



FLEXURAL BEHAVIOR OF COLD FORMED STEEL I-SECTION BEAM WITH CORRUGATED WEB

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ABSTRACT

This paper presents a study on behavior of cold formed steel (CFS) beam with plain web, triangular corrugated web and trapezoidal corrugated web. This study involves in examination of theoretical and experimental investigations of specimens in series. Overall three specimens were tested with length of 1200 mm. All specimens are tested under two point loading with simply supported condition. The theoretical data are calculated using Indian Standard code IS 801-1975. The load carrying capacity and failure modes of beams were discussed. Based on the test beam with trapezoidal corrugated web shows maximum load carrying capacity compared with the plain web.

Keywords: Cold formed steel; load deflective curve; stiffness; failure modes.

1. INTRODUCTION

Structural members in steel construction are classified into two categories such as hot rolled sections and cold formed section. Cold formed steel sections are more preferable than hot rolled sections because of their higher versatility and as they are well suited for economic construction. These Cold formed steel sections are manufacture by two methods such as hot rolling or by method of press-braking. Cold formed steel are extensively used in building industry, and range from purling to roof sheeting and floor decking. In general Cold formed steel section like channel, Z-section and I- section are effectively used as flexural member for purlins, wall grits and roof slab. [1] presents the results of the experimental study on load carrying capacity of cold-formed steel section with trapezoid web. From the study, it is found that the cold-formed steel beam with trapezoidal corrugated web has higher load carrying capacity compared to the beams having plain web and 45 degree corrugated web.[2] conducted experiments to the determination of buckling strength of a plate girder considering rectangular corrugated web plate. The finite element analysis of a plate girder is carried out

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using ANSYS. The results obtained from analysis are then compared with the plate girder with plane web of uniform depth. Various parameters like buckling strength and weight are compared. Thus it proves that corrugated web is economical and has sufficient buckling strength. It is concluded that the corrugated web plate has high buckling strength and sufficient reduction in weight with light gauge elements, than plate girder with plane web. [3] conducted an extensive experimental program to investigate the behavior of eight composite beams are subjected to hogging moment. Built-up cold-formed normal and corrugated web beams are studied. The majority of cracks were formed between the zone of two point loading and also some cracking was also observed near the supports end. The load carrying capacity of encased web beam was significantly higher than that of normal web beam. [4] the effect of web corrugation on the bending strength or flexural strength of cold formed steel (CFS) I section is presented. The purpose of this study for to investigate the efficient and economical designs of girders and beams. Slender web will cause the web to buckle. To overcome this, the corrugated web can be used. In this paper they determine the maximum load carrying capacity of the specimens by using code AISI:S-100- 2007, "Code of practice for use of cold formed structural members in construction". From the results they conclude that as the corrugation web increases the load carrying capacity also increases and the effective shape of the profiled sheeting for practical use is triangular web profile. All beams are crushing on top flange and Local buckling. The entire specimen failed due to crushing on top compression flange and local buckling. [5] studied the structural action of a beam is predominantly bending, with other effects such as shear, bearing and buckling also being presented. And they studied about the behavior of plate girder with flat web and corrugated web. [6] presents the behavior of cold form steel built up I - section with triangular web corrugation at varying depth. From the experimental results they conclude that as the corrugation web depth increases the moment capacity also increases. All beams are crushed on top flange and Lateral torsion buckling occur. Rate of loading for the specimen is 0.05 kN/sec. The load and deflection readings were taken out. Due to loading the beam start buckling, at the end of the test, failure and failure mode were analysed. [7] made finite element models to determine the behavior of cold-formed steel plain angle columns. The main objective of this comparison is to verify and check the accuracy of the finite element model .And also effect of residual stress is also investigated that the measured small membrane residual stresses has a negligible effect on the ultimate load, stiffness of the column, load-shortening behavior, and the failure mode. The curves were plotted with and without the simulation of residual stresses. It gives almost identical ultimate load carrying capacity of the member. [8] presents the buckling behavior of cold-formed steel equally lipped angle columns are analyzed. The initial local imperfections, residual stresses, and corner material properties of the cold-formed steel lipped angle test specimens have been experimentally measured and reported in this paper. [9] series of connection tests which were composed of closed cold-formed steel sections were conducted to investigate the performance of the connections constituting a pitched roof portal frame. The flexural strength of the section was investigated first and the structural behavior of the connections including the moment-rotation relation, the yield, and ultimate moment capacity of the connections were studied experimentally. The connection tests were executed by the displacement control method with the loading velocity of 1 mm/min using a 250 kN testing machine.

2. EXPERIMENTAL PROGRAMME

2.1 Specimen details

Three types of beams were fabricated one beam with plane web and remaining two are trapezoidal and triangular corrugated webs with a corrugation angle of 45 degree the theoretical design was made as per IS 801-1975. The length of the is 1200mm and the dimensions of the beam are depth of 150mm ,width of flanges 120mm and the thickness of web and flanges is 2mm. The details are shown in Table 1 and Figs. 1-3.

Table 1: Dimensions of the beams with corrugated angles

Type of beam	Thickness of flange F_t (mm)	Width of flange F_w (mm)	Thickness of web W_t (mm)	Depth of web W_d (mm)	Corrugation angle (degree)
Beam 1	2	120	2	150	0
Beam 2	2	120	2	150	45
Beam 3	2	120	2	150	45



Figure 1. Beam with normal web



Figure 2. Beam with trapezoidal web



Figure 3. Beam with triangular web

2.2 Test setup

The specimens are tested in loading frames under two point loading at $1/3$ distances as shown in Fig. 4. The specimens are simply supported hinged-hinged over the loading frame. The load is transferred through the load cells which measure the deflection and load increment in the specimens. All the data's are recorded in data acquisition system.



Figure 4. Experimental set up for beam with plain web

The experimental investigation in this research involves the fabrication of beams. To check the load carrying capacity of the beams are tested under two point loading for pure flexure .the beams were undergoes two point loading until its failure. The deflection and failure modes for three different cases were studied. Finally experimental results are compared with the theoretical results.

3. RESULTS AND DISCUSSION

The theoretical load for specimen is calculated as per IS 801-1975, and compared with experimental load of each specimen are presented in Table 2. Theoretically maximum load carrying capacity for the specimen is 14.5kN and experimentally maximum load carrying capacity for beam with normal with normal web is 15.26kN,for beam with trapezoidal corrugated web is 18.60kN and for beam with triangular corrugated web is 22.40kN. The corresponding deflections for the beams with normal web, trapezoidal corrugated and triangular corrugated web are 11.2mm, 10.09mm and 12.47mm respectively. The experimental load carrying capacity increased for beams as compared with the theoretical load carrying capacity. The load carrying for beam with normal web increased by 5.24%,for the beam with trapezoidal corrugated web increased by 28.27% and for beam with triangular corrugated web increased by 54.4%.

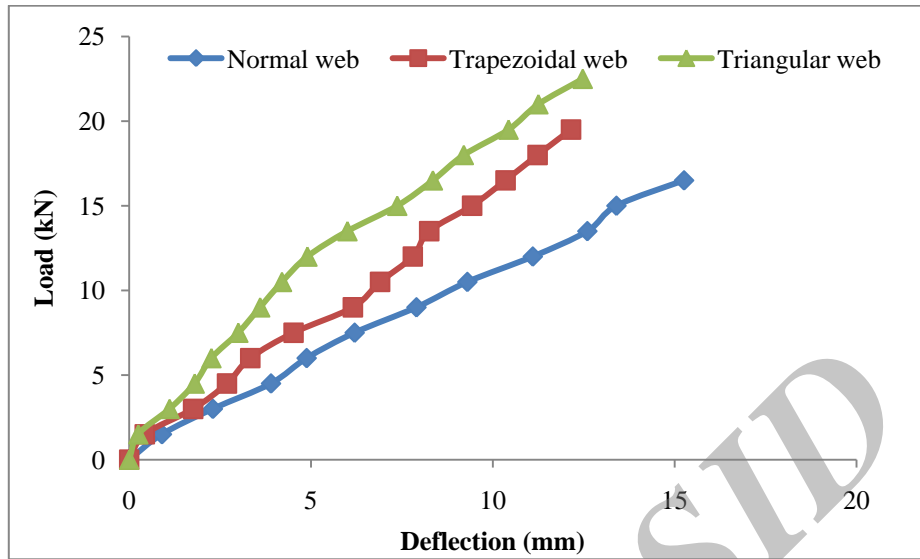


Figure 5. Load – deflection curve

Table 2: Comparison of Experimental and Theoretical load carrying capacity of beams

Type of beam	Theoretical load (kN)	Experimental load (kN)	Increase in load carrying capacity(%)
Beam with plain web	14.50	15.26	5.24
Beam with trapezoidal web	14.50	18.60	28.27
Beam with triangular web	14.50	22.40	54.40

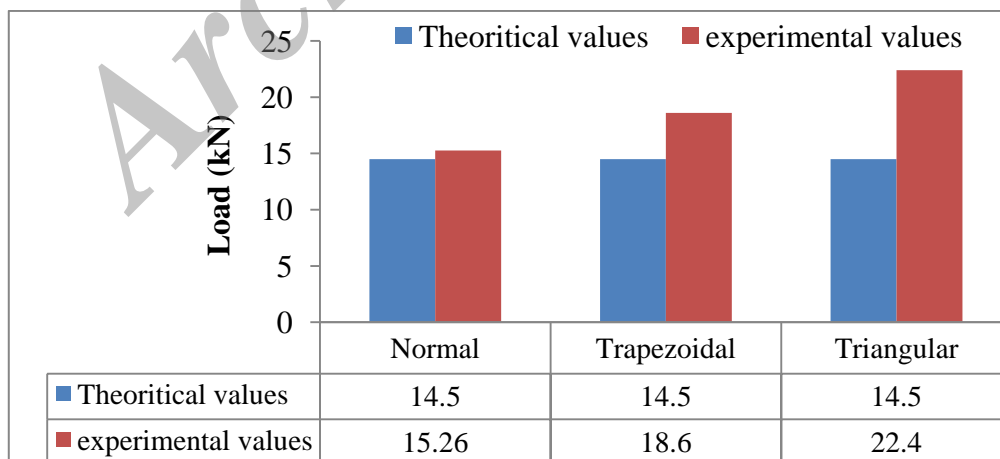


Figure 6. Comparison of Experimental and Theoretical load carrying capacity of beams

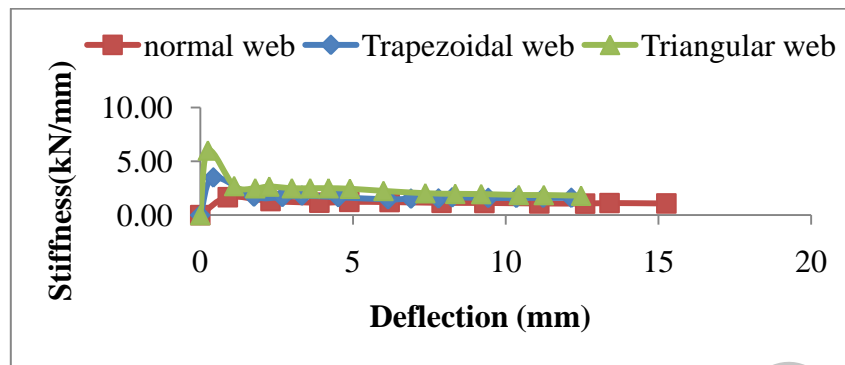


Figure 7. Stiffness vs deflection curve for beams

Initially the stiffness is increased for beam upto a certain load , after that the stiffness gets reduced due yield takes place .The stiffness for the beam with triangular corrugated web is more than the beam with normal web and trapezoidal web are shown in Fig. 7.

3.1 Failure modes

During experiment different failure mode were observed. The beam with normal web failed in shear zone, the beam is twisted along longitudinal direction called torsional buckling. The failure observed for beam with trapezoidal corrugated web was torsional buckling +flexural buckling and for the beam with triangular corrugated web was Local buckling +flexural buckling observed.



Figure 8 Failure mode observed during experiment for Normal web

Table 3: Failure modes observed during test

Type of beam	Failure mode
Beam with normal web	Torsional buckling
Beam with trapezoidal corrugated web	Torsional buckling + flexural buckling
Beam with triangular web	Local buckling +flexural buckling

4. CONCLUSIONS

From the experimental investigations conducted on I section beams with different corrugated shapes in webs to carrying the maximum loads and failure modes , the following conclusions were arrived.

1. From the results load carrying capacity is higher for beam with triangular corrugated web with the comparison of beam with normal web and trapezoidal web.
2. The load carrying for the beam with trapezoidal web is increased by 18% and for the triangular web is increased by 31.8% with comparison of load carrying capacity of beam with normal from the experimental results.
3. The corrugation reduces the torsional buckling failure to local buckling
4. Specimen with corrugated web, local buckling is predominate, failure occurs under the load.
5. Due the corrugation there is no failure in shear zone.
6. From the experimtal results beam with triangular corrugated web has higher load carrying capacity than the beam with normal web and trapezoidal web.
7. The corrugated web element significantly increases in the strength of member.

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