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BUCKLING ANALYSIS OF CASTELLETED COLUMN

Shinde Nilesh*[1], Maniyar Sufiyan[2], Ghogare Akshay[3] & Wani Aditya[4].
[*1,2,3&4]Student, Department of Civil Engineering, Jaihind Polytechnic, Kuran, India

ABSTRACT
Perforated-web steel sections have been used as structural members since the Second World War in an attempt to enhance the flexural behavior without increasing the cost of the material. Nowadays, such sections are widely used in a variety of geometries suitable for various loading conditions. The study considers a wide range of practical geometric dimensions, as well as, various columns' end conditions. Due to the increase in width of column the radius of gyration of column increase and the slenderness ratio of column get reduce. Due to this effect the buckling load carrying capacity of column increase. Castellated column is defined as the column in which increasing width of column without increasing the self-weight of column. Now a day castellated column is a new technique. A castellated column is fabricated from a standard steel I-shape by cutting the web on a half hexagonal line down the center of the beam. The two halves are moved across by one spacing and then rejoined by welding. This process increases the width of the column and hence the major axis bending strength and stiffness without adding additional materials. Due to the opening in the web, castellated column are more susceptible to lateral-torsional buckling. The main benefit of using a castellated column is to increase its buckling resistance about the major axis. However, because of the openings in the web, castellated columns have complicated sectional properties, which make it extremely difficult to predict their buckling resistance analytically.

Keywords*: Castellated Column, Effective Length*

I. INTRODUCTION
Castellated column is defined as the column in which increasing width of column without increasing the self-weight of column. Now a day castellated column is a new technique. A castellated column is fabricated from a standard steel I-shape by cutting the web on a half hexagonal line down the center of the column. The two halves are moved across by one spacing and then rejoined by welding. This process increases the width of the columnand hence the major axis bending strength and stiffness without adding additional materials.Due to the opening in the web, castellated column are more susceptible to lateral-tensional buckling. The main benefit of using a castellated column is to increase its buckling resistance about the major axis. However, because of the openings in the web, castellated columns havecomplicated sectional properties, which make it extremely difficult to predict their buckling resistance analytically.

Types of castellated column
There are four type of castellated column as explained below,

Hexagonal castellated column
In the hexagonal castellated column the opening is provided 45' or 60' angle.Hexagonal castellated column give greater resistance to buckling.

Cellular column
The use of cellular column, with regularly spaced circular openings, increases in steel construction. Those columns are made from hot rolled profiles and provide for an equivalent weight of steel higher mechanical performances compared to the parent standard profile.

Diamond shape castellated column
The Diamond shape castellated columnis a new version of castellated column which achieve by the diamond cutting pattern. The failure chances of this type of column are less as compare to square castellated column.

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Square shape castellated column

In square type of castellated column due to the number of corner the failure chances are more as compare to other type of castellated column.

Column with different end conditions

Alloy steels are generally using as columns in many engineering applications which are subjected to compression and bending loads. The theory of buckling of columns was made early by Euler in 1744. The columns may be failed by buckling when their critical loading is reaching. The buckling may be explained by pressing the opposite faces of a column towards one another. For small amount of loads, the process is aelastic and there is no failure in the structure because there is no buckling displacements after removal of load. But once the load is reaching the critical value we can observe the bulges or waves or ripples commonly encountered in the structure. The buckling analysis of the column can be done by the general formula is,

$$P_{cr} = \frac{n\Pi^2 EI}{L^2}$$

Here,
P_{cr} = Critical buckling load
n = Factor accounting for the end condition
E = Young's modulus of the material
I = Moment of inertia of cross section of the column
L = Length of the column

The factor accounting for the end condition (n) is depending on the type of the condition of the column. The conditions are four types, they may be the following. ·

- Column with both the ends fixed
- Column with both the ends hinged
- Column with one end is fixed and other end is hinged
- Column with one end is fixed and other end is free

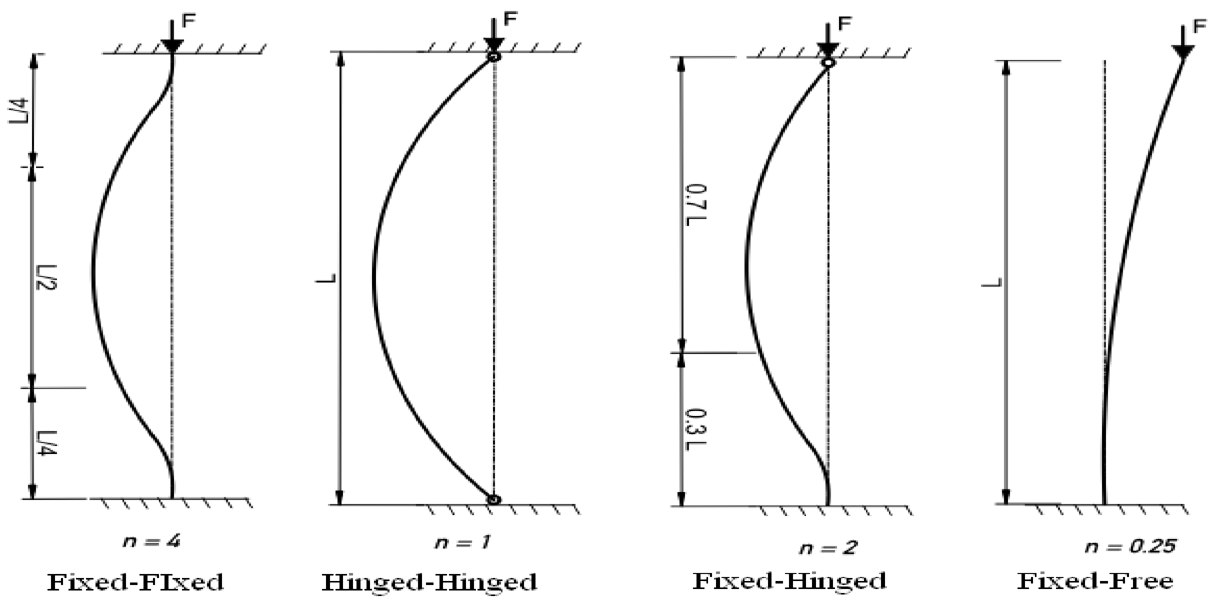

Fig 1 Column with different end conditions

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Design criteria

- ***Shear resistance***

The shear resistance of the perforated section should be sufficient to resist the applied axial force at the openings.

- ***Bending resistance***

The bending resistance of the perforated section should be sufficient to resist the applied bending moment. The optimum positions for web openings along the span of the column depend on the relative proportion of bending moment and shear force.

In general, the openings have a greater effect on the shear resistance of the column than the bending resistance. For web openings with large opening depths under low shear force, flexural failure in the perforated section may be critical.

- ***Local buckling***

The edge of the web above an opening, which is often highly stressed in compression, may buckle locally in compression under global bending action.

- ***Web buckling***

The transfer of forces around the opening leads to local vertical compression in the web, which may cause buckling if the depth-to-thickness ratio of the web is high.

Failure modes of column

- ***Crushing failure***
  This type of failure occur in short column Such member has a critical load cause material failure.

- ***Buckling failure***
  This type of failure occur in long column Such member has a critical load which cause elastic instability due to which the member fail.

- ***Mixed mode of failure***
  The above two failure occur in the extreme cases. For all intermediate value of slenderness ratio the column fail due to combined effect. Most of the practical column fails in this mode.

- **Advantages of castellated column**
  - Increase in width without increase in self-weight of section.
  - Due to the increase in width the radius of gyration of section gets increase and due to this the buckling load carrying capacity of section increase

II. LITERATURE REVIEW

DelphineSonck[et al] (2016) Cellular and castellated members are usually produced by performing cutting and rewelding operations on a hot rolled I-section member

G. Panduranga[etal] (2015) In this paper the buckling analysis of 4140 alloy steel with different cross sections like I-section, C-section and T-section is done in a fixed free conditions.

Jian-zuGu[etal] (2016) These paper presents an analytical solution for calculating the critical buckling load of simply supported cellular columns when they buckle about the major axis.

Jian-kang Chen [etal] (2013) This paper presents an analytical solution for the linear elastic buckling analysis of simply supported battened columns subjected to axial compressed loading.

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JeppeJönsson[et al] (2016) Eurocode allows for finite element modelling of plated steel structures; however the information in the code on howto perform the analysis or what assumptions to make is quite sparse

Khaled M. El-Sway [etal] (2009) In this paper perforated-web steel sections have been used as structural members since the Second World War in an attempt to enhance the flexural behavior without increasing the cost of the material.

Laura Kinget (2015) In this master's dissertation the inuence of the presence of openings in the web of castellated and cellular columns is investigated. First, the geometry of those members is further studied, as well as the limitations of fabrication.

Liliana Marques [et al](2012)EC3–EN 1993-1-1 provides several methodologies for the stability verification of members and frames. When dealing with the verification of non-uniform members in general, with tapered cross-section, irregular distribution of restraints, non-linear axis, castellated, etc., the code mentions the possibility of carrying out a verification based on 2nd order theory; however, several difficulties are noted when doing so, in particular when the benefit of plasticity should be taken into consideration.

Mara Junus[etal] (2014) The purpose of this study is to determine the behavior of beam-column sub-assemblages castellated due to cyclic loading. Knowing these behaviors can if be analyzed the effectiveness of the concrete filler to reduce the damage and improve capacity of beam castellated.

III. ASSEMBLY FOR VARIOUS END CONDITION

There are four end condition given below

- Column with both the ends fixed
- Column with both the ends pin
- Column with one end is fixed and other end is pin
- Column with one end is fixed and other end is free

Assembly for testing of column is prepared from steel material. This is a plate and nut combination assembly which can achieve four end condition of testing. As shown in above figure

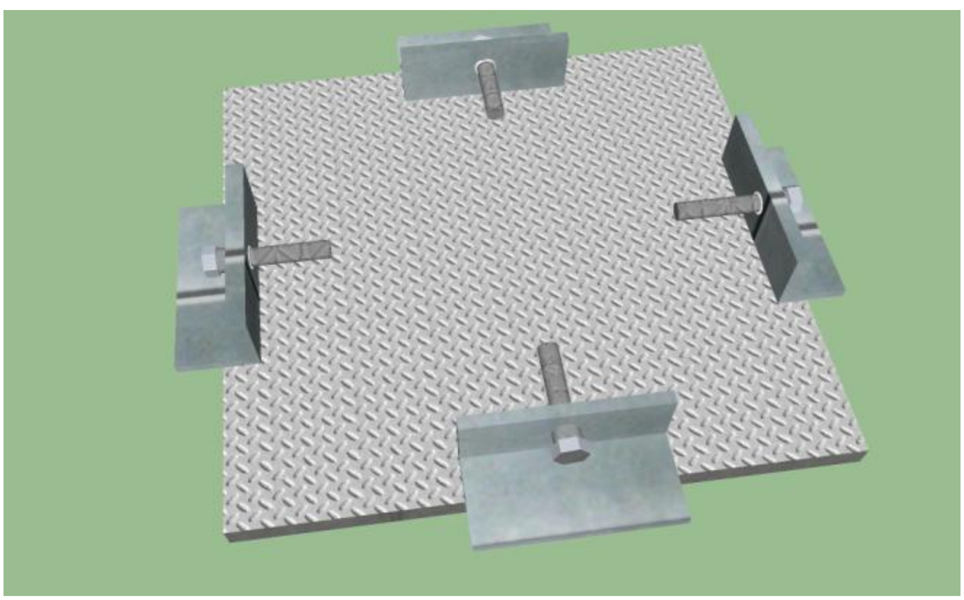

Fig. 2 End Condition Assembly

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Geometry of a typical castellated column.

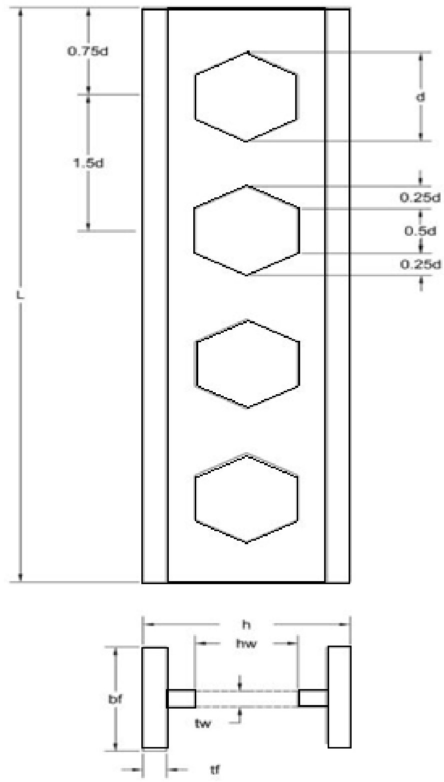

Fig. 3 Geometry of a typical castellated column

Typical geometry of modeled castellated columns is presented in Fig. 3.8. According to this illustration, the typical spacing between castellation is 1.5d, centre-to-centre, where d represents the diameter of the circle enclosing the hexagonal perforation. The gain in the depth of the expanded section, relative to the original depth, is estimated as 0.433h.

IV. CONCLUSION

The current study presents a simplified approach for the assessment of the effect of shear deformations on axially loaded castellated columns and evaluation of the associated buckling load capacity. The influence ofweb shear deformations on the critical buckling loads of castellated columns increases with the cross-sectional area of a tee section. We can achieve four end condition of column by plate and bolt assembly. Theoretically we understood that if section width increase at the same time radius of gyration also increases. Due to this the buckling capacity of column also increases

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