

Evaluation of Effectiveness of SFRC Deep Beams in Shear

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Abstract— The influence of steel fibres on the flexural strength of concrete and mortar is much greater than in the case of the tensile or compressive properties of these materials. The use of steel fibres in concrete significantly increases the flexural strength of the material. Furthermore, the increase of the flexural strength of SFRC is significantly improved with increasing the fibre aspect ratio (i.e. fibre length/fibre diameter ratio) and fibre volume fraction. The rapid ascent of fibre reinforced concrete to the main stream construction material has been spectacular and paralleled by no other construction material. In spite of coming a long way, there still exist a number of areas where fibre reinforcement has shown promise but an extensive use has not been transpired. One of such areas is ‘Structural Concrete’. Deep beam is such a structural element whose span to depth ratio is comparatively very small. Behavior of normal reinforced concrete deep beams and steel fiber reinforced concrete deep beams subjected to predominant shear with or without stirrups and web reinforcement is presented to evaluate the effectiveness of steel fibers in deep beams. The review of research work shows that the inclusion of steel fibres in reinforced concrete deep beams result in enhancing their deformation characteristics at all stages of loading up to failure as well as improving their shear resistance. Therefore, the use of steel fibres is an attractive alternative to test for deep beams for different parameters.

Key words: Deep Beam, Steel Fiber, Shear- Span Ratio, Fiber Volume Ratio, Fiber Aspect Ratio, Longitudinal Steel Ratio, Shear Reinforcement, Web Reinforcement

I. INTRODUCTION

Deep beams are recognized by relatively small values of span-to-depth ratio. As per code provisions given by Bureau of Indian Standards [1] a beam shall be considered as deep beam when the ratio of effective span to overall depth ratio is less than 2.0 for simply beams. Reinforced concrete deep beams have very useful structural applications such as pilecaps, water tanks and tall buildings.

It has been found that the use of steel fibers of short length and small diameter as reinforcement improves the strength & deformational characteristics of cement. An experimental program was therefore, conducted to study the effectiveness of steel fibers as web reinforcement in reinforced concrete deep beams.

The simply supported deep beam is subjected to Point loading with different shear span to effective depth ratios. The failure of the deep beam is in shear and the shear is resisted by shear reinforcement. If the spacing between the reinforcement is less then it is quite difficult to achieve full compaction of concrete. The shear may be resisted by using steel fibers instead of shear reinforcement. Generally three types of cracks, namely flexure, flexure shear and shear develop in deep beams under applied load, depending upon L/D ratio, tensile and web reinforcement, shear span to depth ratio, use of steel fibers etc. These cracks ultimately cause

the deep beams to fail. Apart from these cracks, deep beams also fail due to crushing at their supports or loading points due to insufficient anchorage of the tension reinforcement within the beams themselves.

II. EXPERIMENTAL PROGRAMME

A. Test Material

Ordinary Portland cement of 53 grade was used having fineness modulus of 7.3 and crushed aggregate of maximum size 10mm were used. The grade of concrete is M20 with mix proportion of 1:1.5:3 by weight with water cement ratio of 0.50 was kept constant for all beams [7]. The crimped steel fibers of 0.5 mm diameter with aspect ratios of 100 were used.

B. Specimen Details

All the beams were of rectangular cross section with effective span of 700 mm and width 100 mm. The effective span to overall depth ratio was 2 so as to achieve the desired shear span to effective depth ratio (a/d)

In order to study the shear strength of deep beam, total number of 05 specimens was cast. [02 Plain beams (100mm x 350mm x 700mm)], [02 beams with steel fibres 0.5% (100mm x 350mm x 700mm)] and [02 beams with steel fibres 01% (100mm x 350mm x 700mm)] were cast by using crimped steel fibers with volume fraction (0.5 and 1.0 %). Three bars of 08mm diameter as longitudinal reinforcement were used in all deep beams.

C. Test Procedure

Both the surfaces of beams were white washed to aid to the observations of crack development during testing. The beams were tested to failure under point top loading in compressive testing machine of capacity 200 tones. The first crack load and the ultimate load were determined.

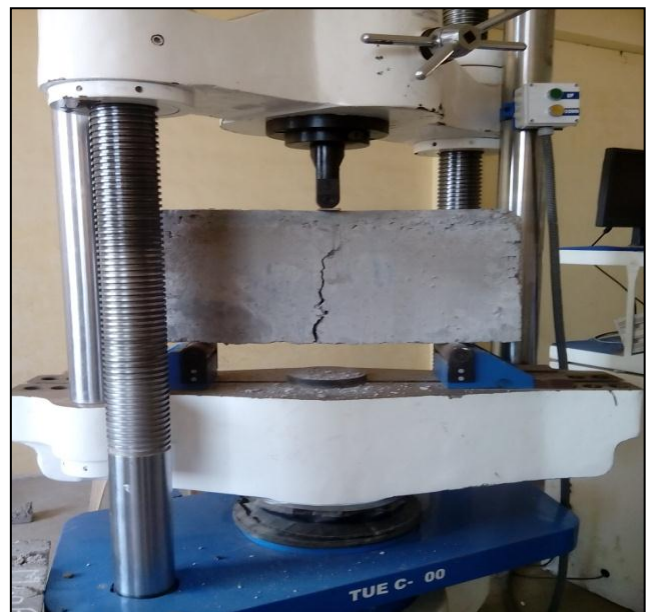


Fig. 1: Test Setup of CTM with Fixed Roller Base for Shear

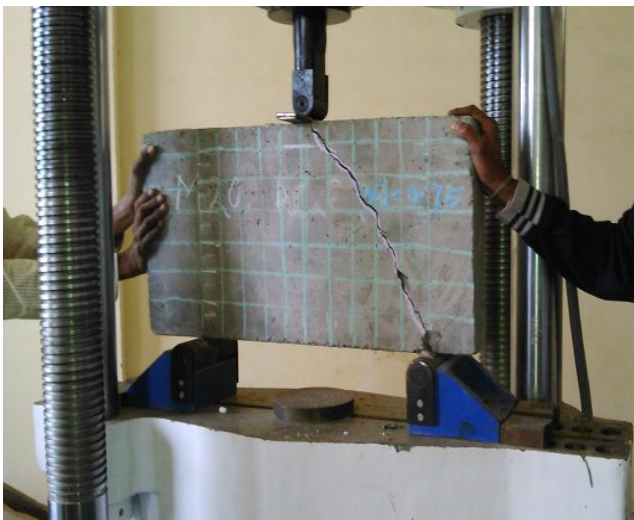


Fig. 2: Failure Pattern of R.C.C. Beam

III. TEST RESULT AND DISCUSSION

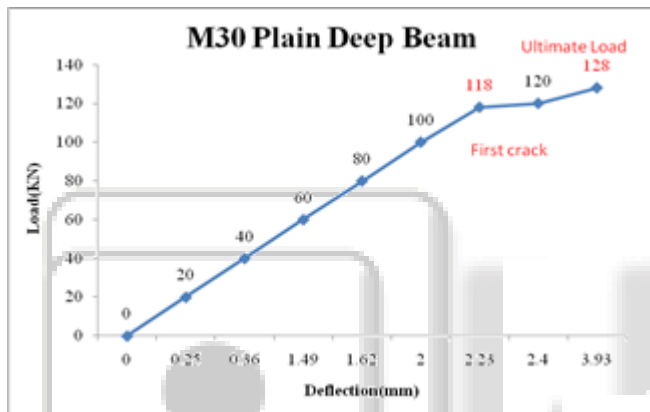


Fig. 3: M-30 Plain Deep Beam-(Load Vs Deflection)

A. Discussion:

The above graph indicates load vs deflection for M-30 plain beam with 100 mm wide. Here the first crack occurs at load-118 KN , deflection of 2.23 mm and the ultimate load is 128 KN with deflection of 3.93mm.

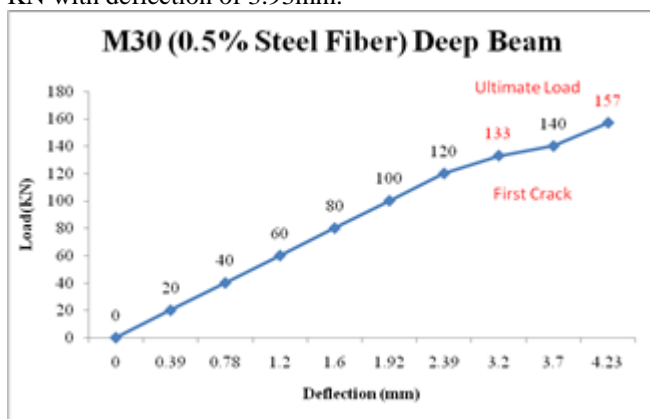


Fig. 4: Deep Beam, M-30 (0.5% addition of steel fibers) load Vs deflection.

B. Discussion:

The above graph indicates load vs deflection for M-20 with steel fibre beam. Here the first crack occurs at load- 133 KN, deflection of 3.2 mm and the ultimate load is 157 KN with deflection of 4.23 mm.

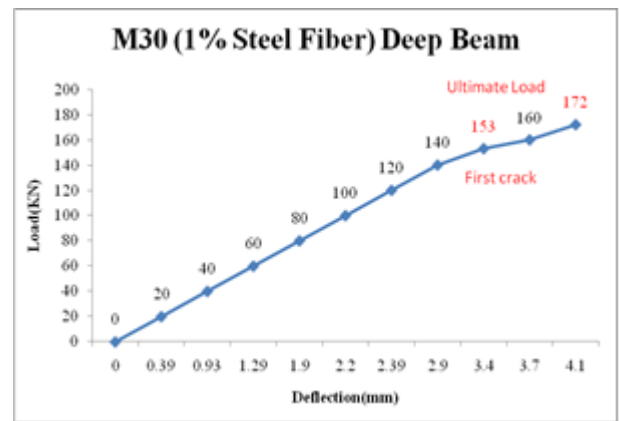


Fig. 5: M30 Deep beam- 2 (1.0% addition of steel fiber)(load Vs deflection)

C. Discussion:

The above graph indicates load vs deflection for M-20 beam with 1.0% steel fibre. Here the first crack occurs at load-153 KN, deflection of 3.4 mm and the ultimate load is 172 KN with deflection of 4.1mm.

It is evident from Figure 3 that ultimate strength is less when there are no Steel Fibres in the deep beam i.e. for Plain beam of M20 grade.

It is clear form Figure 4 and 5 that the addition of steel fibers in concrete mix significantly influenced the cracking behavior, first crack strength and ultimate strength of deep beams. For example beams which contained no fibers and without web reinforcement, exhibited a sudden formation of a long inclined crack. On the other hand, inclined cracks went through a slow process of widening and extension in beams with 0.5 %, 1.0% of fiber content and without web reinforcement.

In beams with steel fibers first diagonal crack formed at about 60 – 66 % of ultimate load almost in the middle of the shear span. As the load was increased inclined crack propagated towards the support and loading points. Further increase in the load resulted in the propagation and widening of the existing cracks leading to shear failure.

Addition of steel fibers in concrete mix significantly influenced the cracking behavior and ultimate strength of deep beam. This lower rate of crack propagation in fiber reinforced beams may attributed to the restraint provided by the steel fibers that bridge the cracks, this contributing to port cracking strength.

IV. CONCLUSION

Following conclusions are draw based on the results discussed in the previous topic

- 1) The inclusion of short steel fibers in concrete mix provides effective shear reinforcement in deep beams and provides better crack control in beams.
- 2) Both the first crack strength and ultimate strength in shear increase for fiber reinforced beams because of their increased resistance to propagation of cracks.
- 3) Shear strength increases with fiber content and decreasing a/d ratio.
- 4) Maximum increase of 40 % in first cracking load for beam containing 0.5 % of fiber was observed when compared with beam containing no web reinforcement.

- 5) When all the beams were tested in this program, maximum shear strength was observed in beams reinforced with 0.5 % and 1.0 % steel fibers followed by beams containing web reinforcement
- 6) These results supports use of 1.0% steel fibers as an alternative to conventional web reinforcement in deep beams.

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