Int. J. Chem. Sci.: 14(S1), 2016, 377-385
ISSN 0972-768X
www.sadgurupublications.com

THE EFFECTS OF BRACED WEB IN COLD-FORMED STEEL BEAMS

J. SAMUEL[*] and P. S. JOANNA

Department of Civil Engineering, Hindustan Institute of Technology and Science, Hindustan University, CHENNAI (T. N.) INDIA

ABSTRACT

The web of a built-up beam is prone to buckling if the web is thin. Stiffeners are provided to increase the post-buckling strength in plate girders. Introducing diagonal bracings is a new concept to increase load carrying capacity in ultimate state. I-section is the most popular steel beam cross-section in use universally. This paper presents the results of the experimental study done on six built-up I-section cold-formed steel (CFS) beams. The specimens were tested with symmetrical two point loading. The nature of loading divides the beam into three equal zones with a central zone subjected to constant flexure and two outer zones in constant shear. The beams were tested by varying the position of diagonal bracings in the central zone and outer zones. The results are compared and contrasted. From the study, it is found that the cold-formed steel beam with braced web in outer zone had the highest load carrying capacity compared to the other beams.

Key words: Cold-formed Steel, diagonal bracings, shear, flexure, zone, load-carrying capacity of beams.

INTRODUCTION

The thin web of a built-up I-section cold-formed steel beam strengthened by bracing is called a braced web. The bracing is a diagonal member welded to the sides of the web on both sides. Braced web increases the overall flexural rigidity of the beam by stiffening the web panel between stiffeners.

Serror[1] experimentally evaluated the rotational capacity of CFS beams and found that stiffeners increase strength, rotational capacity and ductility of beam. Failure took place away from connections, which enabled ductile behaviour without sudden failure. Jun Ye[3] found optimizing relative dimensions and inclination of lips increased the bending capacity

[*]Author for correspondence; E-mail: jsamuel@hindustanuniv.ac.in

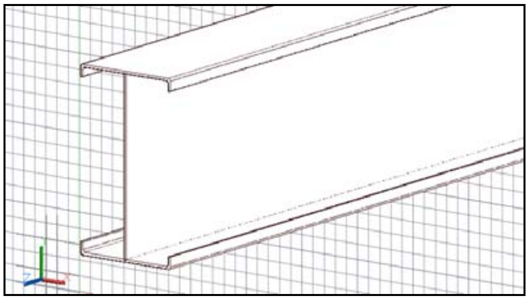
of CFS section up to 30%. Providing folded lips in flanges increased the flexural capacity of CFS beams upto 50% while provision of intermediate stiffeners did not increase the flexural capacity appreciably. CFS beam enhances the mean yield stress by 15% to 20% as compared to hot rolled steel beam Prakash[3]. IS 801: 1975 over predicted the strength of beams subjected to distortional buckling. Experimental and numerical investigation by Sudha[4] on CFS built-up flexural members showed that web element's contribution to strength was appreciable. Vertical stiffeners were required at support and at loading points. Stiffening web element improved the capacity of beam. Members failed by local buckling have more post buckling reserve strength than members failed by distortional buckling.Krishnan[5] investigated on the behavior of cold form steel built up I-section with triangular web corrugation at varying depth. The experimental results are verified with finite element analysis using ANSYS software. The results obtained from test experiments and ANSYS software were compared with the predicted Indian Specifications (IS 801-1975). The experimental result showed that the flexural capacity of the triangular web was larger than flat web. Due to the provision of triangular web corrugation, there was no failure in shear zone or in web portion.

There has been lots of research activity to study about built-up cold-formed steel flexural members. In this investigation, an experimental parametric study of cold-formed steel beam with braced web in different configurations was carried out. A total of six cold-formed steel beams were tested. The two specimens without bracings in webs are considered as control specimens. The provision of bracing in shear zone and flexure zone were the variables among the specimens. The specimens were tested with two point load for pure bending behaviour.

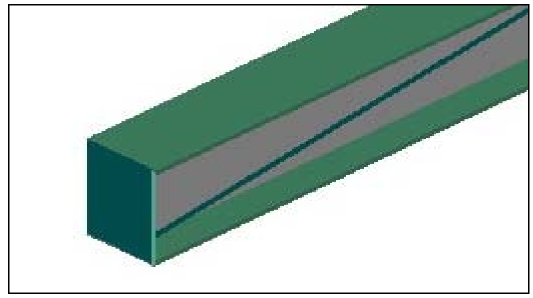
EXPERIMENTAL

Test specimen details

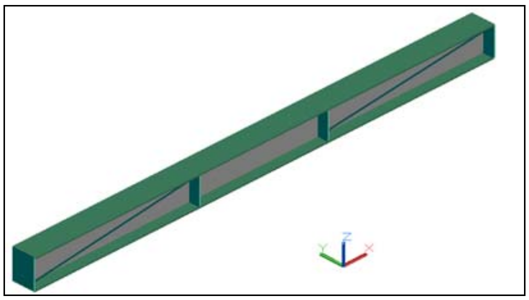
Flanges and webs of required dimensions were cut from parent steel sheet of size 8 feet x 4 feet of 0.2 cm thickness. The flanges were bent at the edges to form a channel section with 1 cm lips. The flanges and webs were assembled together to make the I-section by intermittent fillet welding. Fig. 1(a) shows the specimen without bracing. Fig. 1(b) is specimen with web bracing in outer zone. Fig. 1(c) is the image of a beam with web bracings in two zones and Fig. 1(d) illustrates a beam with web bracings in three zones. Each bracing has a counterpart in the rear side. The details of the specimen CFS section are described in Table 1. The beam specimen is 200 cm long.



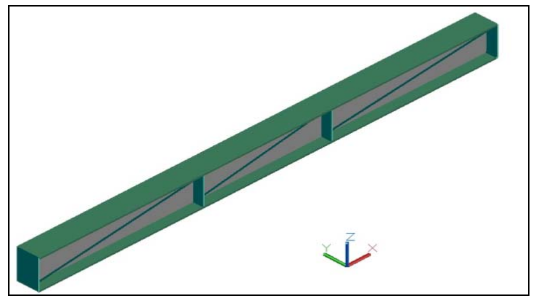
(a) Beam without bracings



(b) Bracing in beam



(c) Specimen with bracings in 2 zones



(d) Specimen with bracings in 3 zones

Fig. 1: Details of beam specifications

Table 1: Details of beam specifications

S. No.	Specimen	Description	Width of flange (cm)	Depth of web (cm)	Depth of lip (cm)	Thickness flange & web (cm)
1	PB-1	Plain beam without web bracings	10	15	1	0.2
2	PB-2					
3	2ZB-1	Beam with bracings in 2 zones				
4	2ZB-2					
3	3ZB-1	Beam with bracings in 3 zones				
3	3ZB-2					

Test set-up

All the specimens were tested for flexural strength under two point loading by using reaction type vertical loading frame. The specimen was arranged with simply supported conditions, centered over bearing blocks adjusted for an effective span of 170 cm. Loads were applied at one-third distance from the supports gradually increased at an uniform rate until ultimate failure. Deflection of the beam was picked up by 3 nos. of LVDT placed at mid-span and below the symmetric two point loads. Strain gauges were also fixed to record stain measurements in the top and bottom flanges and also above and below the neutral axis in the webs. For each load increment the deflection and strain were observed and tabulated. The load cell, LVDT and strain gauges were connected to the DATA logger.

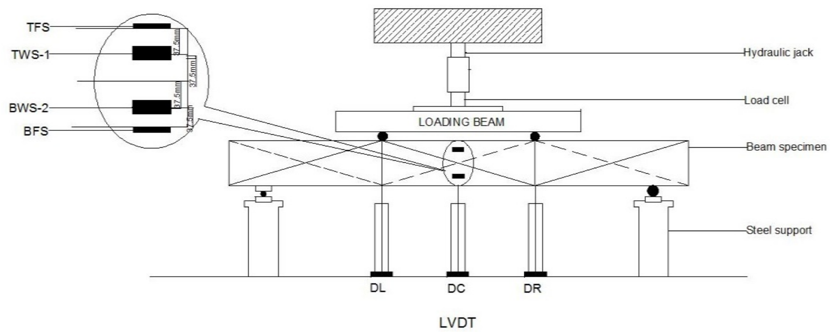


Fig. 2 Position of LVDTs and strain gauges

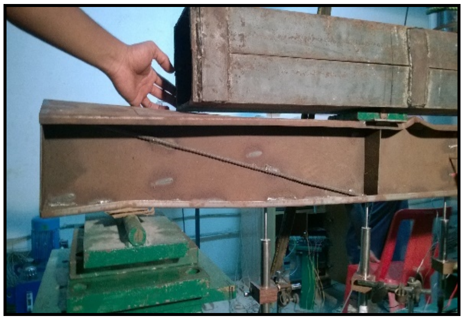
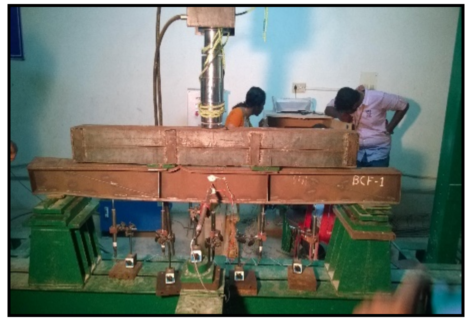
RESULTS AND DISCUSSION

Observed failure mode

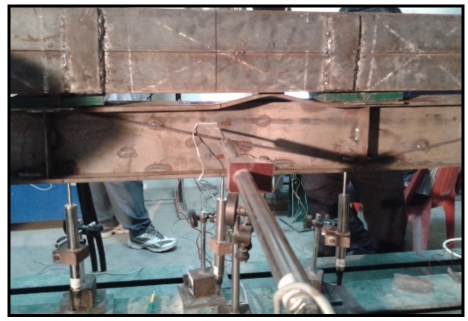
The failure pattern of the test specimens is shown in Fig. 3. Beams without bracings in web failed by lateral torsional buckling of the cross-section. In the specimens with webs bracings in 3 zones and 2 zones, the beams underwent slight lateral torsional buckling and local buckling of compression flange.

(a) PB-1

(b) PB-2

(c) 2ZB-1 **(d) 2ZB-2**

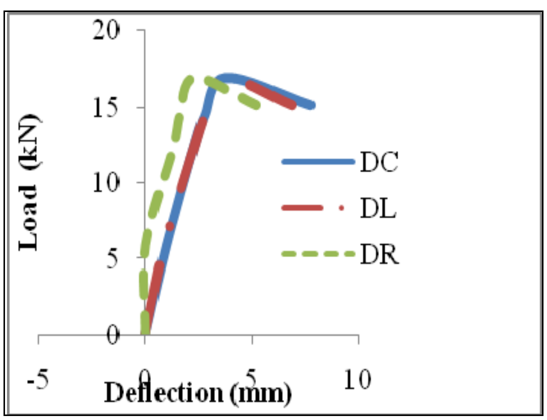
 

(e) 3ZB-1 **(f) 3ZB-2**

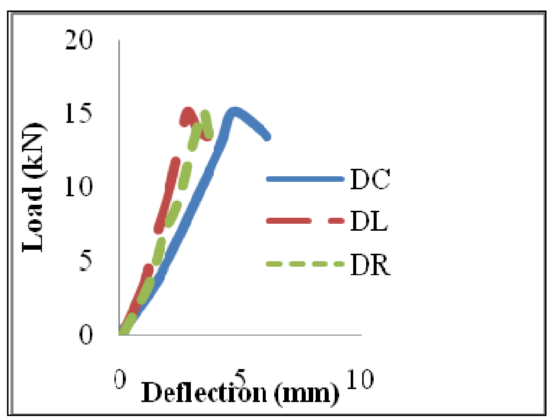
Fig. 3: Failure pattern of the test specimens

Load vs deflection curves

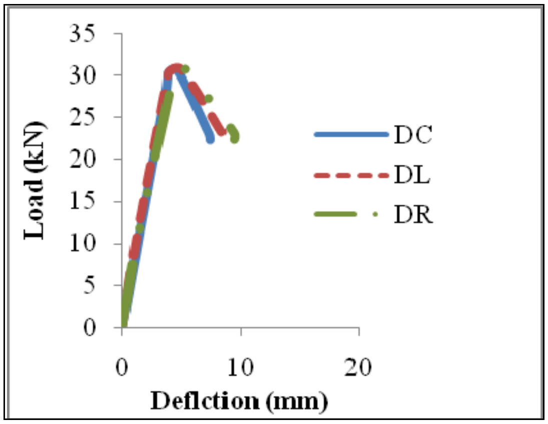
The experimental load-deflection curves of the cold-formed steel beams without bracings and with bracings are shown in Fig. 4.



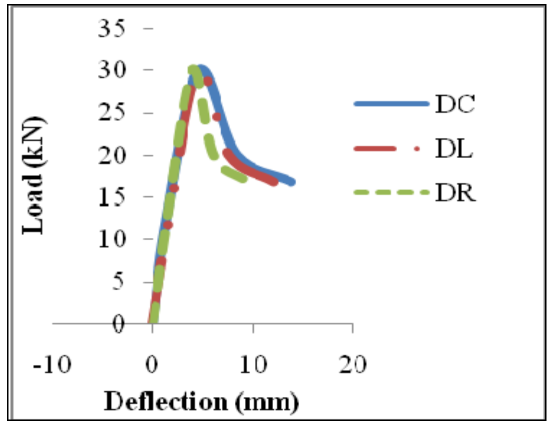
(a) PB-1



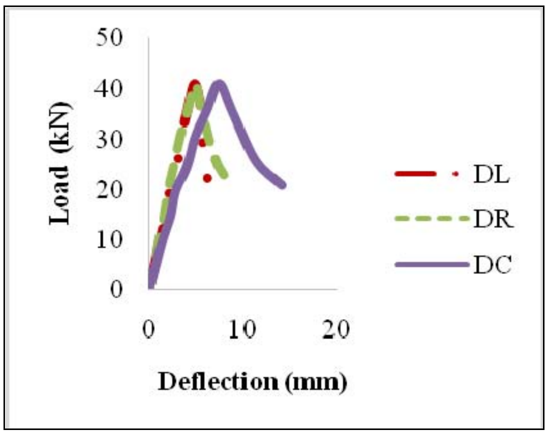
(b) PB-2



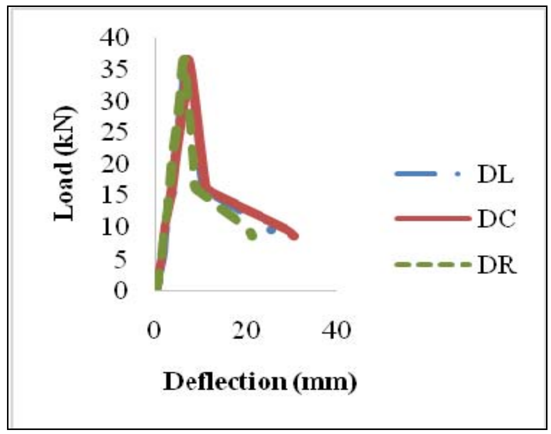
(c) 2ZB-1



(d) 2ZB-2



(c) 3ZB-1



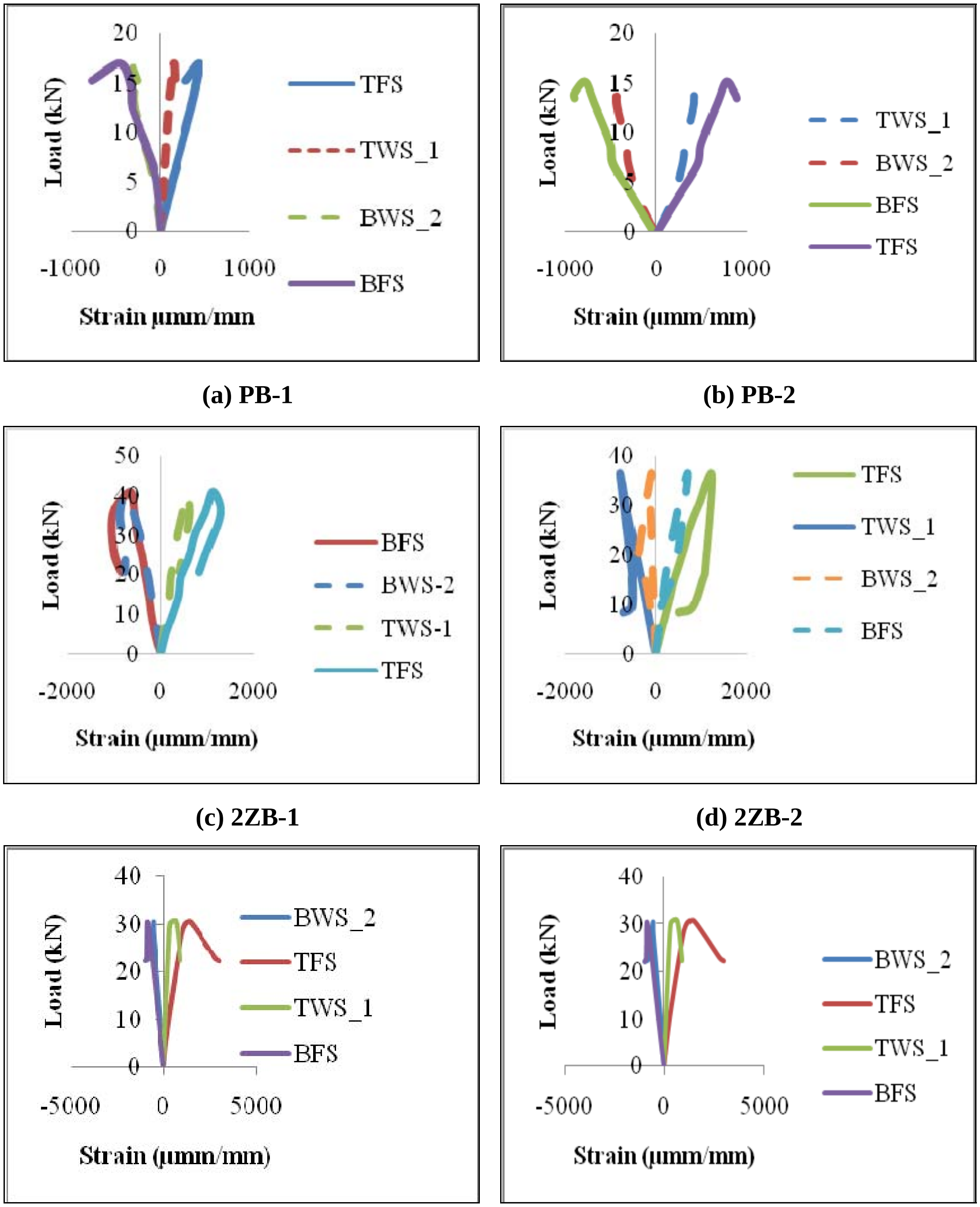
(d) 3ZB-2

Fig. 4: Load versus deflection curves for the test specimens

The specimens without bracings failed at an average load of 16 kN with a average central deflection of 6 mm and specimens with 3 zone bracings and specimens with 2 zone bracings failed at average loads of 30 kN and 39 kN and corresponding average deflections of 5 mm and 8 mm, respectively.

Load vs strain curves

The load versus strain curves of the test specimens are shown in Fig. 5. The measured steel strain at the top and bottom surface (TFS to BFS) at ultimate load varied from 855 to 1425 and 602 to 765 micro strain, respectively for CFS beams without web bracings whereas for the beam with web bracing in 3 zones the strain varied from 1236 to 1296 and 768 to 870 micro strain and for the beam with bracing in 2 zones the strain varied from 2987 to 3357 and 968 to 1374 micro strain, respectively.



(a) PB-1 (b) PB-2

(c) 2ZB-1 (d) 2ZB-2

(e) 3ZB-1 (f) 3ZB-2

Fig. 5: Load versus deflection curves for the test specimens

From the results it is observed that the strain in the beams with web bracings in 3 zones is more than that of the beams with bracings in 2 zones and webs without bracings.

Strength capacity of the specimens

The trajectory of strength capacity of the specimens is shown in Fig. 6. The load carrying capacity of the beam with web bracings in 3 zones was 2.44 times greater than that of beams without web bracings. The load carrying capacity of beams with web bracing in 2 zones was 1.88 times more than the specimens without web bracings

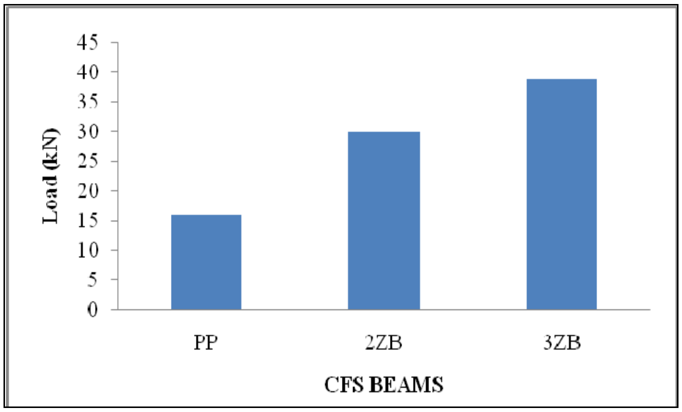


Fig. 6: Comparison of strength capacity of specimens

CONCLUSION

The following observations and conclusions can be made on the basis of the experiments conducted on the six cold-formed steel beams with different web conditions:

(i) The average load carrying capacity of cold-formed steel beam with web bracing in all zones is 2.43 times the capacity of beams without web bracing. But there is a marginal increase in load carrying capacity of beam with web bracings in all zones compared to beams with web bracings in outer zones alone.

(ii) Beams without web bracings clearly underwent lateral torsional buckling, but beams with web bracings exhibited lateral torsional buckling slightly.

(iii) The strain in the beam with web bracings in all zones is more than that of beams without web bracings and beams with web bracing in outer zones.

REFERENCES

1. M. H. Serror, E. M. Hassan and S. A. Mourad, Experimental Study on the Rotation Capacity of Cold-Formed Steel Beams, J. Constructional Steel Res., 216-218 (2016).
2. J. Ye, I. J. Souliha, J. Becque and K. Pilakoutas, Development of More Efficient Cold-Formed Steel Channel Sections in Bending, Elsevier, Thin Walled Structures, **101**, 1-13 (2016).
3. P. M. Mohite and A. C. Karoo, Buckling Analysis of Cold-Formed Steel for Beams, Int. J. Sci. Res. Publications, **5(5)** (2015).
4. K. Sudha and S. Sukumar, Behaviour of Cold-Formed Steel Built-up Section under Bending, Int. J. Engg. Technol. (IJET), **5(6)**, Dec 2013-Jan 2014[5].
5. L. Krishnan, C. S. Dineshraj and S. Prema, Experimental Investigation of Cold-Formed Steel Section-Flexural Member with Triangular Web, IOSR J. Mech. Civil Engg., **12(2)**, 36-39 (2015).

Accepted : 04.05.2016