Experimental Study on Flexural Behaviour of Cold Formed Steel Channel and I Sections Providing Angle Stiffener on the Web

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Abstract

Background: Different products are manufactured from Cold Formed Steel (CFS) are used in the different field of our daily life; in the home, the shop, the factory, the office, the car, the petrol station. These products have many uses ranging from 'tin' cans to structural frame, building members. This investigation presents the analytical study and theoretical study of the behaviour of flexural strength of CFS sections. Methods: Analytical study of CFS section was done by using FEM software (ANSYS Multiphysics Utility – CIVILFEM). Here two Channel sections and two built up I sections are fabricated. Built up I sections are formed by using symmetric channel section with the help of bolts provided in the web part of the section. One of the built up I section and C section are provided with angle stiffener to increase the flexural strength. The analytical results are compared with theoretical results according to IS 801:1975. Findings: From the study it is found that the maximum moment are occurring in between the one third of span to two third of span of the subjected sections. The moment in the zone between the two point loads are same and that portion is known as pure bending zone. Flexural strength is increased by providing angle stiffener throughout the length of the sections at the spacing of 40 mm between two stiffener and for I section and Channel section total stiffeners are provided respectively 24 and 12. Applications: Further works can be focused on determining the behaviour of the channel and built up I section with increasing web thickness, flange thickness and increasing the stiffener dimension. Another useful can be done by using diagonal stiffener with the temperature effect which may change the behaviour of channel and built up I section.

Keywords: Build Up Section, Cold Formed Steel, Flexural Strength, Theoretical and Analytical Study

1. Introduction

Cold Formed Steel also is known as Light weighted steel. In Civil engineering field, Cold Formed steel members are generally used in industrial building as purlin, columns; truss or frame member, storage racks, vehicle bodies, transmission tower members and different types of equipment. During 1940s cold formed steel were used in construction industry as a light weighted material[1-3]. There are many advantage of cold formed steel as a construction material such as high strength and stiffness, ease of prefabrication and mass production, fast and easy erection and installation, economy in transportation and handling in the field of both structural and non structural industry[4]. The mechanical properties (yield point, tensile strength, and ductility) of this kind of steel sections mainly depends on the manufacture process which is known as cold working method. This method is used for strengthening of metal by plastic deformation, also known as strain hardening method (when the metal is strained beyond the yield point)[5]. This is because the cold-forming operation increases the yield point and tensile strength and at the same time decreases the ductility. The aim of this research is to find the flexural strength of Cold Formed Steel (CFS) Channel & 'I' section (back to back bolted built up section) analytically by introducing stiffener angle sections at the web part by using FEM software (ANSYS Multiphysics Utility-Civil FEM software). The stiffeners are introduced

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to enhance the flexural strength of the member. Using the theoretical approach, it is also aimed to calculate the maximum deflection, bending moment and shear.

2. Specifications of the Specimen

The Physical properties of cold formed steel material is given in Table 1. This properties are taken from IS :801-1975.

3. Material Specification

Here “I” sections are fabricated by assembling back to back of two cold-formed steel channel sections as shown in Figure 2. The channel sections are bolted together with 300 mm spacing to assemble the “I” sections. These spacing are used in the loading points to ensure effective force transferring through the bolted connections. Here for fabrication, 10 mm and 8mm diameter of grade 8.8 with 20 mm length bolts are used. The geometrical properties of C built up I section and stiffener angle section are given below and also dimension of these sections are shown in figure 1, figure 2, figure 3.

| Channel section | Built up I section |
|----------------|--------------------|
| 1) Area of Cross section - 6081 mm² | 1) Area of Cross section - 1216 mm² |
| 2) Moment of inertia 3.497435×10⁶ mm⁴ | 2) Moment of inertia -6.994869×10⁶ mm⁴ |
| 3) Length - 1200 mm | 3) Length - 1200 mm |

| Stiffener Angle Section |
|-------------------------|
| 1) Area of Cross section - 231 mm² |
| 2) Moment of inertia -5.9012×10⁴ mm⁴ |
| 3) Length -200 mm |

4. Methodology

In this paper investigation is made to find flexural strength of Channel sections and built up I sections with and without stiffener made of cold formed steel are shown in figure 4.

Table 1. Property of CFS as per IS :801-1975

| Property                | Value         |
|------------------------|---------------|
| Yield Strength         | 235.44 N/mm²  |
| Modulus of Elasticity  | 2×10⁵ N/mm²   |
| Poisson ratio          | 0.3           |
| Modulus of Rigidity    | 0.769×10⁵ N/mm² |
6. Theoretical Study

The theoretical investigation was carried out with reference to the light weighted steel design code IS801-1975. The maximum bending moment and load carrying capacity of the sections are obtained and given in Table 3 by using following formula.

Maximum bending moment- \(0.6 \times f_y \times Z = M\) (kN.m)

Where, \(f_y\) - Yield stress in CFS section.

\[ Z = \text{Section modulus of CFS section.} \]

If the bending moment is \(M\), then, \(W = \frac{M \times Z}{kN} \)

\[ W = \frac{M \times 8}{2} \text{ kN} \]

Where, \(W\) - Maximum Load carrying capacity.

Theoretical actual and permissible deflection is given below.

Actual deflection \(\delta\) = \(\frac{5WL^4}{384EI}\)

Permissible deflection \(\delta\) = \(\frac{5\text{span}}{325}\)

For the applied load \(W = \frac{65 \text{kN}}{2m} = 54.167\text{kN/m}\), actual and permissible deflection of C and build up I section with and without stiffener are given in Table 4.

### Table 2. Deflection from analytical study

| Section                  | Deflection in mm |
|--------------------------|------------------|
| C                        | 5.014206         |
| C with Stiffener         | 0.471161         |
| I                        | 2.507103         |
| I with Stiffener         | 0.235581         |

### Table 3. Bending Moment and Load carrying capacity of “C” and “I” sections from the theoretical study

| Section                  | BM capacity in kN.m | Load Capacity in kN/m |
|--------------------------|----------------------|-----------------------|
| C section                | 4.84                 | 26.90                 |
| C section with Stiffener | 50.94                | 283.054               |
| I section                | 9.64                 | 53.819                |
| I section with Stiffener | 101.89               | 566.108               |
7. Comparison of Results

From the analytical and theoretical investigation, comparative results are shown in the Figure 5. From the Figure5, after applying a load of 65 kN, the deformation of the sections are varying in between Channel section and built up I section with and without stiffener, theoretically and analytically by 90.6603% and 90.60347% respectively, using following equation for both analytical and theoretical study9.

\[
\text{Deflection (mm)} - \delta = \frac{(\delta (\text{without stiffener section}) - \delta (\text{with stiffener section})) \times 100}{\delta (\text{without stiffener section})}
\]

\[
\text{Percentage of deflection reduce(%) =} \frac{[\delta (\text{without stiffener section}) - \delta (\text{with stiffener section})] \times 100}{\delta (\text{without stiffener section})}
\]

\[
\text{Percentage of bending moment capacity increased(%) =} \frac{[BM (\text{without stiffener section}) - BM (\text{with stiffener section})] \times 100}{BM (\text{without stiffener section})}
\]

It is also found that maximum moment, 26 kN.m occur in between the one third of span to two third of span of the sections because of two point loading condition for finding the flexural strength of the sections18.

Table 4. Deflection from theoretical study

| Section                  | Actual -δ in mm | Permissible - δ in mm |
|--------------------------|------------------|-----------------------|
| C section                | 2.12             | 3.692                 |
| C section with Stiffener | 0.198            | 3.692                 |
| I section                | 1.057            | 3.692                 |
| I section with Stiffener | 0.099            | 3.692                 |

8. Conclusion

In this paper, the studies on flexural strength in cold formed steel section are presented. From the theoretical and analytical comparative study of Channel and built up I section, following conclusion can be drawn.

- Under two point load condition the maximum deflection is seen between the one third of the span and two third of the span.
- By providing angle stiffener throughout the length of sections about 90% deformation is reduced compare to Channel and built up I section without stiffener to Channel and built up I section with stiffener.
- By providing angle stiffener throughout the length of sections about 92.42% bending moment capacity is increased compare to Channel and built up I section with stiffener to Channel and built up I section with stiffener.

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