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DOUBLE SKIN TUBULAR BEAM-COLUMNS UNDER REVERSED LATERAL LOADING

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ABSTRACT

Concrete filled double skin tubular (CFDST) members consist of two concentric steel tubes with concrete sandwiched between them. This paper presents an experimental investigation on the concrete filled double skin tubular beam-columns subjected to reversed lateral loading. The specimens consist of cold formed steel square tube as it's outer and inner tube with fly ash concrete infilled in between the two tubes. The behaviour of the fly ash infilled CFDST beam-columns with bolted connections under constant axial load and reversed lateral loading were examined. The results are compared with the concrete filled steel tubular beam-column (CFST) specimens, which were considered as the control specimen. The specimens with square cross-section exhibited better load carrying capacity than the control specimen.

Key words: CFDST, Flyash concrete, Bolted connections, Lateral loading, Beam-columns.

INTRODUCTION

Composite construction has found wide spread acceptance in the construction industry today as it combines the advantages of both steel and concrete. The adaptation of composite construction has resulted in taller structures with lesser cost and faster completion time. The composite members combine the advantages of both steel and concrete thus resulting in a structure with greater load carrying capacity and greater ductility. Concrete filled double skin tubular (CFDST) members are composite members having two concentric steel tubes with concrete sandwiched between them. The sandwiched concrete enhances the strength and ductility of the members while the steel tube provides confinement to the concrete thus enhancing its capacity.

Recent years have seen a large number of research works on CFDST members. Zhao and Grzebeita carried out experimental investigations on the CFDST stub columns and

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beams to understand the strength and ductility of cold formed square inner and outer tubes[1]. From the stub column and the bending tests on beams they concluded that the CFDST have greater ductility when compared to empty steel tubes. The unified theory put forward by Tao et al. introduced a confinement factor, which describes the composite action between the outer steel tube and the sandwiched concrete[2]. The behaviour of the CFDST sections under cyclically increasing flexural loading was investigated by Han et al.[3] The investigations were carried out on CFDST sections with outer square and inner circular tube. They concluded that the CFDST columns exhibit increase in strength, ductility and dissipated energy when compared to empty steel hollow sections. A mechanics model was also put forward by the researchers for analyzing the CFDST columns.

Thus a large number of studies have been carried out to understand the behaviour of CFDST members when used as beams and columns[4-8]. But not much work has been carried out to understand the behaviour of CFDST members when subjected to reversed lateral loading. Hence this study focuses on understanding the behaviour of CFDST beam-column bolted joint members with square cross section when subjected to constant axial load and reversed lateral loading.

EXPERIMENTAL

Specimen details

The beam-column specimens (SQ1 and SQ2) consist of CFDST beam of length 1.5 m and CFST column of height 1.1 m connected by angle plates and bolts. The columns of the CFDST specimen consist of outer square tube of size 100 x 100 mm and an inner square tube of 50 x 50 mm cross section. The beams are concrete infilled square tube. All the steel tubes were of cold formed steel with 3 mm thickness. The space between the two tubes was filled with M30 grade fly ash concrete having 40% of cement replaced with fly ash[9]. The beam and column were connected by means of high tensile strength bolts of 10 mm diameter. The control specimen (CS1 and CS2) consists of a concrete filled cold-formed steel tube of 100 x 100 mm size with 3 mm thickness for both beam and column. The connection between the beam and column was achieved by angle plates and 10 mm diameter high tensile strength bolts. The concrete used in the specimens were mixed with a ratio of cement, sand, aggregate as 1:1.86:2.9 and a water-cement ratio of 0.45. Glenium super plasticizer was added to increase the workability. Self-curing compound was added to aid curing of the concrete. Fig. 1 shows the beam-column connection. Fig. 2 and Fig. 3 shows the fabricated specimen and the concrete filled CFDST beam-column specimen respectively.

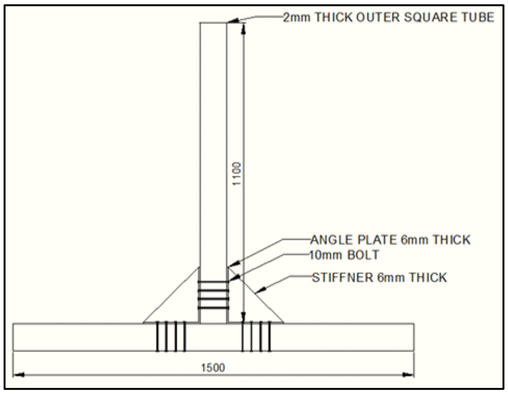


Fig. 1: Beam-column connections

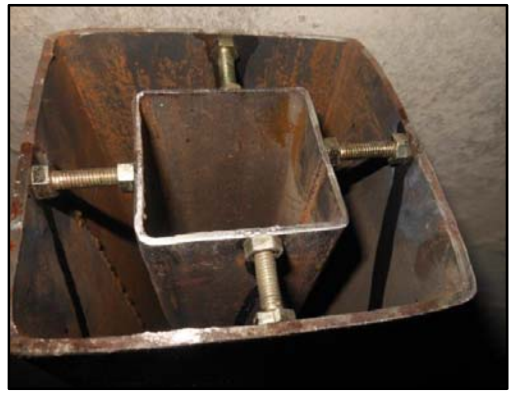


Fig. 2: Fabricated specimen

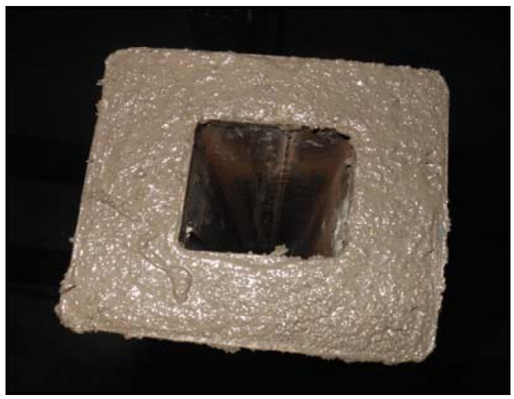


Fig. 3: Concrete filled CFDST specimen

Experimental set up

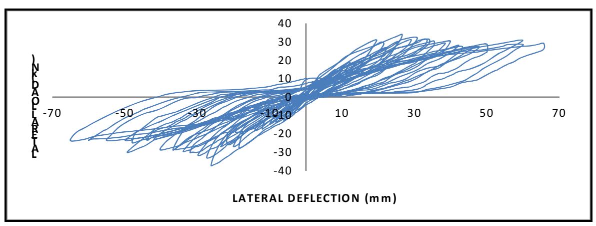
The experimental set-up consist of a reaction frame of 100 kN capacity, a hydraulic actuator of capacity 200 kN with a stroke length of ± 100 mm and a loading frame with hydraulic jack of 200 kN to apply loads to the test specimens. The hydraulic jack was used to apply constant axial compressive load to the specimen through steel rollers placed in between steel plates on top of the specimen. The specimens were subjected to forward as well as reverse lateral loading. Displacement control method was adopted and the displacement was applied in increments of 2 mm till failure. The lateral load applied was measured using a load cell attached to the hydraulic actuator and the lateral displacement at the top of the column was measured using linear variable displacement transducer (LVDT). The test was stopped when the load was found to reduce while the lateral displacement continued increasing. Fig. 4 shows the experimental set up.

Fig. 4: Experimental set up

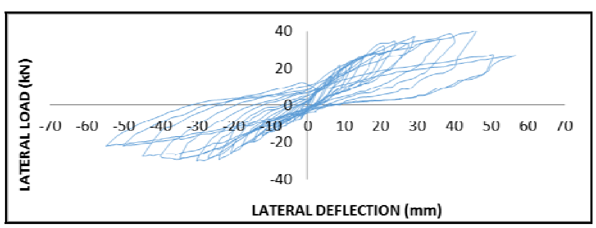
RESULTS AND DISCUSSION

Hysterisis curves

The plot of lateral load and lateral displacement gives the hysteresis loops for the specimens subjected to reversed lateral loading. The hysteresis curves for the four specimens were plotted. The control specimens (CS1and CS2) exhibited an average load carrying capacity of 33.3 kN with an average displacement of 32.15 mm whereas the CFDST specimens with square inner tube (SQ1 and SQ2) showed an average load carrying capacity of 33.4 kN with an average displacement of 34.2 mm. Fig. 5 and Fig. 6 shows the hysteresis curves for the CFDST and the CFST specimens, respectively.

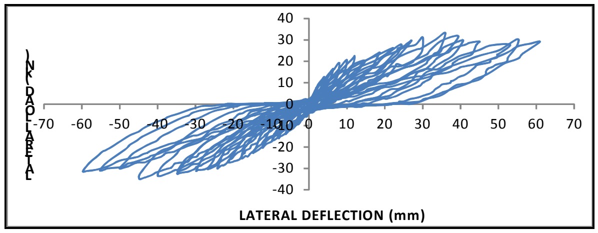


(a) CS1

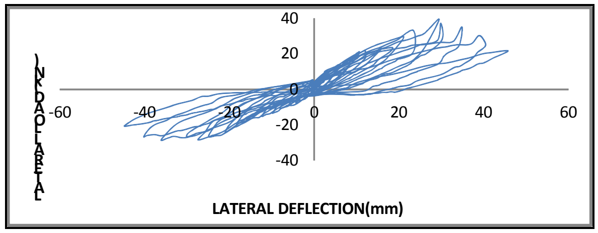


(b) CS2

Fig. 5: Hysteresis curves for control specimen



(a) SQ 1



(b) SQ2

Fig. 6: Hysteresis curves for square CFDST section

Strength capacity of the specimens

The Peak load displacement curves for all the four specimens are shown in Fig. 7. The control specimens CS1 and CS2 exhibited a peak load of 32.1 kN and 34.4 kN, respectively whereas the CFDST specimens SQ1 exhibited a peak load of 32.1 kN and SQ2 showed a peak load of 34.7 kN. Thus the CFDST and the CFST specimens exhibit nearly the same load carrying capacity.

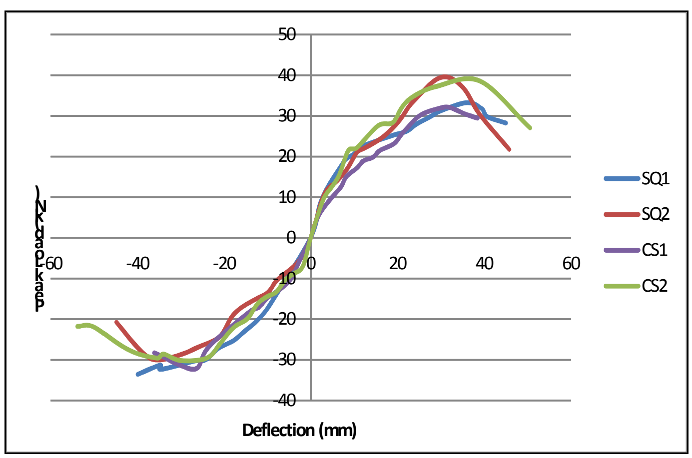


Fig. 7: Peak load-deflection graph

Ductility

Ductility is the ability of the specimen to undergo large deformation without much reduction in strength. A ductility co-efficient (μ) is defined for the analysis purpose. The ductility co-efficient 'μ' is defined as the ratio of the displacement at 85% of the peak load to the yield displacement. From Table 1 it can be seen that the ductility coefficient of the CFDST specimen with square inner tube is greater than the control specimens. The SQ specimens show a ductility coefficient of 3.5 whereas the control specimen shows a ductility index value of 3.3.

Table 1: Ductility co-efficient of the specimens

Specimen	δ_u/δ_y	μ
CS1	2.87	3.3
CS2	3.77	
SQ1	3.77	3.5
SQ2	3.22	

CONCLUSION

The behaviour of bolted CFDST beam-column with inner square tube under reversed lateral loading and constant axial loading was investigated experimentally in comparison with the concrete filled steel tubes. From the results, the following conclusions can be drawn.

- The CFDST sections with square inner tubes exhibit nearly the same load carrying capacity as the concrete filled steel tubes.
- The CFDST sections with the square inner tube exhibit greater ductility value than the control specimens.

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