BEHAVIOR OF COLD-FORMED STEEL STRUCTURAL MEMBERS WITH PERFORATIONS SUBJECTED TO COMPRESSION LOADING

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Abstract- *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. In this paper we carried out compression test on structural steel member of cold formed.*

INTRODUCTION

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 [1]. 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 [2].

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. These move in opposite direction. Such that as the sheet is fed through rolls its shape is slowly changed to the needed profile. There is a flying shearing Machine at the end of the rolling stage. This machine cuts the member into required lengths. This process is used when large volume of long lengths is to be produced.

Effects of perforations in cold formed light gauge steel members

In practice, perforations are either pre-punched or punched on site on the cold–formed sections, to pass through conduits, electrical wires, utility ducts etc. The presence of perforations in a structural member has often created a number of problems and drawbacks and complicates the design process. In general the effect of perforations made specifically for fasteners such as bolts, screws, etc. on the overall strength of a structure may be neglected as holes are filled with material. However, any other openings/perforations generated and not filled with replacement material creates a reduced cross sectional area and cross sectional properties and this should be taken into account in any analysis.

EXPERIMENTAL AND ANALYTICAL PROGRAM

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.

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 The size of the perforations was kept constant and perforation positions were varied as illustrated in 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- sectiondimensions, and perforation areas were keptconstant, having a nominal thickness (0.85 mm) and specimen length (750mm).

- 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.
- The ends of the test piece metal held in suitable grips in the testing machine.

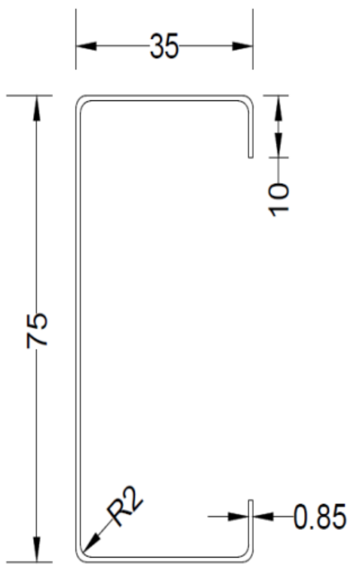

Fig 1: Cross-section of channel section or C-section

Analytical study

There are mainly three methods, of analysis and are listed below.

- Analytical method
- Finite element method
- Finite difference method

From the above three methods the Finite Element Analysis is considered for present project study. The overview of FEA is necessary and is as below.

Analytical method (By IS Code Method IS: 801-1975)

Step 1. Computation of Sectional Properties

Iyy = [2*0.85(35)3/12+2(10-0.85)*0.85(17.5-0.425)2+ (75-1.7) (0.85)3/12]
= 6073.95+4535.14+3.751
Iyy = 10.6*103mm4
Area = (2*0.85*35) +2(10-0.85)*0.85+ (75-1.7)*0.85
A = 137.36mm2
ryy = 10.6*103/137.3
= 8.786mm

Step 2. Computation of Effective Width

For stiffened element
W/t = (10-2.85)/0.85 = 8.41
Design Stress f = 0.6fy
= 0.6*235
f = 141N/mm
For stiffened flanges,
Radius of Curve = 2+0.85 = 2.85mm
W = 17.5-2.85 = 14.65mm
W/t = 14.65/0.85 = 17.23
B/t = 658/f [1-145/ (w/t)*f]
= 658/141[1-145/17.23*141
B/t = 16.13
b = 16.13*t = 13.71mm<14.65*2 = 29.3mm

For web,
W/t = 69.3/0.85 = 81.52
B/t = 658/141[1-145/81.52*141]
B/t = 47.09
b = 40.0mm

Step 3. Determination of factor

Aeff = 137.36-0.85*29.3
= 112.4mm
Q = Fc/F Aeff/A
= 1*112.4/137.36
Q = 0.818

Step 4. Determination of Cc and (L/R) Lim

Cc = √ (2 π2E/Fy)
= (2 π2*2*105/235)
Cc = 129.61
(l/r) lim = Cc/√Q = 129.61/√ (0.818)
= 143.7

Step 5. Determination of Safe Load

Fa = 12/23*QFy-3/23E (QFyL/r/ π) 2
= 12/23*0.818*235-3/23*2*105
(0.818*235*117.48/π)2

= 100.2-33.69
Fa = 66.50
Permissible load = 66.50*137.36 = 9.13*103*2 = 18.27kN
This is the hand calculation made for the specimen without perforation

Experimental result
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.

No.	Thickness t (mm)	Web, H (mm)	Flange, B (mm)	Lip, D (mm)	Fillet radius R (mm)	Length (mm)	H/t	B/t	H/B	B/D	Ultimate, load kN
S1	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	14.61
S2	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	14.12
S3	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	17.85
S4	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	9.025
S5	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	16.28
S6	0.85	75	35	10	2	750	88.2	41.1	2.1	3.5	16.57

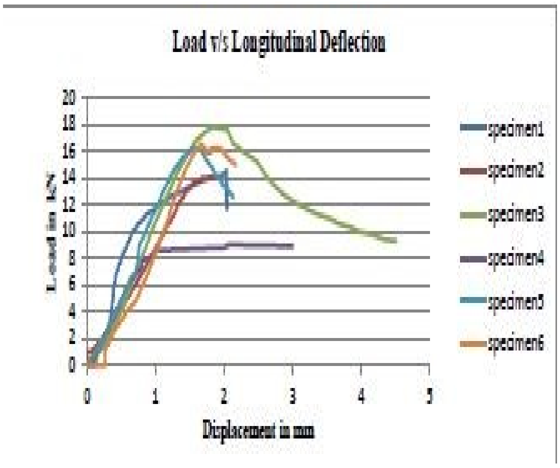

Fig 2: Load v/s Longitudinal Displacement

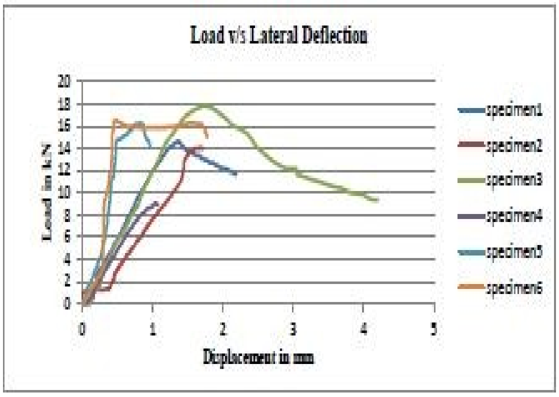

Fig 3: Load v/s Lateral Displacement

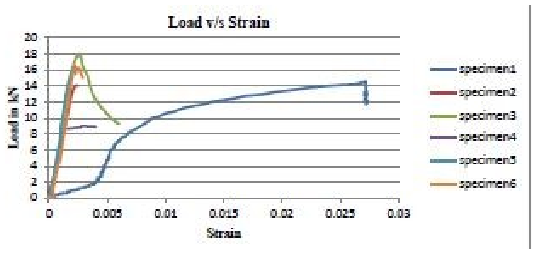

Fig 4: Load v/s Strain

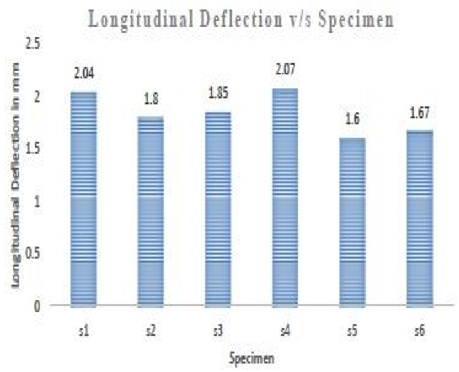

Fig 5:Ultimate Load v/s Specimen

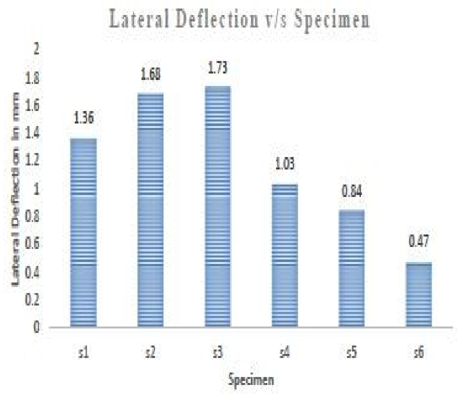

Fig 6: Longitudinal Deflection v/s Specimen

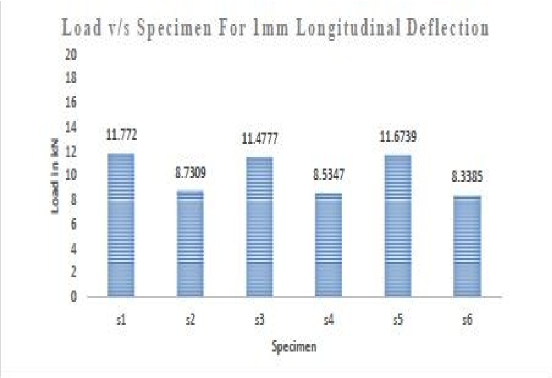

Fig 7: Lateral Deflection v/s Specimen

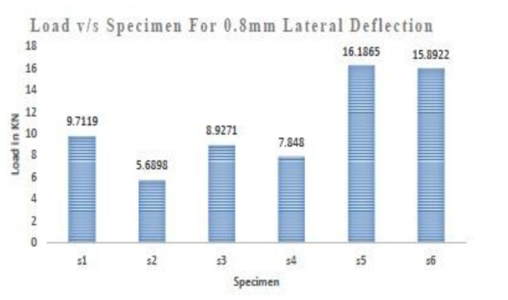

Fig 8: Value of Load Corresponding to 1mm Longitudinal Deflection

CONCLUSIONS

The results obtained from a finite element 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 experimental and analytical investigations.

1. The buckling behavior of channel sections exhibited in the FE models was validated using experimental investigations.

2. Experimental and numerical investigations were used to obtain a better understanding of failure mechanisms of buckling.

3. The finite element analysis was shown to be able to closely predict the buckling behavior of the channel sections with and with- out perforations.

4. The investigation showed that the ultimate load of the structure under compression greatly varied with the perforation position.

5.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.

FUTURE RESEARCH

The results presented in this thesis mainly focused on ultimate load of column members of lipped channel cross-section with different perforation positions. The overall objective of this research program is to investigate buckling behavior of cold- formed steel lipped channel columns with perforations subjected to compression loading. Further work can be carried by studying the influence of the different column testing parameters such as cross-section, specimen length, presence or absence of perforations, perforation size, shape, position, and end condition, on ultimate strength of column members subjected to compression loading. This involves the use of finite element analysis and further experimental validation. Based on the results of the parametric study, design formulae will be proposed in conjunction with British standards (BS), European recommendations, and American Iron and Steel Institute (AISI) to determine the load carrying capacity of lipped channel columns containing perforations.

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