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NUMERICAL INVESTIGATION OF FLEXURAL STRENGTH OF COLD FORM BUILT-UP BEAMS

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ABSTRACT

In cold-formed steel design there are several applications where built-up I sections are used to resist load induced in a structure when a single section is not sufficient to carry the design load. But in India, use of light gauge steel is not in trend for civil structures. Also, the structural behavior of these thin-walled steel structures is characterized by various buckling modes such as local buckling, distortional buckling or flexural-torsional buckling. These buckling problems lead to severe reduction and complication in calculation of their member strengths. The objective of this study is the investigation of the flexural behaviour of built-up I sections with complex edge stiffeners and intermediate web stiffener assembled from cold-formed back to back C sections under bending. The purpose is to increase strength and avoid or delay buckling problems. Detailed parametric studies, based on IS codes, will be carried out to identify the factors affecting the flexural capacity of built-up cold-formed steel sections.

Keywords – Built-up beams, Cold form steel, Edge Stiffener, Flexure Capacity, Intermediate web stiffener.

I. INTRODUCTION

Cold Formed Steel (CFS) members are widely employed in steel construction because of their lighter weight and higher economy than traditional hot-rolled sections. The use of CFS structures has increased rapidly in recent years due to significant improvements in manufacturing technologies. CFS members are made from steel sheets and are formed to different shapes either through press-braking sheared form sheets or coils or more commonly, by rolling done at room temperature. CFS sections are typically thin-walled with a thickness ranging from 0.4 mm to 6.5 mm. The most commonly used shapes of CFS member are lipped channel, Z and C shapes, hat and tubular sections (I.S. 811, 1987) as shown in Figure 1.The CFS sections offer one of the highest load capacity-to-weight ratios among the various structural components currently in the market.

Figure 1 Conventional CFS Profiles

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Under bending, cold-formed steel beams can exhibit different modes of instabilities, namely local, distortional, web buckling, flexural bending, lateral-torsional buckling and interaction between them or among the above buckling modes. The predominant failure modes of the beam are local and distortional buckling. This mode of failure can be delayed/eliminated to have a significant change in strength and behavior of the flexural members. The closed and open sections are the most common in the industry. A new design concept for cold-formed built-up steel beams is introduced by adding the stiffened element at the flange/web junction and edge stiffeners at the flanges and intermediate web stiffeners, to provide a significant change in flexural strength and behavior of the beams.

II. LITERATURE REVIEW:

Adil Dar M., Ashish D. K & Dar A.R, In this paper they have done theoretical analysis for various innovative sectional profiles. Comparison is made for flexure capacity, ultimate load capacity and unit weight based on Is 801 and concluded with best section**.**

Pooja S.Ajay1, Asst. Prof. J Samuel, Dr. P.S Joanna, Prof. Eapen Sakaria ,To improve the elastic buckling stress of the whole thin-walled I section including flanges and lips in pure shear, intermediate stiffeners are added. In this paper, the results of the experiments conducted on coldformed steel beam encased with diagonal stiffened webs with a view to study their flexural strength are presented. Ultimate load carrying capacity and ultimate deflection of each type of beam is calculated and compared. From the experimental investigations carried out to study the flexural behaviour of encased cold-formed steel beams with and without stiffeners, it was found that Cold-formed steel section with stiffeners in filled with concrete has resulted in increased resistance to lateral-torsion buckling.

P. Manikandan and S. Sukumar, An extensive experimental investigation and a finite element analysis of stiffened built-up cold-formed beam sections with complex stiffeners under two point loading is presented. A nonlinear finite element model is developed and verified against test results. All the results are compared with the design strength calculated using the North American Iron and Steel Institute Specification for cold-formed steel structures (AISI: S100, 2007). Following the validation, an extensive finite element parametric study is conducted to study the influences of a range of parameters, and the results are compared with the nominal design strength by AISI: S100 (2007) and suitable recommendation are made**.**

Thomas H.-K. Kang, Kenneth A. Biggs, and Chris Ramseyer,The goals of this study are to understand different buckling modes, determine the buckling mode and maximum buckling capacity of the built-up C-channels, and evaluate the AISI-2001 Specification. For these goals, the following was conducted: 1) different buckling modes of cold-formed steel columns were investigated; 2) previous research on built-up columns and testing rigs for column buckling was reviewed; and 3) the authors' buckling test results of 42 cold-formed built-up columns were examined. The study and review help better understanding of the buckling modes and the effect of design or testing parameters on the buckling behavior. The results show inconsistencies in the calculated values by AISI-2001 as compared to the maximum capacity loads determined from the buckling tests. The orientation of the member substantially impacts the maximum load of the member.

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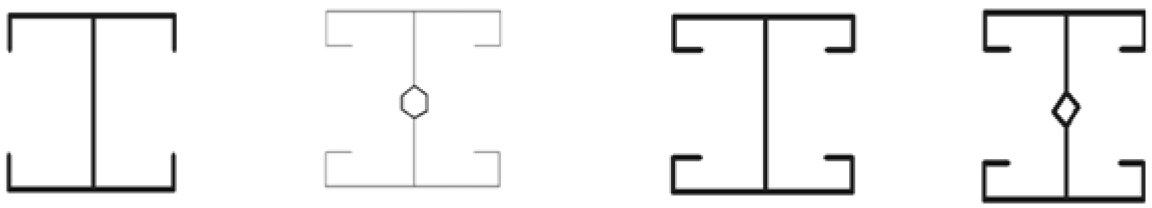
III PROBLEM DESCRIPTION

From above literature, we can conclude that here are several applications where built-up sections are used to resist load induced in a structure when a single section is not sufficient to carry the design load. Hence, we need to come up with new innovative sectional profile and stiffening arrangements which would either delay or completely eliminate this stability failure so that the section is utilized to its full load carrying capacity. It is important to eliminate or delay these buckling problems and simplify the strength calculations. It can be done by making built-up sections with complex edge stiffener and intermediate web stiffener assembled from back to back C sections.

3.1 Section Profiles



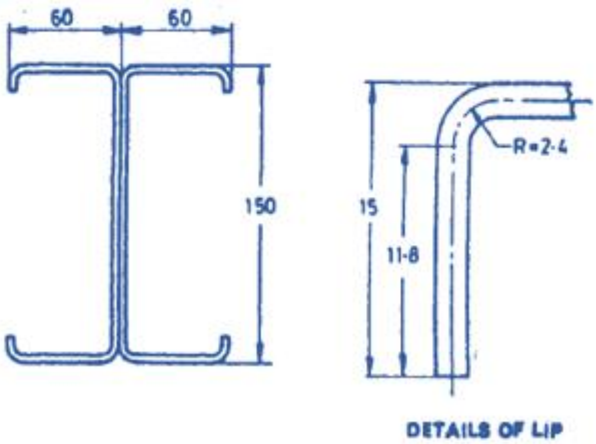
(a) CWES (b) CWCES "A" "B"

Figure 2 Proposed Profiles with edge stiffeners and intermediate web stiffener.

3.2 Data Input

The beam is made by connecting two C channels back to back having simply supported end conditions. Ultimate loading capacity will gives capacity foe two point loading conditions. Height= 200mm, width of flange = 60mm, thickness =4mm , F_y= 2400 kgf/cm^2 . For profile "A" and "B", angle for stiffener is 60° as it gives maximum load carrying capacity. The height of intermediate web stiffener for profile "B" is chosen as 50mm for maximum results. (CWES= Channel with edge stiffener, CWCES= channel with complex edge stiffener, IWS= intermediate web stiffener).

3.3 Basic Design Approach For Flexure Member As Per Is:801



Step:1 Prelimimnary Calculations:Root Radius= 1.5* R

1) Length of Corner= 1.57*R'

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2) Distance of C.G of corner= 0.637R'

3) Effective width of compression elements

Step:2 Calculation of Moment of inertia of section.

Step:3 Calculation of section modulus ,Z= I/y

Step:4 Calculation of resisting moment =Fy*Z

Step:5 Calculation of Load carrying capacity

Step:6 Check for bending stress

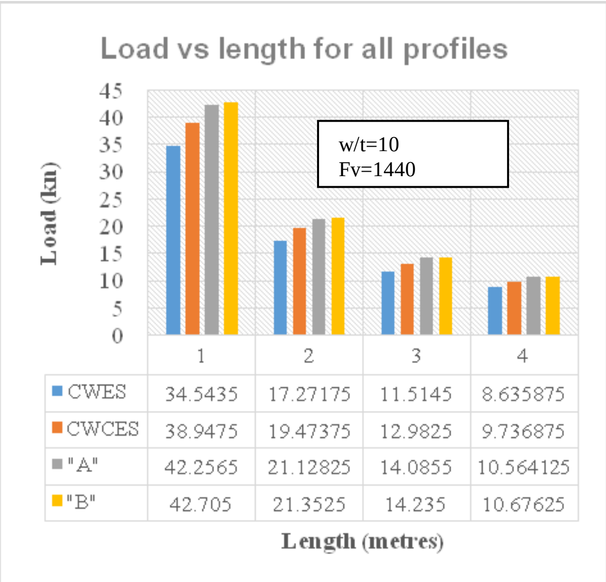
Step:7 Check for Shear in web

Step:8 Check for deflection

IV. EFFECT OF VARIOUS PARAMETERS

4.1 Effect of Length:

Variation of length affects the load carrying capacity and deflection. For the same cross-sectional area : (1) Load carrying capacity decreases as the length of beam increases, (2) Permissible deflection increases with increase in length of beam, (3) Moment of Inertia remains constant as it depends on c/s area , (4) Allowable moment capacity remains constant : M= f*Z beacause stress(f) depends on "w/t" ratio which is independent of length. (5) Above 5m span, deflection limit exceeds the permissible value for above dimensions of c/s.



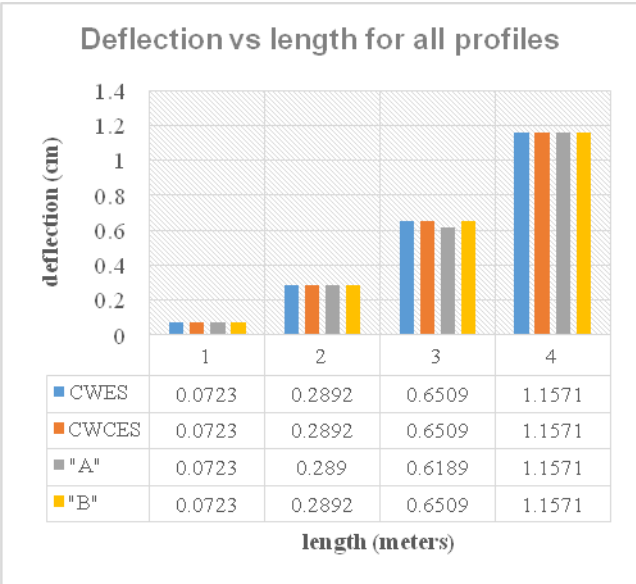


Figure 3 Variation of length vs load and deflection for all profiles.

4.2 Effect Of Depth And Angle Variation:

(1) Depth is varied between 180mm-500mm. Below 180mm , deflection limit exceeds and above 500mm value of combined shear and bending exceeds unity.

(2) Angle is varied as 30°, 45°, 60°. Maximum results are obtained for 60°. Span is kept 4m for all calculations.

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Table 1 Variation of depth For CWES

Depth (mm)	M.O.I (cm^4)	2 point load (kN)	Actual Deflection(cm)	Permissible deflection (cm)	Moment (kN.m)
200	1599.9	8.636	1.571	1.2307	23.029
250	2756	11.906	0.9257	1.2307	31.749
300	4316.6	15.541	0.7714	1.2307	41.442
350	6332.1	19.539	0.6612	1.2307	52.104
400	8851.6	23.899	0.5785	1.2307	63.731
450	11925	28.620	0.5143	1.2307	76.321
500	15603	33.703	0.4625	1.2307	89.874

Table 2 Variation of Depth for CWCES

Depth (mm)	M.O.I (cm^4)	2 point load (kN)	Actual Deflection (cm)	Permissible deflection (cm)	Moment (kN.m)
200	1803.164	9.736875	1.1571	1.2307	25.965
250	3134.67	13.54163	0.9257	1.2307	36.111
300	4923.55	17.72475	0.771	1.2307	47.266
350	7219.78	22.278	0.6612	1.2307	59.408
400	10073.38	27.198	0.5785	1.2307	72.528
450	13534.43	32.48213	0.5143	1.2307	86.619
500	17657.64	38.12963	0.4628	1.2307	101.679

Table 3 Variation of depth of web and angle of stiffeners for "A"

Depth (mm)	Angle	2 point load (kN)	Moment (kN.m)	M.O.I (cm^4)	Actual Deflection (cm)	Permissible deflection (cm)
200	30	10.22175	27.258	1892.295	1.1571	1.2307
	45	10.29975	27.466	1907.393	1.1571	1.2307
	60	10.56413	28.171	1956.633	1.1571	1.2307
250	30	14.1468	37.7248	3274.77	0.9257	1.2307
	45	14.20913	37.891	3289.126	0.9257	1.2307
	60	14.42025	38.454	3338.102	0.9257	1.2307
300	30	18.45308	49.2082	5125.855	0.7714	1.2307
	45	18.50475	49.346	5140.29	0.7714	1.2307
	60	18.681	49.816	5189.23	0.7714	1.2307
350	30	23.1315	61.684	7496.343	0.6612	1.2307
	45	23.17575	61.802	7510.77	0.6612	1.2307
	60	22.95188	61.205	7559.71	0.6612	1.2307
400	30	28.1775	75.14	10436.19	0.585	1.2307
	45	28.2165	75.244	10450.62	0.585	1.2307
	60	28.3485	75.596	10499.56	0.585	1.2307

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450	30	33.5962	89.59	13995.4	0.5143	1.2307
	45	33.62325	89.662	14009.83	0.5143	1.2307
	60	33.73875	89.97	14058.77	0.5143	1.2307
500	30	39.36375	104.97	18223.96	0.4628	1.2307
	45	39.39488	105.053	18238.4	0.4628	1.2307
	60	39.50813	105.355	18287.344	0.4628	1.2307

Table 4 Variation of Depth of web and angle of stiffener for "B"

Depth (mm)	Angle	2 point load (kN)	Moment (kN.m)	M.O.I (cm^4)	Actual Deflection (cm)	Permissible deflection (cm)
200	30	10.58775	28.234	1960.794	1.1571	1.2307
	45	10.6215	28.324	1966.96	1.1571	1.2307
	60	10.67888	28.477	1977	1.1571	1.2307
250	30	14.43938	38.505	3342.51	0.9257	1.2307
	45	14.46638	38.577	3348.73	0.9257	1.2307
	60	14.51213	38.699	3359.352	0.9257	1.2307
300	30	18.69675	49.858	5193.64	0.7714	1.2307
	45	18.71925	49.918	5199.8	0.7714	1.2307
	60	18.7575	50.02	5210.48	0.7714	1.2307
350	30	23.343	62.248	7564.13	0.6612	1.2307
	45	23.35988	62.293	7570.34	0.6612	1.2307
	60	23.3925	62.38	7580.9	0.6612	1.2307
400	30	28.36125	75.63	10503.98	0.585	1.2307
	45	28.37738	75.673	10510.2	0.585	1.2307
	60	28.40625	75.75	10520.8	0.585	1.2307
450	30	33.75	90	14063.2	0.5143	1.2307
	45	33.765	90.04	14069.4	0.5143	1.2307
	60	33.75413	90.011	14080	0.5143	1.2307
500	30	39.51	105.36	18299.8	0.4628	1.2307
	45	39.5235	105.396	18297.9	0.4628	1.2307
	60	39.54375	105.45	18308.6	0.4628	1.2307

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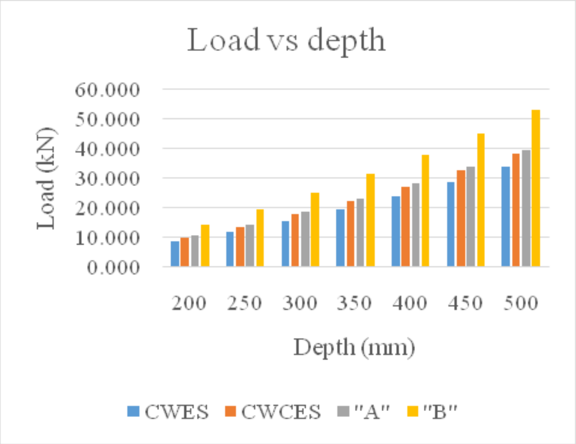

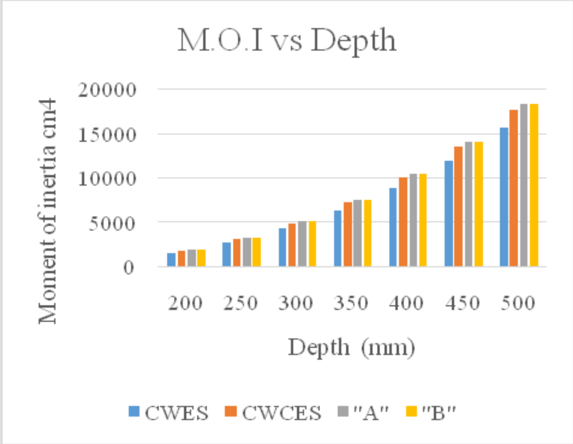

Figure 4 load vs depth , M.O.I vs depth for span=4m, angle=60, IWB=50mm.

V. CONCLUSION

From the above numerical investigation , following conclusions are drawn:

- Addition of edge stiffener adds to flexural strength of section significantly , for same dimensions of cross section and within permissible limits of deflection.
- Load carrying capacity and moment of inertia can be increased, within permissible limits of deflection, by increasing (1) Depth of section, keeping rest of parameters constant for CWES and CWCES profiles , (2) Angle of intermediate stiffener up to 60° for “A” and “B” profiles, keeping horizontal length of stiffener equal to effective width of flange, (3) Vertical length of stiffener up to 50mm for “B” profile.
- The beams having above profiles are safe in deflection criteria for span up to 4 m.ds
- Profile “B” proves to be good for load carrying capacity because intermediate web stiffener and complex edge stiffener are added to profile which affects significantly in flexural strength of members.

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