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Analytical investigations of lightweight concrete infilled cold formed steel quadruple columns

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Abstract - *Designing affordable structures is crucial in the discipline of structural engineering. As a result, cold-formed steel structures were created (CFS). When more members are joined together, the load carrying capability rises. This project involves performing an axial parametric study on a quadruple column with various parametric adjustments. There are C sections and sigma sections. They are rearranged, and the behaviour is investigated. A useful model is discovered from that. It is planned to test the impact of eccentricity loading on light weight concrete fully filled quadruple column. The strength is increased when the tubes are filled with lightweight concrete, and they can also be utilised to build precast lightweight structures.*

Key Words: **Cold formed steel, built up section, column, channel section, sigma section, optimum section, ANSYS, eccentricity, light weight concrete**

1. INTRODUCTION

Cold-formed steel (CFS) built-up box sections are increasingly being used in structural engineering applications, which is growing gradually. Compound sections can be created by combining various sections. The strength of the column is influenced by the screw spacing. The strength of the column increases as the screw spacing decreases [1,2]. Due to its higher strength to weight ratio and simplicity of construction, cold-formed steel structures have also grown in popularity over the past few years in addition to hot-rolled steel sections. Cold formed built-up sections prove to be a stronger and more affordable alternative when hot rolled sections are uneconomical for lighter loads. Channel sections and sigma sections are used in this study.

2. OBJECTIVES

- To determine the optimum shape of the section by considering different arrangements and different cross sections of channel section and sigma section.
- To find the behavior of optimum section filled with light weight concrete to eccentric load cases.

3. METHODOLOGY

Different models are created and analysed in ANSYS. Channel sections and sigma sections are used for the quadruple columns. The effect of cross-sectional changes, configuration of sections, and arrangement of different sections is to be analysed. For this, six models are prepared and the results obtained are compared. The optimum model is fully filled with light-weight concrete and then analysed. Then it is subjected to two eccentric loading cases, and their results are to be evaluated.

4. MODELLING

ANSYS WORKBENCH is used to perform the analysis. The model has a height of 2100 mm. the yield strength of the steel is 441 GPa and its elastic modulus is 210 GPa. At first, six different models are created using channel and sigma sections. The six models are;

a) Channel section face to face (C F-F)

b) Channel section back to back (C B-B)

c) Sigma section face to face (S F-F)

d) Sigma section back to back(S B-B)

e) Sigma and channel sections face to face (S&C F-F)

f) Sigma and channel sections back to back (S&C B-B)

Figures 1, 2,3,4,5 and 6 represent the cross sections of the models.

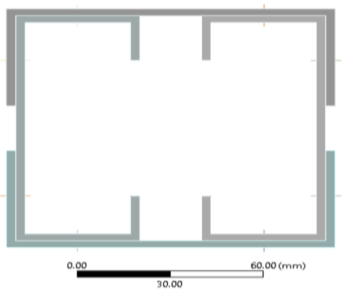

Fig-1: Channel section face to face (C F-F)

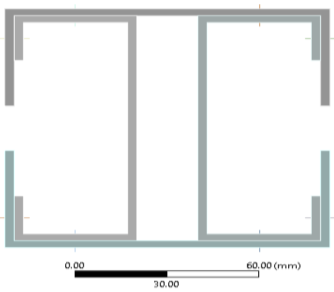

Fig-2: Channel section back to back (C B-B)

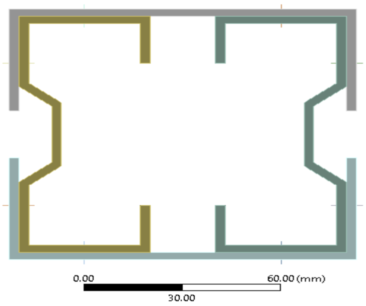

Fig-3: Sigma section face to face (S F-F)

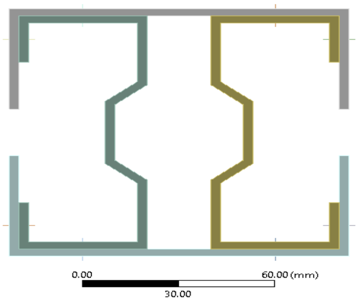

Fig-4: Sigma section back to back(S B-B)

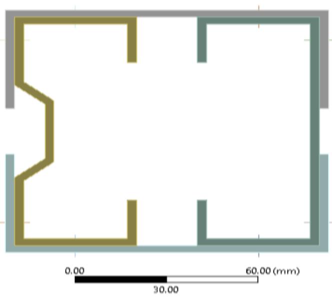

Fig-5: Sigma and channel sections face to face (S&C F-F)

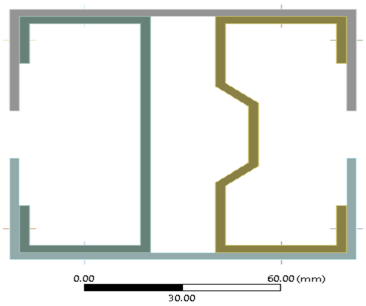

Fig-6: Sigma and channel sections back to back (S&C B-B)

5. BOUNDARY CONDITIONS AND LOADING

The boundary condition is both end-hinged. The loading is given from the top edge. The boundary conditions of all the models are the same. In eccentric loading cases, there is a difference in the position of the applied load. Figure 7 shows the loading for all the six models. Figure 8 and 9 show the eccentric loading with eccentricity of 50% and 100% respectively.

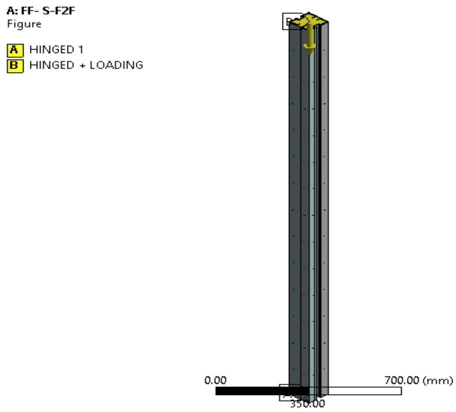

Fig-7: Concentric loading

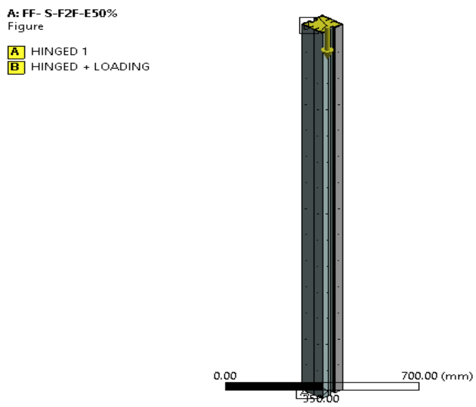

Fig-8:Loading with 50% eccentricity

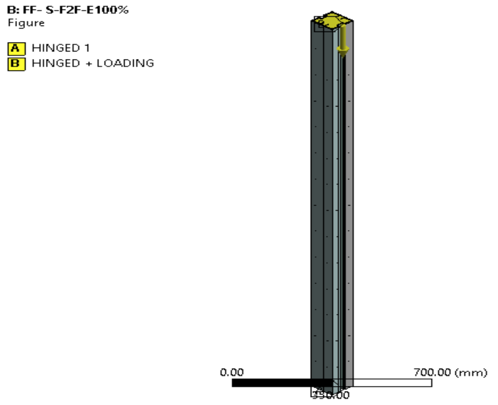

Fig-9: Loading with 100% eccentricity

6. RESULTS AND DISCUSSIONS

Load is applied by the displacement control method until failure. The displacements and the corresponding load capacities of the models are noted. Figure 10 shows the displacement of a sigma section placed face to-face. Figure 11 shows the displacement of a column fully filled with concrete with concentric loading. Figures 12 and 13 show the displacements of columns with 50% and 100% eccentricity respectively.

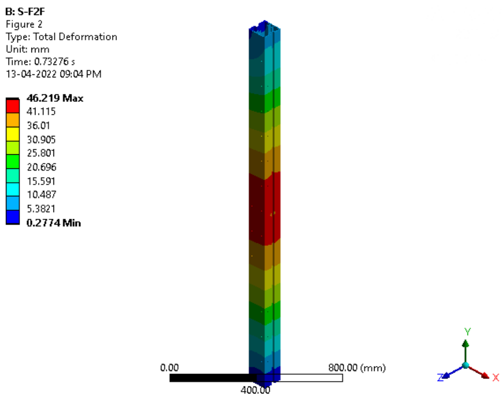

Fig-10: Total deformation of sigma face to face

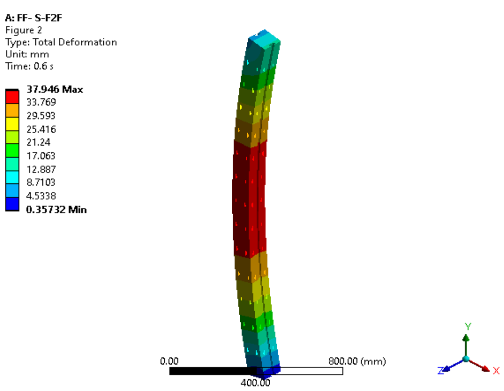

Fig-11: Deformation of column with concentric loading

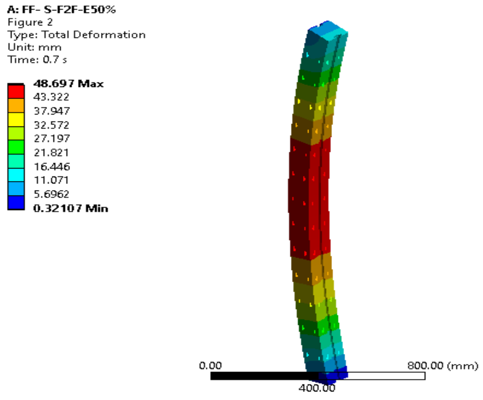

Fig-12: Deformation of column with 50% eccentricity

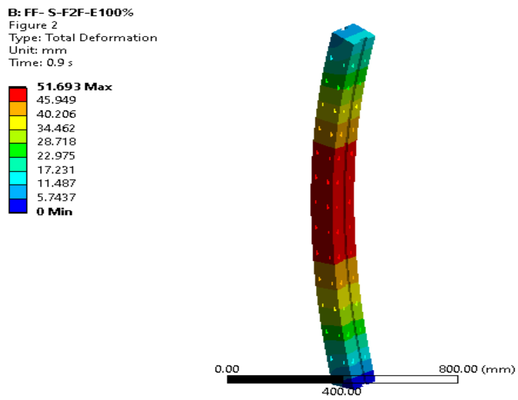

Fig-13: Deformation of column with 100% eccentricity

Table 1 shows the analysis results of the six models. Its deformations and load capacity are shown in the table.

Table -1: Deformation and load capacity of quadruple columns

Model	Deformation (mm)	Load (kN)
C F-F	9.65	687.27
C B-B	12.21	631.27
S F-F	10.28	694.21
S B-B	11.96	649.26
S&C F-F	7.81	695.76
S&C B-B	7.42	668.49

S&C F-F shows the highest load carrying capacity of 695.76 kN and its deformation is of 7.81 mm. Similarly, the model S F-F also shows higher load carrying capacity of 694.21 kN.

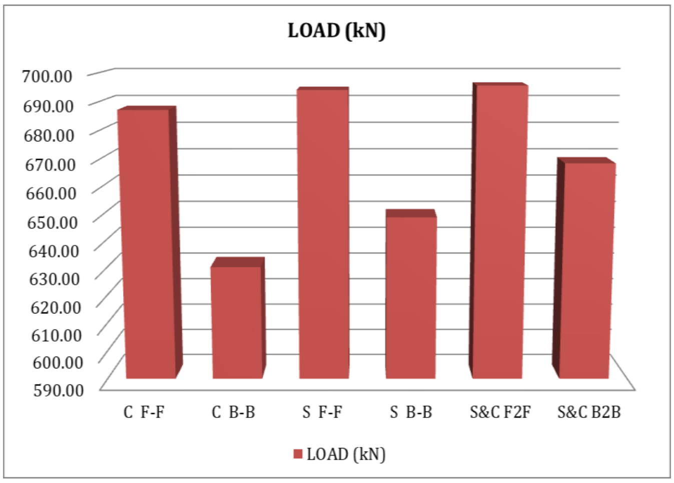

Chart -1: Load carrying capacity of six models

The load capacity of the six quadruple columns is shown in chart 1. Axial deformation increases linearly with load. It

It was found that the difference in load carrying capacity is due to the change in moment of inertia. In the S-F model, two sigma sections are used face to face, thus the model is symmetric. Also, S-F-F has a higher load-carrying capacity. Therefore, S-F is taken as the optimum model.

The optimum model is fully filled with light weight concrete and it is analysed with concentric and eccentric loading. Table 1 shows the load deflection values of columns with eccentric loadings.

Table -1: Deflection and loading of eccentric columns

Models	Deflection (mm)	Load (kN)
FF-E0%	37.946	1307.4
FF-E50%	48.697	877.62
FF-E100%	51.693	618.07

When eccentricity increases, deflection also increases and the load carrying capacity decreases. Chart 2 shows the load carrying capacity of fully filled columns with eccentricity.

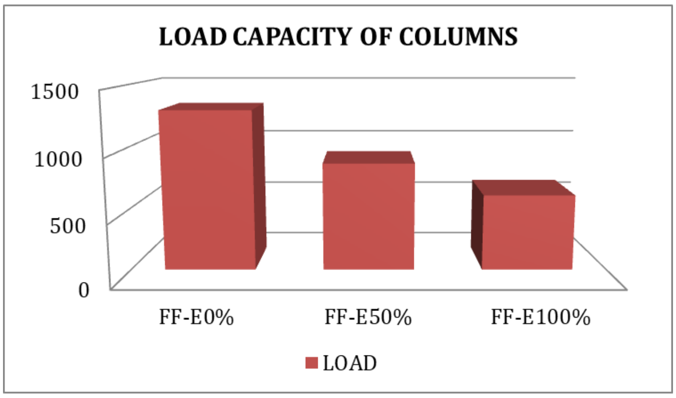

Chart -2: Load carrying capacity of column with eccentricity

The load carrying capacity of column is higher for concentric loading. As the eccentricity increases, the load carrying capacity decreases. For concentric loading, the load capacity is 1307.4 kN whereas, it is 618.07 kN for column with 100% eccentricity. That is, the column with eccentricity can carry only half the load of column with concentric loading.

7. CONCLUSIONS

Channel sections and sigma sections are arranged in different ways to form columns. Six models are created and analysed. The optimum model is selected and filled with light-weight concrete and subjected to different eccentric loading conditions. The results obtained are compared.

The conclusion is as follows:

- The section S-F is the optimum section as it has the highest load-bearing capacity.
- When light weight concrete is filled in the optimum model, it can carry double the load of a column without concrete.
- The deflection of the model increases with eccentricity.
- A column with concentric load can carry double the load of a column with eccentricity.

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