structural application. It is readily available in urban areas at relatively low cost. Concrete is strong under compression yet weak under tension. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance and long service life. Several earthquakes in recent years throughout the world have prompted the structural engineering community to pursue considerable research on the behaviour of structures under seismic loading. One area of research has been to improve the design of conventional reinforced concrete for better performance under seismic shaking. Another potential area of research, believed by many structural engineers as more appropriate is to develop innovative composite materials with improved seismic performance. One such new structural material is the fiber reinforced concrete (FRC).

FRC is a composite material made of hydraulic cement, aggregates and small diameter, short length randomly distributed fibers. It may also contain mineral admixture and chemical admixture commonly used with conventional concrete. Addition of these fibers significantly improves many of the engineering properties of mortar and concrete. Moreover, fibers when introduced into concrete make it more homogeneous and isotropic and transform it to a more ductile material. When concrete cracks, the randomly distributed fibers arrest the micro cracking mechanism and limit the crack propagation thus improving the strength and ductility. The extent of improvement depends on the type, aspect ratio and volume fraction of fibers as well as the quality of concrete mix.

Recron 3S prevents the micro shrinkage cracks developed during hydration, makingthe structure/plaster/component in herently stronger. Further, when the loads imposed on concrete approach that of failure cracks will propagate, sometimes rapidly. Addition of Recron 3 s to concrete and plaster arrests cracking caused by volume change (expansion and contraction), simply because 1 kg of Recron 3s offers millions of fibers which support mortar/concrete in all directions. The modulus of elasticity of Recron 3s is high with respect to the modulus of elasticity of the concrete or mortar binder. Recron 3s fiber helps in increasing flexural strength. The post cracking behavior has shown its ability to continue to absorb energy as fibers pull out.

1.1 Advantages of Recron Fiber

- Improve homogeneity of the concrete by reducing segregation of aggregates
- Reduce shrinkage crack
- Increases compressive, Flexural and Tensile Strength.
- Reduce water permeability
- Improves ductility of concrete under cyclic loading
- Increases freeze/thaw resistance
- Improves durability of the concrete
- Replaces or reduces " Non Structural Steel" in floors, roads and pavements and concrete overlays i.e. slab on grade

II. LITERATURE REVIEW

It is reported that fatigue strength of 74% and 83% of the first crack static flexural strength at 2 million cycles of completely reversal and non-reversed loads respectively for a steel fiber content of 2.98% by volume (Batson et al., 1972).[1]

Behavior of steel fiber mortar overlaid concrete beams under cyclic loading was investigated (Wei et al., 1996) whereas the behavior of composite concrete sections reinforced with conventional steel bars and steel fibers, and subjected to flexural cyclic loading was analyzed (Spadea and Bencardino, 1997) and mechanical model of the same was developed.[2]

A paper (Jun and Stang, 1998) reported that the accumulated damage level in fiber reinforced concrete in fatigue loading was 1~2 order of magnitude higher than the level recorded in static testing of the same materials.[3]

III. MATERIALS

It is necessary to get the maximum performance out of all of the material involved in producing a concrete. The materials involved in this project are Portland cement, coarse aggregate, fine aggregate. The additional material involved in this project is Triangular Polyester Fiber-Recron Fiber.

3.1 Cement

The cement used for this investigation was OPC 53 grade Binani cement. The specific Gravity of the cement was found 3.15 and it is conforming to IS 12269-1987.

3.2 Fine Aggregate

The fine aggregate used for all the specimens was complying with IS 383-1970. The specific gravity of fine aggregate was 2.63, sieve analyses were conducted and it was found that the sand used was conforming to Zone II grading. The fineness modulus of fine aggregate was 2.82.

3.3 Coarse Aggregate

The coarse aggregate used was hard broken stone drawn from an approved quarry. Mean size of 20mm and nominal size of 10 mm aggregate were used. The specific gravity of 20 mm coarse aggregate was 2.86. And 10 mm aggregate were 2.84. And it was confirming to IS 383-1970.

3.4 Water

Portable water available in the laboratory was used for casting all the specimens in this investigation. The quality of water was found to satisfy the requirements of IS 456-2000.

3.4 Recron Fiber

The fiber used is a 12 mm long, with an Aspect ratio of 240. For a mean sized aggregate of 20 mm, 12mm fiber length is adequate. Tensile strength is 4000-6000 Kg/Cm2.

Figure 1: Recron Fiber

3.5 Mix Design

In this study, Indian Standard recommended Method (IS 10262-2009) has been adopted for mix Design.

Table 1: Material Specification

S. No.	Material	Name of Property	Experimental result
1	Cement	Specific gravity	3.15
		Fineness of cement	8%
		Initial setting time	115
		Standard consistency	34%
		Final setting time	240
2	Fine aggregate	Specific gravity	2.63
		Grading	Zone II
		Water absorption	1.25
		Fineness modulus	2.82
3	Course aggregate	Specific gravity	2.86

		Water absorption	0.58%
4	Recron Fiber	Specific gravity	1.35
		Length (mm)	12
		Diameter (mm)	0.05
		Aspect ratio	240

The mix proportion adopted for concrete is 1:1.886:3.068 with W/C ratio of 0.5 for a desired slump of 75mm-100mm. The volumes of fiber added from 0.5% to 5% weight of cement. Casting of 66 concrete beams (15cm x 15cm x 70cm) using Recron fibers in the concrete for determining flexural strength of concrete.

3.6 Testing

One normal concrete beam of size (700mmX150mmX150mm) is casted in the mould and kept to cure for 24 hours. It is then unmolded and kept in water tank for 28 days. After 28 days, the beams would be tested for their flexural strength in the following method. The bed of the testing machine should be provided with two steel rollers, 38mm in diameter on which the specimen is to be supported. This rollers should be so mounted that the distance from centre to centre is 60 mm for 150 mm specimen.

The bearing surfaces of the supporting and the loading rollers shall be wiped, clean and any loose sand or other material should be removed from the surfaces of the specimen where they are to make contact with the rollers.

Two points loading can be conveniently provided by the arrangement as shown in figure. The load is transmitted to through a load cell and spherical seating on to a spreader beam. This beam bears on rollers seated on steel plated bedded on the test member with mortar, high strength plaster or some similar material. The test member is supported on the roller bearings acting on similar spreader plates. The loading frame must be capable of carrying the expected test load
without significant distortions.

Ease of access to the middle third for crack observations, deflection readings and possibly strain measurement is an important consideration, as is safety when failure occurs.

The specimen was placed over the two steel rollers bearing of 50 mm left from the ends of the beam. The remaining 600 mm was divided into three parts of 200 mm each as shown in the figure. Two point loading arrangement was done as shown in the figure. Loading was done by the hydraulic jack of capacity 600 KN. At the centre one dial gauges were used for recording the
deflection of the beams.

Figure 2 : Beam Testing Setup

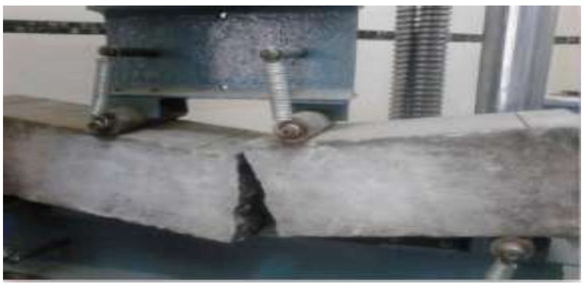

Figure 3 : Beam After Two Point Loading

IV. RESULT ANALYSIS

Table 2 Test Result for Flexural Strength (IS 516-1959)

Sr.No	% of	Load in KN		Avg.Braking Dist. in mm	Flexural Strenth N/mm
		No.			
1	0%	1	29.86	248.33	5.36
		2	30.86		
		3	29.57		
2	0.5%	1	35.55	240.00	6.46
		2	37.25		
		3	34.14		
3	1%	1	32.90	258.33	5.96
		2	32.20		
		3	34.14		
4	1.5%	1	35.25	271.66	6.74
		2	38.21		
		3	38.80		
5	2%	1	37.51	266.67	6.68
		2	38.46		
		3	35.35		
6	2.5%	1	35.37	278.33	6.83
		2	40.67		
		3	37.78		
7	3%	1	38.06	266.67	7.62
		2	42.56		
		3	47.85		
	3.5%	1	40.42	253.33	
		2	50.53		
		3	47.85		
8	4%	1	44.13	250.00	8.60
		2	53.15		
		3	48.78		
	4.5%	1	49.26	261.00	
		2	56.30		
		3	49.15		
9	5%	1	55.34	253.33	9.82
		2	59.13		
		3	50.95		
10	6%	1	73.86	263.33	12.81
		2	74.68		
		3	67.30		

From the result I can obtain the percentage of Recron fibers to be added to attain the required flexural strength i.e. 10% increase in flexural strength compared to normal concrete.

Table 3 Percentage of Recron fiber W.R.T Desire Strength

Sr.No.	Required increase in Flexural Strength	% of fiber required by weight of concrete
1	10%	0.36%
2	20%	0.73%
3	30%	2.58%
4	40%	2.92%
5	50%	3.43%
6	60%	3.98%
7	70%	4.42%
8	80%	4.86%
9	90%	5.12%
10	100%	5.30%
11	110%	5.48%
12	120%	5.61%

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