

Experimental and Analytical Study on the Behaviour of Conventional and Steel Fibre Reinforced Concrete Beam-Column Joints

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Abstract - Beam-column joints are critical regions in reinforced concrete framed structures where the transfer of loads between beams and columns occurs. Inadequate strength or poor confinement in the joint region may lead to brittle failure and structural instability. This study presents an experimental investigation on the behaviour of conventional reinforced concrete beam-column joints and steel fibre reinforced concrete (SFRC) joints subjected to beam-end loading. Concrete specimens were prepared using M25 grade concrete with Portland Pozzolana Cement (PPC). Hooked-end steel fibres were incorporated into the concrete mix to improve crack resistance and load carrying capacity. Beam-column joint specimens were cast and tested under loading conditions to evaluate parameters such as crack initiation, ultimate load capacity and displacement behaviour. The results indicate that the steel fibre reinforced specimen showed improved structural performance compared to the conventional joint. The SFRC specimen exhibited delayed crack formation, higher load carrying capacity and increased ductility. The study demonstrates that the addition of steel fibres can significantly enhance the behaviour of beam-column joints and improve their structural efficiency.

Key Words: Beam-column joint; Steel fibre reinforced concrete (SFRC); Load carrying capacity; Crack behaviour; Ductility; Experimental investigation

1. INTRODUCTION

Beam-column joints are one of the most important structural components in reinforced concrete frame structures. These joints are responsible for transferring loads from beams to columns and maintaining the stability of the structural system. Due to the concentration of stresses in the joint region, cracking and failure may occur when the joint is subjected to heavy loads. In conventional reinforced concrete structures, beam-column joints often experience diagonal cracking and shear failure. Such failures reduce the load carrying capacity and affect the durability of structures. Therefore, improving the behaviour of beam-column joints has become an important area of research in structural engineering. Steel fibre reinforced concrete (SFRC) is widely used to improve the mechanical properties of concrete. The addition of steel fibres helps in bridging micro-cracks and distributing stresses throughout the concrete matrix. This improves the tensile strength, crack resistance and energy absorption capacity of concrete. Steel fibres are particularly effective in regions where high stresses occur, such as beam-column joints. The fibres help control crack propagation and enhance the ductility of structural members. The present study investigates the behaviour of conventional and steel fibre reinforced beam-column joints under beam-end loading.

2. OBJECTIVE

The main objective of this study is to investigate the structural behaviour of beam-column joints using steel fibre reinforced concrete. The study aims to compare the performance of conventional reinforced concrete joints with steel fibre reinforced concrete joints in terms of load carrying capacity and structural response. It also focuses on evaluating crack initiation, crack propagation, and the overall ductility of the joint region. Another objective is to analyse the improvement in displacement capacity and strength due to the addition of steel fibres in the concrete mix

3. SCOPE

The scope of this study is to analyse the effectiveness of steel fibre reinforced concrete in improving the performance of beam-column joints. The research focuses on evaluating the load-deflection behaviour and crack control characteristics of fibre reinforced specimens compared with conventional concrete specimens. It also examines the influence of steel fibres on the strength, ductility, and structural stability of the joint region. The findings of this study can help in understanding the advantages of

using steel fibres in reinforced concrete structures and contribute to improving the design and durability of beam–column joints.

4. REVIEW OF LITERTURE

P.Soroushian investigated The study of behavior of steel Fibre Reinforced Concrete Beam column joint under loading in the year (2000) on behaviour of beam–column joints made with steel fibre reinforced concrete. The authors analysed the effect of steel fibres on crack control, strength, and structural performance. The results showed that the addition of steel fibres improved the load carrying capacity and delayed crack formation in the joint region.

S.P.Shah and Lee Investigated the research on Performance of Fibre Reinforced Concrete in Structural Members in the Year (2001) focused on the application of fibre reinforced concrete in structural members such as beams and columns. The study reported that steel fibres improve ductility, energy absorption capacity, and resistance to cracking. The findings suggested that fibre reinforced concrete can enhance the durability and performance of reinforced concrete

5. METHODOLOGY



6. CASTING OF SPECIMEN

Bars with 3 Number of 10mm diameter are used in the compression zone,while bars with a 2 Numbers of 8mm diameter are used in the tension zone for a length 600mm beam and column of length 1.2m of 4 no's of 10mm diameter.Clear cover of Beam and column joint is 25mm and spacing 100mm.

7. EXPERIMENTAL AND TESTING SETUP:

All beam-column joint specimens were tested after 28 days of curing under laboratory conditions. The column was rigidly fixed in the loading frame, while the beam acted as a cantilever member. Load was applied gradually at the free end of the beam using a hydraulic loading system until failure occurred. Deflection was measured using deflectometers placed at the beam midspan and free end to record the displacement during loading. In addition, strain measuring devices were installed near the reinforcement region to monitor strain development. Load, deflection, and strain readings were recorded at regular intervals to evaluate the load-deflection behaviour and structural response of the beam-column joint.



Fig. 8.1.1 Test Setup of Conventional Beam and column joint



Fig. 8.1.2 Test Setup of Steel Fibre Beam and column joint

7.1 Testing of Beam and Column Joints

The Beam and column joint was tested under Cantilever Loading and Beam End. Deflection was measured using dial gauges placed at critical locations, and cracking behaviour and ultimate load were recorded.



8.1.3 Test Setup of Conventional B&C joint



8.1.4 Test Setup of Steel Fibre B&C Joint

8. CRACK PATTEN AND FAILURE MODES:

8.1 Cack patten and Failure modes of Conventional Beam and Column Joint:

Cracks were observed at the Joint near Region, and the cracks initiated in the tension zone at the Top of Beam. The first crack appeared at the Tension zone at a load of 16 kN, and the beam ultimately failed at 46kN



Fig. 9.1.1 Cack patten and Failure modes of Conventional Beam and Column Joint.

8.2 Cack patten and Failure modes of Steel Fibre Beam and Column Joint:

Cracks were observed and Developed at the Joint Core Area, and the cracks initiated overall in the tension zone at the Top of Beam. The first crack appeared at the Tension zone at a load of 20 kN, and the beam ultimately failed at 58kN



Fig. 9.1.2 Cack patten and Failure modes of Steel Fibre Beam and Column Joint

8.3 LOAD DEFLECTION CURVE

The load-deflection behavior of the beam column joint was analyzed from both experimental testing and numerical analysis. Initially, all specimens exhibited a linear relationship between load and deflection, indicating elastic behavior. As the load increased, the stiffness gradually reduced due to crack initiation and propagation in the concrete. The beam and column joint specimen showed noticeable deflection at free end of beam. The crack extends and expand at joint core area. and Compared to conventional beam and column joint & Steel fibre beam and column joint. SF joint takes maximum load compared to conventional joint.

8.4 Load Displacement Curve of Conventional and Steel Fibre Beam and column Joint:

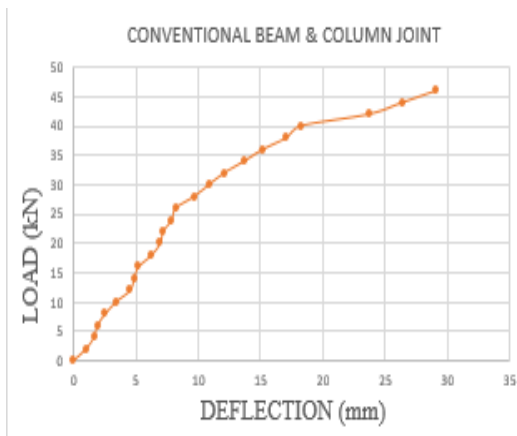


Fig.9.1.5 (a) Load-Deflection Curve of Conventional joint

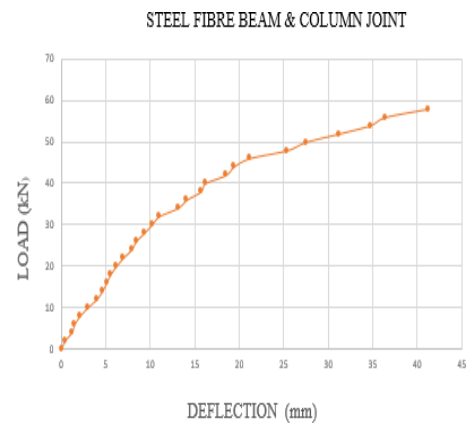


Fig.9.1.6 (b) Load-Deflection Curve of Steel Fibre joint

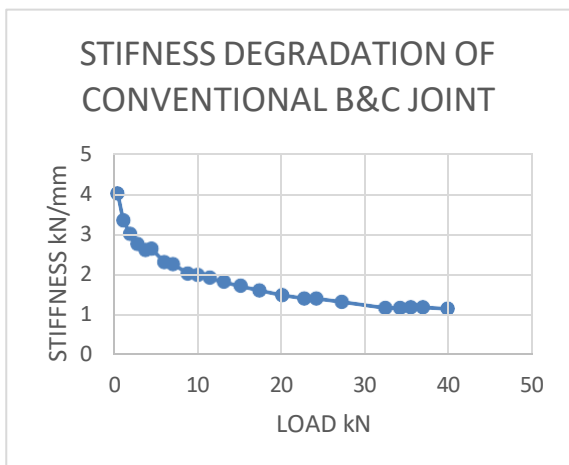


Fig.9.1.7 (a) Stiffness D Curve of Conventional Beam and Column Joint

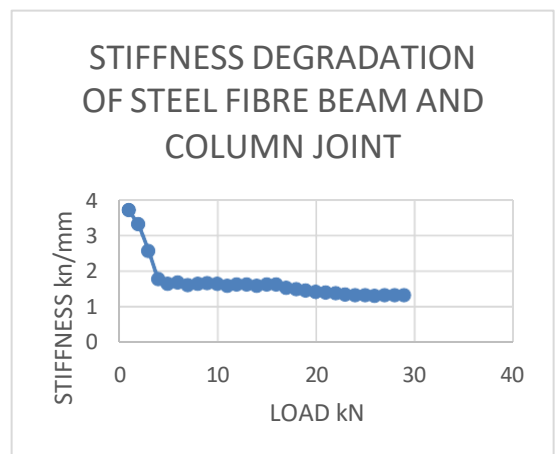


Fig.9.1.8 (b) Stiffness Degradation Curve of Steel Fibre Beam and Column Joint

9. NUMERICAL MODELING IN ABAQUS:

Numerical analysis was carried out using the finite element software ABAQUS to evaluate the structural behaviour of the beam, column, and slab specimens. Three-dimensional models were developed based on the actual dimensions and reinforcement details used in the experimental program. Concrete and reinforcement materials were assigned appropriate mechanical properties to represent their realistic behaviour under loading. The boundary conditions and loading arrangements were defined to simulate the same conditions used during the experimental testing. The interaction between concrete and reinforcement was also considered in the model. The numerical results obtained from the analysis, such as load–deflection behaviour and deformation patterns, were compared with the experimental results to validate the accuracy of the finite element model.

9.1 Numerical Peak Load Deflection of Beam and Column

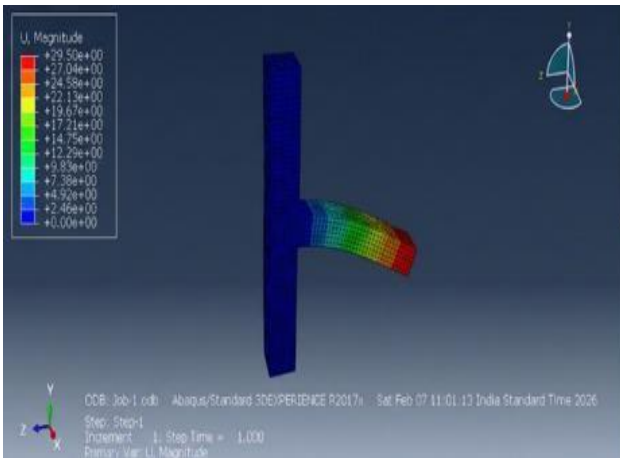


Fig.10.1.1 (a) Conventional Beam column joint

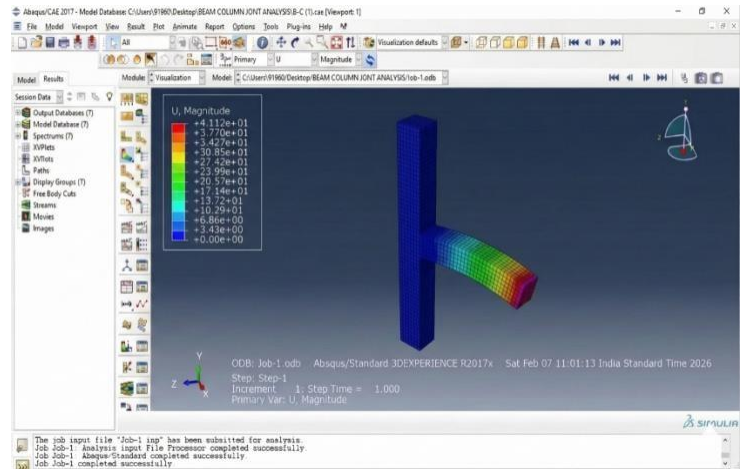


Fig.10.1.2 (b) Concrete with added steel fibres

10. CONCLUSION:

The experimental results indicate that the incorporation of steel fibres significantly enhances the behaviour of beam–column joints. The steel fibre reinforced specimen exhibited a higher load carrying capacity compared to the conventional specimen. The presence of steel fibres delayed the initiation of cracks and helped in controlling crack propagation within the joint region. In addition, the fibre reinforced joint demonstrated improved ductility and greater displacement capacity during loading. Overall, the study shows that steel fibre reinforced concrete can effectively improve the structural performance and crack resistance of beam–column joints in reinforced concrete structures.

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