IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X.
PP 30-36
www.iosrjournals.org

Experimental and Numerical Study on Torsional Behavior Of Light Gauge Steel Angle Section

P.Arun Shankar [1], S.Suresh Babu [2]
[1](*P.G. Student, M.E. Structural Engineering, Department of Civil Engineering, Valliammai Engineering College, India)*
[2](*Assistant professor, Department of Civil Engineering, Valliammai Engineering College, India)*

ABSTRACT: *Experimental and numerical study of torsional behavior of back to back angle section is presented in this paper. The equal size of cold formed steel angle sections are connected back to back through its full length with the help of bolt connection. Detailed measurement of material properties, residual stresses and geometrical imperfection were conducted. The section capacities were obtained from the test. The present study aims to determine the following parameters by conducting test on steel section loading condition, displacement behavior, stress behavior, maximum load and deflection. The experimental results are compared to the predicted numerical values with the reference of Indian Standard codes.*
Keywords : *Back to back connection, torsoinal behavior, bending test and moment resistance, numerical comparison.*

I. INTRODUCTION

Light gauge steel structural members are cold form steel sheets or strips. Various cold formed light members can be used. The thickness for framing members ranges from 1.2 mm to 4.0 mm. The thickness of floor and wall panel section and for long span roof deck varies from 1.2 to 2.5 mm. The thickness of cladding and standard roof deck varies from 0.8 mm to 1.2 mm. In India, light gauge members are widely used in bus body construction, railway coaches etc., and thickness of the section may vary from 1.0 to 3.2 mm.

Cold formed steel structural members are playing a greater role in modern steel structures due to their high strength and light weight whi9ch are leading to cost reductions in the construction industry. The manufacture of cold formed products is becoming increasingly refined featuring now in-line galvanizing as part of the forming process. The in-line galvanizing process taken in conjunction with cold forming has been found to enhance the strength properties of the section upto 30%. The new cold formed section fit between the current hot-rolled sections which usually have a stress grade of 250-300 MPa, and the thin walled cold formed sections such as purlin shapes with the stress grade of 450, 500 and 550 MPa.

This paper presents the result of torsional behavior of back to back connected angle section through its full length. The Indian Standards such as IS 801-1987 and IS 811-1974 are the codes books for use of cold formed light gauge steel structural members in general building construction.

II. MATERIAL PROPERITIES

Section Size

The nominal section size of unequal angle was selected from the codal provision such as IS 811-1995. The size of the angle section is 80×50×20mm. Here 80mm is the web of the section, 50mm is flange portion of the section and 20mm is lip of the section. The nominal thickness of the section is 2.5mm. The selection of the section based on the slenderness of the section.

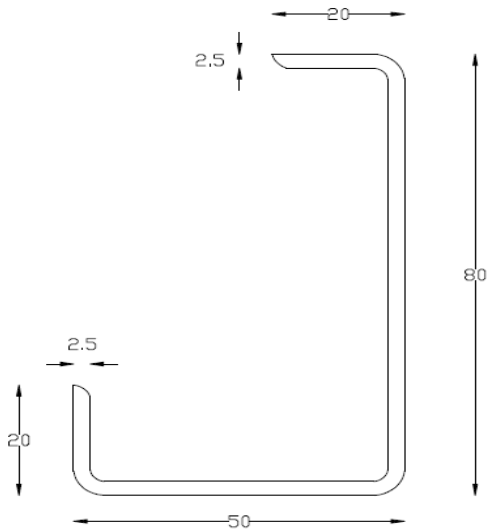

FIG.1 Single Angle Section

The unequal angle was connected back to back with the other angle section had the same dimension with the help of bolts. The two angle sections were drilled at the centre portion of the web area for placing bolt to connect the angle section. The sections were drilled at 8mm dia and 6mm dia bolts are used. High tensile 6mm bolts are used to connect the section. Then the section was turned as unequal I section for the projection of lips.

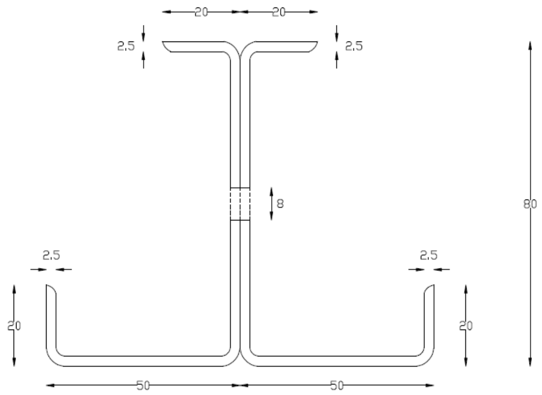

FIG.2 Back to Back Angle section Dimension

At the edge of the angle section mild steel plates are welded for the use of torsional test. The mild steel plate was 10mm thick and arch welded.

FIG.3 Back to Back Angle section

III. LOAD CALCULATIONS

ALLOWABLE LOAD

The allowable safe load and deflection are to be determined in the Numerical approach. The numerical approach method are done with the help of codes.

Specimen size : 80×50×2.5mm
Lip size : 20mm
Length : 1500 mm

3.1. Computation of effective width

The effective width of compression flange will be found on the basis of design stress

$f_b = 0.6\, f_y$

$f_y = 235$ N/mm^2

$f_b = 0.6 \times 235 = 141$ N/mm^2

For load determination, effective width is given by the equation,

$$\frac{b}{t} = \frac{658}{\sqrt{fb}}\left[1- \frac{145}{\frac{w}{t} \times \sqrt{141}}\right]$$

$$\frac{b}{t} = \frac{658}{\sqrt{141}}\left[1- \frac{145}{\frac{40.5}{2.5} \times \sqrt{141}}\right]$$

$$\frac{b}{t} = 13.6$$

$b = 13.6 \times 2.5 = 34.11$ mm

Then the required effective width is determined as notation of b.

3.2. Determination of moment of inertia and section modulus

The section is unequal. Then the moment of inertia was calculated as $I_{yy.}$

$I_{yy} = A \times hk^2$ mm^4

$I_{yy} = 461.15 \times 10^3$ mm^4

3.3. Determination of safe load

$M = f_b \times z$ N-mm

$M = 141 \times \frac{461.15 \times 1000}{100}$

$M = 1.625$ KNm

$\frac{w \times l^2}{8} = \frac{1.625 \times 8}{(1.5)^2} = 5.78$ kN/m

3.4. Check for web shear

Max. shear force = $\frac{5.78 \times 1.5}{2}$

= 4.335 kN

Max. average shear stress =

$\frac{4.335 \times 1000}{2 \times 2.5 \times 75} = 11.56$ N/mm^2

$\frac{h}{t} = \frac{7.5}{2.5} = 30$; $\frac{1425}{\sqrt{235}} = 92.96$

$f_r = \frac{396\sqrt{235}}{30} = 202.034$

$\leq 0.4 \times 236 = 94.4$ N/mm^2

fr = 94.4 N/mm^2 which is much greater than the maximum avg shear stress 4.62 N/mm^2. The beam is therefore safe in shear.

3.5. Check for bending compression in web

$f_{bw}' = f_b \times \frac{100-t}{100}$ N/mm^2

$= 141 \times \frac{40-2.5}{40} = 132.18$ N/m^2

permissible $f_{bw} = \frac{3525000}{(30)2} = 39.16$

If f_{bw} is greater than f_{bw}', hence safe.

3.6. Determination of deflection

For determination of deflection, one may use effective section at max. B.M.

$\frac{b}{t} = \frac{842}{\sqrt{fb}}$ [1- $\frac{145}{\frac{w}{t} \times \sqrt{141}}$]

$= \frac{842}{\sqrt{141}}$ [1- $\frac{145}{\frac{40.5}{2.5} \times \sqrt{141}}$]

= 2.346

b = 2.346 × 2.5 = 5.86 mm

Then the effective width b and I were computed as earlier.

3.7. Permissible load

$\delta = \frac{5}{384} \frac{(wL)L^3}{EI}$

= 4.12 mm

Permissible $\delta = \frac{1500}{325} = 4.61$ mm

Here the value of δ is compared with the permissible δ value. If the permissible value is greater, then the load is safe in limit.

IV. BEHAVIOROF STEEL BEAMS

Laterally stable steel beams can fail only by flexure, shear or bearing, assuming the local buckling of slender components does not occur. These three conditions are the criteria for limit state design of steel beams. Steel beams would also become unserviceable due to excessive deflection and this is classified as a limit state of serviceability.

The factored design moment, M at any section in a beam due to external actions shall satisfy

$M \leq M_d$

where M_d = design bending strength of the section.

IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X.
PP 30-36
www.iosrjournals.org

4.1BUCKLING BEHAVIOR

The steel section buckles differently because of the load applied to the section. This buckling may differs with its length of the section.

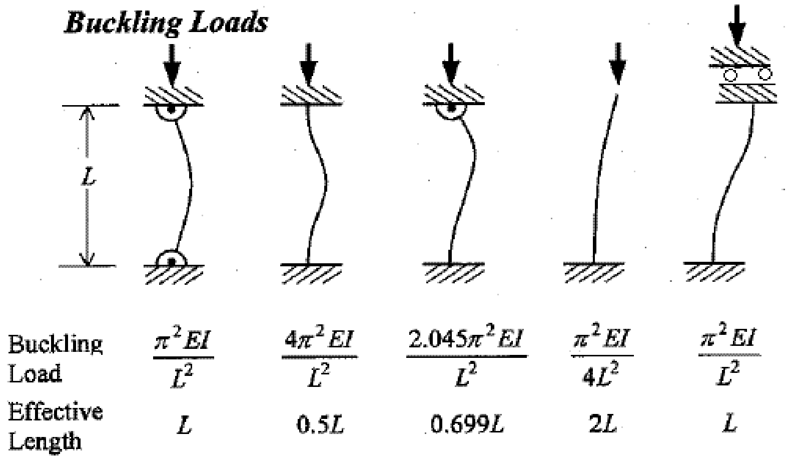

FIG 4.1 : BUCKLING BEHAVIOR

V. TORSIONAL BEHAVIOR

5.1Lateral Torsional buckling of beams

Lateral torsional buckling is a limit state of structural usefulness where the deformation of a beam changes from predominantly in-plane deflection to a combination of lateral deflection and twisting while the load capacity remains first constant, before dropping off due to large deflections. The analytical aspects of determining the lateral torsional buckling strength are quite complex, and close form solutions exists only for the simplest cases.

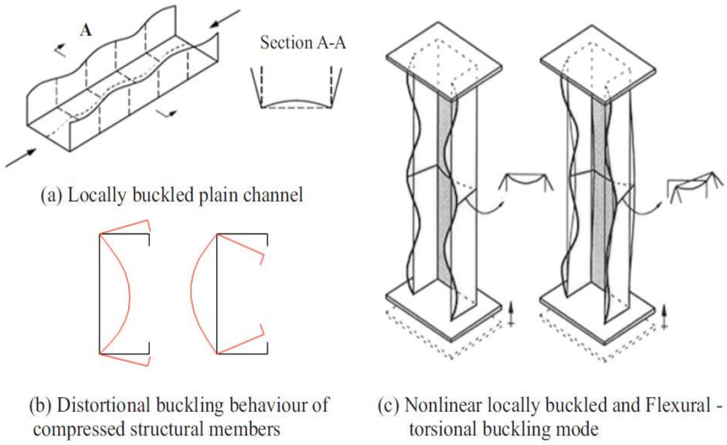

Fig 5.1 : Buckled Sections

5.2 The various factors affecting the lateral-torsional buckling strength are:

Distance between lateral supports to the compression flange.
Restraints at the ends and at intermediate support locations.
Type and position of load.
Moment gradient along the length.
Type of cross-section.
Material properties.
Initial imperfections of geometry and loading.

If concentrated loads are present in between lateral restraints, they affect the load carrying capacity. If this concentrated load applications point is above shear centre of the cross-section, then it has a destabilizing effect. On the other hand, if it is below shear centre, then it has stabilizing effect.

For beam with particular maximum moment, if the load carrying capacity is more than the beam with same maximum moment uniform along its length. The torsional test was conducted in the unequal I section with proper arrangements.

5.3 TORSIONAL TEST

Need for test

To study the shear stress and shear strain behavior of the beam.
To study the deflection and torque property of the beam.

TEST SETUP

After complete fabrication of angle section, strain gauges are placed in the correct position such as, strain gauges are placed in the mid portion where the deflection attains due to the twisting of the section.

Fig 5.3.1 : Placing Strain Gauge in Beam

After placing the strain gauges, the steel beam should be placed in the loading frame. Then the loading beam which is having two steel rod at the desired distance for applying load to the angle section was placed over the angle section in loading frame Then the hydraulic jack and proving rings are placed over the loading beam. Then load was applied through hydraulic jack and applied load was determined by the proving ring. The strain gauges are used to note the result. The load is applied till the section attains ultimate load capacity and buckles.

Fig 5.3.2 : Full Loading Setup

5.4 TEST RESULT

In loading frame, the placed beam is ready to test. Then the hydraulic jack is used to applied the load. For every 0.25 kN amount of load applied the corresponding strain gauge readings are noted down. The load is applied till the beam complete buckle such as the applied load ranges reversed. Some of the reversed strain gauge readings are noted for the graph plottings.

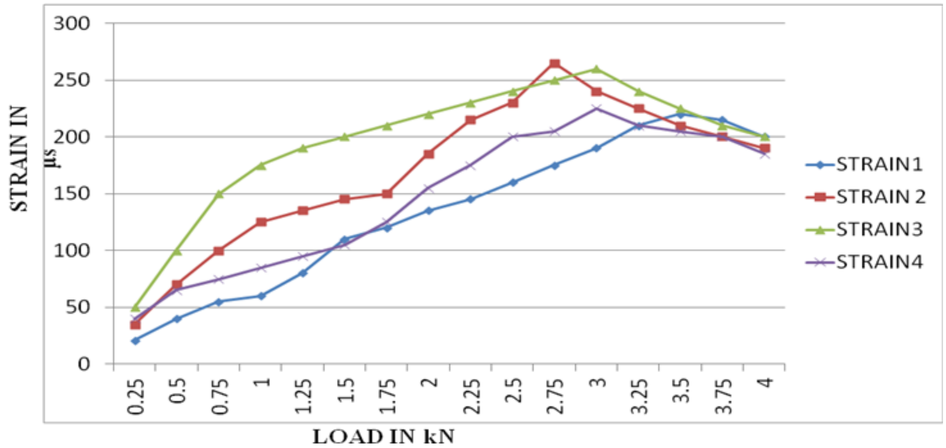

FIG 5.4.1 : Load Vs Strain Graph

VI. CONCLUSION

6.1 From the present study the conclusions are following made

- ✓ The back to back cold formed steel angle section properties are studied.
- ✓ The fabrication process of the back to back steel angle section was studied.
- ✓ The allowable load for the back to back angle section was determined theoretically.
- ✓ The torsion test setup was fully studied. Then the section was prepared for the torsion test.
- ✓ The section was fully buckled and strain gauge, proving ring values are noted down.
- ✓ Then the values are used to plot graph such as load versus strain.
- ✓ The determined ultimate load value is compared to the numerical values.
- ✓ This values are helps to use the light gauge angle sections as secondary beams.

References

[1] D. Popovic,[1] G. J. Hancock,[2] and K. J. R. Rasmussen3, Axial Compression Tests Of Cold-Formed Angles (J. Struct. Eng. 1999.125:515-523.)

[2] Ben Young, M.ASCE[1] Experimental Investigation of Cold-Formed Steel Lipped Angle Concentrically Loaded Compression Members (J. Struct. Eng. 2005.131:1390-1396.)

[3] D. Popovic,[1] G. J. Hancock,[2] and K. J. R. Rasmussen[3] Compression Tests On Cold-Formed Angles Loaded Parallel With A Leg (J. Struct. Eng. 2001.127:600-607.)

[4] G.J. Hancock , Cold-formed steel structures (*Journal of Constructional Steel Research 59 (2003) 473–487*)