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Flexural Performance of Concrete Filled Steel Tube Beams

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***Abstract*— Concrete-Filled Steel Tubes (CFST) are composite members consisting of a steel tube infilled with concrete. The behavior of the composite member will be better than the simple combination of two materials. In the construction of high rise buildings, CFST is one of such innovative new building material, which provides not only an increase in the load carrying capacity but also economy and rapid construction, and thus results in cost saving. Earlier works carried out on CFST have indicated that these sections possess high ductility, fire resistance, strength, resist bending moment, prevents local buckling of steel, spalling of concrete and stiffness properties. The tube acts as a formwork in construction hence decreases its labor and material costs. In earthquake prone areas multi-storied buildings are erected by considering the above properties. This paper portrayed the flexural behavior of CFST structural members with and without reinforcement.**

Keywords— Concrete filled steel tubes, finite element analysis, flexural behavior.

I. INTRODUCTION

The concrete-filled steel tubes are composite sections which are used in different areas of construction and becoming an attractive solution. CFST structures show many advantages over conventional steel and RC sections and hence these CFST sections are becoming more popular in recent years. The CFST sections are formed by filling concrete into a hollow steel tube section, and this steel section resist tension, bending moments and also increases stiffness of CFST as steel has a higher modulus of elasticity. Fig.1.shows a rectangular concrete filled steel tube section. It offers resistance to applied load through the composite action of steel and concrete and shows good bond strength under fire exposure[6]. In CFST section the steel tube act as longitudinal as well as transverse reinforcement.

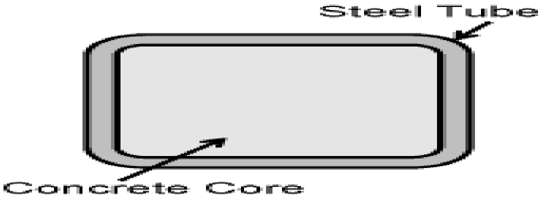

Fig 1: Rectangular CFST tube

They are widely used in high-rise buildings for the benefit of increased load carrying capacity for a reduced cross section and multistory buildings as columns and beam-columns, bridges and off-shore structures. These CFST can sustain worst combination of loads, with high stiffness, speeder construction, increased useful space, reduced load on foundation and reasonable money. The uses of steel members have an advantage of high tensile strength and ductility, whereas concrete members have an advantage in compressive strength and stiffness delays local buckling[8]. Concrete filled steel tube structures shows higher load bearing capacity mainly due to the confining effect of steel tube around concrete core[4].The failure modes have a significant effect on the characteristics of stress distribution and shows a superior seismic behavior for the beam to CFST column assembly with a shear failure at the panel[7]. A new fiber beam column element was used for the time history analysis of curved steel–concrete composite girder bridges and shows high modeling speed and solution efficiency for the non- linear analysis of concrete filled steel tube column subjected to the combined action of compression, bending and torsion[10]. Also observed an improved crack pattern for concrete encased CFST structures and the bond strength between the steel tube and outer concrete is larger than that between the steel tube and core concrete[12].

II. VALIDATION

For the validation, data was collected from the analytical study conducted by Lin-Hai Han, was modelled to validate the FE model. A three-dimensional FE model was created using Solid65 elements to model the beam. Load was applied till the failure and the numerical results obtained were compared with the experimental results. The corresponding displacements were noted. The results of the FE model were compared against the experimental work. For a 25 mm displacement, maximum obtained value of moment carrying capacity of a concrete filled steel tube beam is 28 kNm in experiment as well as in FEM. Fig.2.shows the moment displacement diagram from the experiment and from the FEM model.

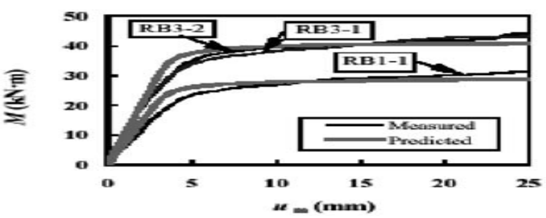

Fig 2: (a) Moment Displacement Diagram From Experiment..

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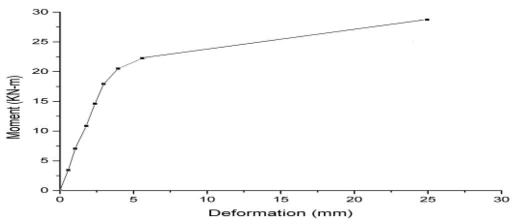


(b) Moment Displacement Diagram From FEM

III. FLEXURAL BEHAVIOUR

A rapidly used material concrete is widely used in various conditions to sustain the compression loads and the corresponding shear stress and bending due to the applied compressive loads. The main drawback in concrete is that it is poor in tension whereas it is very efficient in compression. Hence to rectify this major drawback the concrete must be reinforced inorder to make a homogeneous substance which can sustain tension as well as compression. Steel is the material used for the reinforcement of concrete.

The stress strain behaviour of both concrete and steel are mostly similar. In order to make it safe and economic conditions of RCC it is necessary to assess the conditions of ultimate loads and corresponding deflections. The desirable results can be obtained by conducting an experimental analysis. When an RC beam is subjected to some external load the beam tends to bend shows some deflection due to loading. At any point in the cross section of the beam is considered the stress distribution is in such a way that all the fibres above the neutral axis which passes through the CG are in compression, whereas all the fibres below the neutral axis are in tension.

A. Details of Geometry

Beam of size 300 x 400 mm is used. Span length of 4500 mm. Grade of concrete used as M25 and Fe 415 grade steel as internal reinforcement. Here totally four numbers of 25 mm diameter bars are used as tension reinforcement and two numbers of 16 mm diameter bars as compression reinforcement. 8 mm 2 legged stirrups were used. In case of a CFST beam with reinforcement, the thickness of steel sheet used were 1mm and by reducing the number of bars and its corresponding diameter, with two numbers of 25 mm diameter bars are used as tension reinforcement and two numbers of 12 mm diameter bars as compression reinforcement, 8 mm 2 legged stirrups were used. Finally for a CFST beam without reinforcement the thickness of steel sheet adopted is 1.68 mm with similar geometric details. Fig.3 shows the cross-sectional diagram of a beam.

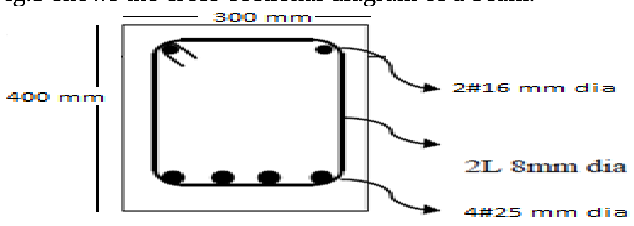


Fig.3: Cross-Sectional Details of Beam

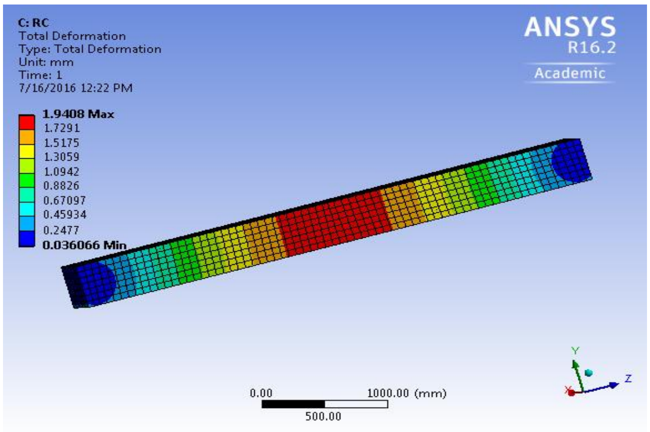
B. Results and Discussions

From the analysis it was observed that CFST beam with minimum reinforcement shows the first crack at 62.560 kN, that was greater than the simple reinforced and CFST beam without reinforcement. Table 1 shows the different results of the three beams. And the deformation value was also less for the CFST with reinforced beam compared with other two beams.

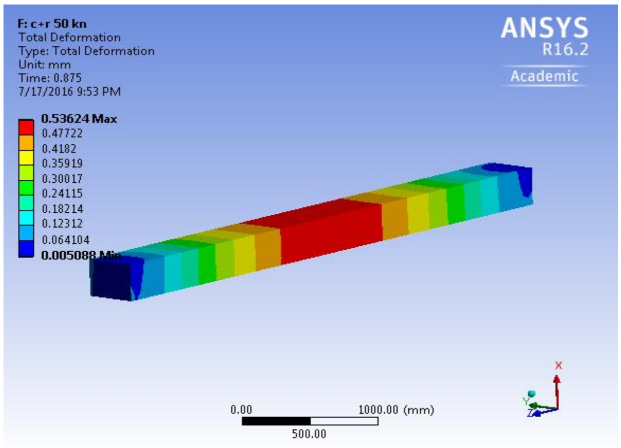
TABLE 1: Results

	RC Beam	CFST + RC Beam	CFST
Maximum Deformation	1.94 mm	0.53625 mm	0.6762 mm
First Crack	27.50 kN	62.560 kN	36.250 kN
Shear Stress	1.303 MPa	2.9649 MPa	15.318 MPa

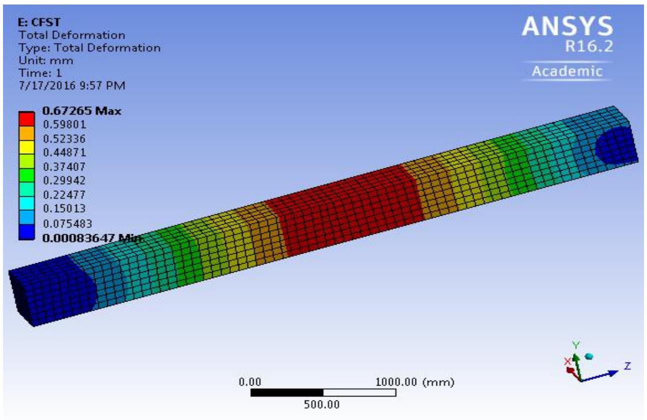
When compared with an ordinary reinforced beam, by reducing the number of bars and the bar diameter and providing a steel covering forms a CFST beam with reinforcement section. Fig.4 (a) to (b) represents the deformation of three beams.



(a). RC Beam Deformation



(b). CFST + RC Beam Deformation



(c).CFST Beam

Fig.4. Represents the deformation of three beams.

IV. CONCLUSION

From the studies conducted on three different beams it can be seen that a concrete filled steel tubular section with reinforcement resists tension, bending moments and also increases load carrying capacity when compared to a normal reinforced concrete and steel section of similar dimensions. It combines the advantages of both steel and concrete. They are being widely used in high-rise buildings and hence there is a need to understand the seismic response of CFST columns and beams which are provided in such buildings by considering the behavior of such frames with and without reinforcements. The available literature mainly deals with study of individual CFST beams and columns and not frames or buildings as such. So studies should be conducted to determine the efficiency of bringing these elements into the designing scenario of modern building.

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