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BUCKLING ANALYSIS OF RECTANGULAR HOLLOW FLANGE COLD FORMED STEEL SECTION

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Abstract* — Cold formed steel is preferred over hot rolled steel section because of its high strength to weight ratio. Open cold formed steel sections such as C, Z and hat sections are commonly used but they suffer certain buckling modes due to their mono symmetric and eccentricity of shear centre to centroid. Hence hollow sections with two torsionally rigid rectangular hollow flange sections connected by a web are invented in order to eliminate the buckling failures and to increase their load carrying capacities. This study aims to investigate the buckling behaviour of RHFB analytically using ABAQUS 6.16. The aspect ratio of hollow flanges varied as 1, 1.6, 2 with varying thickness as 1.2, 1.6, 2 mm. The stiffeners are placed at a distance of L/3 from both ends. The length of all the specimens are kept constant as 2000 mm. The coupon test was conducted to obtain the material properties. Finally the analytical results for the sections is compared to find out the optimal section exhibiting better load carrying capacity and flexural behaviour.

***Keywords*— Cold Formed Steel, Aspect Ratio, Buckling Modes, Local Buckling, SCC, Finite Element Analysis and ABAQUS 6.16**

I. INTRODUCTION

Cold-formed steel components are made from steel plate, sheet materials. These plates are manufactured by one of two processes: press braking or cold roll forming, where they are shaped according to the required specifications. Press-braking is used to create simple shapes in small quantities.

The reduction in the density of steel produces economies both in steel costs as well as in the costs of handling transportation and erection. Also cold form steel is protected against corrosion by proper galvanizing or powder coating in the factory itself.

Cold forming increase the yield strength of steel, the increase being the consequence of cold working well into the strain-hardening range. The effect of cold working is thus to enhance the yield stress by 15% - 30%. For design purpose, the yield stress may be regarded as having been enhanced by a minimum of 15%.

The strength and behaviour of cold formed steel members are governed by the material and sectional properties. It can be improved in a various ways. The flexural strength of the cold-formed steel section in bending is generally improved by introducing various innovative sections like hollow flange section.

The hollow flange section has high buckling capacity due to its unique shape where its distortional buckling is eliminated by the torsionally rigid hollow flanges while its local buckling capacity is improved due to the absence of free edges and reduced web width.

In this research different aspect ratios of the rectangular hollow flange cold formed steel sections are considered and their weights are kept constant. The buckling analysis for different sections are performed using Finite element analysis software ABAQUS 6.16.

II. MATERIAL PROPERTIES

Plastic deformation is mostly observed in materials, particularly metals. Elastic deformation is an approximation and its quality depends on the time frame considered and loading speed.

The young's modulus is given for various thickness obtained from the stress-strain curve from coupon test results. The poisson ratio is given as 0.3.The yield stress and plastic strain values are calculated from engineering stress -strain and are given to the flexural member.

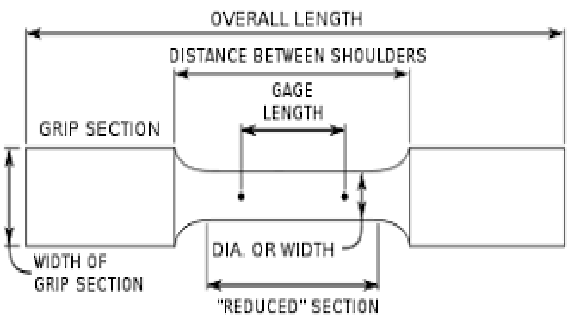


Fig. 1 Coupon test specimen

Tensile strength tests are used to predict the behaviour of a material under forms of loading other than uniaxial tension. IS 1608: 2005 ISO 6892: 1998 "Metallic Materials – Tensile Testing At Ambient Temperature". Coupon specimens (9 no's) of various thickness are tested and the results are carried for non-linear analysis in Abaqus6.16. Various thickness considered are 1.2mm (3 no's), 1.6mm (3 no's), 2mm (3 no's).

The tensile coupons were tested in a 100KN UTM machine. A load range 10% was adopted for the test. The coupons were mounted using the gripping devices and aligned with vertical axis of the machine. The axial load was applied gradually. Extensions were recorded using electronic extensometer and compiled with data acquisition system.

Fig. 2 Coupon specimen after testing

III. SECTION GEOMETRY

The section is formulated by varying the flange aspect ratio and depth of web by keeping the profile length same. Flange aspect ratio is ratio of the width of the flange to the depth of the flange section. In the present investigation 9 different RHFB profiles of constant length 2000 mm have been modelled using finite element software ABAQUS 6.16.

The aspect ratio of the hollow flanges are varied as 1, 1.6, 2 and thickness of the sections are varied as 1, 1.6, and 2 mm by keeping the weight same. The perimeter of 270 mm is taken as a constant length

Modelling is done using finite element software ABAQUS 6.16. 3D deformable shell element is chosen in the software and nonlinear analysis is carried out from the coupon test data results.

The modelling of RHFB was started by creating three dimensional, deformable SHELL part in ABAQUS. The shell element (S4R) was used in all the finite element models.

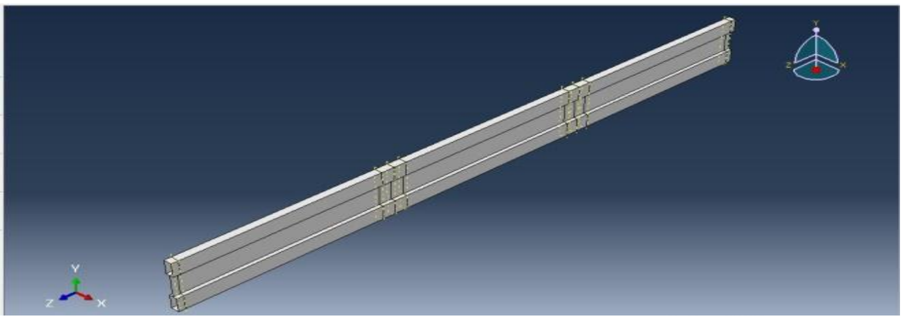


Fig 3 Modelling of the RHFB using ABAQUS 6.16

IV. MESHING AND BOUNDARY CONDITIONS

The size of the mesh is taken as 1cm. Rigid body constraint was created between the stiffener and beam section & tie constrains are given at both ends of the section.

Quadrilateral meshing is done to the model by fixing the global seed as 10. It is most common in structured grids. Quadrilateral elements are usually excluded from being or becoming concave.Boundary conditions in Abaqus/CAE take effect through different steps where we may be applying different load cases to a model.

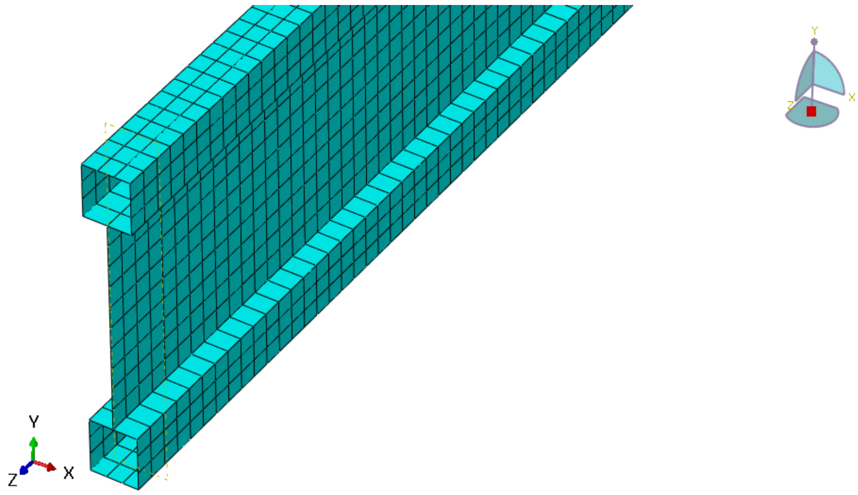


Fig 4 Meshing View of RHFB section

Finite element models the RHFB with the boundary condition assigned to each member of the instance is hinged at one end of the base while the other end of the beam section is roller. Two point loading systems were developed.

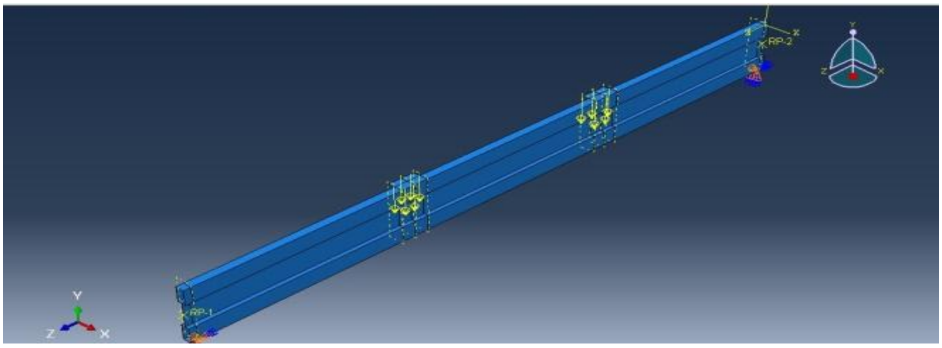
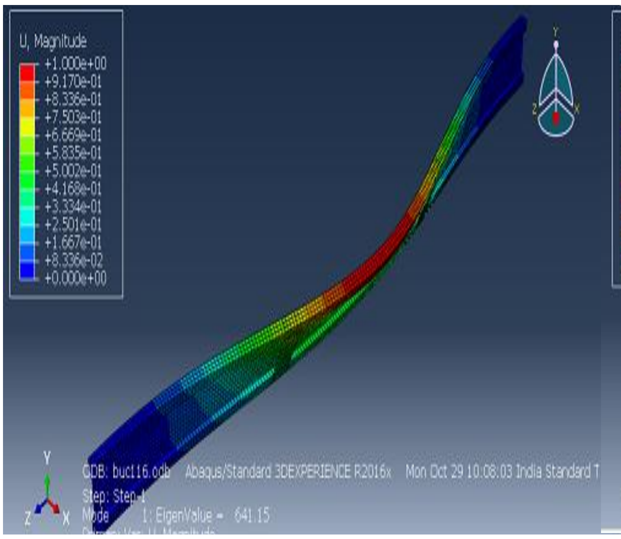


Fig.5 Loading with Boundary Condition

V. ANALYSIS

Non - linear analysis is carried out by enabling the linear perturbation option in the STEP and BUCKLE method is created. Concentrated force of 1 N is applied in the Y direction. The deformation may be composed of either rigid body translations and rotations, or a combination of both.

From the result of buckling analysis it clear that for AR 1 thickness 1.2mm the 1st mode shape is a half sinusoidal wave with lateral torsional buckling. Similarly 2nd mode shape is a sinusoidal wave with lateral torsional buckling and 3rd mode shape experiences lateral torsional buckling.



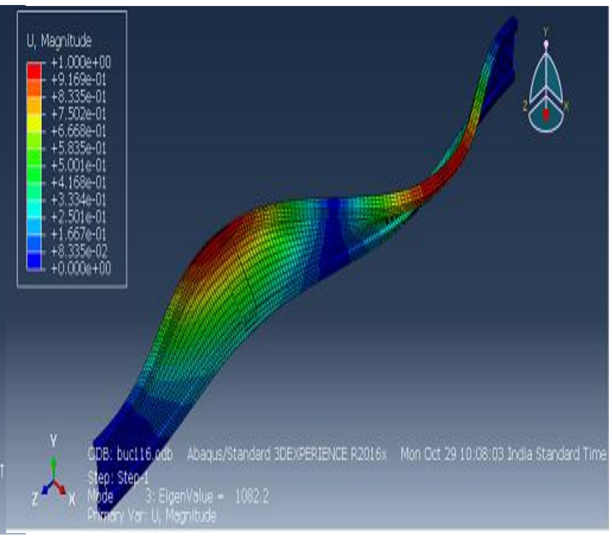


Fig.6 1st Mode Shape for AR 1 Tk-1.2mm Fig.7 2nd Mode Shape for AR 1 Tk-1.2mm

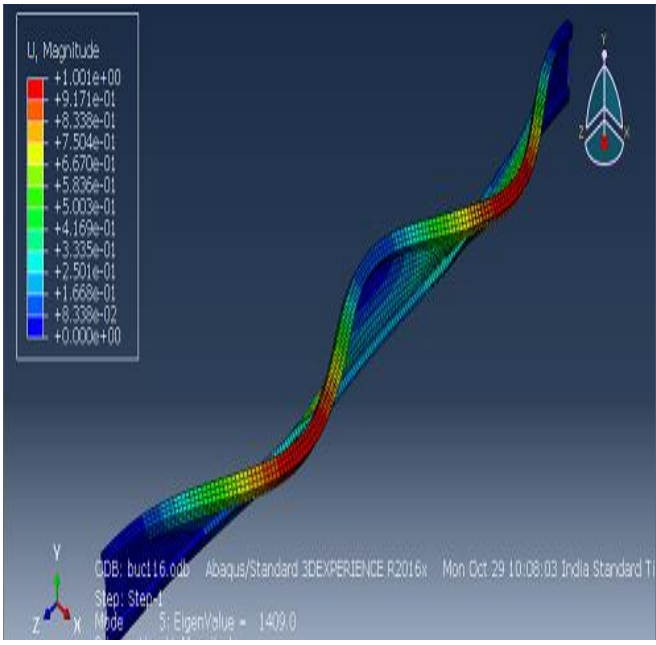


Fig.8 3rdmode Shape for AR 1 Tk-1.2mm

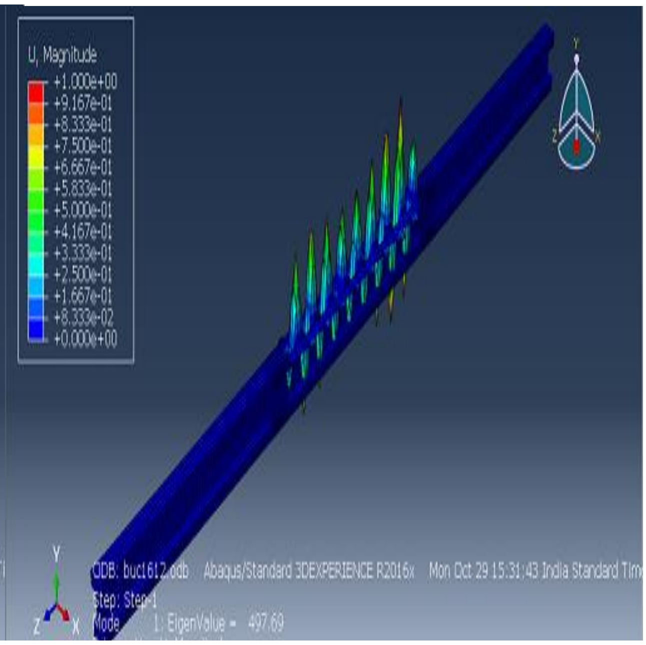


Fig.9 1st Mode Shape for AR 1.6 Tk-1.2mm

VI. RESULTS AND DISCUSSIONS

Buckling analysis result for RHFB having thickness 1.2, 1.6,2 mm for various aspect ratio. The Eigen value of fundamental mode and buckling behaviour of first 3 modes are presented.

TABLE 1 BUCKLING ANALYSIS RESULT FOR RHFB 1.2mm THICKNESS

SECTION NAME	EIGEN VALUE (N)	1st MODE TYPE	2nd MODE TYPE	3rd MODE TYPE
RHFB 25x25x1.2	465.60	LTB(half sine wave)	LTB (full sine wave)	LTB
RHFB 40x25x1.2	497.69	LB	LB	LB
RHFB 50x25x1.2	342.30	LB	LB	LB

TABLE 2 BUCKLING ANALYSIS RESULT FOR RHFB 1.6mm THICKNESS

SECTION NAME	EIGEN VALUE (N)	1st MODE TYPE	2nd MODE TYPE	3rd MODE TYPE
RHFB 25x25x1.2	641.15	LTB(half sine wave)	LTB (full sine wave)	LTB
RHFB 40x25x1.2	1181.20	LTB(half sine wave)	LB	LB
RHFB 50x25x1.2	905.92	LB	LB	LB

TABLE 3 BUCKLING ANALYSIS RESULT FOR RHFB 2mm THICKNESS

SECTION NAME	EIGEN VALUE (N)	1st MODE TYPE	2nd MODE TYPE	3rd MODE TYPE
RHFB 25x25x1.2	828.24	LTB(half sine wave)	LTB (full sine wave)	LTB
RHFB 40x25x1.2	1513.10	LTB(half sine wave)	LB	LB
RHFB 50x25x1.2	1994.2	LB	LB	LB

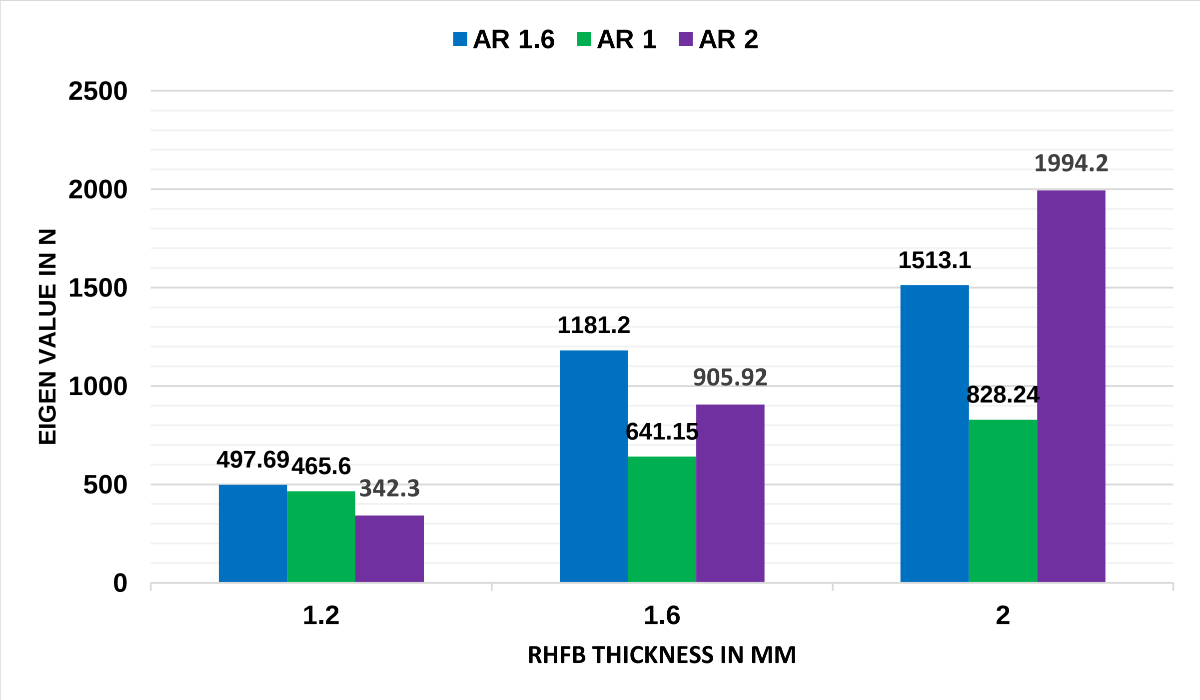


Fig.10 Buckling load comparison for RHFB

VII.CONCLUSION

In this study it is aimed to investigate the buckling behaviour and mode shapes of RHFB. Finite element analysis is carried out for 9 specimens using ABAQUS 6.16.

RHFB of AR 1 undergoes lateral torsional buckling and RHFB AR of 1.6 and 2 experiences local buckling in compression flange for thickness 1.2mm.RHFB of AR 1 and 1.6 undergoes lateral torsional buckling and RHFB AR of 2 experiences local buckling in compression flange for thickness of 1.6 and 2mm.

RHFB with AR 1 and 1.6 of thickness 1.2 mm and 1.6 mm respectively have maximum buckling load capacity similarly RHFB with AR 2 of thickness 2 mm have maximum buckling load capacity.

REFERENCES

[1] Wei- Wen- Yu (1991), " Cold Formed Steel Design" .

[2] Cheng Yu (2016)," Recent Trends in Cold Formed Steel Construction".

[3] Somadasa Wanniarachchi. (2005), "Flexural Behaviour and Design of cold formed steel Beams with Hollow flanges".

[4] Tharmarajah Anapayan (2010), "Flexural Behaviour of hollow flange steel beams", Queensland university of technology.

[5] Yener, M., Pekoz, T. (1983), "Limit state Design in Cold Formed Steel", Journal of Structural Engineering, ASCE, Vol. 109, No. 9, pp. 2033-2047.

[6] Avery, P., Mahendran, M. and Nasir, A. (2000a),"Flexural Capacity of Hollow Flange Beams", Physical Infrastructure Centre, QUT, Brisbane, Australia.

[7] Avery, P., Mahendran, M. and Nasir, A. (2000b),"Flexural Capacity of Hollow Flange Beams", Journal of Construction Steel Research, Vol 53, pp 201-203.