

Flexural and Torsional Strength of Light Gauge Steel built-up Channel sections

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Abstract- Cold-formed steel members are widely used in building construction, bridge construction, storage racks, highway products, grain bins, transmission towers, car bodies, railway coaches, and various types of equipment. Cold-formed steel has been widely used in construction industry also. In this paper, an attempt has been made to investigate the Flexural and Torsional strength of a open built up and closed built up channel sections. A built up cold formed steel beam has been adopted for a span of 1.25m. The strength is evaluated both theoretically and experimentally and the results are compared in this study. The load carrying capacity of light gauge steel channel sections subjected to flexural and torsional buckling is studied. It is noted that the load carrying capacity of built up sections are more than the sections. The failure patterns of this section were extracted. All specimens are subjected to two-point loading with simply supported condition. The experimental result shows that the Torsional and flexural capacity of the built-up cold formed steel beam with lip and without lips condition.

Index Terms- Closed built up sections, cold form steel, local buckling, and lateral Bucklin

1.INTRODUCTION

Cold-formed steel (CFS) section is commonly applied in secondary structural members and load-bearing primary structural members. Prefabricated modular house using light steel framing system is a suitable alternative to replace conventional wet-casting concrete structures when rapid construction is needed. CFS light steel framing is also more sustainable as compared to timber modular house system, as it avoids massive cutting down of trees and the steel materials are almost 100% recyclable. For CFS light steel framing, the previous research was concentrated on member analysis: connection

and roof truss testing. However, CFS sections are different from the hot-rolled steel sections in structural behavior due to their thin-walled and slender profiles.

Cold forming has the effect of increasing the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range. These increases are predominant in zones where the metal is bent by folding. The effect of cold working is thus to enhance the mean yield stress by 15% - 30%. For the purposes of design, the yield stress may be regarded as having been enhanced by a minimum of 15%.

Advantages of Cold-Formed Steel as compared with hot rolled steel counterpart are

- Cross sectional shapes are formed to close tolerances and these can be consistently repeated for as long as required.
- Cold rolling can be employed to produce almost any desired shape to any desired length.
- Pre-galvanized or pre-coated metals can be formed, so that high resistance to corrosion, besides an attractive surface finish, can be achieved.
- All conventional jointing methods, (i.e. riveting, bolting, welding and adhesives) can be employed.
- High strength to weight ratio is achieved in cold-rolled products.
- They are usually light making it easy to transport and erect.

It is possible to displace the material far away from the neutral axis in order to enhance the load carrying capacity (particularly in beams).

There is almost no limit to the type of cross section that can be formed. Some typical cold formed section profiles are sketched in Fig.1.

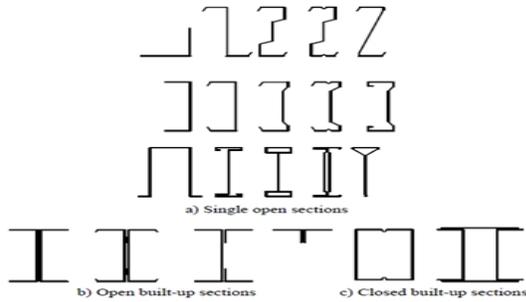


Fig.1. Various types of Cold-Formed Sections
2.SPECIMEN

The test specimens were fabricated at the University of SRM Civil Engineering Structural Laboratory.

The specimens consisted of lipped C- sections arranged face to face and connected by cover plate through intermittent weld connection an (Fig. 2).

The key cross-sectional parameters for each tested cross-section are summarized in

Table.1.

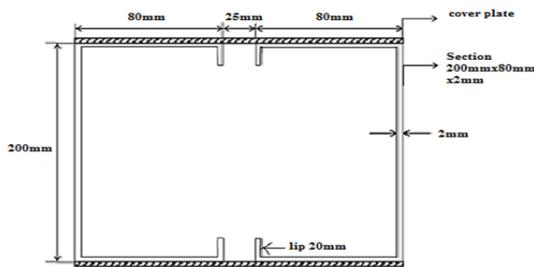


Fig. 2. Specimen Details

3.TEST PROCEDURE AND INSTRUMENTATION

3.1 Flexural Testing

The testing was carried out in a loading frame of 400kN capacity. All the specimens were tested for flexural strength under two point loading. The specimens were arranged with simply supported conditions having an effective span of 1.0 m. Loads were applied at one-third distance from the supports at a uniform rate till the ultimate failure of the specimens occurred.



Fig. 3: Test Setup for flexure

Table-1 Size of Closed built up channel Section Specimen

Name of the specimen	Beam section LxB xDx Lip (mm)	Thickness of cover plate, 't'(mm)	Design strength, fy (N/mm ²)	Type of weld	Total length of weld (mm)	Weld spacing (mm)
Closed builtup channel section	125 0x8 0x2 00x 20	2	350	Intermittent weld	500	113

Deflections were measured at the loading points and at the centre of the beam using deflectometers. Strain gauges are fixed at the top and bottom plates at the centre. The strain gauges were connected to a data logger from which the micro strain was noted at every load interval until failure of the beam occurred. The experimental set-up for the test specimens are shown in Fig. 3.and failure pattern of the specimen after loading condition shown in Fig.4.



Fig 4: Failure pattern

3.2 Torsional test

Lateral torsional buckling is a limit state of structural usefulness where the deformation of a beam changes from predominantly in-plane deflection to a combination of lateral deflection and twisting while the load capacity remains first constant, before dropping off due to large deflections.

The various factors affecting the lateral-torsional buckling strength are:

- Distance between lateral supports to the compression flange.
- Restraints at the ends and at intermediate support locations.

- Type and position of load Moment gradient along the length.

- Type of cross-section. Material properties, Initial imperfections of geometry and loading

The beams were given coating with iron oxide at the surfaces before testing. Using permanent marker the locations of the supports are marked, and Linear Variable Differential Transformer (LVDT) points to measure deflections were marked. A self-straining frame of 50 ton capacity fixed over strong floor was used for testing. The beams were simply supported with a pure torsion region of 600 mm c/c. An arm of 500mm length is been placed on both the sides of the specimen which is made up of hot rolled angle section torsional load is been given using a spreader beam (a rolled steel I-joist) LVDTs were used to measure the twist of the beams. One LVDT was kept at side faces of each ends. Loading was applied by means of 20 KN hydraulic jack of capacity. The behavior of the beams was keenly observed from the beginning to till the collapse. The experimental set-up for the test specimens are shown in Fig. 5.and failure pattern of the specimen after loading condition shown in Fig.6.



Fig 5: Test setup Torsion



Fig 6: Failure pattern

4. EXPERIMENTAL RESULTS

4.1 Flexural & Torsional Testing

From the figure 7 it has been observed from the experimental result that while placing the LVDT at the support the ultimate deflection of 2.98 mm for the load 42 KN. Similarly from figure 8 while placing the LVDT at the other support the ultimate deflection of 2.75 mm for the load 40 KN. From the figure 9 the ultimate load was found to be 42KN and the corresponding strain value is 371 and from fig 10 the ultimate Torque value is 14.4 rad/m and Twist is 0.00075KNm.

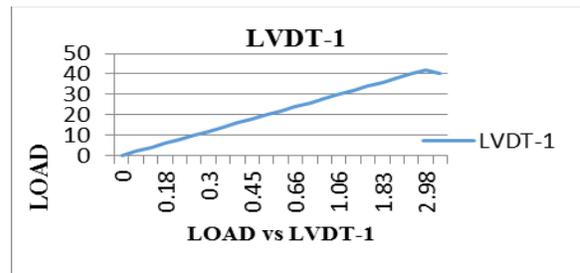


Fig-7 (Load vs LVDT-1)

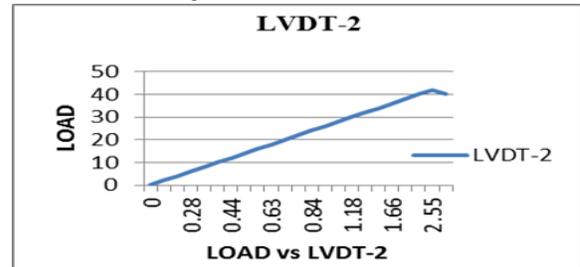


Fig-8 (Load vs LVDT-2)

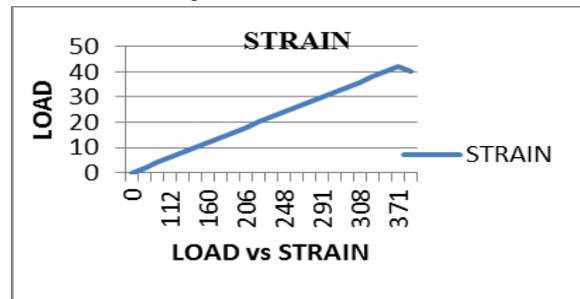


Fig-9 (Load vs Strain)

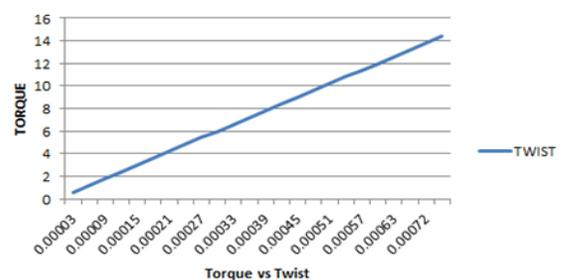


Fig-10 (Torque vs Twist)

5. THEORETICAL ANALYSIS

The present study is carried out to understand the Flexural and Torsional behaviour of cold formed light gauge steel using IS: 801-1975 & BS 5950-5:1998. Different countries use different codes as per Indian standard IS: 801-1975 is a code of practice for use of cold-formed light gauge steel structural members in general building construction the design of members is carried out by working stress method whereas the BS: 5950-5:1998 structural use of steelwork in building – Part5. Code practice for design of cold formed thin gauge sections, here the design of members is carried by limit state method. Thus, results for both IS code & BS codes obtained and tabulated in Table 2 & 3 for to compare

Table 2: Theoretical Torsional Result

Specimen (mm)	200x80x2
Max shear stress (N/mm ²)	34.70
Ixx (mm ⁴)	18060000.6
Section modulus, Z (mm ³)	184280.3
Web shear (N/mm ²)	27.2
Permissible safe load (kN)	43.52
Allowable Deflection (mm)	3.85
Maximum Deflection (mm)	3.28
Maximum Twist	0.00085 kNm
Maximum Torque	15.5 rad/m

Table 3: Theoretical Flexural Result

Specimen (mm)	200x80x2
Max shear stress (N/mm ²)	34.70
Ixx (mm ⁴)	18060000.6
Section modulus, Z (mm ³)	184280.3
Web shear (N/mm ²)	27.2
Permissible safe load (kN)	43.52
Allowable Deflection (mm)	3.85
Maximum Deflection (mm)	3.28

6. RESULTS AND DISCUSSIONS

S.no	Description	Twist (kNm)	Torque (rad/m)
1	Theoretical results	0.00085	15.5
2	Experimental	0.00075	14.4

This paper presents a practical method to obtain a economical CFS build-up section are made from the above study:

- The cover plates at top and bottom of flange increases the flexural capacity of the beam.
- Numerical validation has been carried out to verify the appropriateness of the experimental results and find that they are quite closer to the corresponding test result. Failure due to shear in web is eliminated due to the presence of cover plates.
- The results obtained based on the various codes are conservative with the increment of depth of the strength and stiffness of the beam also increases.
- The entire beam failed at local buckling of the top flange. This mode of failure is mostly seen in cold-formed steel as compared to hot rolled steel.
- The angle of twist obtained from theoretical investigation is more than that of experimental values.
- The face to face cold formed steel angle section properties are studied. The fabrication process of the face to face steel angle section was studied.
- The section was fully buckled and strain gauge, proving ring values are noted down. Then the values are used to plot graph such as Twist versus Torque.

7. CONCLUSIONS

- The Ultimate load was found to be decreased by 3.5% when comparing the experimental load with theoretical value.
- The Value of Experimental deflection value is 3.12 mm which is 4.9 % less than the theoretical deflection value and 19 % less than the allowable deflection value.
- By Comparing the Experimental and theoretical results the Torque and Twist is found to be decrease by 7 % and 11.76%.
- It was, therefore, concluded that in the case of closed built up section the experimental value for all the properties is lesser than the Theoretical value.

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