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Cyclic Behaviour of Concrete Filled Double Skinned Tubular Columns (Inner And Outer Square Light Gauge Tubes)

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Abstract— **Concrete filled double skinned steel tubular (CFDST) sections are nowadays used in construction of structural elements. CFDST sections consist of two concentric steel section and concrete sandwiched in between these two steel sections and leaving the inner steel section hollow. Here for this study, CFDST column sections of two concentric light gauge steel square section of thickness 3mm and fly ash concrete of M30 grade is cast and results are compared with concrete filled light gauge steel tubular (CFST) columns under constant axial and reversed lateral loading. The paper covers the cyclic behavior of CFDST section under varying lateral load and also compare the failure pattern, hysteresis curve, peak lateral load Vs displacement curve, ductility and weight of specimens among the CFDST and CFST specimens.**

Keywords—concrete filled double skinned steel tube (CFDST),concrete filled steel tubes (CFST), cyclic behaviour, hysterisis curve,ductility.

I. INTRODUCTION

Cold-formed rectangular steel tubular columns have become popular in seismic regions, especially for high-rise structures. Cold form tubes are very efficient compression members due to their larger radius of gyration and resistance to local stresses. In spite of having these advantages; tubes are susceptible to early cracking, which causes subsequent loss of ductility and strength. Preventing severe local buckling is the key to preventing early fractures. Thus the concept of confined concrete has been widely accepted and applied in structural engineering. Concrete filled steel tubes (CFSTs), as an economical type of column, have been used for several years due to their advantages over either pure steel or pure reinforced concrete members. The inner concrete of CFST enhances the stability of the member while the steel tube gives triaxial stress state, and thus includes a confinement effect. CFDST (Concrete-filled double skin steel tube) is a new type of construction, which consists of two concentric steel tubes with concrete infilled in the space between them. CFDST members combine the advantages of the concrete-filled steel tube (CFST) and the conventional hollow reinforced concrete (RC) columns. Thus, CFDST columns have a series of advantages, such as high strength and better ductility, good seismic performance and lesser weight .This paper summaries the test results and comparison done on the CFDST specimen with CFST under varying lateral and constant axial loading.

II. EXPERIMENTAL INVESTIGATION

A. *Casting of specimens*

The columns were cast with light gauge steel sections as per IS 801:1975 and IS 811:1987 and are in-filled with flyash concrete. The light gauge steel square section of 3mm thick is used as both inner and outer concentric tubes for CFDST column sections. The space in between these tubes is infilled with flyash concrete. CFST columns are casted with outer light gauge square section of 3mm thick and are completely filled with flyash concrete. The Specific gravity of cement and fine aggregate used were 2.78 and 2.71 respectively.

Total of four specimens were cast, two of them are control specimens which are concrete filled light gauge steel (CFST) columns named as CS-1 and CS-2 and the other two are our test specimen which are concrete filled double skinned light gauge steel tubular(CFDST)(inner and outer square)column sections named as SQ-1 and SQ-2. Height of columns for both control specimen and test specimens is 1000mm and of 100mmx100mm size. Fig.1 shows the test specimen and control specimen before and after concreting.

Figure . 1. Test specimen SQ-1 and contol specimen CS-1 before and after concreting

B. *Experimental setup and loading*

Figure.2: Experimental set-up

The test set-up consist of a reaction frame, a hydraulic actuator of capacity 200 kN with a stroke length of ± 100 mm, loading frame with hydraulic jack of 110kN to apply loads to test specimens. 110kN hydraulic jack was used to apply constant axial compressive load through steel rollers placed with the support of steel plates in between the jack and column head. A steel reaction frame was used to support the 200 kN actuator providing lateral load to the specimen. Linear variable differential transducers (LVDT) is used for measuring the lateral displacement at the top of the column and one load cell attached to actuator was used for the measuring the reversed lateral loads. The vertical load was chosen to a design compression rate 40% of axial resistance found in the analysis and the rest 60% of axial resistance was given as moment ie, as lateral load.

Test specimens and control specimens are mounted on the loading frame, lateral displacement corresponding to positive and negative cycles of lateral load are noted using LVDT. Fig.2 shows the experimental set-up with specimen mounted for testing.

III. RESULTS AND DISCUSSION

Experimental results are compared on the lateral load-displacement hysteresis curve, peak lateral load-displacement curve, ductility and weight of specimens among the concrete filled double skin light gauge steel tubular (CFDST) columns and concrete filled light gauge steel tubular columns (CFST).

A. *Hysteris curve*

Hysteresis curves were plotted for specimens CS-1, CS-2, SQ-1 and SQ-2. Fig.2 and Fig. 3 shows the lateral load Vs lateral displacement curve –hysteresis curve of two sets of test specimen and control specimen. The results obtained from graphs are tabulated. The control specimens without inner tubes CS-1 and CS-2 failed at an average lateral load of 14.6kN with a lateral displacement of 37.85mm. The specimens with inner and outer square tube SQ-1& SQ-2 (with fly ash and tested at 28days) and failed at an average loads of 26.2kN with the corresponding displacement of 32.8mm.The average lateral load carrying capacity and the average maximum lateral displacement of the test specimens are compared with the control specimens and are shown in fig.4 and fig.5 respectively. Table.1 shows the comparison on lateral load capacity and displacement among the specimens

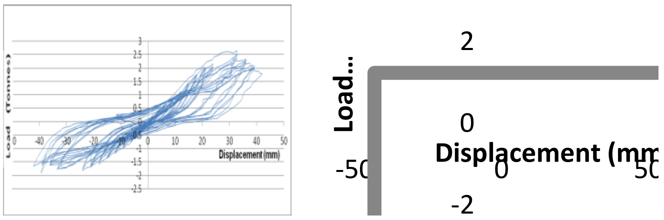

Figure: 4. Hysteresis loop for test specimen SQ-1 and control specimen CS-1 set- I.

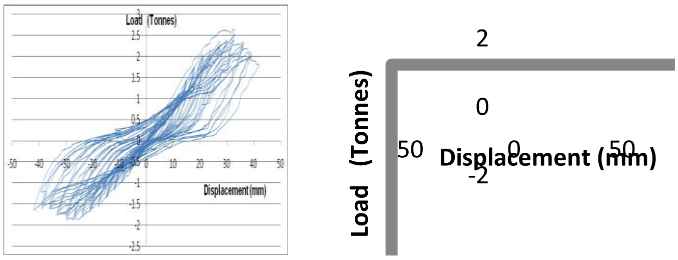

Figure: 5.Hysteresis loop for test specimen SQ-2 and control specimen CS-2 set –II.

TABLE: 1.COMPARISON ON LATERAL LOAD CAPACITY AND DISPLACEMENT AMONG SPECIMEN

Specimen	Load (kN)	Average load (kN)	Displacement (mm)	Average displacement (mm)
SQ-1	26.2	26.2	32.8	32.8
SQ-2	26.2		32.8	
CS-1	15	14.6	39.7	37.85
CS-2	14.2		36	

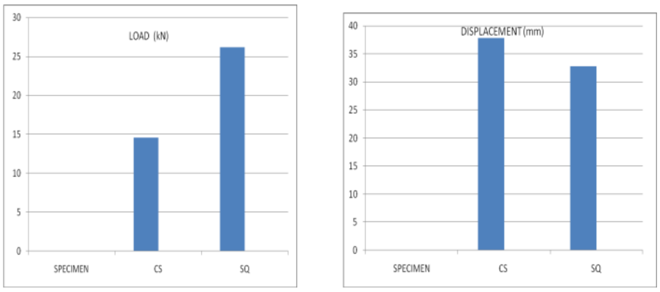

Figure. 6. Lateral load and lateral displacement comparison among specimens.

From Table.1and fig.6 we can see that, the lateral load carrying capacity of the specimens with concrete confined in between double skinned light gauge sections tested at 28 days is 79% greater when compared with specimens without inner tubes, which indicates that it can be effectively used in seismic areas.

B. *Ductility*

Ductility is the property which allows the structure to undergo large deformation without losing its strength. Here, the ductility is quantified by the ductility factor. It is the ratio of displacement at the failure to the displacement at yield point. The displacement at yield and failure of the specimens can be obtained from the peak lateral load versus lateral displacement curves. Yield displacement can be obtained by drawing a horizontal line from the point 75% of the ultimate load on the peak value curve. Point at which the horizontal line meets at straight portion of the curve will give the yield displacement point.   Fig.7 shows the comparison of peak lateral load and peak lateral displacement of all four specimen from which the yield displacement and displacement at failure point is determined.

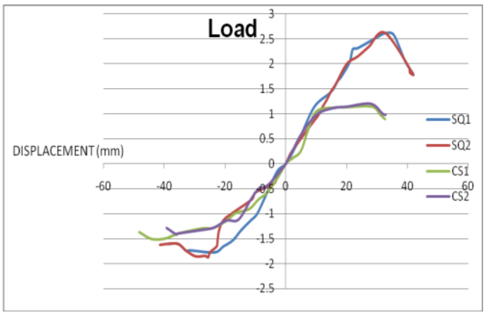

Figure.7: Comparison of peak value of lateral displacement and lateral load among specimen.

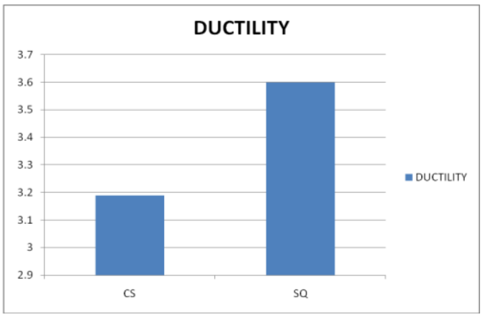

Figure.8: Comparison of ductility ratio.

Fig.8 shows the comparison of ductility ratio among control specimen (CFST) columns and test specimen (CFDST) columns. The specimen,concrete filled double skinned light gauge steel tubular columns tested at 28days has the higher ductility when compared to the controlled specimens.

As per studies, sections with ductility ratio ranging between3 to 4 can be effectively used in seismic areas.

IV. CONCLUSION

Experiments were conducted on concrete filled double skinned light gauge steel tubular (CFDST) column sections and concrete filled light gauge tubular (CFST) column sections respectively. The specimens were tested under constant axial load and reversed lateral load and the following conclusions are drawn.

- The lateral load capacity of the CFDST (concrete filled double skinned light gauge tubular columns) tested at 28 days is greater by 79% than control specimens (CFST concrete filled light gauge column section).
- The Ductility ratio of the concrete filled double skinned light gauge (CFDST) column sections tested at 28 days greater by 12.8% when compared with the control specimens (CFST concrete filled light gauge column section).

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