Experimental Investigation of Buckling Behavior of Lipped Unequal Angle Cold Formed Steel Section Subjected to Compression

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***Abstract*— An experimental investigation of cold formed steel lipped unequal angle concentrically loaded compression members is presented in this paper. The size of specimens is 60mmx30mm, 80mmx50mm, and lip of the specimen is 25mm and thickness of the sheet is 1.2mm. The unequal angle specimen is tested between fixed ended conditions for uniform lengths. Distortional buckling and interaction of these modes are observed in the column tests. The material properties of the specimen are obtained using tensile coupon test. Two nominal section sizes are tested. The limiting values of slenderness ratio for the equivalent radius of gyration with the least radius of gyration are discussed to establish the buckling behavior of lipped unequal angles. Experimental investigation of lipped unequal angles are compared with IS code provisions.**

Keywords*— Buckling behavior, cold formed steel, Lipped angle, Effective width method.

I.INTRODUCTION

Cold formed section(CFS) sometimes called light gauge steel section. The thickness of the steel sheet used in cold formed is usually 0.9mm to 6.4mm [4]. Cold formed steel is the common term for products made by rolling or pressing thin gauge of sheet into goods. CFS are created by the working of sheet steel using stamping, rolling or pressing to deform the sheet into the usable product .CFS members have been used in building, bridge, storage racks, car bodies, railway coaches, transmission towers, transmission poles etc. the lipped channel and zed column were investigated experimental with and without stiffeners and had been compared with effective with method [7]. The predicted failure mode of CFS by AISI S100 was different with that from test result conduct the experimental investigation on axially compressive capacity for high strength, built up box section members with stiffeners. Buckling of CFS column members with perforation size, shape and position were varied. Current design rules can be improved by including the effects of non-linear stress strain characteristic at elevated temperature.

II.METHODOLOGY

The axial compression test on CFS was studied on stiffened unequal angle compression. The series of tests are performed on CFS stiffened angle columns compressed between fixed ends .the behavior of CFS lipped angle columns are efficiently analyzed using the effective width method to understand the behavior of columns subjected to compression. The angles are tested between fixed ends and loaded axially with axially load which caused buckling behavior. Equivalent radius of gyration approach is an attempt to understand the theory of torsional-flexural buckling [4] by taking into account all the basic parameters that contribute to this buckling. The load vs. axial shortening and deflection in the specimen are compared between the individual element test and structural test. Experimental results are analyzed and compared

III.BUCKLING BEHAVIOR OF COLD FORMED STEEL UNEQUAL ANGLE SECTION

Buckling

Buckling behavior thus characterized by deformation developed in a direction or plane normal to that of the loading that produced it. When the applied load is increased the buckling deformation also increases, Buckling occurs mainly in members subjected to compressive stress.

Generally there are four types of buckling such as local buckling, Flexural buckling, Torsional buckling and Distortional buckling.

- Global buckling is a buckling mode where the member deforms with no deformation in its cross-sectional shape, consistent with classical beam theory.
- local buckling is normally defined as the mode which involves plate-like deformations alone, without the translation of the intersecting lines of adjacent plate elements.
- Torsional buckling causes the element to twist parallel to the loading direction.
- Distortional buckling is a mode with cross-sectional distortion that involves the translation of some of the fold lines (intersection lines of adjacent plate elements).

Bucking vs. yielding

As stated, classical buckling analysis is independent of material yield strength [4]. This is evident in the equation:

$$P_{cr} = \pi^2 EI/L^2 \quad \text{———} 1$$

But in fact yielding consideration should never be totally ignored. One should always divide by the column cross section area. The various dimensions of the specimens are shown in figure 1,and the designation of the specimen are given in Table 1

$$\sigma_{Cr} = Pcr/A \quad \text{———} 2$$

IV.MATERIAL PROPERTIES

The nominal section sizes of unequal angle are selected based on the code provision such as IS 811-1995and IS 801-1975. The sizes of the angle section are 60mmx30mmx25mmx1.2mm, 80mmx50mmx25mmx1.2mm. Here 60mm and 80mm are the web of the section, 30mm and 50mm are flange portion of the section and 25mm is lip of the section. The nominal thickness of the section is 1.2mm. The selection of the section based on the slenderness ratio.

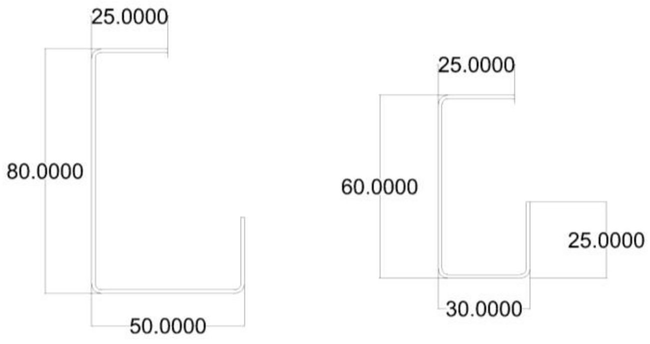

Figure1 Dimension of angle specimen

Table 1 specimen designation

UEA60-T1	Unequal angle 60x30x25x1.2 Trial-1
UEA60-T2	Unequal angle 60x30x25x1.2 Trial-2
UEA80-T1	Unequal angle 80x50x25x1.2 Trial-1
UEA80-T2	Unequal angle 80x50x25x1.2 Trial-2

The end condition for the compression member is provided by end plates at top and bottom respectively. The end plates are designed for the compressive forces and thickness is arrived as 10mm.The mild steel plates are 90mmx90mmx10mm thick and110mmx110mmx10mm arch welded at the top and bottom of the member

V.DESIGN METHODS FOR LIPPED UNEQUAL ANGLE COLD FORMED STEEL SECTION

a. Effective Width Method (EWM)

The basis of the Effective Width Method which has been followed in the IS 801 code is that the local plate buckling leads to reductions in the effectiveness of the plates that comprise of cross-section. More formally, this loss in plate effectiveness can be understood as an approximate means to account for equilibrium in an effective plate under a simplified stress distribution as opposed to the actual (full) plate with the actual nonlinear longitudinal stress distribution that develops due to buckling .Each plate in a cross-section has been reduced to its effective width and this reduction from the gross cross section to the effective cross-section is fundamental to the application of the Effective Width Method.

b. Design and load calculations

The design and load calculations of the lipped angles are designed as per the IS801-1975 code provisions

c. Allowable load

The allowable safe load and deflection are to be determined in the Numerical approach.

Specimen size: 80×30×1.2mm

Lip size: 25mm

Length: 600 mm

d. Computation of effective width:

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

$f_b = 0.6\ f_y$ ——— 3

Where,

f_b = Bearing stress N/mm^2

f_y = Yield strength N/mm^2

f_y = 250N/mm^2

$f_b = 0.6 \times 250 = 150$ N/mm^2

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

$\frac{b}{t} = \frac{2120}{\sqrt{f}}[1 - \frac{465}{\frac{w}{t}\sqrt{f}}]$ from the IS801 clause 5.2.1.1 ——— 4

b/t= 32.43

b =32.43x1.2

=38.91mm

Hence, the required effective width is determined

b. For deflection determination:

b/t=$842/\sqrt{f}(1 - \frac{186}{\frac{w}{t}\sqrt{f}})$ ——— 5

b/t=53.25x.52

b/t =38.19mm

b =38.19x1.2

b =45.82mm

Stiffened compression elements:1

Effective width=$\frac{b}{t} - 0.10(\frac{w}{t} - 60)$ —— 6

Effective width=43.44mm

For determination of Q-FACTOR:

$P_{ult} = A_{eff}$ x f_y ——— 7

P_{ult} = (1x250)(80x1.2)

P_{ult} = 24kN

VI. EXPERIMENTAL INVESTIGATION

a. METHODOLOGY

The methodology involves the following,

1. Purchased CFS sheet

2. Fabrication of specimen
3. Welding the member with end plate
4. Compression test
5. Analyzing the buckling behavior
6. Analysis of result

Fabrication & Welding

The sheet is purchased and then it is fabricated as shown in figure2 into designed dimensions. The centroid of the base plate is marked then the specimen is placed over the end plates with respect to the centroid of the end plates and then the member is welded using arc welding.


Figure 2 Fabricating machine

Compression test

100T UTM as shown in Figure3 is used to test the compression member. The CFS angle specimens welded with the end plates are placed in the UTM in such a way that the centroid of the end plates coincide with the centroid of the loading plate in UTM as shown in Figure4. The dial gauge is placed vertically to measure the axial deformation of the member. The load is applied gradually and the deflection is measured for each load increment correspondingly. The onset of buckling occurs yet the specimen continuous to take further called as post buckling carry as With further load increase in load leads to decrease or reversing of load occurs and that point corresponds to maximum load carrying capacity of the member. At certain load the specimen will tend to buckle such load is called f_{max} or maximum load after that the load get reversed.


Figure 3 UTM


Figure 4 Marking of centroid of specimen & loading plate

Analyzing the buckling behavior

Then after the compression test, the buckled specimen is observed and then its behavior of specimen is found to be distortional buckling as shown in figure7&8.


Figure7 Specimen After buckling


Figure8 Distortional buckling behavior

VII. RESULT AND DISCUSSION

After analysis, the deflection readings observed and the respective loads are plotted.

1. Critical load as per IS801-1975

   The critical loads for the specimens are obtained based on the effective width method given in IS code the loads obtained are presented in table 1

Table 1 Specimen and their respective load comparison

Specimen Designation (mm)	Length (mm)	Slenderness ratio le/r	Critical load (kN) as per (IS801)
UEA60-T1	600	27.47	33.6
UEA60-T2	600	27.47	36.75
UEA80-T1	600	18.75	37.60
UEA80-T2	600	18.75	38

2. *Ultimate load from experiment*

The ultimate load versus axial shortening obtained from experimental investigation for various angles are presented in table 2. The variation is shown in figure 5&6

Table 2Ultimate load with respective b/t

Specimen designation (mm)	b/t	Ultimate load (kN)
UEA60-T1	26.34	18
UEA60-T2	26.34	18
UEA80-T1	32.43	24
UEA80-T2	32.43	24

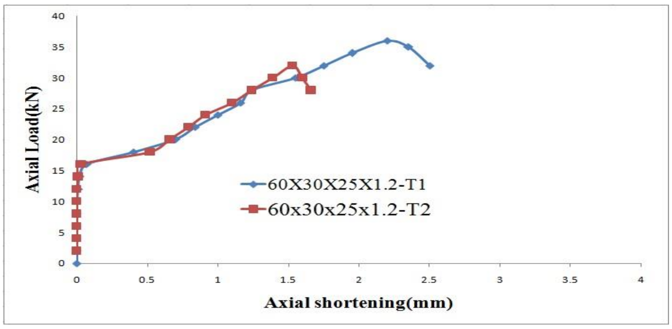

Figure 5 Load vs. deflection for UEA60-T1 & T2

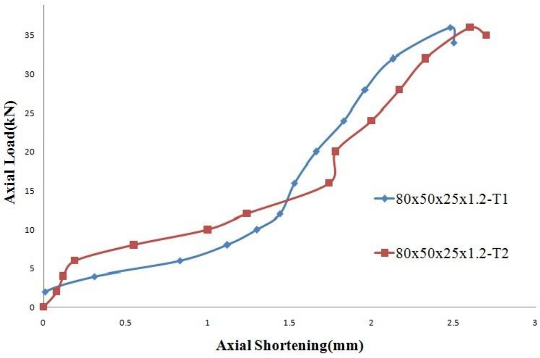

Figure 6 Load vs. deflection for UEA80-T2 & T2

VIII. CONCLUSION

- A compression test was carried out on lipped angle sections and their behavior has been observe and studied.
- The column strength obtained from the investigation are compared with the design strength obtained using IS801-1975 for CFS compression member.
- the distortional buckling behavior is observed for the tested specimen with stiffener
- The F_{max} is obtained exceeds the design load from IS code
- The deflection increases when the specimen reaches the ultimate load

IX. REFERENCE

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