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Analysis and Design of Axially Loaded Cold Formed Steel Column

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Abstract— *Cold-formed steel members are either cold-rolled or brake-pressed into structural shapes. As a result, cold-formed steel open sections are usually singly-point- or non-symmetric. The most common types of singly-symmetric sections are channel and angle. Analysis and design of axially compressed cold formed steel column is going to be performed in this project, in which design based on Euro Codes Specification for the design of cold-formed steel structural members. A detailed literature survey was carried out in-order to know the behavior of CFS open section especially channel section under axial compression is studied. The ultimate strength and behaviour of the various Cold-Formed Steel sections such as stiffened open section and unstiffened open section are tested under axial compression by experiment investigation and their results are compared with the numerical analysis by using finite element analysis software ANSYS.*

Keywords— *Cold-formed steel, compression, open section, unstiffened, ANSYS.*

I. INTRODUCTION

Cold-formed steel sections as show in Fig. 1 are increasingly using these days in structural applications due to their inherent high strength to weight ratio. Light weight steel construction plays an important role in industrial structures due to their economy, the ease and speed with which they can be fabricated and erected. They result in reduction of dead load, while fully meeting the strength requirements. Hence the usage of light weight and stiff structures are steadily increasing. In order to improve usage of steel, the solution lies in encouraging the manufacture of built-up (latticed) welded structures as show in Fig. 2 out of hot-rolled products and cold-formed sections.

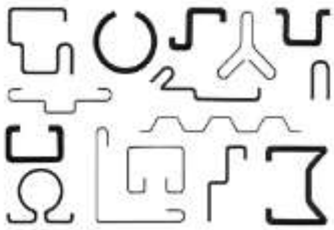

Fig. 1. Various CFS sections

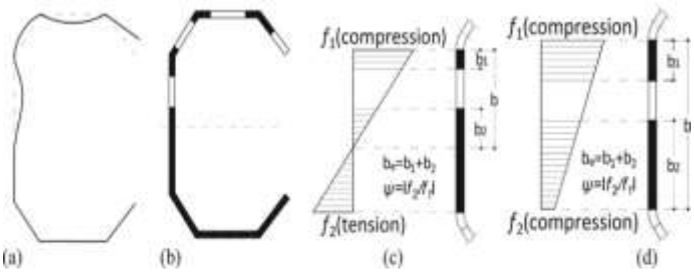

Fig. 2. CFS open section

In compression, cold formed open-section as shown in Fig. 2 can be exhibited three modes of instabilities: local, distortional and flexural or flexural-torsional buckling. The short and intermediate length columns are more common in the field. The predominant failure mode of interaction length column is distortional buckling.

II. PROBLEM FORMULATION

Though many research works have been conducted on buckling of cold-formed steel columns, only limited works have been made on the behavior and strength of the CFS with complex geometries. From the literature, it is observed that the stiffened element with edge stiffener is a key factor that influences the member behavior. The behavior and strength of CFS may be affected by local and distortional buckling. In this study, five series of experiments are conducted with the cold-formed steel open section with unstiffened and stiffened cold-formed steel open section with or without edge/intermediate stiffeners. Their effects on the strength and behaviour of the members are studied.

III. SELECTION OF SECTION

To eliminate or delay distortional buckling mode and to increase the ultimate strength, the stiffened element at the flange / web junction and edge stiffeners at the flanges are introduced. A series of compression tests focused on the unstiffened section, stiffened cold-formed steel open section with or without edge/intermediate stiffeners under compression status is studied.

Unstiffened and stiffened CFS open sections with five types of different cross sectional geometries are chosen for testing. The experimental work is divided into two parts. In the first part, two beam sections, unstiffened column (USC) and stiffened column (SC) are tested to find out their ultimate strength and mode of failure. The second part of the study SB section are tested again by adding edge stiffeners at the flanges and intermediate web stiffeners .The primary (USC) is a simple column, second (SC) is a stiffened column, third (SC-U) is a stiffened column with upright edge stiffener fourth (SC-C) is a stiffened column with complex edge stiffener, fifth (SC-I-C) is a stiffened column with complex edge and

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intermediate stiffener. Dimension of the tested section are presented in table 1.

TABLE 1. Dimensions of Cold-Formed Steel Open Column

Specimen	Gross Area (sq.mm)	Section Dimensions (mm)						
		L	Flange Width-W				H	t
			A	B	C	D		
USC-1	421.93	840	65		0	0	150	1.6
USC-2	498.58	840	65		0	0	200	1.6
SC-1	422.58	840	50	15	0	0	150	1.6

IV. MECHANICAL PROPERTIES

The tensile specimens (coupon) are prepared using the same material which are used to prepare the test specimens and tested according to IS 1608-2005 (1).The material properties are shown below:

Yield stress (f_y) = 270 N/mm^2
Ultimate stress (f_u) = 403 N/mm^2
Young's modulus (E) = 2.01E5 N/mm^2
Tangent modulus (E_t) = 2E3 N/mm^2
Poisson's ratio (m) = 0.3

All the columns are tested in a loading frame of capacity 200 kN. Specimens are painted and levelled, to apply the load vertically. The specimens are mounted between the plates and it's vertically is checked. At either ends between the plates and the end plates of the specimen rubber gasket are placed to facilitate the hinge conditions at either supports. The overall stability of the experimental setup is verified and a small amount of preload is applied to seat the specimen in position and released. All the instruments are initialized and load is applied with a hydraulic jack of 200 kN capacity.

V. RESULT AND DISCUSSION

The failure modes such as combined local and distortional buckling and distortional buckling are observed experimentally and verified numerically by using the finite element analysis (ANSYS). The failure modes obtained through experiments are in good agreement with ANSYS output results. On observation it clearly indicates that the predominant mode of failure of the unstiffened section is local buckling.

TABLE 2. Comparison of Experimental, ANSYS Results Cold-Formed Steel Open Section

S.No	Specimen	Ultimate Strength (kN)		P_{ANSYS}/ P_{EXP}	Failure Mode
		Experiment (P_{EXP})	ANSYS (P_{ANSYS})		
1	USC-1	23.6	31.37	1.33	LB
2	USC-2	24.2	25.71	1.06	LB
3	SC-1	33.30	36.30	1.09	DB
Mean				1.16	
Standard Deviation				0.15	
(LB-Local Buckling, DB-Distortional Buckling)					

TABLE 3. Comparison of Experimental, DSM Results Cold-Formed Steel Open Section

S.No	Specimen	Ultimate Strength (kN)		P_{DSM} /P_{EXP}	Failure Mode
		Experiment (P_{EXP})	-DSM (P_{DSM})		
1	USC-1	23.6	33.57	1.42	LB
2	USC-2	24.2	30.31	1.25	LB
3	SC-1	33.30	40.17	1.21	DB
Mean				1.29	
Standard Deviation				0.11	
(LB-Local Buckling, DB-Distortional Buckling)					

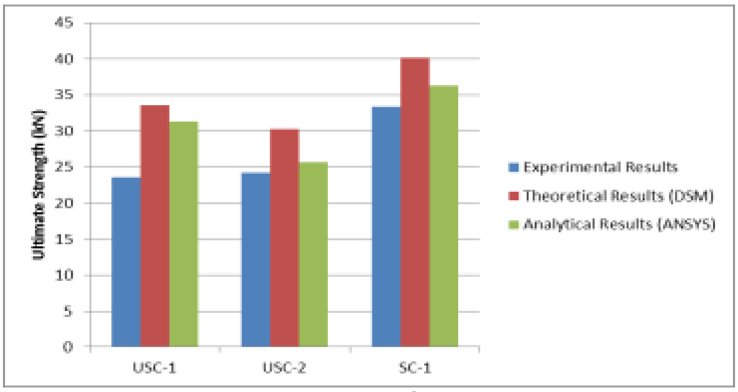

Fig. 3. Comparison chart

VI. CONCLUSIONS

- The parametric study has shown that the strength as well as the behaviour of a stiffened cold-formed section was significantly affected by the height-to-thickness ratio.
- This study proved that the provisions of stiffened element at the flange / web junction, intermediate and edge stiffeners are increasing the strength and improves the behaviour.
- For stiffened cold-formed steel section with or without edge stiffeners, the ultimate strength predicted by the AISI-DSM specification are overestimated.
- This study is also proved that the provisions of connectors increase the strength and improves their behaviour.
- The ultimate strength of the section increases with increases in depth and number of connector.
- This investigation has shown that the use of connectors at proper depth and spacing do help increasing not only load carrying capacity but also vary mode of failure.
- For open sections, the design capacity predicted by AISI-DSM codal provisions are unconservative.

This investigation has shown that the provision of stiffened element at flange/web junction, the intermediate edge stiffeners and spacer plates improve the behaviour and increase the strength of the section.

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