ISSN 2395-1621

Structural analysis of various cross section steel columns for axial compressive eccentric loading

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ABSTRACT

Structural stability is an important factor in structural design. A column is a one of the basic element of a structure. The column may fail due to various factors, lateral torsional buckling is also one of them. This paper deals with the elastic lateral-torsional buckling behavior of regular I section steel column under axial compression with eccentric loading conditions. Different cross section steel columns are considered (i.e hollow square, hollow rectangular, hollow circular, C shape) to compare with regular hollow circular cross section column for lateral torsional buckling behavior. A finite element (FE) program using beam elements is developed to study LTB behaviors. The thickness and length is constant for all models (i.e thickness = 10 mm and 12 mm and Length = 2 mtr and 3 mtr). Structural analysis is done to examine the influence of the section dimension due to axial eccentric compressive loading. Using the study it is observed that not only the cross section of steel column, but also the taper ratio influences the resistance to lateral torsional buckling of steel column.

Keywords— Lateral torsional buckling, steel column, cross section, taper ratio, axial compression, eccentric loading.

ARTICLE INFO

Article History

Received: 25th May 2020

Received in revised form :

25th May 2020

Accepted: 28th May 2020

Published online :

30th May 2020

I. INTRODUCTION

Steel is an important member in structure and contains 2.1% carbon of its weight. Steel has great strength and stability also has good ductile property, available easily, cheaply and can be manufactured easily. Steel also can be recycled easily and structured in any shape again [1]. Steel structure can buckle under axial compressive load and can be described as bending of a structure. Column is a structural member which is slender in nature who supports the axial eccentric compressive load. If load is increases or may be eccentric in nature, due to instability, column starts to buckle. Buckling or lateral torsional buckling is an important factor in designing the steel structure [5].

Structures can be unstable due to various factors; one of them is sometimes structural member's reaches to their yield strength. Structure may collapse due to maximum deflection or fracture of member [4]. There is no specific study is done yet on different cross section and taper ratio of steel column with thickness variation. In now a day's tapered structural members are commonly used for stability purpose, they look good astatically too [2].

II. METHODLOLOGY

After reviewing the various literatures and papers in order to understand the mechanism behind bending & lateral-torsional buckling and failure analysis of regular column subjected to eccentric loading, herewith provide some steps to analyse the column for different cross section and taper ratio with variation in thickness. The analysis is done with the help of CAE software.

- Analysis of regular I section steel column.
- Analysis of standard shaped hollow column i.e square, & circular column
- Analysis of channel shaped column i.e C shap, I shape channel.
- Finalize the best possible solution for the concern problem.

Parameter selection

1. Shape
   a. Standard shape: Square, circular & rectangular
   b. Channel: C shape, I shape
2. Thickness: 10mm, 12mm,
3. Length: 2mtr, 3mtr

III. FINITE ELEMENT ANALYSIS

This section explains the assumptions on finite element (FE) modeling and evaluates the methodology selected for validation of simulation in the software modeling.

A. Assumptions of Modeling

CATIA is used to create the models and are defined in terms of geometric features that must be subdivided into finite elements for solution. This process of sub division is called meshing. Mesh datasets contain information about element types, element discretisation and mesh type. The I-beam models were assigned ungraded mild steel for its material property with Young's modulus, E= 2.1x105 N/mm2, shear modulus, G = 79x103 N/mm2 and Poisson ratio of 0.3. The convergence of the mesh was established by independently increasing the mesh density in each part of the model beam section.

B. Eigen value Buckling Analysis

The main objective of an Eigen value analysis is to obtain the values of lateral torsional buckling resistance, bending capacity. In this study, all models were assumed to buckle under perfect conditions, where there is no initial imperfectness and eccentric load. Loading conditions are also same for all models, two types of loads are considered. The assumptions used in linear buckling analysis are that the linear stiffness matrix does not change prior to buckling and that the stress stiffness matrix is simply a multiple of its initial value.

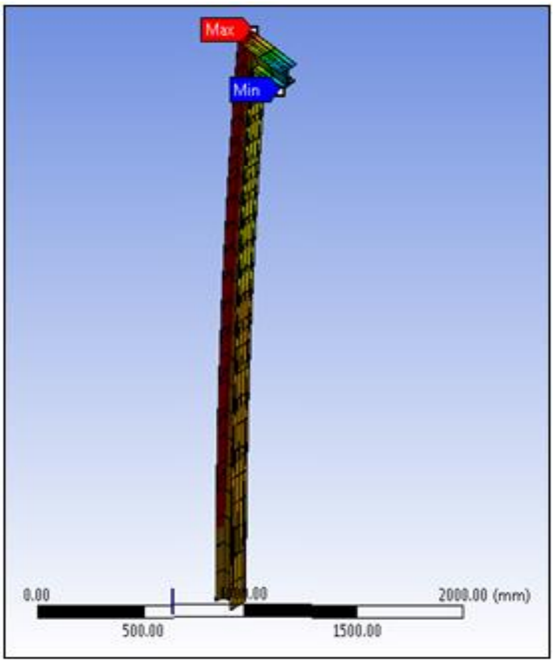

Fig 1: Analysis I section column for buckling

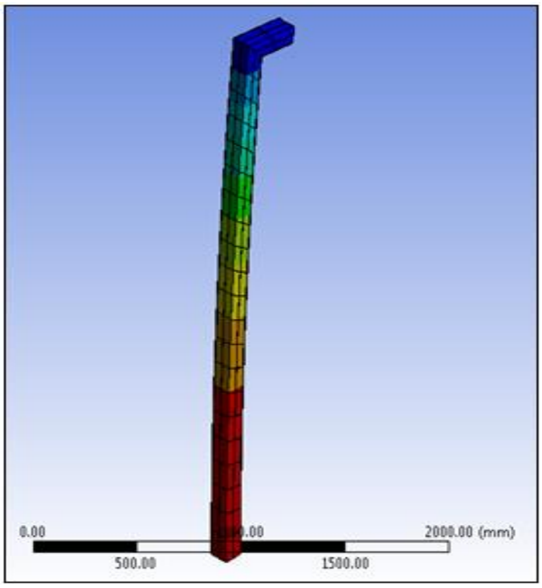

Fig2: Analysis square section column for buckling

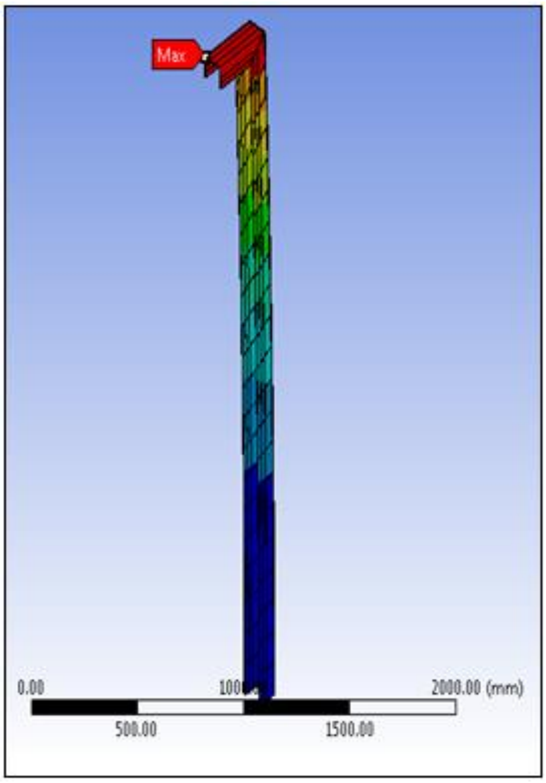

Fig 3: Analysis square section column for buckling

C. Results & discussion

The effect of some geometric parameters on the performance of steel column loaded with eccentric axial compressive load, such as effect of thickness, cross section of column and taper ratio were investigated. In the following table, the results of these parameters are presented in detail.

Table 1: FEA results of different shape column

Sections	Column Thickness	Web Thickness	Bending in X Axis
Circular Section	10	-----	40.28

Circular Section	12	-----	37.64
I Section	10	3	25.33
I Section	12	3	24.11
Square Section	10	-----	23.71
Square Section	12	-----	21.26
C Section	10	-----	63.65
C Section	12	-----	60.89

D. Graph related to FEA results

The effect of some geometric properties on the performance of steel column loaded with eccentric axial compressive load, such as effect of column cross section, web thickness, web cross section, web angles, etc were investigated and the other geometric parameters such as length and thickness are kept constant for column parameter where thickness is vary for web parameter. Followings are the graph shows results in curve type.

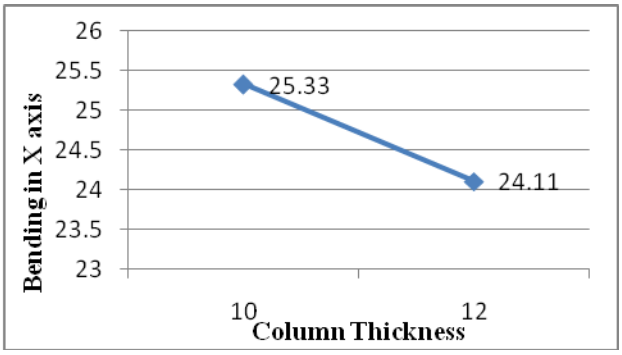

Fig 4: Effect of column thickness on buckling of I section column

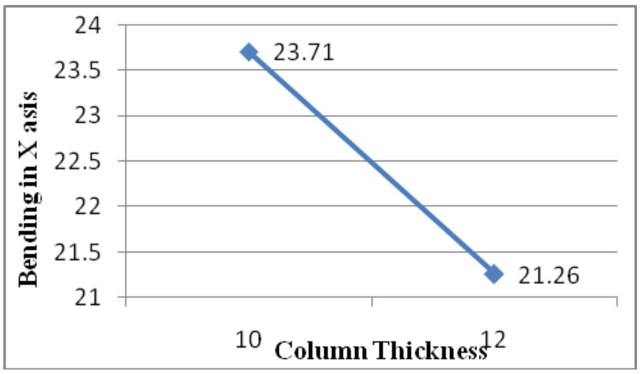

Fig 5: Effect of column thickness on buckling of square section column

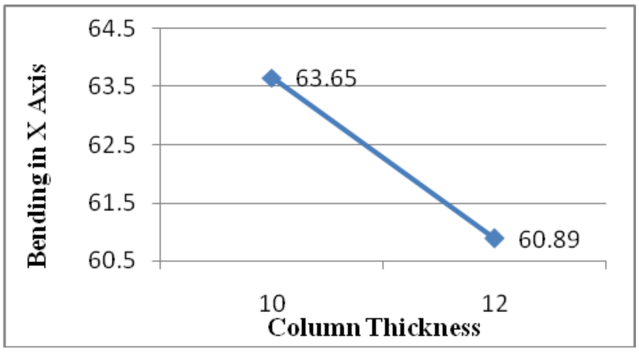

Fig 6: Effect of column thickness on buckling of square section column

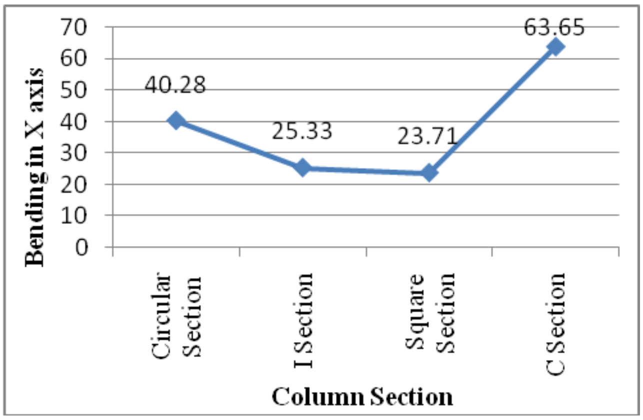

Fig 7: Effect of column section on buckling (for column thickness 10 mm)

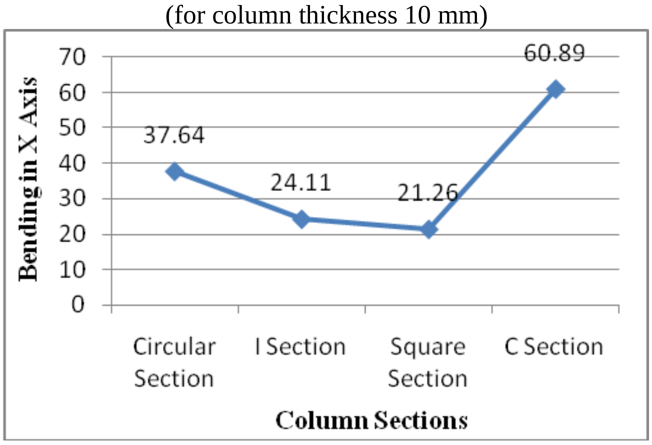

Fig 8: Effect of column section on buckling (for column thickness 12 mm)

IV. CONCLUSION

A finite element analysis is done on the behaviour of different steel column section and compared the same with regular steel section when applied an eccentric axial compressive load, and the following points are concluded:

- Square beam gives better resistance to buckling.
- Increasing thickness of column gives increasing resistance to buckling.
- Taper columns give better results against buckling for certain ratio only.

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