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Experimental Study on the Effect of Axial Loading on Light Gauge Steel Fluted Column

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Abstract - *Cold formed steel have effectively started replacing hot rolled steel section that are used for various applications. In recent years researchers have been developing various cross sections to use cold formed steel as a load bearing structural member. One such is the hollow circular light gauge steel column with trapezoidal flutes. In this project, an attempt has been made to use this structural member as a column with a modification on number of flutes in steel circular column. Trapezoidal flutes enhances the aesthetics and development area of the column. This enhanced development area results in increase of moment of inertia. Axial load behaviour of this increased moment light gauge steel hollow fluted column is analyzed. To improve the load carrying capacity of hollow circular columns, detailed study is conducted on this hollow circular fluted columns with modification of the number of flutes (trapezoidal shape). A analysis of the local and post local buckling behaviour of different sections like four, five and six numbers of trapezoidal fluted column sections is studied by the finite element analysis software (ANSYS 18.2). Furthermore this study is preceded by experimental study under axial loading condition. The column sections is designed according to IS 801:1975 Code of practice for use of Cold-Formed Light Gauge steel.*

Key Words: **Light Gauge Steel, Hollow Circular Column, Fluted Column, Trapezoidal Flutes.**

1. INTRODUCTION

Structural steel is a kind of steel used in making materials in construction processes. Steel members are extensively used in all kind of structures due to its high strength to weight ratio, resulting in the reduction of dead weight. In building constructions there are primarily two types of structural steel ,one is hot rolled steel, and the other is cold formed steel. In hot rolled steel shapes are formed at elevated temperatures while cold-formed steel sections are formed at room temperature. Cold-formed steel structural members are sections commonly manufactured from steel plate, sheet metal or strip material. Cold formed steel sections are commonly manufactured either by press braking or by cold roll forming to achieve the desired shape. The press braking process of manufacturing involves producing one complete fold at time along the full length of the section using brake press dies. cold forming has the effect of increasing the yield strength of steel, this increase results in cold formed steel working well in strain-hardening range. These increases are predominant in zones where the metal is bent by folding. The effect of cold working is thus to enhance the mean yield stress by 15% - 30%. Hollow columns have less seismic mass, thus make the superstructure comparatively safe. Also, this type of structural member may be economically viable in some cases, when compared to usual solid members. By using hollow columns the cost can be controlled efficiently since the area used is very less. Also by using hollow columns, the entire weight of the structure is significantly reduced. Flutes are nothing but a vertical groove running along the entire length of column. The fluted column increases strength and stiffness which in combination with cold formed steel makes the structure more safe. This structural member when used as a column with a modification in number of flutes along the surface enhances the aesthetics and development area of column. This enhanced development area results in increase of moment of inertia. By using hollow columns the cost can be controlled efficiently since the area used is very less. Also by using hollow columns, the entire weight of the structure is significantly reduced.[3]

2. SECTION SPECIFICATION

Built-up hollow column section dimentional parameters was selected based on IS 801-1975 standards with consideration from literature reviews for column dimensions are as follows,

- Length of column = 1000 mm
- Internal diameter of column = 200 mm
- External diameter of column = 220 mm
- Thickness of sheet = 2 mm
- Mean diameter of column = 170 mm
- Limiting width = 65 mm
- Base Length of flute = 40 mm
- Depth of flute = 20 mm
- Width of flute = 30 mm

Table-1: Properties of light gauge steel

Yield Strength	210 N/mm^2
Modulus of Elasticity, E	2.0x10^5 N/mm^2
Poisson ratio	0.3

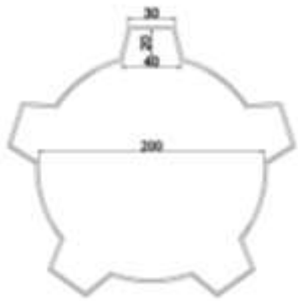

Fig -1: Cross section of hollow circular fluted column

Fig -2: TFC - 0

Fig- 3: TFC - 4

Fig -4: TFC - 5

Fig -5: TFC - 6

Where,

TFC- 0- Hollow circular column with no flutes

TFC -4- Hollow circular column with 4 numbers of flutes

TFC -5- Hollow circular column with 5 numbers of flutes

TFC -6- Hollow circular column with 6 numbers of flutes

3. EXPERIMENTAL STUDY

3.1 Fabrication

The fabrications of hollow circular columns with and without trapezoidal flutes are included in this chapter. Following that, experimental testing of the specimens is adopted. The experimental test results are discussed with the load Vs axial deformation graphs plotted and results are interpreted with the same. The columns with and without flutes are fabricated. The columns are made with varying D/t ratio of 100 and will be tested under axial loading conditions. All the columns are circular in shape. The columns that are made with four , five and six numbers of trapezoidal flutes running along the entire circumference of the column.

Initially the cold formed steel sheets are bought with required thickness of 2 mm. With the help of press brakes, the columns are provided with flutes at required points as specified by design. The resulting section then closed using tack and arc welding which needs to be running along the entire length. The welding made in such a way so that, the columns shall not fail at the welded zones. All the specimens are 1000 mm in length. The theoretical study of column is done on the basis of IS: 801-1975 & IS: 811-1987.

3.2 Testing

The Specimens are tested under axial compression loading condition in Column Testing Frame with the capacity of 500 KN. The Load is applied gradually by hydraulic jack 50 tonne capacity.

Fig -6: Experimental setup for TFC(s)

Linear Variable Differential Transformer (LVDT) is used to measure the deformation of the specimen. It is placed at the bottom base plate that it can measure the axial shortening of the column.

When the load is gradually increased under axial loading the cold formed steel hollow circular fluted column starts axial shortening and at the same time local buckling occurs at the bottom of the specimen and the distortional buckling occurs in top of the sections. The axial deformation and the ultimate load is measured correspondingly up to the specimen failure, and a LVDT was used to monitor the axial deformation continuously.

Fig -7: TFC - 0

Fig- 8: TFC - 4

Fig- 9: TFC - 5

Fig- 10: TFC - 6

Failure patterns of TFC(s)

4. RESULT AND DISCUSSION

The LOAD Vs AXIAL SHORTENING graph shows the axial shortening values of hollow circular column without flutes of steel column of thickness 2 mm

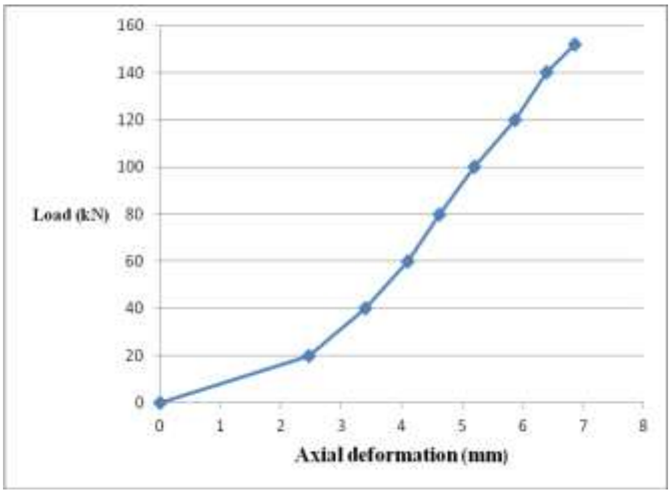

Fig-11: Load Vs Axial deformation graph of TFC- 0

Figure 11 shows the load Vs axial deformation of TFC-0 column. The initial buckling starts at a load of 104 kN at a deflection of 5.24 mm and fails at a load of 152 kN at a deflection of 6.87 mm.

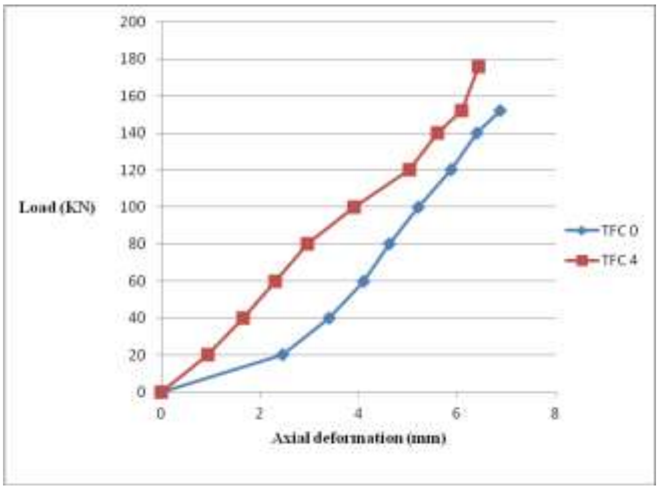

Fig-12: Load Vs Axial deformation graph of TFC-4

Figure 12 shows the load Vs axial deformation of TFC-4 column in comparison to TFC-0 column. The initial buckling starts at a load of 144 kN at a deflection of 5.64mm and fails at a load of 176 kN at a deflection of 6.43 mm

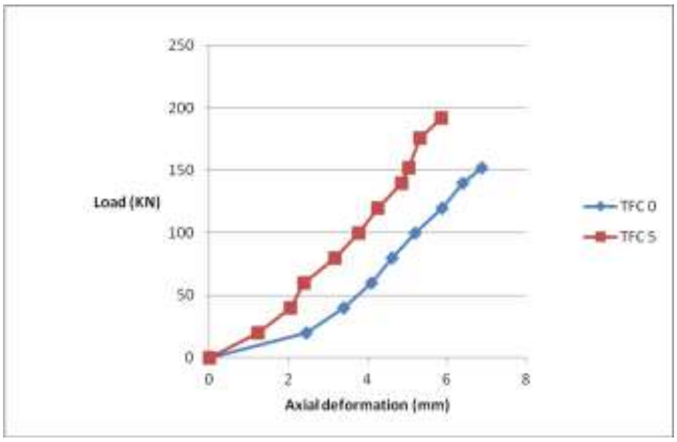

Fig.13 Load Vs Axial deformation graph of TFC-5

Figure 13 shows the load Vs axial deformation of TFC-5 column in comparison to TFC-0 column. The initial buckling starts at a load of 148 kN at a deflection of 4.74 mm and fails at a load of 192 kN at a deflection of 5.86 mm.

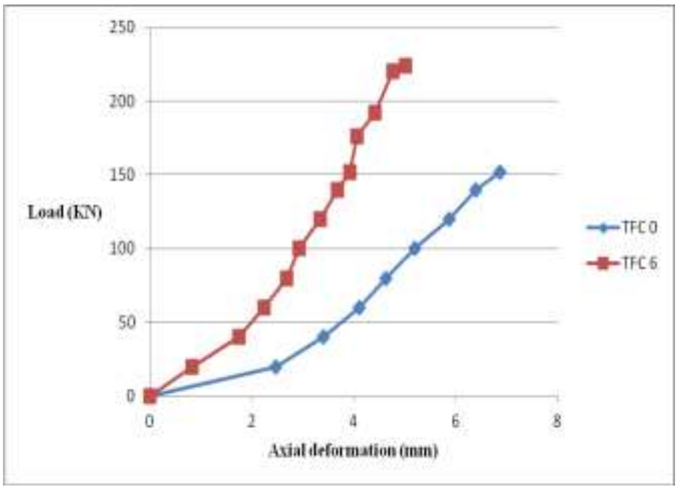

Fig-14: Load Vs Axial deformation graph of TFC-6

Figure 14 shows the load Vs axial deformation of TFC-6 column in comparison to TFC-0 column. The initial buckling starts at a load of 164 kN at a deflection of 3.96 mm and fails at a load of 224 kN at a deflection of 5.01 mm.

5. CONCLUSION

Both experimental and analytical investigations were carried out to make a study on the behaviour of light gauge cold-formed hollow circular column with and without flutes and following conclusions were made,

- From the analytical study, the maximum stress at yield of TFC-0 is 5.81%, 16.33% and 25.36% less than TFC-4, TFC-5 and TFC-6 respectively.
- The maximum strain value of TFC-0 is 8.19%, 13.11% and 19.6% more than TFC-4 , TFC-5 and TFC-6 respectively.
- For a steel column of thickness 2 mm, the ultimate load carrying capacity of hollow circular column without flutes are 7.84%, 40.38%, and 72.88% less than columns with 4 numbers of trapezoidal flutes , 5 numbers of trapezoidal flutes and 6 numbers of trapezoidal flutes respectively.
- From the experimental study, the stress value at center of TFC-0 is 15.7%, 25.61% and 47.10% less than TFC-4, TFC-5 and TFC-6 respectively.
- And the maximum strain value of TFC-0 is 10.84%, 16.86% and 33.73% more than TFC-4 ,TFC-5 and TFC-6 respectively.
- For a steel column of thickness 2 mm, the ultimate load carrying capacity of hollow circular column without flutes are 15.78%, 26.38%, and 47.46% less than columns with 4 numbers of trapezoidal flutes , 5 numbers of trapezoidal flutes and 6 numbers of trapezoidal flutes respectively.
- The stress values obtained for hollow circular column without flutes is lesser than the hollow circular columns with trapezoidal flutes.
- The maximum strain values obtained shows that the hollow circular column with flutes is found to have lesser strain as compared to the columns without flutes.
- For a steel column of thickness 2 mm, the axial deformation of hollow circular column without flutes is 6.2%, 14.1% and 27% more than the columns with 4 numbers of trapezoidal flutes , 5 numbers of trapezoidal flutes and 6 numbers of trapezoidal flutes respectively.
- From the analytical results, the maximum axial deformation values obtained for the hollow circular column with trapezoidal flutes is always lesser than the hollow circular column without flutes.
- The experimental study reveals a better load carrying capacity of 46.15% , 57.14%, 33.33%, and 27.27% increases for the specimens, TFC-0, TFC-4, TFC-5 and TFC-6 respectively in comparison with the analytical results.
- It is concluded from the results that the trapezoidal fluted column with 6 flutes have more load bearing capacity with lesser value in axial deformation when compared to the hollow circular column without trapezoidal flutes.

FUTURE SCOPE THE STUDY

- The study can be extended to other L/D ratios and D/t ratios, and the behaviour can also be studied for different support conditions.
- The effect of the thickness of the steel sheet on the behaviour of light gauge steel hollow circular

columns can be studied by changing the D/t ratios keeping D constant.

- The behaviour of the hollow circular fluted columns can be further studied under various loading conditions like cyclic loading and transverse loading.
- The light gauge steel hollow circular trapezoidal fluted columns can be further studied for the concrete infilled circular fluted columns.
- The study can also be extended by using various fiber reinforced polymers such as CFRP, GFRP sheets for strengthening the hollow circular fluted columns.

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