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An Analytical and Experimental Investigation of Cold-Formed Stiffened Channel Section in Compression

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Abstract: ***This research paper reports on the numerical, experimental study of the cold formed steel column. The primary objective is to study the buckling modes, load carrying capacity and failure load of the stiffened channel sections. The buckling mode and load carrying capacity was determined using both analytical and experimental investigation. Analytical investigation is carried using finite element model in ANSYS 16.1 and results are documented for comparison. Two types of columns are considered one without stiffeners which is open cold formed steel thin walled section, with web width of 80 mm, thickness 5mm and length of lip is 25mm.Another member with stiffeners having web width of 80 mm thickness 5mm and length of lip is 25mm. The thickness of intermediate stiffeners is varied from 10 mm, 20 mm and 30 mm. The length of the Cold formed steel column is 1000 mm. The comparison of analytical and experimental study shows that error percentage is 5% only. It's observed that cold formed steel column may fail due to local and distortional buckling. This failure can be rectified by introducing stiffener throughout the length of the column. Also use of stiffener in the column increase the load carrying capacity. The load carrying capacity was increased by increasing width of the stiffener.***

Keyword: ***cold formed steel, stiffener, finite element analysis and local buckling.***

I. INTRODUCTION

In future the usual hot rolled steel sections will be replaced by the cold formed steel sections in light gauge steel design [1].CFS sections mostly use open cross sections that are fabricated by multiple folding the thin sheet of metal, so they have high slenderness ration leads to local and distortional buckling undercompressive stresses[2].The parameters to be considered for CFS members are Local, distortional and flexural torsion buckling [3]. When the length of the member is short the difference in strength due to effect of local bukling is reduced [4].The seriesof testswere performedand the equations for the design CFS columns wereproposed [5].The strength and behavior pf the CFS section were significantly affected by the provision of intermediate stiffeners and also increases with modifying the CFS cross-sectional geometries [6] . It observed that in the absence of test data and for the purpose of preliminary design, the ANSYS finite element analysis provides quite an approximate prediction capability odf CFS sections[7]. It hasbeen proved that the normal finite element method of analysis not always leads to acceptable ultimate load values,

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Especially atlengths where failure is predominantly distortional [8].When the slenderness ratio (L/r ratio) increases the collapse load carrying capacity of the specimens decreased slightly hence its is proposed that critical load carrying capacity is inversely proportional to slenderness ratio (L/r ratio)but it is observed that when the D/t ratio increases the critical load carrying capacity of the specimens has been increased. With larger area, the failure is initiated by distortional buckling. For the intermediate columndistortional buckling is the dominant failure [9]. The identification of column sections prone to secondary bifurcation kind L-D interaction is very difficult [10].The *PDSM*−1.2*t*, which is having 1.2 times the thickness in the contact area of the web as one rigidly connected section, are generally conservative and reliable and having more design strength, and *PDSM*−*t* are slightly more conservative and also reliable on the aspect of design strength[11].

II. METHODOLOGY

The present study is divided into two phases such as Analytical Investigation and Experimental Investigation. The finite element method (FEM) is deemed the best possible method when conducting complicated engineering analysis and computational issues. The ANSYS, widely applied engineering analysis package software, is large non –linear finiteelement analysis software with analytic function of structure, fluid, electric field, andmagnetic field. In this study, FEM was carried out through the ANSYS software tounderstand the mechanical behavior of structures under compression.

A. Analytical Investigation

a. Geometrical Properties

The fig.1 is the analysed section which is an open CFS thin walled section, whose characteristics dimensions are: web width of 80 mm, thickness 5mm and length of lip is 25mm without stiffeners. The column is 1000 mm length.

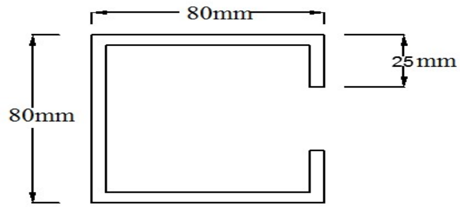

Fig.1 Section of Column without Stiffener

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The analysed section shown infig. 2 which is aCFSopen thinwalled section, which is having a web width of 80 mm in which the stiffener is provided thickness 5mm andlength of lip is 25mm. The length of thecolumn is 1000 mm. The stiffener is provided at middle.

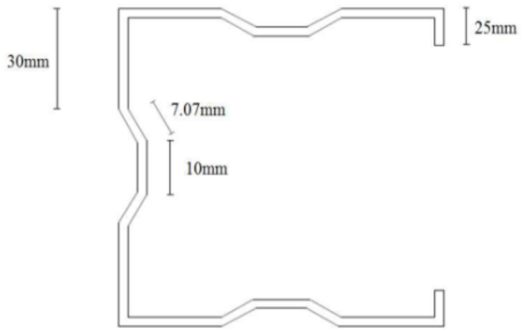

Fig.2 Section of column with stiffener

b. Boundary Condition &Loading Condition

The loading end and reaction end was modelled at the centroidal of the column section that is considered as master node. These master nodes were coupled to the each node on the edge of the cross section. The hingedconditions for the specimen are modelled by providing, restrained the rotation about y axis and translations in both x and z directions at the loaded end. And bottom end is translation is restrained in three directions x, y, z and defined as a master node that was modelled at the centroidal of the column section. These master nodes were coupled to the each node on the edge of the cross section.

Fig.3 Boundary and Loading Condition

B. Experimental Investigation

a. Material Properties

- Density = 7850kg/m^3
- Young's modulus =2x10^5
- Poisons ratio = 0.3

b. Experimental Setup

The column tests were performed in a loading frame in which the capacity of the loadcell is about 500 kN. The column is restrained in rotation and translation at one end and restrained only in translation at other end. The loading of column is done withthe help of hydraulic jack provided in theloading frame. A load cell is placed on the top of the column 3 dialgaugeswere equiped. A dial gauge is fixed at top of thaecolumn and two dial gauges are provided atcentral either side of the column. A load isapplied corresponding reading from the dial gauge is noted.

Fig.4testing of a CFS column

III. RESULTS

A. Analytical Results

S. No.	Stiffener Size(mm)	Buckling load (kN)
1	0	288.47
2	10	304.79
3	20	356.97
4	30	373.33

Table 1.Buckling load of CFS column

The values in Table 1 show that the buckling load of a column increased when stiffener size increased. Fig.4 shows the load deflection curve from which that the column with 30mm stiffener has high load carrying capacity comparing to others.

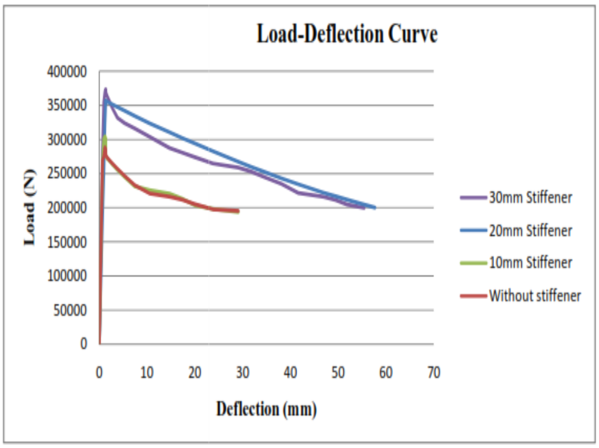

Fig 5. Deflection vs load

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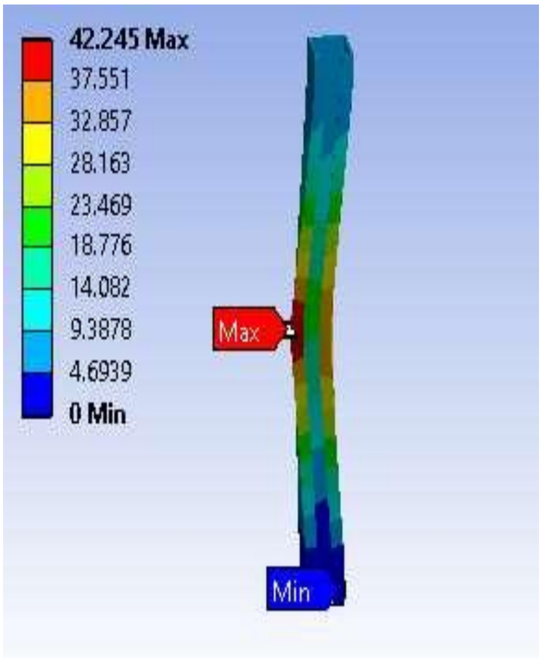

Fig.6 Deformation of the Column

Fig.5 represents that after application of load on the specimen and the displacement is maximum at the mid span of the column and local buckling failure.

B. Experimental Results

The maximum loadcarrying capacity$P_{test}$was the maximum tested axial load that the CFSchannel section could withstand before failure.

S. No	Specimen Type	Buckling Load (kN)
1	Without stiffener	274.04
2	With stiffener	362.23

Table2.Experimental Results

a. Comparison of Experimental and Analytical Results

<table>
<tr><th>S/no</th><th>Specimen description</th><th>Type of analysis</th><th>Buckling load (kN)</th><th>Percentage of error</th></tr>
<tr><td rowspan="2">1</td><td>Without stiffener</td><td>Finite element analysis</td><td>288.47</td><td rowspan="2">5.02</td></tr>
<tr><td>With 30mm stiffener</td><td>Experimental analysis</td><td>274.04</td></tr>
<tr><td rowspan="2">2</td><td>Without stiffener</td><td>Finite element analysis</td><td>373.33</td><td rowspan="2">3.027</td></tr>
<tr><td>With 30mm stiffener</td><td>Experimental analysis</td><td>362.23</td></tr>
</table>

Table3.ComparisonofAnalyticalandExperimentalResult

From table 3, it is experientialthat the bucklingcapacity of the CFS column with stiffener ishigh comparing to column without stiffener. The stiffened CFS columns carrying 37.5 % more load than unstiffened column. So in the design we can introduce stiffener instead of increasing the cross sectional area of the column.

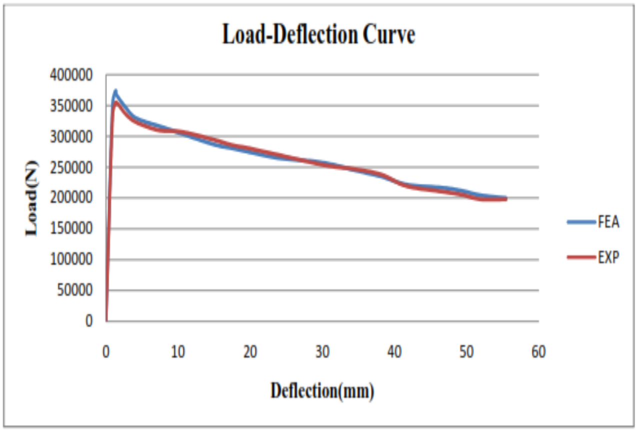

Fig.7 Comparison of Load vs. Deflection

IV. CONCLUSION

It is to be concluded that the CFS column may fail due to local and distortional buckling. This failure can be rectified

1. Introducing of stiffener along the length of the column.
2. Intermediate stiffener can be provided in CFS columnsto increase the buckling capacity of the column instead of increasing the cross sectional area which will increase the weight of the column leads to increase the total cost of the structure.
3. The load carrying capacity was increased by increasing width of the intermediate stiffener.

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