International Journal of Research and Innovation in Engineering Technology
Volume: 02 Issue: 12
ISSN: 2394 – 4854
Pages: 48 – 53

IJRIET

NUMERICAL INVESTIGATION ON FLEXURAL BEHAVIOUR OF COLD FORMED STEEL I SECTION WITH TRIANGULAR CORRUGATED WEB

Revathi.N[1], Satheshkumar G.K[2], Dr.Arunkumar.G[3]
[1]*M.E (Structural) Student, Department of Civil Engineering, Government College of Engineering, Salem, Tamilnadu, India*
[2]*M.E (Structural) Student, Department of Civil Engineering, Government College of Engineering, Salem, Tamilnadu, India*
[3]*Assistant Professor, Department of Civil Engineering, Government College of Engineering, Salem, Tamilnadu, India*

E-mail-ID: [1]revathichandra22@gmail.com, [2]satheshcivil@gmail.com, [3]arunkumar@yahoo.co.in

Received 17 May 2016, Accepted 20 May 2016, Available online 02 July 2016

Abstract

The objective of this paper is to study the flexural behaviour of cold formed I –section with triangular corrugation. The effect of parametric change on the flexural strength of cold formed steel (CFS) I section is presented in this paper. The web is corrugated at regular interval into a triangular shape along the length of the beam. Totally twelve specimens are theoretically and analytically analysed by changing depth of corrugation, h_w also span. All specimens are numerically analysed under two point loading with simply supported condition. The theoretical results are verified with finite element analysis using ABAQUS software. Theoretical analysis is done with code provision of AISI S100-2007, AS/NZS 4600:2005 specification. Within the parametric study the effect of corrugation in web on the flexural strength capacity is discussed and presented.

Keywords: Triangular Corrugated Web, Cold-Form Steel, ABAQUS, Flexural Strength.

1. INTRODUCTION

One of the issues raised since the steel structure was introduced in the construction industry is how to reduce the weight and cost of the component parts such as girder and beams. Efficient and economical designs of girders and beams normally require thin webs. Slender web will cause the web to buckle. To overcome this, the corrugated web can be used, which require no stiffening, so it permits the use of thinner plates with significant weight saving.

Economical design of girders and beams normally requires thin webs. But if the web is extremely slender the problem of plate buckling may arise. Possible ways to reduce this risk are by using thicker plates; and web stiffeners or the latest innovative technique by strengthening the web by making it corrugated. Cold-formed steel members are widely employed in steel construction because they are lighter and more economical than traditional hot-rolled ones. Nowadays the easy availability and accessible cost of high-strength low alloy steels, weathering steels, and zinc-coated steels have led to members with height/thickness ratios, rendering them even more susceptible to local buckling and to another buckling mode called distortional buckling, Z section, hat, rack, etc. The primary objective is to study the behaviour of cold formed build up I sections with the triangular corrugated web. Determine the flexural strength or load carrying capacity of the specimen as per code AISI S100-2007, AS/NZS 4600:2005 Specification. Study the possible mode of failure of the specimen in experimental and numerical.

2. LITERATURE SURVEY

Pasternak et al (2010) suggested that for branded sinusoidal girders local buckling effects do not occur before the web reaches its yielding shear capacity**.**

Fatimah Denan (2010) suggested that steel beam with trapezoidally corrugated web section have higher resistance to lateral torsional buckling compared to that of section with flat web. This shows that corrugation thickness influence the resistance to lateral torsional buckling.

Kankanamge (2012) carried out numerical study on simply supported cold-formed steel lipped channel beams subjected to uniform bending by using FEA software ABAQUS and its accuracy was verified using available numerical and experimental results.

G. Arunkumar (2013) suggested that the flexural capacity of the corrugated web is larger than flat web. Within the parametric study the effect of hw/tw ratio on the flexural strength capacity is discussed. The effect of web corrugation and hw/tw ratio on the flexural strength of cold formed steel (CFS) lipped I section is studied.

3. THEORETICAL ANALYSIS

The calculation of the maximum load carrying capacity of the specimens was arrived by using code AISI S100-2007, AS/NZS 4600:2005 specification The Angle between the triangular webs is 45^0 for all the beams. The Table 1 gives the details of triangular corrugated beams. The details include Depth of web(h_w), flange thickness (t_f), web thickness(t_w), flange width (b), depth of corrugation (D_c), span of Beam (L).

4. ANALYTICAL ANALYSIS

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Most of the engineering problems today make it necessary to obtain approximate numerical solutions to problems rather than exact closed form solution. The basic concept behind the finite element analysis is that structure having infinite degrees of freedom to finite degrees of freedom. For the finite element analysis software ABAQUS 15 was used .One end of the specimen was constrained in *X, Y and Z* directions and the other end of the specimen was constrained in Y and Z direction. The nodes at the vertical side of the compression flange above the end stiffeners were constrained in the Z direction. The load applied along the transverse lines of the upper surface of the top flange above the stiffeners. The type of element chosen for finite element model idealization plays an important role in the prediction of the actual behavior of the structure. The elastic properties of the material were assigned to create a model of the triangular corrugated web beam. The value of Young's modulus E is given as $2x10^5$ N/mm^2 .The Poisson's ratio is given as 0.3. The yield stress of the material is 210 MPa. The density of the material is given as $7850x10^{-9}$ N/mm^3.

5. SPECIMEN DETAILS

Specimens	h_w	t_f	t_w	b	d_c	L
TCD$_C$1	100	2.0	1.2	120	30	1500
TCD$_C$2	100	2.0	1.2	120	40	1500
TCD$_C$3	100	2.0	1.2	120	50	1500
TCD$_C$4	100	2.0	1.2	120	60	1500
TCh$_w$5	100	2.0	1.2	120	50	1500
TCh$_w$6	150	2.0	1.2	120	50	1500

TCh$_w$7	200	2.0	1.2	120	50	1500
TCh$_w$8	250	2.0	1.2	120	50	1500
TCL9	200	2.0	1.2	120	50	1200
TCL10	200	2.0	1.2	120	50	1500
TCL11	200	2.0	1.2	120	50	1800
TCL12	200	2.0	1.2	120	50	2000

Table: 1 Detail of Specimens

5.1 Create Parts

The geometric Modeling is done using ABAQUS. The connectivity between web and flanges for weld tie coupling is done. The dimensions of the created solid model are same as the dimensions of the specimen going to use in the experimental test.

5.2 Material Properties

The elastic properties of the material were assigned to the created model of the triangular corrugated web beam. The value of Young's modulus E is given as $2x10^5$ N/mm^2 The Poisson's ratio is given as = 0.3. The yield stress of the material is 250 Mpa. The density of the material is given as $7.850x10^{-9}$ N/mm^3.

5.3 Assembly of Sections

Figure 1 Shows the assembly of triangular corrugated web with lower and upper flanges.

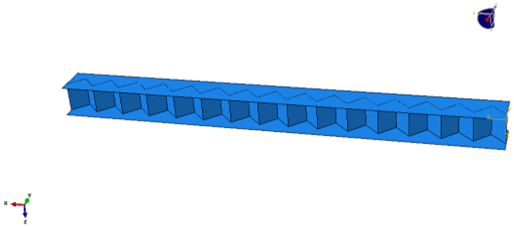
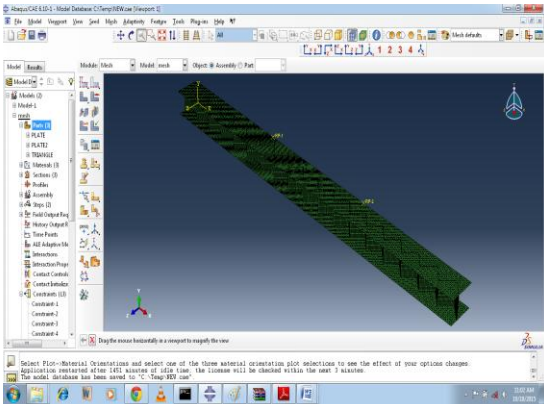


Figure: 1 Assembly Of corrugated web and flanges of Sections

5.4 Meshing

The construction of a 3D Finite element model usually requires a variety of mesh generation techniques. In our case (10mm) free meshing is done. Depending upon the range of fine and coarse meshing the computer time varies to run the process. The Figure 2 represents the modeling of the specimen with meshing size 10mm.



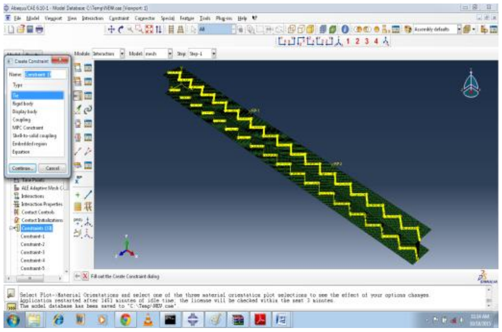
Drag the mouse horizontally in a viewport to magnify the view

```
Select Plot->Material Orientations and select one of the three material orientation plot selections to see the effect of your options changes.
Application restarted after 1451 minutes of idle time; the license will be checked within the next 3 minutes.
The model database has been saved to "C:\Temp\NEW.cae".
```

Figure: 2 Meshed test Specimen with boundary condition and loading.

5.5 Applying Displacement Constraints

Boundary conditions imposed on a finite element solid model is usually given in ANSYS by specifying the nodal point index and then restraining the necessary displacement component. Here in our problem the corrugated web beam is analyzed by simply supported end condition. So that displacement components $U_{x,}$ $U_{y,}$ and U_z are restrained at one end and displacement components U_y and U_z are restrained at the another end. Figure 3 shows that constraints created to tie the surface and nodes of the section.

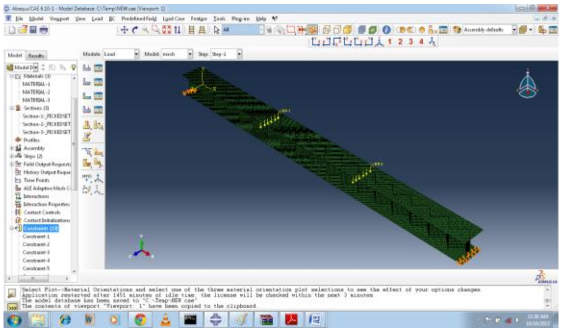


```
Select Plot->Material Orientations and select one of the three material orientation plot selections to see the effect of your options changes
Application restarted after 1451 minutes of idle time; the license will be checked within the next 3 minutes
The model database has been saved to "C:\Temp\NEW.cae".
```

Figure: 3 Constraints of sections

5.6 Applying Loads

Loads can be applied to the finite element model in various forms such as applying loads to the key points, lines, areas, elements and at the nodes. For our problem the analysis is carried out for the two points loading on corrugated beam. The load applied along the stiffener line at loading point in the nodes created. The Figure 4 represents the two point loading of the specimen, displacement at the supports as simply supported beam to get the pure bending.



```
Select Plot->Material Orientations and select one of the three material orientation plot selections to see the effect of your options changes
Application restarted after 1451 minutes of idle time; the license will be checked within the next 3 minutes
The model database has been saved to "C:\Temp\NEW.cae"
The contents of viewport "Viewport: 1" have been copied to the clipboard
```

Figure: 4 Assigning boundary conditions and load

5.7 Buckling of Specimen

Figure 5 and 6 shows the deformation of specimens under loading with local buckling and lateral torsional buckling.

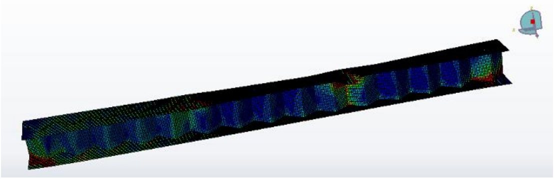
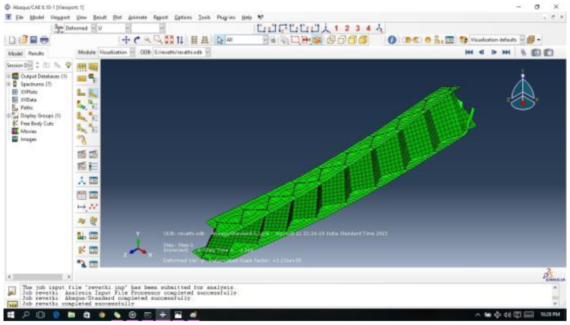


Figure: 5 Deformation of specimen



```
The job input file "revathi.inp" has been submitted for analysis.
Job revathi: Analysis Input File Processor completed successfully.
Job revathi: Abaqus/Standard completed successfully.
Job revathi completed successfully
```

Figure: 6 Lateral torsional buckling of another section.

6. THEORETICAL AND NUMERICAL TEST

Theoretical and numerical result are presented in table 2.

Specimen	AISI S-100:2007 M$_u$ (KN.m) X10^6	AS/NZS 4600:2005 M$_u$ (KN.m) X10^6	ABAQUS M$_u$ (KN.m) X10^6	MODE OF FAILURE
TCD$_C$1	3.026	3.163	3.425	LB
TCD$_C$2	3.029	3.249	3.674	LB
TCD$_C$3	3.054	3.092	3.714	LB
TCD$_C$4	3.076	3.116	3.752	LB
TCh$_w$5	3.076	3.302	3.755	LB
TCh$_w$6	3.043	3.412	7.711	LTB
TCh$_w$7	3.558	3.791	10.457	LTB
TCh$_w$8	3.243	3.423	12.368	LTB
TCL9	3.490	3.598	3.676	LB
TCL10	3.475	3.866	3.755	LB
TCL11	3.449	3.603	11.654	LTB
TCL12	3.421	3.992	14.278	LTB

Note LB- LOCAL BUCKLING,
LTB-LATERAL TORSIONAL BUCKLING

Table: 2 Moment carrying capacity of specimens

7. CONCLUSION

From the results it is found that as the corrugation web increases the load carrying capacity also increases and the effective shape of the profiled sheeting for practical use is triangular web profile. All beams are crushing on top flange with local buckling and lateral torsional buckling. Figure 7 Shows that the ultimate load for the triangular corrugated specimens.

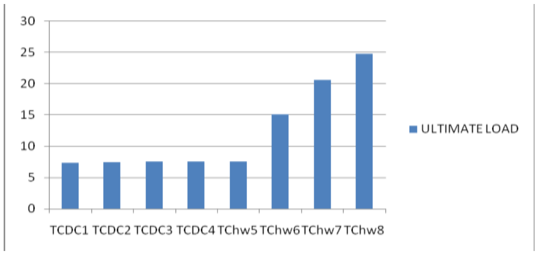


Figure: 7 Ultimate load for Specimens.

8. LOAD Vs DEFLECTION CURVE

Load – deflection curve for different configuration depth of the specimen and triangular web in change in depth of the web are presented in Figure 8, 9 and 10 respectively.

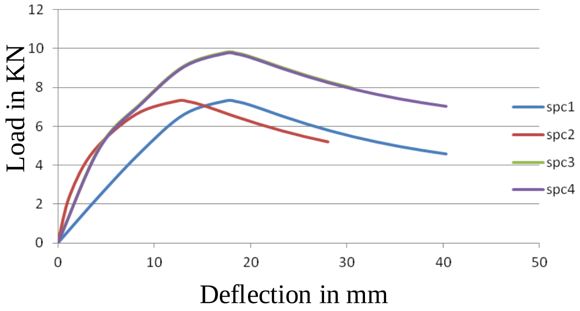


Figure: 8 Load – Deflection curve for different corrugation depth of specimens.

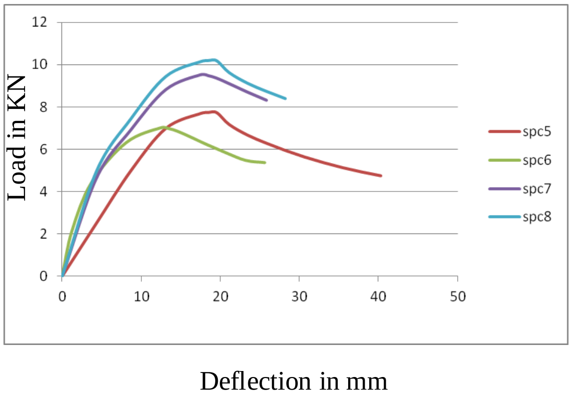


Figure: 9 Load – Deflection curve for triangular web with change in depth of web

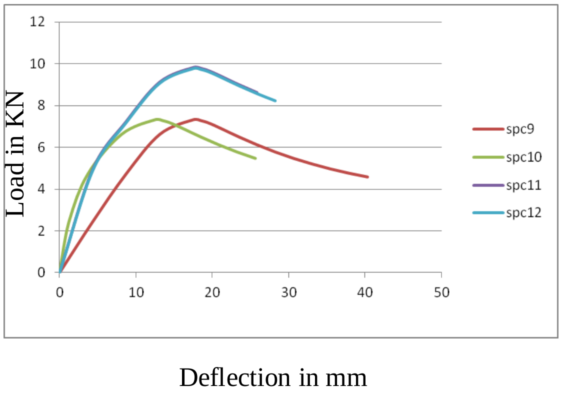


Figure: 10 Load – Deflection curve for triangular web with change in length

9. CONCLUSION

From the investigation, the following conclusions were drawn.

1. The linear and non-linear analysis has been studied for the specimen with varying in depth of web ,depth of corrugation and span.

2. Welded plate girder for different corrugation of the web plate increases the flexural capacity of the specimen.

3. When the triangular corrugation web increases the flexural capacity also increases than the trapezoidal web and flat web.

4. All the specimen failed due to crushing on the top compression flange with lateral torsional buckling and local buckling.

5. Numerical validation has been carried out to verify the appropriateness of the analytical results and found they are quite closer to the corresponding results.

6. Due to the corrugations, there is no failure in shear zone of web portion.

7. The code results are conservative.

References

[1] Australian/new zealand standard 4600:2005 specification for the design of cold form steel structural members AS/NZS 4600:2005

[2] North american specifications for the design of cold form steel structural members AISI (100 - 2007).

[3] IS-1608: 2005 code book for material test metallic materials - tensile testing at ambient temperature.

[4] Elgaaly, M., Hamilton, R. W. & Seshadri, A. (1996).Shear Strength of Beams with Corrugated Webs.Journal of Structural Engineering, Vol. 122, pp.390-398.

[5] Elgaaly, M., Seshadri, A. & Hamilton, R. W. (1997). Bending Strength of Steel Beams with Corrugated Webs. Journal of Structural Engineering, Vol. 123**,** pp.772-782.

[6] Elgaaly, M. & Seshadri, A. (1997).Girders with Corrugated Webs under Partial Compressive Edge Loading. Journal of Structural Engineering,Vol.123**,** pp.783-791.

[7] Elgaaly, M. & Seshadri, A. (1998).Depicting the behavior of girders with corrugated webs up to failure using non-linear finite element analysis. Advances in Engineering Software,Vol. 29**,** pp.195-208.

[8] Papia Sultana (2007),Predictions of Flexural Behaviour of Built- Up Cold-Formed Steel Sections,Vol.12,pp 36_39.

[9] Fatimah Denan1, Mohd Hanim Osman & Sariffuddin Saad (2010), IJRRAS,The study of lateral torsional buckling behaviour of beam with trapezoid web steel section by experimental and FEA,pp.232-240,

[10] Fatimah de'nan,salwani hashim (2013) experimental study on bending behaviour of triangular Web profile steel beam section,ijret, vol.03,pp.384-390.