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Research Paper

CRACK WIDTH STUDY ON ASBESTOS FIBRE RCC BEAMS

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Fiber reinforced concrete is relatively an effective construction material in which the main use of fibers is to bridge across the cracks that develop in concrete. The main aim was to carry out a comparative study on crack width on Reinforced Cement Concrete (RCC) beams with and without the addition of fibers. By providing optimum dosage of volume fraction of asbestos fibers, studies on cracking behavior of Asbestos Fiber Reinforced Concrete (AFRC) beams were made in concrete under flexure. An experimental investigation was carried out to study the behavior of RC specimen with asbestos fiber and also to determine the optimum volume fraction of asbestos fibers (AFRC). The test results of beams obtained by static loading were used to determine the parameters like stress-strain relationship, moment curvature relationship and crack width on both RCC beams and AFRC beams. This paper dealt with crack width only. It was also found that with increase in the volume fraction of asbestos fibers resulted in reduction of crack width.

Keywords: RCC beams, Asbestos Fiber Reinforced Concrete (AFRC), Volume fraction, Crack width

INTRODUCTION

Concrete is one of the widely used construction materials for structures. Cement concrete is an artificial stone produced by hardening mixture of cement, sand, stone chips and water. Since cement concrete is very good in compression but weak in tension, steel reinforcement are to be provided in tension zone. The low tensile strength and brittle character of concrete have been bypassed. Such combination of concrete and steel is called Reinforced Cement Concrete (RCC). The inclusion of small fraction (usually 0.5 to 2% by volume) of short fibers to the concrete, mortar and cement paste can enhance many of the engineering properties of basic materials such as fracture toughness, flexural strength and resistance to fatigue, impact and spalling. The incorporation of fibers into concrete has been found to improve several properties primarily cracking resistance, impact and wear resistance and ductility. For

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this reason, Fiber Reinforced Concrete (FRC) is now being used in increasing amounts in structures such as airport pavements, highway overlays, bridge decks and machine foundations.

TYPES OF FIBERS

FRC is a concrete made primarily of hydraulic cements, aggregates and discrete discontinuous fibers. Typical types of fibers are steel, glass, plastic, carbon and asbestos fibers. The inclusion of fibers in concrete generally improves the material properties including ductility, toughness, flexural strength, impact resistance, fatigue resistance and to a small degree, compressive strength. The type and amount of improvement is dependent upon the fiber type, size, strength and configuration and the amount of fiber. The numerical parameter describing a fiber is its aspect ratio, which is defined as the fiber length divided by an equivalent fiber diameter.

ASBESTOS FIBERS

Asbestos fiber is a mineral fiber and has proved to be most successful of all the fibers as it can be mixed with Portland cement. The tensile strength of asbestos varies between 560 to 980 N/mm^2. The maximum length of asbestos fiber is 10 mm but generally fibers are shorter than this. The composite product called asbestos cement has considerably high flexural strength than Portland cement paste. Asbestos minerals belong to the class of water silicates of magnesium, iron, partly of calcium and sodium. According to their mineralogical characteristics and crystal structures, asbestos fibers have been divided into 3 types namely: chrysotile, amosite and tremolite. Chrysotile (white asbestos) is a white curly fiber, accounts for 90% of asbestos in products and is a member of serpentine group containing magnesium silicate. Amosite is a brown or grey-colored straight fibers belonging to amphibole group, containing iron and magnesium. Tremolite is a grayish green colored fiber containing calcium, magnesium, and iron silicates.

MIXING PROCEDURE FOR AFRC

- Coarse and fine aggregates were mixed for 1 min in a mixer.
- Cement was added to the mix and the matrix and the materials were mixed for another minute.
- The required Super plasticizer was poured into the total water outside of the mixer and the solution was added gradually for a period of 3 min.
- While the mixer was rotating, the asbestos fibers were added and then the mixer was allowed to rotate for 3 min.
- At this stage, slump test was performed according to the test method for slump of Hydraulic cement concrete (ASTM C 143) standard.

EXPERIMENTAL PROCEDURE

General

A total number of six beams were cast and tested for static loading. Out of which two were control beams and they were tested with two-point loading. The remaining beams were cast with asbestos fiber (Figure 1) in RC beams with different volume fractions of 0.75% and 1.0 % (AFRC).

Figure 1: Asbestos Fiber

DETAILS OF THE TEST SPECIMEN

The details and dimensions of the six RC beams with a span of 3,200 mm (3,000 mm effective span), 125 mm wide and 250 mm depth were casted, using 3 numbers of 10 mm diameter bars with yield strength of 415 N/mm^2 as tension reinforcement and 2 numbers of 10 mm diameter bars as compression reinforcement and 8 mm diameter. MS stirrups with yield strength of 250 N/mm^2 were provided throughout the length. The RC beams were prepared using M_{20} Grade of concrete. The Concrete mix used was 1 : 1.51 : 3.2 with W.C ratio 0.50. Asbestos fibers are analyzed using Scanning Electron Microscope (SEM) shown in Figures 2 to 6 and the chemical properties are tabulated in Table 1. Figures showed the size of fibers to ascertain the Aspect ratio.

Figure 2: Asbestos Fiber Cluster

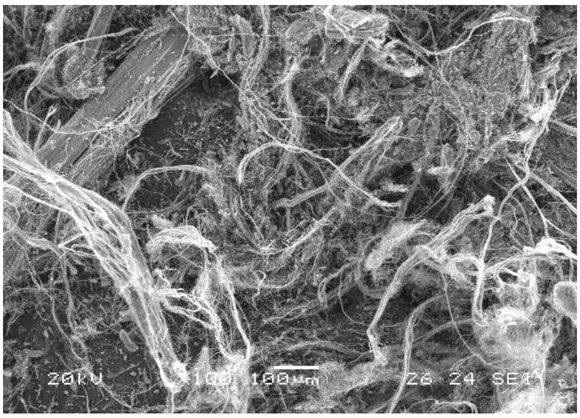

Figure 3: Asbestos Fiber Cluster

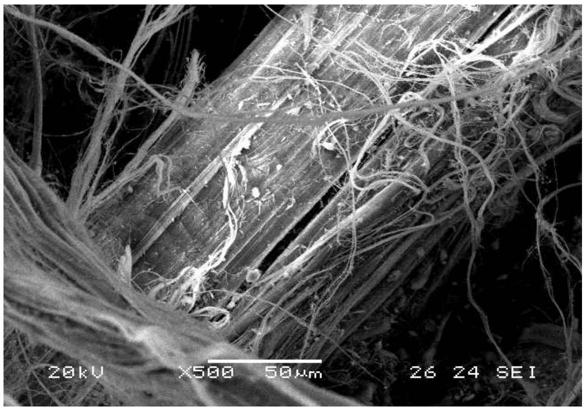

Figure 4: Asbestos Fiber Size

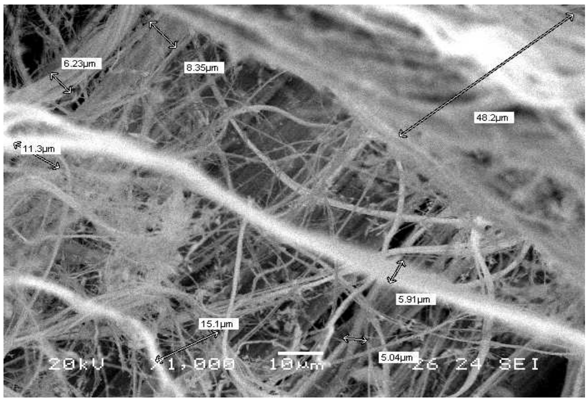

Figure 5: Asbestos Fiber Size

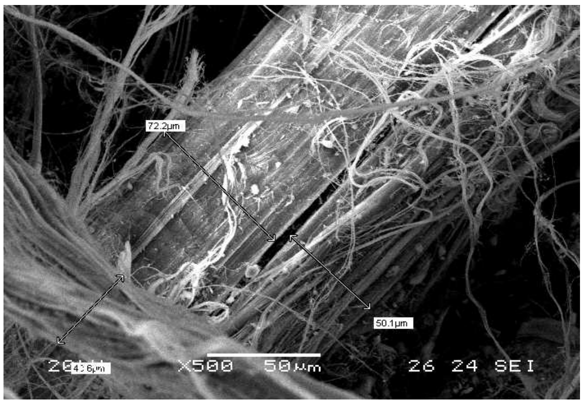

Figure 6: Spectrum of Chemical Composition of Asbestos Fiber

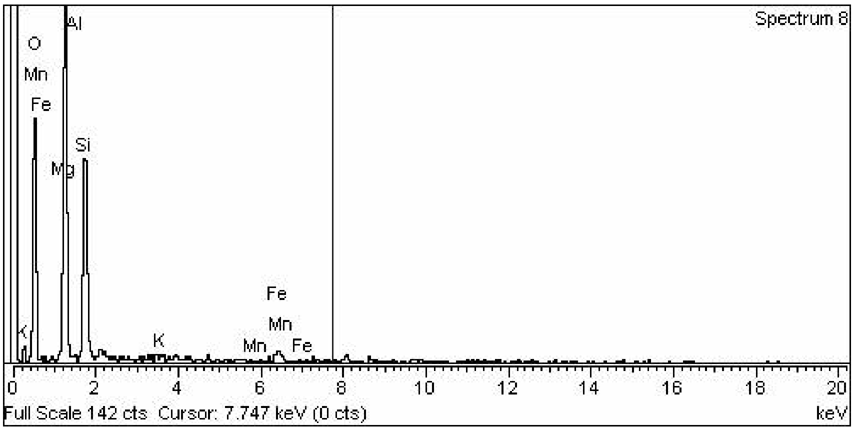

Table 1: Chemical Analysis of Asbestos Fiber

Element	Weight %	Atomic %
O	51.83	63.94
Mg	27.30	22.16
Al	0.32	0.23
Si	18.18	12.78
K	0.30	0.15
Mn	0.16	0.06
Fe	1.91	0.67
Total	**100.00**	

MATERIALS

M_{20} Grade of concrete was used for casting the test beams with the following details.

Cement – Portland pozzulana cement

Fine aggregate – Natural sand (river sand)

Coarse aggregate – Maximum size 20 mm

Steel – 10 mm, 8 mm dia. bars

Water – Treated water with potable quantity

Super plasticizer – Coroplast Super at 1.65% by weight of cement

Fiber – Asbestos fiber with 0.75% and 1.0% volume fraction

CASTING AND TESTING OF BEAMS

Testing of Flexure Beams

The flexural strength of concrete was determined by subjecting a plain concrete beam to flexure under transverse loads. The theoretical maximum tensile stress reached in the bottom fiber of a standard test beam was often referred to as “modulus of rupture”, the magnitude of which depends on the dimensions of beam and type of loading. Before casting of the beams, flexure beams were cast and tested. They were cast with different volume fractions of 0.75%, 1.0%, 1.25%, and 1.50% of asbestos fibers. After 28 days, they were tested to get the flexural strength. It was found that the maximum flexural strength was attained for beams with 0.75% and 1.0% V_f of asbestos fiber reinforced specimen.

Testing of Beams

Beams are cast in a mould as shown in Figure 7. The points of loading and placement of the reference pins were marked on the beam as per the required measurement. Dial gauges were placed on the beam to measure the deflection. Loading was applied on the beam by means of Demec gauge. For every increment of load, the dial gauge and Demec gauge readings was noted. Loading was continued up to the failure of the beam. The crack pattern of failure was noted. The same procedure was repeated for both control and AFRC beams. Graphs for load Vs. deflection, stress-strain relationship, and moment-curvature relationship were plotted. The test setup was shown in Figure 8. The load was applied using 50 ton capacity hydraulic jack and it was measured using 50 ton—proving ring with LC of 0.002 mm.The Demec gauge was used to measure strains. Demec gauge pellets were pasted at the topmost compression fiber and axis of steel, i.e., tension zone where middle third zone of beam. The load was given increments of 0.25 kN and at each stage of loading, the deflection were measured using LVDT. Crack widths were measured using crack detection microscope and strains were measured using Demec gauge.

Figure 7: Casting of Beam

TEST RESULTS AND DISCUSSIONS

The results were tabulated in Table 2.

Figure 8: Test Set Up

Table 2: Test Results of Beams

S. No.	Parameter	Control Beam	0.75% V_f of AFRC Beam	1.0% V_f of AFRC Beam
1.	Load at ultimate (kN)	4.75	5.0	5.5
2.	First crack load (kN)	1.0	1.0	1.5
3.	Deflection at ultimate stage (mm)	11.33	7.15	13.59
4.	Maximum crack width (mm)	0.32	0.20	0.16

CRACKING LOAD

Test results showed that the first crack load was same for both control and 0.75% volume fraction of AFRC beam. But it was found there was an increase of 33.33% of first crack load for beam with 1.0% volume fraction of AFRC beam.

LOAD AT ULTIMATE STAGE

For 0.75% volume fraction of AFRC beam, there was a decrease of 5.5% of load carrying capacity when compared to control beam. Also there was an increase of 13.64% of load carrying capacity for 1.0% volume fraction of AFRC beam.

DEFLECTION

Deflection at ultimate stage for 0.75% volume fraction of AFRC beam was found to decreased by 31.6% and increased by 16.69% for 1.0% volume fraction of fiber reinforced specimen and further decreased by 50% for beam with 1.0% volume fraction of AFRC beam. The results of crack width are shown in Table 3.

Table 3: Crack Width of All Beams

S. No.	Load (kN)	Crack Width for Control Beam	Crack Width for 0.75% V_f of AFRC Beam	Crack Width for 1.0% V_f of AFRC Beam
1.	0	0	0	0
2.	2.5	0	0	0
3.	5.0	0	0	0
4.	7.5	0	0	0
5.	10.0	0	0	0
6.	12.5	0	0	0
7.	15.0	0	0.04	0
8.	17.5	0.04	0.06	0.02
9.	20.0	0.06	0.08	0.04
10.	22.5	0.10	0.10	0.06
11.	25.0	0.12	0.14	0.06
12.	27.5	0.16	0.16	0.06
13.	30.0	0.18	0.18	0.10
14.	32.5	0.20	0.20	0.10
15.	35.0	0.22	0.20	0.10
16.	37.5	0.22	–	0.12
17.	40.0	0.24	–	0.12

Table 3 (Cont.)

S. No.	Load (kN)	Crack Width for Control Beam	Crack Width for 0.75% V_f of AFRC Beam	Crack Width for 1.0% V_f of AFRC Beam
18.	42.5	0.26	–	0.14
19.	45.0	0.28	–	0.16
20.	47.5	0.30	–	0.16
21.	50.0	0.32	–	0.16

CONCLUSION

- Test results shows that the first crack load was same for both control and 0.75% volume fraction of AFRC beam. But it was found there was an increase of 33.33% of first crack load for beam with 1.0% volume fraction of AFRC beam.
- For 0.75% volume fraction of AFRC beam, there was an increase of 5% of load carrying capacity when compared to control beam.
- Also there was an increase of 13.64% of load carrying capacity for 1.0% volume fraction of AFRC beam.
- Deflection at ultimate stage for 0.75% volume fraction of AFRC beam was found to decrease by 31.6% and increase by 16.69% for 1.0% volume fraction of fiber reinforced specimen.
- Crack width at ultimate stage was observed to be decrease by 37.5% for 0.75 % volume fraction of fiber reinforced specimen when compared to control specimen and further decrease by 50% for beam with 1.0% volume fraction of AFRC beam.
- It was observed that there in reduction in crack width with increase in the volume fraction of asbestos fibers when compared to control specimen. Hence the asbestos fibers acts as crack arrestors.

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