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Cyclic Lateral Behaviour Of Cold Formed Steel Double Skinned Concrete In-filled Beam-Column With Outer Square and Inner Circular Sections

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Abstract *— The present study focus on the comparative study of light gauge double skinned steel beam-column specimen in-filled concrete between the skins(with outer square and inner circular sections), with that of light gauge beam-column specimens fully filled with concrete. The specimens were subjected to constant axial loads and varying lateral loads. Fly ash concrete with 40 % fly ash was used in the investigation and Lateral load capacity; Ductility and Weight of specimens were compared. A magnitude of 190kN was used to apply constant axial compressive load with a maximum lateral capacity of 200kN. The vertical load was chosen to design compression rate 40 % of axial resistance found in the analysis. The results obtained after the specimens tested at 28 days of curing such that strength capacity(lateral load capacity), ductility of the double skinned steel beam-column in-filled concrete specimens increased by 4.45 % and 13.6 % respectively with reduced weight compared to control specimens(sections fully filled with fly ash concrete). Hence with a reduced specimen weight due to less amount of concrete required, higher lateral load capacity and higher ductility for concrete in-filled double skinned beam-columns, they are more adaptable for structures in seismic regions.*

Keywords*- Cold- formed column-beam, Double-skinned column-beam, In-filled concrete column-beam, Light-gauge double skinned column-beam.*

I. INTRODUCTION

Cold-formed steel (CFS) is the common term for products made by rolling or pressing thin gauges of sheet steel into goods. Cold-formed rectangular steel tubular columns have become popular in seismic regions, especially for high-rise structures. Tubes are very efficient compression members due to their larger radius of gyration and resistance to local stresses. Closed shapes also provide greater torsional strength and stiffness. 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. Review of past studies on concrete-filled columns provides the clue that concrete filling might be an effective way to delay or prevent early cracking caused by severe local buckling. Also the reduced weight of light gauge sections provide a reduction in the weight of each structural members and thereby reducing the overall weight of the structure which is highly adaptable in seismic regions.

II. EXPERIMENTAL INVESTIGATION

2.1 General

This experimental study deals with the behaviour of double skinned light gauge steel sections in-filled with fly-ash concrete under variable reversed lateral loading and constant axial load and compare that with light gauge steel beam-column sections fully filled with concrete.

2.2 Experimental program

Two numbers of double skinned light gauge columns in-filled with fly ash concrete and control specimens were tested in the reversed lateral load testing frame. Fly ash concrete with 40% cement was used in the investigation. The height of the column was 1000mm and of 100mm x 100mm size in all sections. Inner diameter of the double skinned steel tube is 50 mm The details of the specimens tested are given in Table 1. Columns were in-filled with M30 grade concrete. Same test procedure is conducted on control specimens also (concrete in-filled box section. The specimens were designed and detailed as per and IS801:1975.

2.3 Casting Of Specimens

The columns were cast with Light gauge steel sections conforming to IS801:1975 was used. The Specific gravity of the cement was used 3.08.River sand passing through 4.75mm IS sieve conforming to IS: 383 was used and having fineness modulus of 2.18 and Specific gravity of 2.71 was used as fine aggregate. The Coarse aggregate from

Crushed granite stones of size 10mm & 20mm, conforming to IS: 383 were used. The fineness modulus and specific gravity of coarse aggregate used were 2.76 and 2.75 respectively.

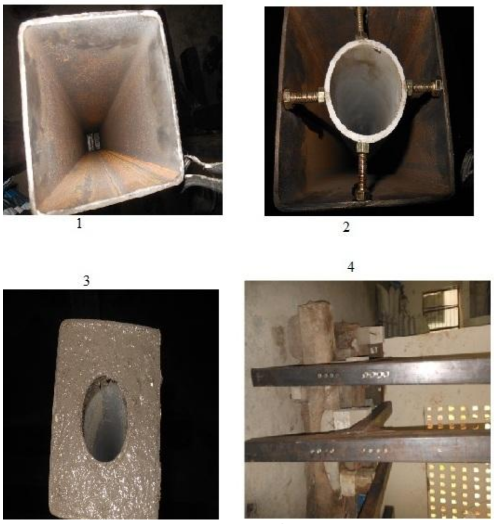


Figure 1. Casting of specimens

Table 1. Details Of The Beam-Columns Tested

Specimen	Beam sizes (mmxmm)	Inner tube diameter of column (mm)	Outer tube of column (mmxmm)	Thickness of outer light gauge section (mm)	Thickness of inner light gauge section (mm)
Control Specimen C1	100 x 100	-	100x100	3	-
Control Specimen C2	100 x 100	-	100x100	3	-
Test Specimen F1	100 x 100	50	100x100	3	2
Test Specimen F2	100 x 100	50	100x100	3	2

2.4 Test Set-Up

The test set-up consist of a reaction frame, a hydraulic actuator of capacity 200 kN laterally with a stroke length of ± 100 mm, loading frame with hydraulic jack of 190kN to apply loads axially to test specimens using steel rollers.. A steel reaction frame was used to support the 200 kN actuator providing lateral load to the specimen. Instrumentation included linear variable differential transducers (LVDT) for lateral displacement measurement at the top of the column and one load cell attached to actuator was used for the measurement of reversed lateral loads. A loading frame was used to apply a vertical constant axial load through steel rollers placed with the support of steel plates in between the jack and column head. The vertical load was chosen to a design compression rate 40% of axial resistance found in the analysis. The experimental set-up is shown in Figure 2.

2.5 Loading

The specimen was mounted on the loading frame. A loading frame was used to apply a vertical constant axial load of 190kN through steel rollers placed with the support of steel plates in between the jack and column head and lateral loads were applied incrementally.

Figure 2. Test set-up

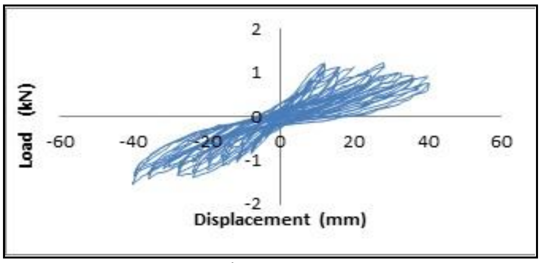
Specimens were instrumented with Linear Variable Differential Transducers (LVDT) for lateral displacement measurement having a least count of 0.2 mm.

III. RESULTS AND DISCUSSIONS

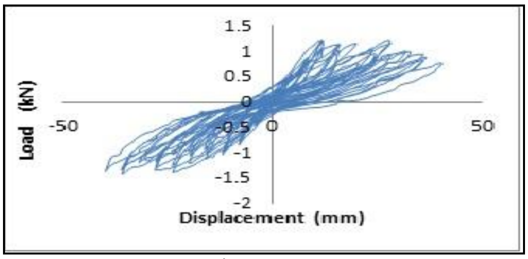
3.1 Lateral Load Versus Lateral Displacement Curve

The Hysteresis Curves are plotted for the variation of lateral displacement with that of the lateral load for all the specimens as shown in Figure 3.

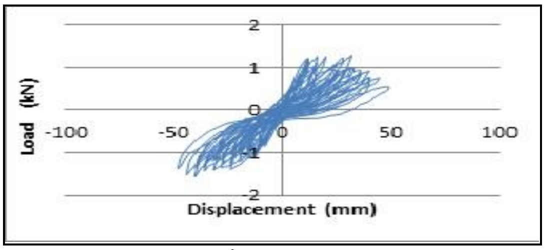
The control specimens without inner tubes C1 and C2 failed at an average lateral load of 14.6 kN with a lateral displacement of 37.85 mm. The test specimens with inner tubes F1 & F2 (in-filled with concrete and tested at 28days) and failed at an average load of 15.25kN with the corresponding displacement of 40.05mm.



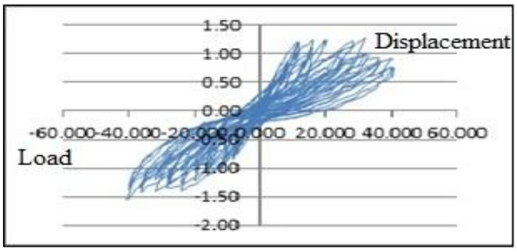
Specimen C1



Specimen C2



Specimen F1



Specimen F2

Figure 3. Load displacement curves for the test specimens (for specimens C1,C2,F1&F2 respectively)

From the hysteresis loops indicated, the maximum lateral load carried by the specimens series F1 and F2 (double skinned in-filled with concrete and tested at 28days) are significantly higher than that of the control specimens series C1 and C2. The average lateral load carrying capacity and the average maximum lateral displacement of the column of the specimens are compared with the control specimens and are shown in Figure 4. Table 2 shows the comparison on lateral load capacity and displacement among the specimens

Table 2. Comparison on lateral load capacity and displacement

Specimen	Load (kN)	Average Load(kN)	Lateral Displacement(mm)	Average Lateral Displacement (mm)
F1	15	15.25	39.7	40.05
F2	15.5		40.4	
C1	15	14.6	39.7	37.85
C2	14.2		36	

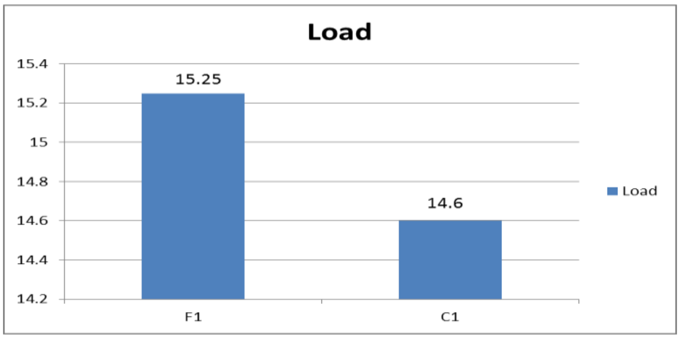


Figure 4. Comparison on lateral load capacity among the specimens

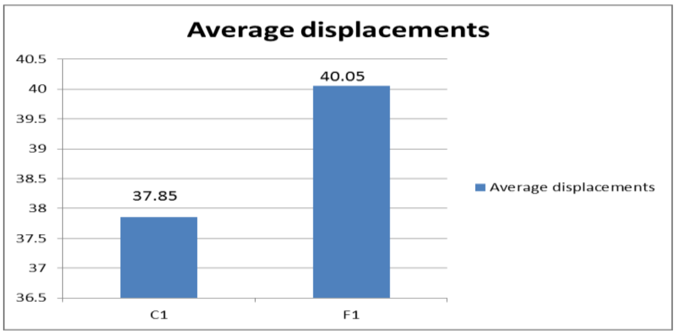


Figure 5. Comparison on maximum lateral displacement among the specimens

3.2 Ductility

Ductility is the property which allows the structure to undergo large deformation without losing its strength. 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 of the corresponding specimens. The Table 3 shows the yield load and the failure load of the test specimens

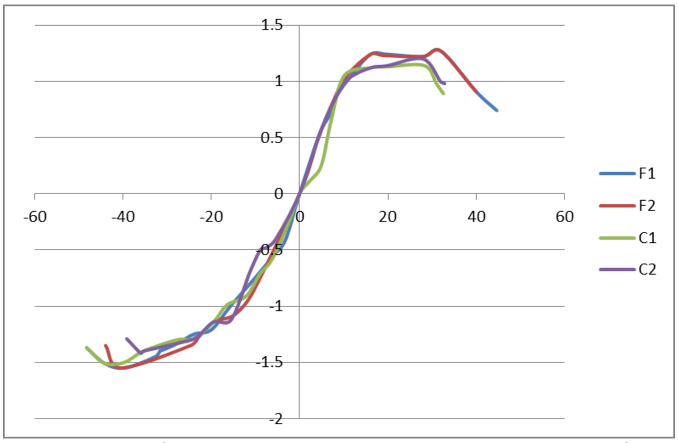


Figure 6. Comparison of peak lateral loads-lateral displacement of the specimens
F1 & F2 – Test Specimens
C1 & C2- Control Specimens

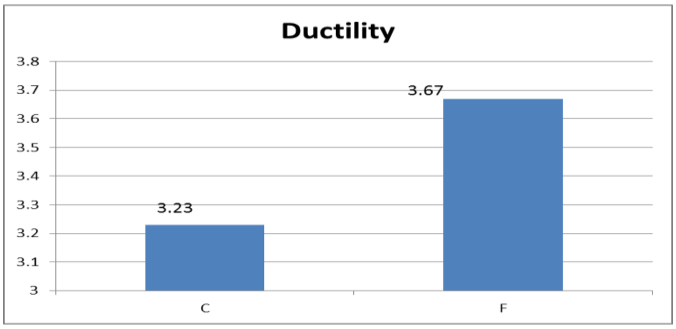


Figure 7. Comparison of ductility ratio with the specimens
F- Test Specimens(F1 and F2)
C- Control Specimens(C1 and C2)

It is observed that from Table 4, there is 13.6% increase in the average ductility ratio for the specimen series F1 & F2. This shows that the specimens withinner tube have increased the ductility of the column in lateral loading. The specimen with double skinned inflilled concrete and tested at 28days (F1 & F2) has the highest ductility when compared to the controlled specimens.

Table 3. Ductility ratio of test specimens

Specimen Series	Yield Displacement (mm)	Ultimate Displacement (mm)	Ductility Ratio	Average Ductility Ratio	Percentage increase in ductility ratio,%
C1	12.1	39.7	3.28	3.23	--
C2	11.3	36	3.18		
F1	11	39.7	3.61	3.67	13.6
F2	10.8	40.4	3.741		

IV. CONCLUSIONS

Two experiments were conducted on double skinned light gauge sections and boxsections with fly ash concrete respectively. The specimens were tested under constant axial load and varying lateral load and the following conclusions are drawn.

4.1 Lateral load Capacity of Specimens.

The lateral load carrying capacity of the specimens F1 and F2 with double skinned steel in filled concrete and tested at 28 days increases by 4.45% when compared with control specimens.

4.2 Ductility.

The Ductility of the specimens F1 and F2 with double skinned steel in filled concrete and tested at 28 days increases by 13.6 % when compared with control specimens.

Experimental study on the behaviour of double skinned light gauge steel sections with fly-ash concrete under reversed lateral loading and constant axial load were done. The specimens tested were of double skinned light weight steel columns with in-filled fly ash concrete. It can be conclude that we can achieve a better strength capacity and ductility ratio, even if the weight of the section is reduced by using CFDST (cold formed double skin Steel Tubes) in-filled with concrete in between the tubes.

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