Behavior of Cold-formed Steel Structural Members with Perforations subjected to Compression Loading

An Experimental study of Cold-formed thin-walled lipped channel section

Sudhir Reddy
Assistant Professor
Department of Civil Engineering,
Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India

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***Abstract*- Cold-formed steel sections are widely used in building structures like transportation machineries, storage racks, domestic equipment's and other. Cold formed steel sections are widely available with difference sizes and shape. Cold formed steel sections are manufactured with difference process such as folding, press-breaking and rolling etc. The yield strength and tensile strength of the cold formed steel section increases but ductility decreases specially the corners. And the properties will diff. At the corners in CFLGSS compared to the flat steel sheet, plate and strip or base before forming. Buckling analysis plays an important role in the research and design of cold formed steel members. But we know many structural cold formed steel members are provided with perforation of diff, size and shape to accommodate electrical, plumbing, and heating services. The ultimate strength and elastic stiffness of structural members can vary with perforations made especially for fastens such as bolts, screws etc. may be neglected as perforation to make the member economical i.e. to reduce the steel the reduction in cross sectional area caused by their perforations should be taken into account for this purpose. Finite element model using ANSYS FEM Package and one can develop its accuracy will validated using experimental and theoretical results. And from numerical, experimental and theoretical investigation, the load carrying capacity of column members for diff, sizes of channel sections with various arrangements of perforations positions, subjected to compression loading will be done. Where after validations we are aiming to remove the material where the stress will be less or zero and on the same member experimental investigation will be carried out. Both the analytical and experimental load carrying capacity of the member will be compared and possible reduction in the material will be concluded.**

***Index Terms* –Cold-formed, ultimate strength, elastic stiffness, longitudinal displacement, LVDT.**

I. INTRODUCTION

Cold-formed steel sections are widely used in building structures, storage racks, bus body construction, railway coaches etc., The use of light gauge steel sections is not new but it was being used in the form of corrugated sheet to serve as roof covering‘s. However, its use has increased considerably in the recent past. The cold-formed structural members are used in preference to the usual hot-rolled sections in the following situations.

a) Where moderate loads and spans make the thicker hot-rolled shapes uneconomical; for example, joists, purlins, girts, roof trusses, complete framing for one and two story residential, commercial and industrial structures:
b) Where it is desired that load carrying members also provide useful surface; for example, floor panels and roof decks, mostly installed without any shoring and wall panels.
c) Where sub-assemblies of such members can be prefabricated in the plant reducing site erection to a minimum of simple operations; for examples, sub-assembly of panel framing up to 3x4 m or more the thickness for framing members generally ranges from 1.2 mm to 4.0 mm. The thickness of floor and wall panel sections and for long span roof deck varies from 1.2 to 2.5 mm.

The thickness of wall claddings and slandered roof deck varies from 0.8 to 1.2 mm. But In General Thickness of Member Less Than 4.5 mm Will Be Considered As Cold Formed Light Gauge Steel Members. The use of cold-formed steel members in building construction began in the 1850s in both U.S. and Great Britain. However such steel members were not widely used in buildings in the U.S until the 1940s at the present time cold-formed steel members are widely used as construction material worldwide.

In the manufacture of Cold-formed steel members by cold rolling machines coils of 1.0 m to 1.25 m in width, sheets are purchased. These are then slit longitudinally to the correct width appropriate to the sections needed. Then, these are fed into series of roll forms. There are two dies (male and female) in these rolls. These are arranged in pairs.

II. LITERATURE REVIEW

M.P. Kulatunga, M. Macdonald “Investigation of cold-formed steel structural members with perforations of different arrangements subjected to compression” (2013) has studied cold-formed steel sections subjected to compression loading was undertaken using Finite Element Analysis to study the effects of perforation positions on the load capacity of column members of lipped channel cross-section. For this purpose, a finite element model was developed using ANSYS and its accuracy was verified using experimental and theoretical results. The study showed that the ultimate load of the lipped channels under compression varied greatly with the perforation position. Comparisons of the finite element results and the test results are also made with existing design specifications and conclusions are drawn on the basis of the comparisons.

III. SCOPE OF STUDY

Design methods currently available are based on the effective width concept, and equations modified to account for openings have been proposed by a number of researchers. The major problem with the design of thin-walled steel structural members is the local instability of plate elements in compression. The precise analysis of enumerating the weakening effect of local instability on the strength of cold-formed steel section is highly complex because of its dependence on the shape of the cross section, material and geometric non-linearity, effects of cold forming, effects of perforations, and mainly on boundary condition etc. A parametric study has been carried out in the present study, covering parameters position of perforations in channel section. Results obtained by both the analytical and experimental study is compared and possible position of the perforation is concluded

IV. METHODOLOGY

a. The proposed work include the experimental program in two stages namely making specimen and testing of full scale column section with variable in position of perforation.
b. The columns are tested in UTM under compression loading. The parameter studied during the test will be ultimate load carrying capacity, failure pattern and deformation laterally and longitudinally.
c. Then comparison between IS code method, and experimental will be done and finally possible position of the perforation will be concluded.

V. EXPERIMENTAL STUDY

Thin-walled cold-formed lipped channel sections subjected to compression loading were considered in the investigation. The experimental investigation was aimed at studying the influence of perforation positions on the ultimate strength and the failure modes of lipped section columns.

a. Test Specimens-

In order to provide sufficient stiffness and to avoid primary buckling of the stiffener itself, cross-section shape and dimensions were selected as shown in Fig. 1 and The size of the perforations was kept constant and perforation positions were varied as illustrated in Fig. 2 and 3, in order to investigate the effect of perforation positions on the ultimate strength. A channel section without perforations was also tested. The column lengths, cross- section dimensions, and perforation areas were kept constant, having a nominal thickness (0.85 mm) and specimen length (750mm).

i. The test piece has a Flange (B) of 35mm, length (L) of 750mm, Web (H) of 75mm, fillet radius (R) of 2mm, lip (D) of 10mm and thickness (t) 0.85mm.
ii. The ends of the test piece metal held in suitable grips in the testing machine.

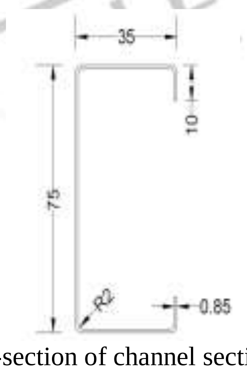

Figure 1- Cross-section of channel section or C-section

b. Material Properties

Tensile coupon tests were carried out for the sheet steels used in this thesis. Tensile coupons demonstrated a gradual yielding behavior. Three tensile tests were conducted for each different steel sheet and yield stress, σ_y was determined with the 0.2% strain offset method. Load–displacement curves obtained from the tensile tests were used to obtain engineering stresses. Further, engineering stress values and engineering strain values were transformed into true stress and true strain values and modified prior to their implementation in ANSYS to ensure plasticity initiated at the yield stress and not the proportional limit.

c. Test Equipments and Procedure

In this investigation specimens were tested on a Universal Testing Machine. Ends of each specimen were milled flat and parallel, to ensure that they bear directly against load bearing plates. All column specimens were loaded with displacement control at a constant rate, and a high level of accuracy of the Universal Testing Machine crosshead displacement was achieved by using linear variable displacement transducers (LVDT).

Column sections bear directly on load bearing plates to represent flat-end boundary conditions, and therefore, specimen preparation and alignment can be performed without welding or the use of any attachments, then constant load is applied to the specimen and results will be saved in 24 channel data acquisition system for decision and conclude.

Figure 2-Perforation positions (All dimensions are in mm)

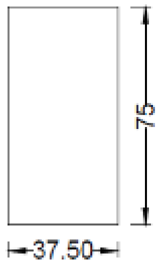

Figure 3-Perforation shape and size (All dimensions are in mm)

VI. CONCLUSION

In this chapter, a few conclusions are drawn based on the results obtained during the present experimental with perforations subjected to compression loading.

1. Specimen which is having perforations equally spaced from both top and bottom ends takes maximum load.
2. Among 6 specimens, specimen S3 taken maximum load i.e. 17.85kN may be due to equally spaced perforation from both top and bottom ends.
3. The results obtained from Experimental investigation into the load capacity of column members of lipped channel cross-section subjected to compression loading were compared against the failure load predicted by analytical investigations.
4. Experimental and numerical investigations were used to obtain a better understanding of failure mechanisms of buckling.
5. The investigation showed that the ultimate load of the structure under compression greatly varied with the perforation position.

The experimental and numerical investigations showed that in the case of slender cross sections, which are substantially affected by local buckling, the incorporation of perforations in the areas near to ends has a greater weakening effect than the same perforations at other locations.

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