EXPERIMENTAL STUDY OF BUILT-UP COLD-FORMED STEEL BEAMS

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ABSTRACT

Steel beams have a high span to weight ratio and have extensive engineering applications. Built-up steel beam are used as girders. Cold-formed steel (CFS) beams carry lesser load than their hot rolled steel counterparts and are employed for light loads and short spans. A cold-formed steel beam can be built-up in the same manner as a rolled steel beam to increase its load-carrying capacity. In this study cold-formed steel beams are built in the form of plate girder and tested to failure. The flanges and webs are made thin. Out of the four beam specimens, two beams have lesser depth. The load carrying capacity, deflection, failure mode and strain parameters are investigated by varying the depth.

Keywords: Cold-formed steel beam, Built-up beams, Load carrying capacity, Deflection

I INTRODUCTION

Hot rolled steel and concrete are two proven materials used as structural members. Cold- formed steel members are used extensively in recent years particularly in the earthquake- prone regions. Cold-formed steel can be used as lipped channel sections for purloins, beams and as columns. The failure modes of CFS beams are due to local buckling, distortional buckling, overall buckling and their interactions.

Wilkinson [1] predicted the rotation capacity of cold-formed RHS beams using finite element analysis. Finite element analysis of cold-formed rectangular hollow section beams to predict the rotation capacity was performed. Perfect specimen without imperfections achieved rotation capacities much higher than those observed experimentally. Hsu[2] researched on Flexural performance of symmetrical cold formed thin-walled members under monotonic and cyclic loading. It was found that members with higher flexural rigidities exhibited stiffer pre-buckling. Cheng [3] studied local buckling tests on Cold-Formed Steel Beams of C and Z sections. New methods were proposed for design, and an interim method was adopted in the North American Specification. Lea [4] presented optimum design of cold-formed steel channel beams using micro Genetic Algorithm. As numerical results, the optimum design curves are presented for various load level. The structural behaviour of composite beams was studied by Richard [5] and found that by replacing the conventional steel reinforcing bars with thin-walled, cold-formed steel sections of equal cross sectional areas, the ultimate strength of the composite beams in bending and shear could be achieved. This paper presents the results of beam testing on our built-up CFS I-section beams with different depths and stiffener conditions.

II EXPERIMENTAL INVESTIGATON

2.1 Test Specimen Details

In the present study, cold formed built up I sections with flange width of 100mm and thickness of the section (both web and flange portions) is 2mm. Depth of the section adopted is 150mm and 200mm. The depth of lip is 10mm. The web on both sides is braced with HYSD 415 bars welded diagonally in the shear zone and flexure zone as shown in Figures (1) and (2).

Totally four specimens were fabricated. As the specimen was a built up I section, its three components (i.e. top and bottom flanges, vertical web) were assembled by welding and fabricated like a plate girder. Spot welding was used to assemble the components. The details of the specimen are shown in Table 1.

Fig.1. Cold-formed Steel Beam

In the specimen designation the first three letters 'CFS' describe the material of the beam, the second string '150' denotes the depth of the beam and the third string '-1' denotes the series in each depth.

Table 1- Details of the specimen

S.No	Description of the Specimen	Width of flange (mm)	Depth of web (mm)	Depth of lip (mm)	Thickness flange & web (mm)
1	CFS 150-1	100	150	10	2
2	CFS 150-2				
3	CFS 200-1	100	200	10	2
4	CFS 200-2				

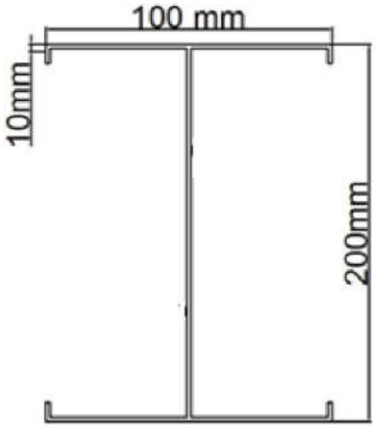


Fig 2. CFS beam cross section

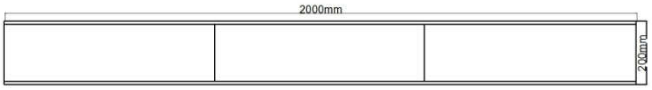


Figure.3 Longitudinal cross section of beam

2.2TEST SETUP

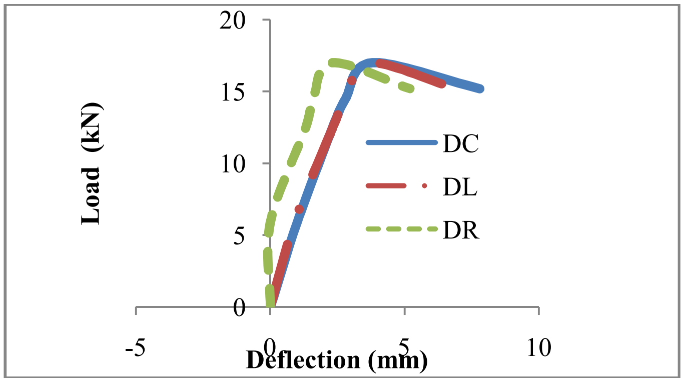
The testing was carried out in a loading frame of 400 k N capacity. All the specimens were tested for flexural strength under two point loading in the vertical loading frame. The specimens were arranged with simply supported conditions, centred over bearing blocks adjusted for a effective span of 1.7m. Loads were applied at one-third distance from the supports at a uniform rate till the ultimate failure of the specimens occurred. Linear voltage displacement transducers (LVDTs) were used for measuring deflections at different locations, one at mid span, two directly below the loading points and two near the end supports as shown in the figure 4. `From which the readings were recorded by a computer at every load interval until failure of the beam occurred. The beams were subjected to four point bending under a load control mode. The experimental set-up for the test specimens are shown in figure 4.

Fig. 4. Experimental set-up for Test Beams

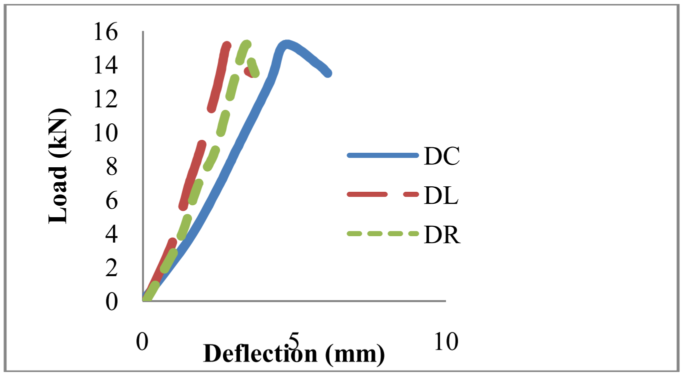
III RESULTS AND DISCUSSIONS

3.1LOAD versus DEFLECTION

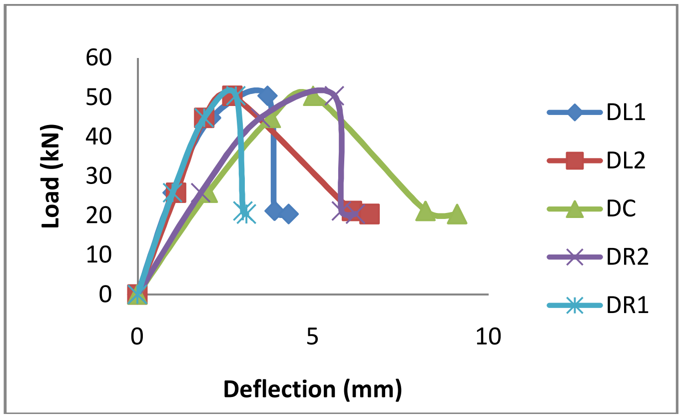
The linear Variable Displacement Transducers were used to measure deflection and the obtained deflections were plotted against their corresponding load obtained from the experimental results.



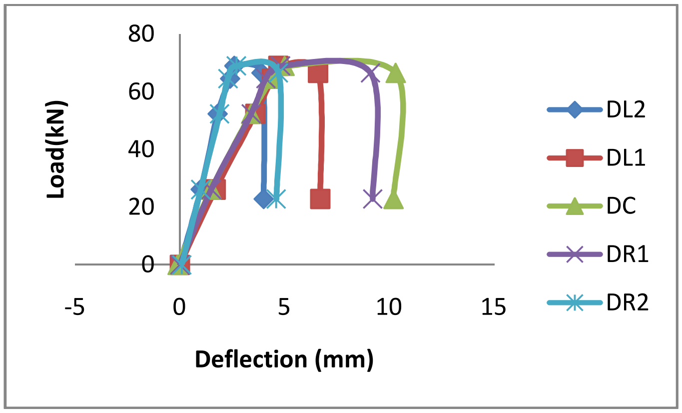
(a) CFS 150-1



(b) CFS 150-2



(c) CFS 200-1



(d) CFS 200-2

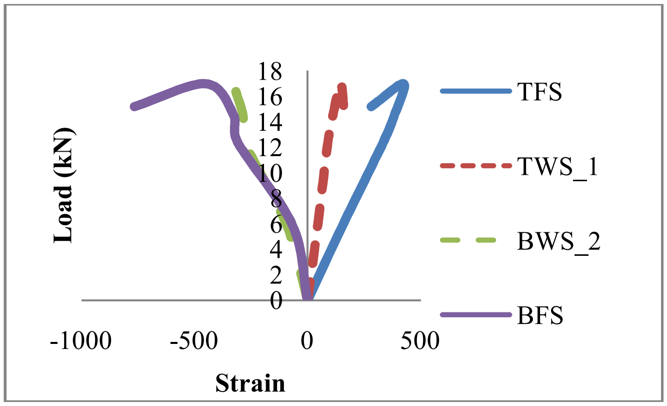
Figure.5Load versus Deflection curves for the test specimens

The ultimate load carrying capacity of the specimens CFS150-1 and CFS150-2 are 17kN and 15kN respectively. The ultimate deflection of CFS 150-1 and CFS 150-2 are 3mm and 4.5mm respectively .Thus the average ultimate load of the beams CFS 150-1 and CFS 150-2is 16kN and the average deflection corresponding to ultimate load is 3.75mm.

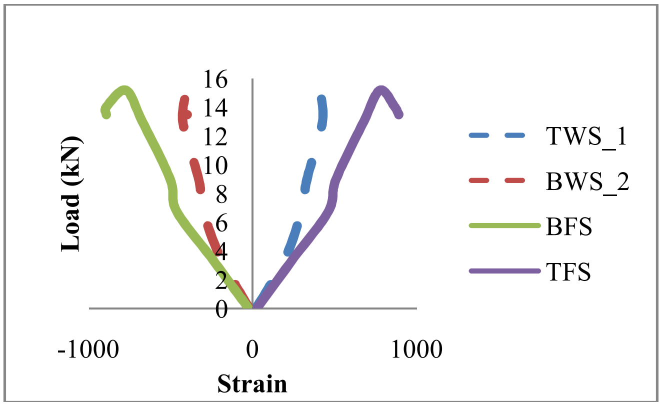
The ultimate load carrying capacity of the specimens CFS 200-1 and CFS 200-2, are 67kN and 77kN respectively. The ultimate deflection of CFS 200-1 and CFS 200-2 are 5 mm and 10 mm respectively. Thus the average ultimate load of the beams CFS 200-1 and CFS 200-2 is 72kN and the average deflection corresponding to ultimate load is 7.5mm.

3.2 LOADS versus STRAIN

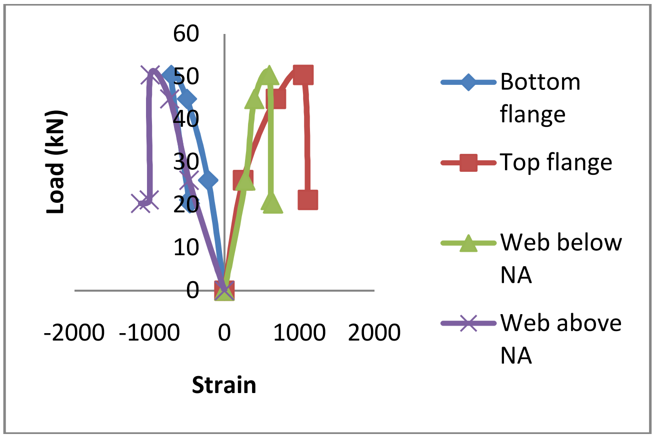
The Strain gauges were used to measure the strain developed in the specimens at top flange, bottom flange, above neutral axis and below neural axis. The obtained strain values were plotted against their corresponding load values obtained from the experimental results.



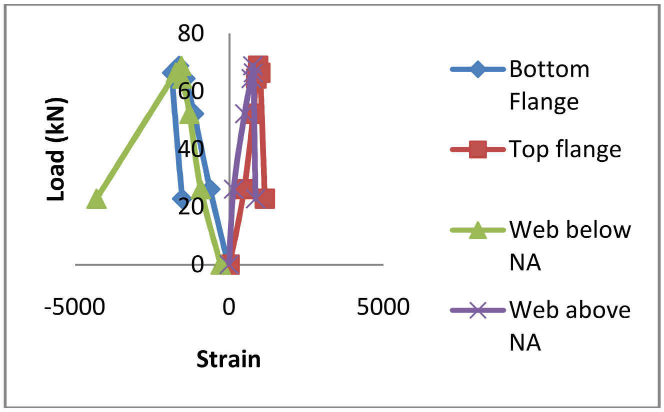
(a) CFS150-1



(b) CFS 150-2



(c) CFS 200-1



(d) CFS 200-2

Fig. 6Load versus strain curves for the test specimens

The load versus strain curves of the test specimens are shown in Figure 6. The measured steel strain at the top and bottom surface (TFS to BFS) at ultimate load varied from 430 to 810 micro strain & 525 to 860microstrain respectively for CFS 150-1 & 2 where as for a beam CFS 200-1 & 2 the values varies from 500to 760microstrain & 1010 to 1300microstrain respectively. From the above results it is observed that the strain in the beams with depth 200mm is more than that of the beam with 150mm depth.

3.3. OBSERVED FAILURE MODE

Both the beam with 150mm depths failed by lateral tensional bucking. The 200 mm beam underwent local bucking. The flange buckled at the flange and web junction between stitch welds. The compression flange developed local buckling in both cases and underwent large deflection. But there was no buckling noticed in the web portion as shown in Figure 7.

Fig.7(a) Failure pattern of 100 mm Beam

Fig.7 (b) Failure pattern of 200 mm Beam

3.4. Strength Capacity of the Specimens

The comparison of strength of the specimens is shown in Figure 8. For the specimen with depth 200mm the load carrying capacity of the beam is 375% higher than the specimen having 150mm depth.

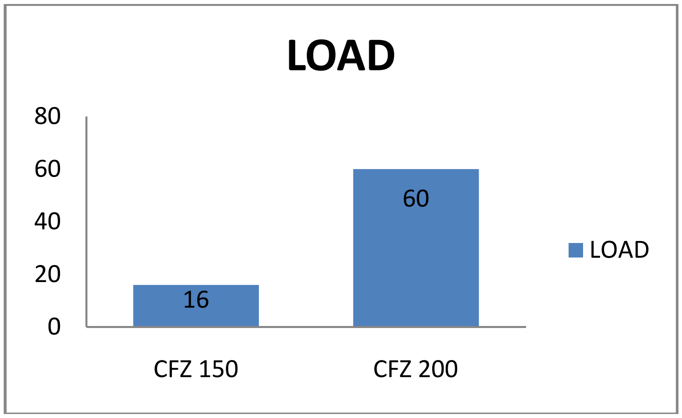


Fig.8 comparison of strength capacity of specimens

IV CONCLUSIONS

The experiments were conducted on cold-formed steel beams braced web with varying depths and the following conclusions are drawn.

- The load carrying capacity of the specimen with 200mm depth is 3.75 times greater than the specimen with 150mm depth.
- Lateral tensional Buckling of the beam was prevented by the stiffeners in the web. There was no lateral tensional buckling for the 200mm beam while 150mm beam underwent severe- lateral tensional buckling.

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