Flexural Behaviour of Cold Formed Steel Sigma Shaped Beam

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Abstract - *The primary aim of this paper is to study the load carrying capacity of the two different shapes of cold formed open sections, they are back to back sigma section and back to back channel section. The cold formed sections are widely used as a secondary member in steel structures. This paper is geared towards being used as the primary flexural member. In this analysis, the flexural behavior of built-up sigma section beam is compared with built-up channel section beam, by considering the built-up channel section beam as a conventional member. Generally, there will be a different behavior for corrugated section of cold-formed steel when compared to straight section. They tends to enhance the ultimate strength and degrades the deflection in beam. The analytical study has been carried out for the picked specimen respectively. These specimens were modelled in the ABAQUS software with span 1.2m, and were analyzed with simply supported end condition under two-point loading. Here, the major advantage was observed from this analytical research, that there was an increase in ultimate load carrying capacity for corrugated section in flexural member. The failure pattern and the area of failure are examined in this analysis.*

Key Words: **Cold Formed Steel, Flexural member, Sigma section, ABAQUS software and Failure pattern.**

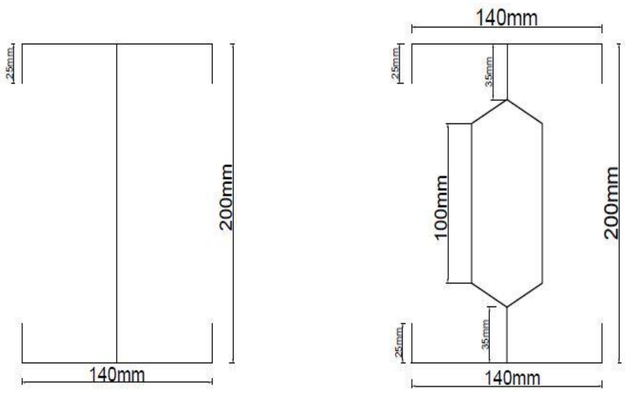
1. INTRODUCTION

Cold formed steel is the term used for products that are produced by rolling or pressing thin sheet metal gauges into objects with desired shape and size at room temperature. Since CFS is a high strength steel, the thickness is reduced and constructed as a light weight members. It can be manufactured in multiple thickness for both structural and non-structural purposes. It is easy to handle, transport, lift and assemble since it is light weight steel. The key advantage is it has high strength and stiffness and it cannot deform from its location. CFS is most preferable because of their high strength to weight ratios. They are suitable for seismic prone areas to withstand the earthquake force. They are generally, angle section, channel section, hat section, z-section etc. Built-up sections are formed by connecting back to back section or face to face section (i.e., web of two channel sections or flanges of two channel sections are connected by any conventional connection methods). CFS has more moment of inertia and when compared to hot rolled. Hence, the load carrying capacity and moment resisting capacity are high. The sheet thickness usually lies between 1mm and 8mm. Various conventional sections are used commonly for industries as purlins, girts, light struts roof sheeting and floor decking etc. Whereas, sigma sections are used for constructing curtain and partition walls, as well as for ceiling joists, eaves beams, frame beams and roof purlins. Sigma purlins are now preferred more than other conventional steel sections due to their improved load resistance performance. They also have higher web stiffness that makes them to carry heavy loads. This paper discuss the flexural behaviour of thin walled beams by means of analytical study conducted mainly on two types of beams, namely channel section and sigma section to study the load carrying capacity of the previously mentioned section, the cold formed beams have been modelled and analysed using a finite element software, ABAQUS software and results of two beams are compared and concluded.

2. OBJECTIVES OF THE WORK

- To investigate the analytical result of cold formed steel sections of built-up sigma section and built-up channel section.
- To reduce the lateral bending of the beam.
- To promotes the structures with high stiffness, ductility, toughness of seismic loads.

3. SPECIMEN DETAILS



(a) Built-up C-Section beam (b) Built-up Sigma Section

(a) Depth of the beam = 200mm
(b) Length of the specimen = 1200mm
(c) Thickness of the specimen = 2.5mm
(d) Width of the beam = 140mm
(e) Corrugation angle = 30^0
(f) Lip of the section = 25mm

4. NUMERICAL ANALYSIS

4.1 FINITE ELEMENT ANALYSIS

In this project ABAQUS software is used, it is FEA software which is used for both modelling and analyzing. In this paper the flexural behavior of built-up channel section and sigma section is studied using this finite element software. The geometry is stimulated using S4R shell element. It follows modelling, assigning property and section, meshing, defining boundary conditions and analyzing. Further, the beams are modelled as the 3D planar shell element and as section model with required geometric parameters.

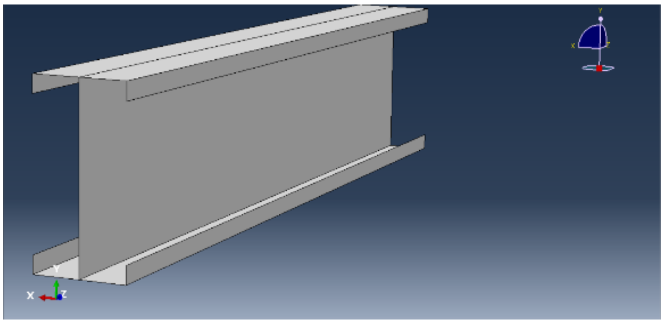


Fig -1: Creation of 3D model built-up C- section

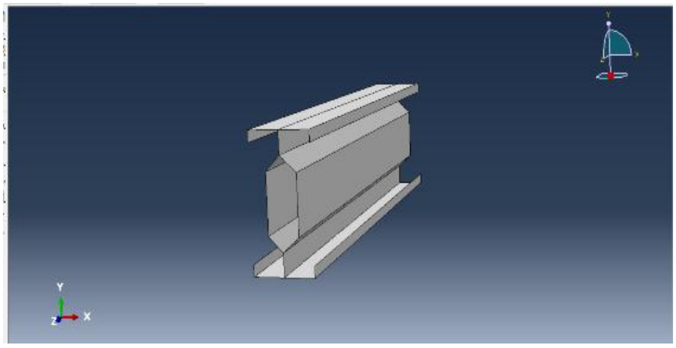


Fig - 2: Creation of 3D model built-up sigma section

4.2 PREPROCESSING

The built-up channel section and sigma section beams are modelled using S4R shell element. The beams are analyzed under the boundary condition, simply supported with two-point loading condition, further the supports are provided with lateral constraints. The material non-linearity of the specimen was modelled by the phenomenon of yield and isotropic hardening by Von Mises. The general material properties of cold formed steel are,

Table -1: Material properties

Description	Steel
Density	7.8×10-9 N/mm3
Poisson's ratio	0.3
Young's modulus	2.010×105N/mm2
Yield strength	380 N/mm2

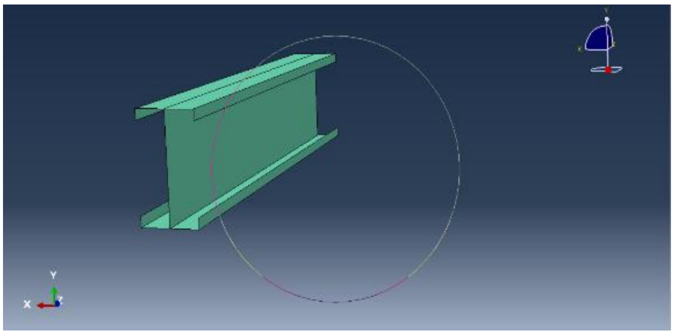


Fig - 3: Assigning section properties of built-up C-section

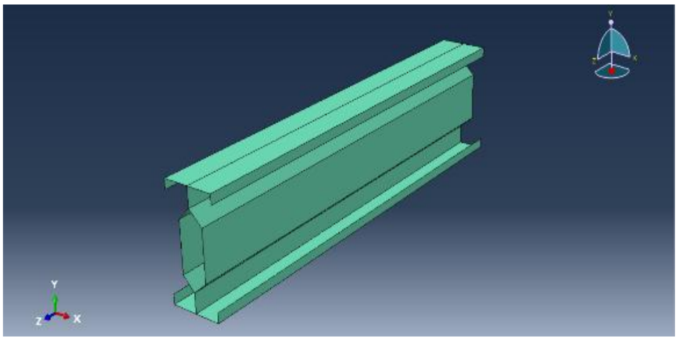


Fig - 4: Assigning section properties of built-up sigma section

4.3 MESHING

The accuracy obtainable from any FEA model is directly related to the finite element mesh used. The meshing is the process that undergoes the operation, which the finite element mesh is involved to subdivide the CAD model into smaller domains is known as elements, for which the number of equations is solved. Here the built-up channel section and sigma section models are subdivided into smaller elements and to solve problems.

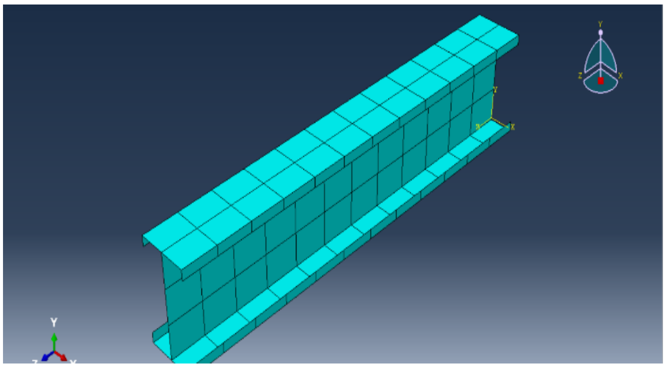


Fig - 5: Creation of meshes for built-up C-section

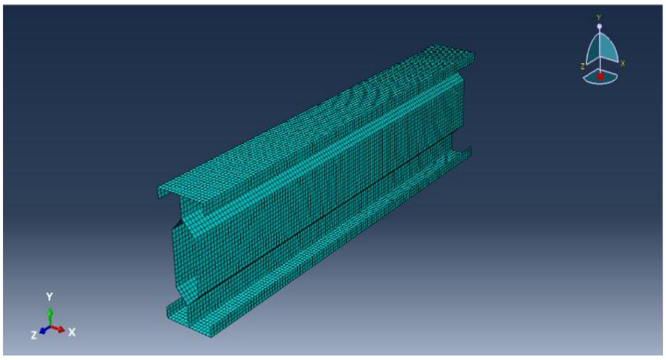


Fig - 6: Creation of meshes for built-up sigma section

4.4 LOADING AND BOUNDARY CONDITION

These the beams are analyzed under the simply supported boundary condition with two point loading condition. The lateral restraints are provided at the support of the beam. The modelled specimens are two point loaded at the one-third distance from the support, in this way the beam is under pure bending state.

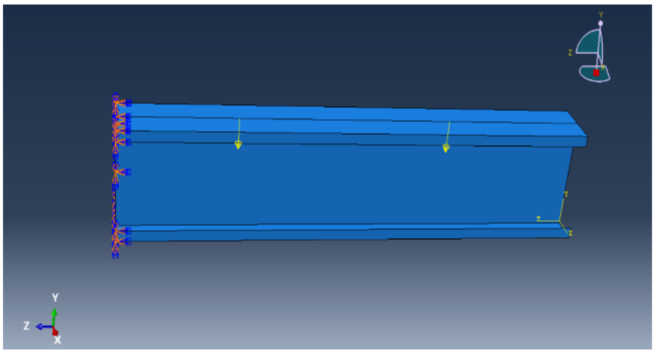


Fig - 7: Application of load for built-up C-section

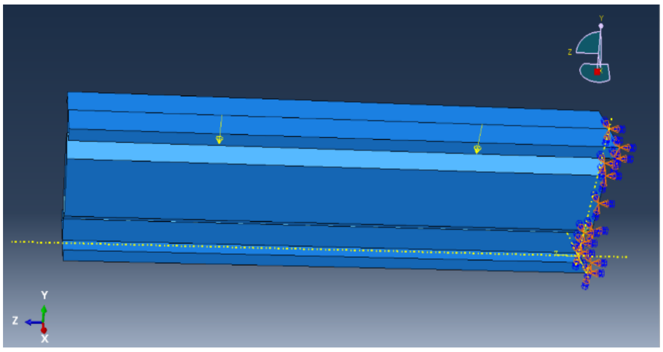


Fig - 8: Application of load for built-up sigma section

4.5 RESULTS AND DISCUSSION OF FINITE ELEMENT ANALYSIS

The beam specimens are tested under two point loading with simply supported end condition by incremental loading. The obtained ultimate strength of built-up sigma section beam and built-up C section beams are 73KN and 65KN. And the deflection is 4.7mm and 5.2mm, therefore it is clearly obtained that the deflection occurs greater in straight section when compared to corrugated section. The test results exhibited through FEA using ABAQUS the corresponding deflection obtained from the corrugated section is varied by 12% lesser than the deflection occurred in straight section.

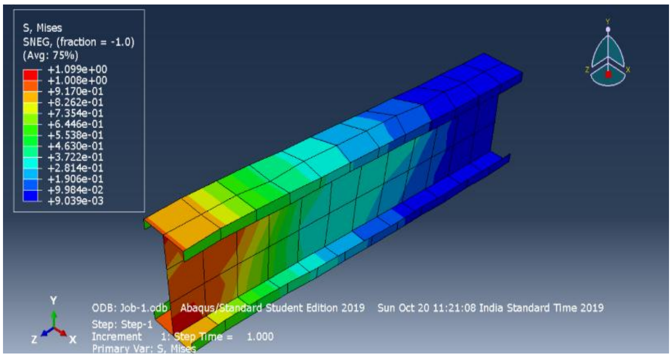


Fig - 9: Stress distribution in C-section beam

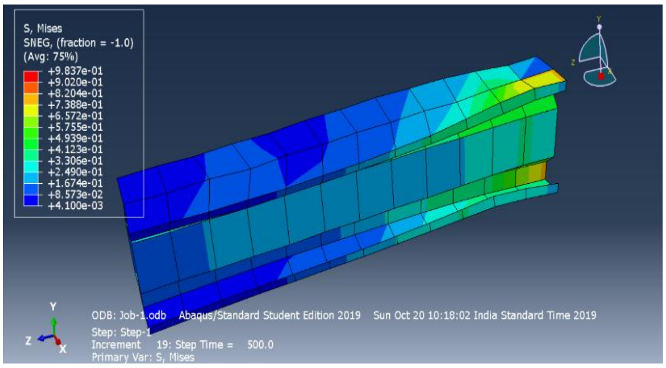


Fig -10: Stress distribution in sigma section beam

5. COMPARISON OF RESULTS

TABLE -2: Load Vs Deflection of built-up C-section

LOAD	DEFLECTION
0	0
10	1.2
20	1.7
25	2.2
30	2.7
40	3.3
45	3.8
50	4.3
55	4.8
65	5.2

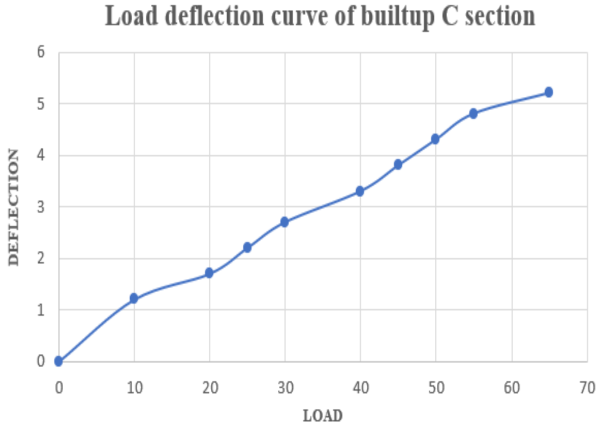


Chart -1: Load vs deflection curve of built-up C-section beam

TABLE -3: Load vs Deflection for built-up sigma section

LOAD	DEFLECTION
0	0
15	1.2
30	1.9
40	2.3
47	2.7
55	3.3
60	3.8
65	4.1
70	4.5
73	4.7

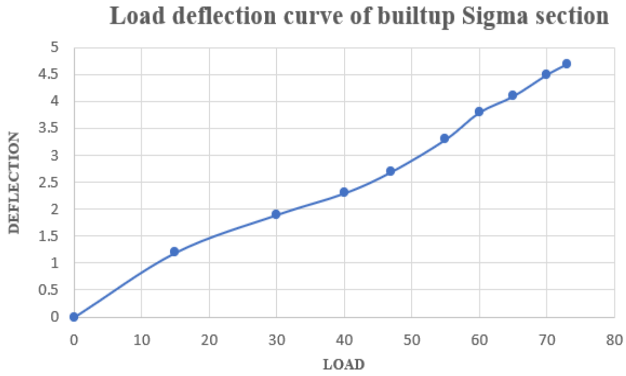


Chart -2: Load vs deflection curve of built-up Sigma section beam

6. CONCLUSIONS

The results yield are found to be within acceptable limits, from the comparative study on chosen specimens results which are satisfied to be concluded as,

1. Sigma beam is more effective when two single sections are bolted together and it serves better than the straight section (C-section).
2. The maximum sustainable load of built-up C-section is 12% greater over built-up sigma section.
3. Considering overall effectiveness it is clearly shown that the performance of built-up sigma section is satisfactory.

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