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Experimental and Numerical investigation on Cold-Formed Steel built-up beams

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Abstract

Cold-formed steel has many advantages to construction, such as high strength to weight ratio, ease of handling, transportation and sustainability credentials. However, the structural behaviour of built-up cold-formed steel members characterized by various buckling modes is not yet fully revealed. A lack of fundamental understanding of the behaviour of built-up members, as well as the absence of sufficient design guidance in the current design codes (AISI S100 -2016; CEN 2005; IS:801), often lead designers to use overly conservative assumptions, which prevents the exploitation of the real potential of these types of sections. In these study choosen built-up section are subject to experimental testing and the Numerical analysis was carried out using ANSYS 18.2.*Also,this study investigates the buckling behaviour and capacity of built-up cold-formed steel members subjected to bending.*

Keywords: *ANSYS,Cold-formed steel, Buckling, built-up members, bending, design code.*

1. Introduction

Cold-formed steel (CFS) sections can be effectively used as a structural element of light weight structures in cases where hot-rolled sections or others are inefficient. However, flexural members may undergo local, distortional, flexural, lateral-torsional buckling and interaction between them or between the above buckling modes, the accurate prediction of the member strength becomes more complex. Nowadays, cold-formed steel section, have been widely used in civil engineering as structural elements, all over the world, especially in developed countries but it is developing in India now.

The strength and behaviour of cold formed steel members are governed by the material and sectional properties, it can be improved in a various way. The flexural strength of the web of a cold-formed steel section in bending is generally improved by the presence of intermediate stiffeners and stiffened elements (P Manikandan, and S. Sukumar2016) However, for webs with relatively large depth-to thickness ratios, the local buckling mode in bending occurs in the web.Depth and thickness of the section had significant effects on strength and behaviour of the beam (Pastor and Roure ,2008).The structural efficiency of such webs can be improved by adding an intermediate stiffener longitudinally in the middle of the web. Compression flanges with un-stiffened edges do not perform well under flexure due to the vertical displacement of the un-stiffened edges/distortional buckling. A stiffened element at the flange/web junction and edge stiffener at the flanges provides longitudinal support to the compression flange(P Paczos, P Wasilewicz, 2009). It can increase the strength and improve its behaviour.The edge stiffeners had a greater influence on the bending strength and the Beams with upright edge stiffener showed a higher strength than the beams with inclined edge stiffenerboth in pure bending and non-pure bending tests(Wang and Zhang 2009).

Eventhough several studies have been performed on the buckling behaviour of the cold-formed steel beams,few studies have been made on improving the efficiency of cold-formed steel built-up sections which are used in the load carrying members. Depending on the span to depth ratio and lateral support length of the members, cross-sections, shapes and dimensions, any of the buckling modes may be critical(N D Kankanamge, M Mahendran 2012). From the above, it is observed that it is desirable to look for new shapes of cross-sections of cold-formed beams. This study helps in development of more efficient cold formed steel built-up sections by providing folded flanges and with edge stiffeners and web stiffeners which is to improve its behaviour and to study the failure modes of proposed section.

CFS sigma sections have evolved from the conventional C sections by adding inserts in the web as stiffeners. The presence of stiffeners in the web brings the shear centre of the section closer to the web and hence reduces torsion introduced by applied load.

2.Objective

The objectives of the present work in cold formed steel built-up sections are

- To investigate the fundamental buckling behaviour and the capacity of cold-formed steel built-up sections with different geometric cross-sectional profile under bending.
- To analyse the proposed cold formed steel built-up sections by using Finite Element Method software ANSYS WORKBENCH 18.2.
- To carry out the experimental investigation and to determine the ultimate strength of the proposed cold formed steel built-up sections.

3.Material properties

The specimens used in the present experimental investigation are fabricated from sheets of thickness 2 mm. Kankanamge & Mahendran (2012) gave the guidelines for selection of the D/b ratios of cold-formed steel beams in the range of 2 to 3.3. In order to study the material properties of the sheets used for fabrication of sections, tension tests are carried out on standard tensile coupons cut from the Cold formed steel sheet used to fabricate the beam. The Size and Shape of test specimens are in accordance with IS 1608-2005(Part -1). All physical dimensions of the coupons are measured at salient locations and the gauge length is marked. The coupons are tested in the tension testing machine. Three coupons are tested for the cold formed steel and Table 1 shows the average values are taken as the Yield strength and Young's modulus of the material.

Table 1 Average result of Tensile coupon test

Thickness (mm)	Yield stress fy (MPa)	Ultimate stress fu (MPa)	Young's modulus E (MPa)	% Elongation
2mm	250	350	2.01×10^5	16

4.Specimen Nomenclature

Totally 3 built-upspecimens were prepared from the Sigma section which shown in Fig 1. Three specimens are labelled based on the name. In the specimen "B2B100", the label 'B2B' represents the "Back-to-back". '100' defines the Bolt spacing. The thickness of all the specimen is 2 mm. The other sections B2B100, F2F100, B2B150 are built-up sections using basic sigma section. Here the F2F represent the "Face to Face" connection of individual sigma section with an additional top and bottom layer.

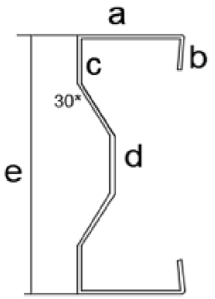


Fig.1 Sigma section

Table 2 Section dimension

Dimensions in mm						
a	b	c	d	e	Thickness	Length
65	20	32	38	175	2	1200

5.Experimental investigation

Built-up section consists of two identical sigma sections connected using bolt of 8mm diameter with a spacing of 100 mm and 150 mm for the corresponding specimens. Prepared Specimens are tested in a loading frame with a capacity of 500 kN under the simply supported boundary condition subject to two-point loading as shown in Fig2. All the necessary data such as the applied load using load cell and the lateral deformation using LVDTs for the specimens are recorded.

Fig.2 Testing setup

The two LVDTs were placed underneath the specimens, at the loading points[L/3] and at mid-span [L/2] , as illustrated in Figure 2. Three LVDTs were used to record the lateral deformation of the beams as shown. Let L1 be the LVDT at lip nearer to support region, other two L2 and L3 are LVDTs at L/2 and L/3 region of the web of sigma from the same side.

The tested specimens are shown in the Fig.3. The test specimens are undergone to distortional type of buckling. Experimental observations are plotted as graph in the Fig.4

The experimental result values are represented in table.3. Out of these three specimen F2F100 attain a maximum load of 85.23 kN.

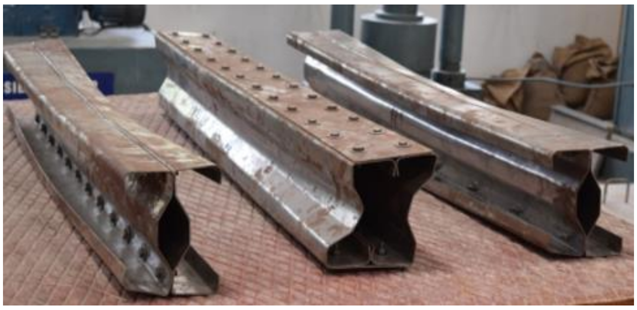


Fig.3 Tested specimens

Specimen	Ultimate load (kN) P_{EXP}	% increase in strength
		With respect to B2B100
B2B100	70.21	-
F2F100	85.23	21.3%
B2B150	65.33	-17%

Table 3 Experimental test results

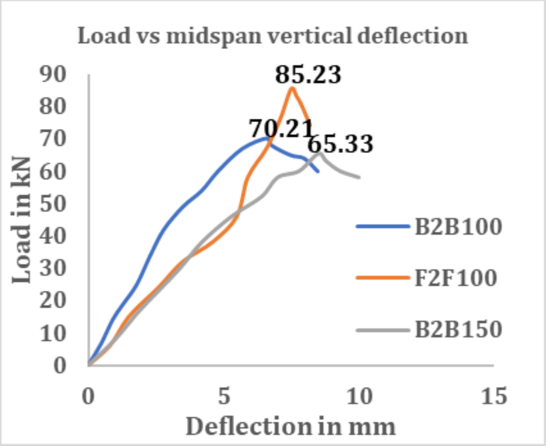


Fig.4 Ultimate load vs midspan deflection

6.Numerical investigation

Cold-formed steel sections have thickness which is extremely small compared to the other two dimensions which are modelled as plate-shell elements. The commercial non-linear finite element analysis software ANSYS WORKBENCH 18.2 is used to predict failure loads and failure modes of the built-up sections. In Numerical analysis, loading are carried out similar to the experimental test setup. Shell181 elements were used. Fig.5 shows the modelling of specimen F2F100.

The load value obtained from eigen value buckling analysis for respective modes is applied. The Nonlinear analysis is performed and the load versus vertical deflection at mid-span is taken from Time History plot of ANSYS.

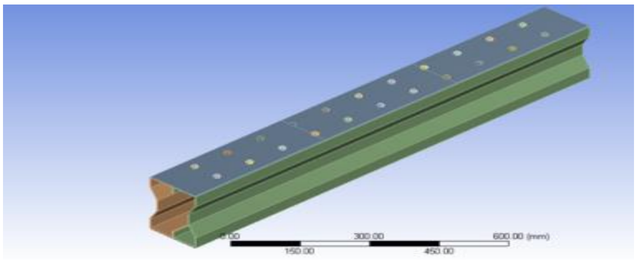
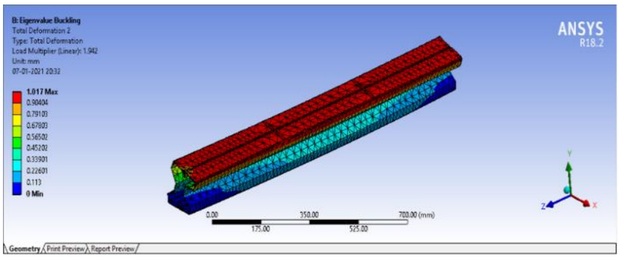


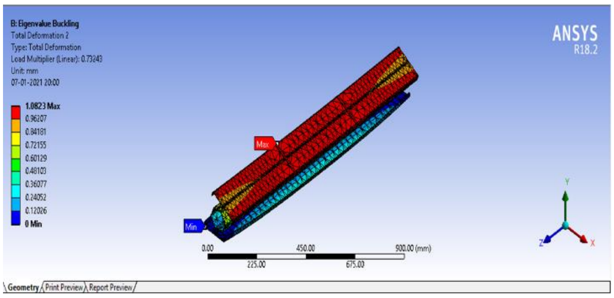
Fig.5 Modelling of specimens F2F100

Fig 6 shows the buckling mode of F2F100, Fig 7 shows the buckling mode for B2B100 and then Fig 8 shows the B2B150 specimen. From these the distortional type of buckling was occurred in the all specimens. The Eigen value buckling load obtained from the ANSYS were tabulated.



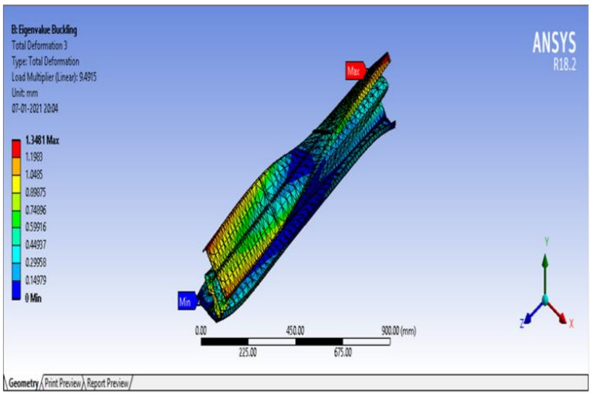
B: Eigenvalue Buckling
Total Deformation 2
Type: Total Deformation
Load Multiplier (Linear): 1.942
Unit: mm
07-01-2021 20:32

Fig.6 Buckling mode of specimen F2F100



B: Eigenvalue Buckling
Total Deformation 2
Type: Total Deformation
Load Multiplier (Linear): 0.73243
Unit: mm
07-01-2021 20:00

Fig.7 Buckling mode of specimen B2B100



B: Eigenvalue Buckling
Total Deformation 3
Type: Total Deformation
Load Multiplier (Linear): 9.4915
Unit: mm
07-01-2021 20:04

Fig.8 Buckling mode of specimen B2B150

The finite element result from the ANSYS were represented in Table.4.From these table, the numerical results are quite higher than the experimental result. These may be due to the geometric imperfection are not considered in the numerical analysis. Comparison graph between experimental and numerical result are shown in Fig.9.

Table 4 Numerical analysis results

Specimen	Ultimate load (kN) P_{FEA}	P_{EXP}/P_{FEA}
B2B100	74.69	0.94
F2F100	88.78	0.96
B2B150	70.24	0.93

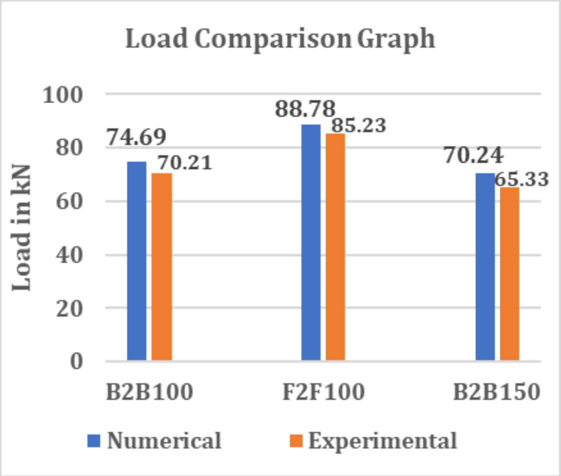


Fig.9 Comparison graph for load carrying capacity

Conclusions

From the present investigation the following conclusions are drawn.

1. From the analytical and experimental results, it is found that F2F100 is the most effective section among the proposed built-up beams.
2. Reducing the bolt spacing within allowable limit enhances load carrying capacity.
3. Initial geometric imperfections are unavoidable in cold-formed steel members, and since both their magnitude and shape have a significant effect on the buckling behaviour of these members, which are leads to variations in the final results of ANSYS from experimental values.
4. The finite element model using ANSYS software is accurate in predicting the strength and behaviour of the beams. Therefore, the finite element analysis can be used with a high level of confidence in predicting the load capacity of the flexural member.
5. Design of cold-formed steel beams requires consideration of local, distortional, bending, web buckling and lateral-torsional buckling.

References

ANSYS®, User's and Theory Reference Manual 10.0, ANSYS Inc.2006.

B Schafer and SAdany (2010), Buckling analysis of cold-formed steel members using CUFSM:conventional and constrained finite strip methods.

F.J Meza, J. Becque, and I. Hajirasouliha(2020),Experimental study of cold-formed steel built-up columns,*Thin Walled Struct*. pp. 140-155

H Wang, Y Zhang (2008) Experimental and numerical investigation of cold-formed steel C-section fexural members,*J Constr Steel* Res 65 ,pp.1225–1235.

J.Alex, and G.R Iyappan(2016), Experimental study on flexural behaviour of cold formed steel section, *International Journal of Innovative Research in Science, Engineering and Technology*, pp 219-222.

L Wang and B. Young (2015),Beam tests of cold-formed steel built-up sections with web perforations , *J. Constr. Steel Res.* 115 (Dec), pp. 18–33.

L Xu, P Sultana,X Zhou (2009), Flexural strength of cold-formed steel built-up sections,*Thin Walled Struct* 47, pp.807–815.

M Anbarasu (2019), Simulation of flexural behaviour and design of cold-formed steel closed built-up beams composed of two sigma sections for local buckling,*journal of Engineering structures*Vol.191, pp.549-562.

M R Haidarali&Nethercot(2011), Finite element modelling of coldformed steel beams under local buckling of combined local/distortional buckling, *Thin-Walled Structures*, vol. 49, pp. 1554-1562.

N D Kankanamge,M Mahendran (2012), Behaviour and design of cold-formed steel beams subject to lateral-torsional buckling, *Thinwalled Structures*, vol. 51, pp. 25-38.

P Manikandan, and S. Sukumar (2016),Behaviour of cold-formed steel built-up closed section with intermediate web stiffener under bending, *Asian Journal of Civil Engineering (BHRC)*, Vol. 17, No. 2, pp. 249-257.

P Paczos, P Wasilewicz(2009), Experimental investigations of buckling of lipped, cold- formed thin walled beams with I-section. *Thin Walled strut* 47:1354–1362

Sivaganesh Selvaraj, Mahendrakumar Madhavan (2019), Structural design of cold-formed steel face-to-face connected built-up beams using direct strength method, *Journal of Structural engineering* vol.163, pp.613-628.