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Performance Evaluation of RC Beams with Dramix Steel Fibres

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ABSTRACT

This paper presents a study on the flexural performance of reinforced concrete beams with Dramix steel fibres. The effect of fibre content on the strength and ductility performance of steel fibre reinforced concrete (SFRC) beams having different fibre volume fractions was investigated. The parameters of this investigation included service load, yield and ultimate load, service load deflection, yield and ultimate load deflection, deflection ductility and energy ductility. The fibre volume fraction V_f ranged from 0.0 to 2.0 percent. The strength and ductility performance of steel fibre reinforced concrete beams was compared with that of control beam. The test results show that addition of 2.0 percent by volume of steel fibres improves the strength and ductility performance appreciably.

Keywords: Ductility; Fibre; Steel fibre reinforced concrete; Strength.

I. INTRODUCTION

Concrete is a relatively brittle material. Addition of fibres to concrete transforms it from a brittle to a more ductile material[1-4]. The function of short-cut fibres as secondary reinforcement in concrete is mainly to inhibit crack initiation and propagation[5]. The basic purpose of using fibres is to control cracks at different size levels, in different zones of concrete (cement paste or interface zone between paste and aggregate), at different curing ages and at different loading stages[6]. Fibre reinforced concrete specimens, unlike that of their counterparts, do not fail immediately. After the first crack, the load is transferred from the concrete matrix to the fibres[7-8]. Information available on the performance of reinforced concrete beams with Dramix steel fibres is still limited. Hence an attempt has been made to study the strength and ductility performance of reinforced concrete (RC) beams with steel micro-reinforcements.

A. EXPERIMENTAL PROGRAMME

Table 1 Properties of Fibre

Sl. No.	Fibre Properties	Fibre details Steel
1	Length (mm)	30
2	Shape	Hooked at ends
3	Diameter (mm)	0.5
4	Aspect Ratio	60
5	Density (kg/m^3)	7850
6	Young's Modulus (GPa)	210
7	Tensile strength (MPa)	532

Specimen details

A total of five beams were tested in this study. The test programme was designed to study the strength and ductility performance of fibre reinforced concrete beams with and without fibres. All the beams were rectangular in cross-section. They were 150-mm wide, 250-mm deep and the overall length was 3000 mm.

Material Properties

Cement concrete having cube compressive strength of 26.65 MPa was used for casting the specimens. 2 nos. of 12mm diameter HYSD bars were used as longitudinal reinforcement. 8mm diameter 2-legged stirrups at 120mm c/c were used as shear reinforcement. Table 1 shows the properties of fibre used in the experimental work.

TESTING OF SPECIMENS

All the beams were tested under four point- bending in a loading frame of 500 kN capacity. The beams had 100 mm bearing on both ends, resulting in a test span of 2800 mm. Two point loads were applied through a spreader beam. The deflections were measured at mid-span and load points using mechanical dial gauges of 0.01mm accuracy. Two dial gauges were mounted on the compression face of the specimen over supports to measure slope at both ends.

All dimensions in 'mm'

Fig. 1 Test Setup and Instrumentation

The deflection at ultimate load level was also measured using a specially designed mechanical dial gauge. All the above measurements were taken at different load levels until failure. The details of instrumentation are shown in Fig. 1.

TEST RESULTS AND DISCUSSION

The principal test results are presented in Table 2. The ductility ratios of test beams are presented in Table 3. Typical load-deflection curves of the beams are shown in Fig. 2. The test results show that the load carrying capacity increases with increase in fibre content. The increase in yield load and ultimate loads was found to be 28.5% and 51% respectively, with 2.0% fibre content when compared to that of reference beam. The ultimate load for beams with and without fibres is shown in Fig. 3. From the test results furnished in Table 2 and Fig.2, it can be observed that the reinforced concrete beams with steel fibres exhibit increase in deflection with increase of fibre content at all load levels when compared to the reference beam. The increase in yield and ultimate load deflection was found to be 49.0% and 137% respectively with 2.0% fibre content when compared to the reference beam.

Table 2 Principal Test Results of Beams

Fibre Volume Fraction, $V_{f,}$ (%)	Yield Load (kN)	Yield Deflection (mm)	Ultimate Load (kN)	Ultimate Deflection (mm)
0	34.24	8.83	41.69	30
0.5	36.08	12.09	49.87	56
1	39.6	12.28	52.8	59
1.5	41.5	13.13	53.95	65
2	44.5	13.16	62.95	71

Table 3 indicates that the reinforced concrete beams with steel fibres exhibit enhanced ductility than that of the reference beam. The increase in deflection ductility ratio with 2.0% fibre content was found to be 1.59 times than that of reference beam. The increase in energy ductility ratio with 2.0% fibre content was found to be 2.15 times than that of reference beam. The ductility comparison of tested beams is shown in Fig. 4. The failure modes for beams with and without fibres are shown in Figs.5 and 6.

Table 3 Ductility Ratio of Test Beams

Fibre Volume Fraction, V_f (%)	Deflection Ductility	Energy Ductility
0	3.40	5.43
0.5	4.63	8.14
1	4.80	10.16
1.5	4.95	11.22
2	5.40	11.65

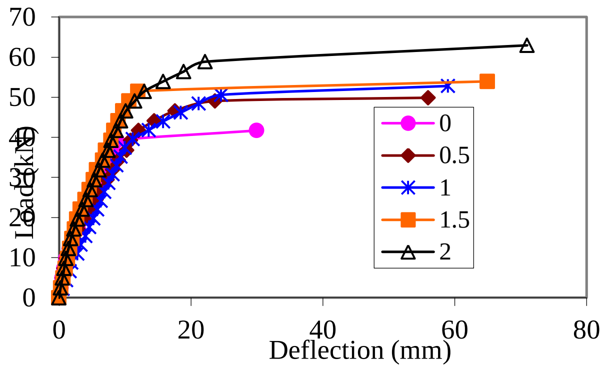

Fig. 2 Load-Deflection Behaviour of Steel Fibre Reinforced Concrete Beams

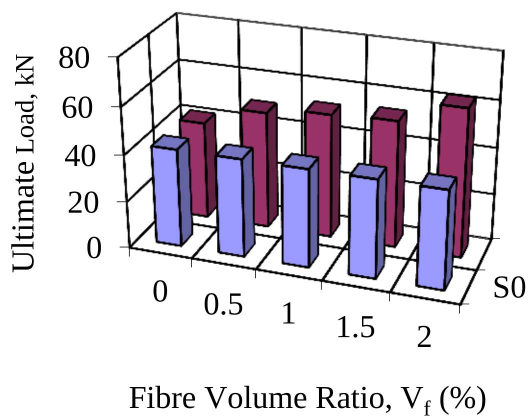

Fig. 3 Ultimate Load for Tested Beams with and without Fibres

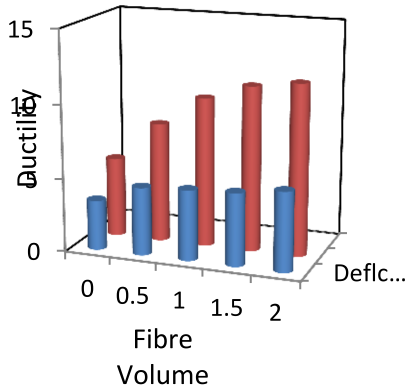

Fig. 4 Ductility Ratio of Tested Beams with and without Fibres

Fig. 5 Failure Mode of Reference Beam

Fig. 6 Failure Mode of SFRC Beam

CONCLUSIONS

1.A fibre volume fraction of 2.0% significantly improves the strength, deformation and ductility performance of reinforced concrete beams.
2.The fibre reinforcement enhances the load-carrying capacity of concrete beams. The maximum increase in ultimate load was found to be 51% when compared to the reference beam.
3.The fibre reinforced concrete beams exhibit increase in deflection to the tune of 137 % in comparison with the reference beam.
4.The fibre reinforcement enhances the ductility of concrete beams. The increase in energy and deflection ductility was found to be 1.59 & 2.15 times than that of reference beam.

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