

# COMPARATIVE STUDY AND BUCKLING ANALYSIS OF HOLLOW CASTELLATED COLUMN BY EXPERIMENTATION AND SOFTWARE ANALYSIS

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**Abstract** - Existing studies on castellation have shown that width of castellated column increases, without increasing self-weight of column where, due to increase in width of column radius of gyration increases and slenderness ratio reduces. Also load-carrying capacity of castellated column can be influenced by the shear stresses particularly those around web openings, which could lead column to various failure modes. The study considers use of hollow square column with variety of geometries of castellation, suitable for various loading conditions under buckling. Castellations are mainly provided for giving ground clearance. The purpose is to developing analytical solution, experimental solutions and commercial software Ansys Evaluation for comparative study as well as validation of project.

**Key Words:** Castellation, Hollow square column, Buckling.

## 1. INTRODUCTION

Castellated column is the column which has openings and is mainly provided for giving ground clearance. It increases the width of the column but decreases the self-weight due to castellation. It's a new technique and is most commonly used in industries where height of the structure is greater than 6m. The main benefit of castellated column is to increases its buckling resistance about the major axis by increasing width of column. But load carrying capacity of castellated column can be influenced by the shear stresses particularly those around web openings, which could lead column to various failure modes.

### 1.1 Hollow Section

A hollow structural section (HSS) is a type of metal profile with a hollow cross section. The term is used predominantly in the United States, or other countries which follow US construction or engineering terminology. HSS members can be circular, square, or rectangular sections, although other shapes such as elliptical are also available. HSS is only composed of structural steel per code.

Rectangular and square HSS are also commonly called tube steel or box section. Circular HSS are sometimes mistakenly called steel pipe, although true steel pipe is actually dimensioned and classed differently from HSS.

### 1.2 Use of hollow steel sections

Rectangular HSS, are commonly used in welded steel frames where members experience loading in multiple directions.

Square and circular HSS have very efficient shapes for this multiple-axis loading as they have uniform geometry along two or more cross-sectional axes, and thus uniform strength characteristics. This makes them good choices for columns. They also have excellent resistance to torsion. However, the HSS has superior resistance to lateral torsional buckling.

Elliptical HSS are becoming more popular in exposed structures for the same aesthetic reasons.

In the recent past, HSS was commonly available in mild steel, such as A500 grade B. Today, HSS is commonly available in mild steel, A500 grade C. Other steel grades available for HSS are A847 (weathering steel), A1065 (large sections up to 50 inch square made with SAW process), and recently approved A1085 (higher strength, tighter tolerances than A500).

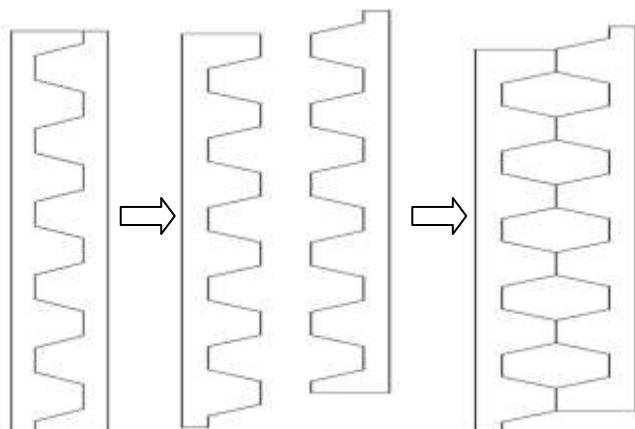
### 1.3 Advantages of castellated hollow column

- The uniform shape of HSS makes it easy to fabricate and well suited for architecturally exposed application.
- Less surface area than open sections allows for reduced cleanup and painting.
- The flat square surfaces of HSS can ease construction.
- Castellated column can be used for providing services such as fire pipes, AC vents, piping, wires passing.
- Castellated column can also be used as tools keeping rack, switch board mountings.

### 1.4 Castellation Process

Castellation is done by fabricating standard hollow square column. Castellated columns are such structural members, which are made by flame cutting a rolled column along its axial centerline and then rejoining the two halves by welding so that the overall column width is increased by 50%

for improved structural performance. The columns with circular openings are called as cellular columns as a modification, in castellated column with hexagonal opening, the corners of opening are made round so as to offer smooth stress transfer area to avoid stress concentration. The columns with such curved shaped openings are known as castellated columns with sinusoidal openings. These columns can also be used for platforms and temporary structures for off shore shores and for marine oil drilling rig etc.



Marking  
On column

Cutting and  
rearranging the  
Section

Welding and  
Joining the  
Section

## 2. METHODOLOGY

### 2.1 Modes of failure of column

1. Crushing
2. Buckling
  - 2.1 Flexural Buckling
  - 2.2 Torsional Buckling
  - 2.3 Flexural-Torsional Buckling

### 2.2 Typical Geometry

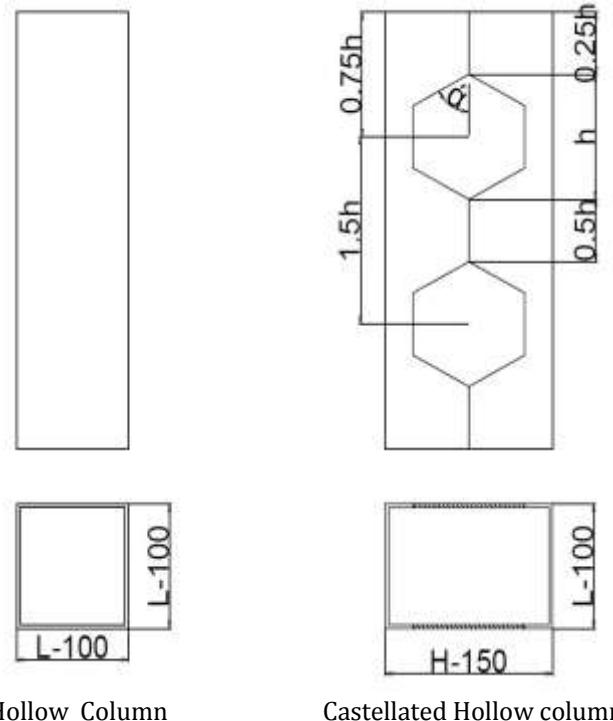
#### Section Properties

Width of HSS L= 100mm

Castellated model breadth H=150mm

Castellation height h=100mm

Angle of castellation  $\alpha= 62^\circ$



Hollow Column

Castellated Hollow column

### 2.3 ANSYS Software implementation

ANSYS structural analysis software enables you to solve complex structural engineering problems and make better, faster design decisions. With the finite element analysis (FEA) tools available in the suite, you can customize and automate solutions for your structural mechanics problems and parameterize them to analyze multiple design scenarios. You can connect easily to other physics analysis tools for even greater fidelity. ANSYS structural analysis software is used throughout the industry to enable engineers to optimize their product designs and reduce the costs of physical testing.

#### 2.3.1 Software working procedure

##### STEP 1- Engineering Data

In this command required material grade and properties are setup.

##### STEP 2- Geometry

In this command geometry of the structure is prepared. For following section an HSS is drawn with dimensions 150x100 x3mm and a height of 800mm. A base plate of 300x300x6mm is inserted along with Fixed support setup.

Hexagonal opening according to specification is provided.

##### STEP 3- Modeling and Result Analysis

In geometry section each material is defined with material is to be provided.

Co-ordinate system is automatically generated based on the geometry assigned.

Connections based on joints is provided, i.e along the length of perforation, connection between base plate angles welded connection is provided.

Meshing based on connections and FEM analysis should be generated.

In static structural command- Fixed support to the base plate and cleat angle and Remote force on top surface in downward direction along the depth of column is provided. In Solution command- Maximum principal stress and Deformation is analyzed.

### 2.3.1 Experimental working procedure

#### Selection of Square hollow section for experimentation

A hollow structural section (HSS) is a type of metal profile with a hollow cross section. The term is used predominantly in the United States, or other countries which follow US construction or engineering terminology. In our project, a SHS of size 100mmX100mmX3mm was selected for experimentation. The height of the prototype was taken 800mm, with an angle of 62° castellation for achieving hexagonal pattern. The castellated section becomes 150mmX100mmX3mm. Following images shows how the castellation process is carried out by cutting the column first, followed by welding the section and obtaining the final castellated column.

#### STEP I: Cutting the section



Fig -1: Cutting of Hollow column

#### STEP II: Rearranging and welding the section



Fig -2: Rearranging and welding the section

#### STEP III: Hollow castellated column



Fig -3: Hollow Castellated Column

### 3. CONCLUSIONS

- According to software analysis Hexagonal castellation is feasible for casting since the stress bearing capacity of hexagonal castellation is greater.
- Cellular columns are also feasible as they have lesser deflection and stress bearing capacity is also greater, cellular columns are also popularly used.
- Deflection in square section is less but due to the edges the stress bearing capacity is reduced.
- Pentagonal and Elliptical sections has lesser deflection but castellation process becomes difficult, therefore these sections are not preferred.
- Deflection is greater in castellated column than normal hollow column. Hollow Column carries 33.33% greater load than Castellated hollow column.
- Width of Castellated Hollow column increases without increasing self-weight of column due to

which radius of gyration increases and slenderness ratio decreases.

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