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Analysis of Castellated Column and Its Buckling Behaviour

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***Abstract*:** *Castellated columns have been widely used in structures and steel buildings. Compared to traditional I-section structural members, castellated structural members can have large section depth and thus have great flexural capacity while they are bent about their major axis and large flexural buckling. The study aimed to investigate the strength and buckling behavior of axially loaded tapered castellated cruciform steel columns with the application of the finite element analysis. Although a significant of research body exists on the failure of different columns, there is not introduced a proper criterion to determine the point of buckling in the equilibrium path of an imperfect column. The study presented in this paper is a consideration of a wide range of practical geometric dimensions and fix to fix end conditions by the application of ABAQUS software. The summary of findings are reported for about 77 samples of castellated I- shaped sections and a simplified approach for the evaluation of the buckling capacity in castellated columns, in the form of slenderness – load curve, is developed. In addition, the axial compressive capacities of those steel sections are investigated in a numerical way in the current study. The results of nonlinear analyses of these columns revealed that load carrying capacity of castellated steel in square, pentagon rectangular, circle, hexagonal , rhombus in shape og opening in various length.*

Keywords: *Castellated Column, Tapered Shape, Load carrying capacity, ABAQUS software*

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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 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 is 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.

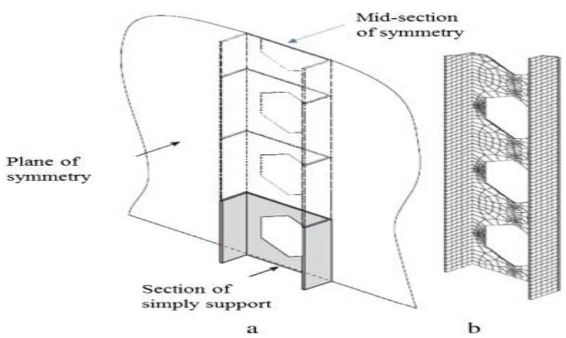

Figure 1 Cross Section of Castellated Column.

1.1. Advantages And Disadvantages

The primary advantages of castellated member are the improved strength due to increased depth of the section without any additional weight. However one consequences of the increased depth of the section is the development of stability problem during the erection. This section summarizes the main advantages and disadvantages of cellular members

✓ **Advantages**

- Increased spans possible (flexibility)
- Passage of services through web openings feasible (functionality)
- Specifications are easy to adjust towards specific needs (adaptability)
- The offer of a new means of architectural expression (appearance)
- availability of high- performance design tools (support)
- Material savings and reduction of the number of foundations (sustainability & economics)

✓ **Disadvantages**

- Less suitable for concentrated loads
- More calculation effort required
- Severe reduction in pure axial capacity
- Increased production costs

1.2. Research Methodology

Figure describes the proposed work methodology adopted in this study. The proposed work comprises analysis and behavior of castellated column under axial loading also the design of column with and without opening by considering I section. Following methodology will be adopted during progress of work. Firstly collect literature and Study all past literature available related to castellated column and find out Research Gap then revision the concept of castellated column and their cutting process, behavior, advantages and disadvantages of castellation. Secondly finalize the various shapes of opening for the castellated column. Analysis of castellated column is using ABAQUS software and find out load carrying capacity of I section with and without opening in different length. Lastly compare the results of LCC of different shape of castellation and its performance deflection point of view. Results are validated with past literatures and software results.

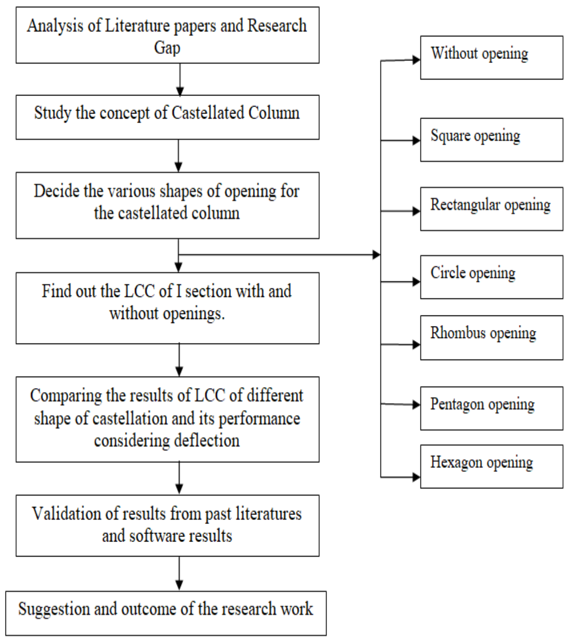

Figure 2 Flowchart of Methodology

II. LITERATURE REVIEW

1. Khaled M. El- Sawy, Amr M. I. Sweedan, Mohamed I. Martini, *(2009).*

Current research uses the FEM to learn the buckle aptitude associated with the axial buckle properties of axially weighed down I steel pillar. Extensive numerical analysis is perform to compute the depletion in buckle capacity of the crown support due to shear & bending deformation. The sequel s obtained are worn to notify the dimensionless buckle correction factor Z & the relevant equivalent cross-sectional properties that can be implemented to assess the critical buckle load of the pillarunder consideration. This learntakes into account the serrated perturbations of actual geometric dimensions & the transmission conditions of the various pillars. A simplified procedure for appraise the buckle opposition to of the crown support has been proposed. The chart was developed to allow practitioners to more accurately estimate the buckle load of such types of crown supports.

2. Wei-bin Yuan a, Boksun Kimb, Long-yuan Li *(2014).*

This manuscript presents a new analytical solution for calculating the critical buckle load of a simply supported crown pillarwhen buckle around the spindle. This analytical solution takes into account the effects of web shear deformation on crown pillar buckle & is derived according to the steady-state potential energy principle. The equating derived to rekoning the critical buckle load is shown for a wide range of cross-sectional dimensions using data from other published finite element analyzes. The upshot of web shear deformation on the critical buckle load of the crown pillar was initiate to increase with the C/S area of the T section & the depth of the web opening, but decrease with the length & thickness of the web. It can be look that including the shear deformation of the web significantly reduces the buckle opposition to of the crown support. Ignoring the shear deformation of theweb can overestimate the critical buckle load by up to 25%, even with a small MOI of area.

3. Jin-Song Lei, Wei-Bin Yuan, & Long-Yuan Li, *(2016).*

This manuscript is inspection the problem of axial pressure buckle of the crown support around the spindle under load. An analytical formula for estimate the critical buckle load of the crown pillar is derived. This takes into account the nonuniform c/s temp. diffusion due to asymmetric loads, as well as the shear deformation upright of the web opening. The sequel s show that at the same average hotness, the critical buckle load of a crown support with a non-uniform hotness diffusion is smaller than that of a crown support with uniform hotness diffusion. The web shear upshot caworn by the web openings can significantly reduce the critical buckle load on crown pillars, especially for pillars with short lengths or wide flanges. At the same average hotness, the important buckle load of a crown support with non-uniform hotness diffusion is smaller than that of a crown support with uniform hotness diffusion. The considerable the hotness difference among the two T profiles, the considerable the depletion in critical buckle load.

III. CASTELLATED COLUMN DESIGN

✓ **Examined Geometries**

Cellular and castellated members are made by cutting and rewelding a hot-rolled I-section, which is referred to as the parent section. By varying the cutting pattern and the fabrication procedure, it is possible to obtain a large variety in member and opening geometries, such as tapered and even curved members, or asymmetric members with a different top- and bottom section. However, only prismatic members with a doubly symmetric cross-section, made from the same parent section will be considered in this work.

In the numerical study, the critical weak-axis buckling load Ncr and the weak-axis buckling resistance NRd were determined for a large number of simply supported compressed castellated and cellular columns. For the cellular columns, the complete range of commonly used and feasible geometries starting from these parent sections was considered by varying the opening height a = fa·h and the web post width w = fw·‘0 = fw·a (Fig. 3.2). For each of these geometries, the resulting total cellular member height can be calculated according to Eq. (1), with rb being he cut width used during the cutting procedure, taken equal to a typical value of 8 mm. The dimensions of each obtain geometry were checked against the constraints given by existing technical documentation and standards, to obtain all feasible geometries made from the six parent sections

$$H = \square + \frac{\sqrt{(a-2r_b)^2-w^2}}{2} \quad \text{.....................} (1)$$

For the castellated columns, a wide range of possible geometries was considered by varying the final member height H = fH·h = h + a/2, as well as the value of the opening angle α and the web post width w = fw·‘0 = fw·(w + 2c) (Fig. 3.3). The chosen values for the three parameters fH, α and fw are listed he web post width w allowed for a large variety of opening shapes, going from very narrow diamond web openings to very wide web openings, similar to those that would occur in an Angelina™ beam with wide sinusoidal openings, as investigated (amongst others). Additionally, it was checked whether the obtained geometries were feasible by comparing them with the geometric constraints given in the previously mentioned technical standards and documentation.

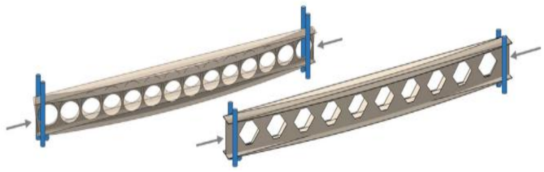

Figure 3 Weak-Axis Flexural Buckling Failure Of Cellular And Castellated Members Loaded By A Central Compressive Force

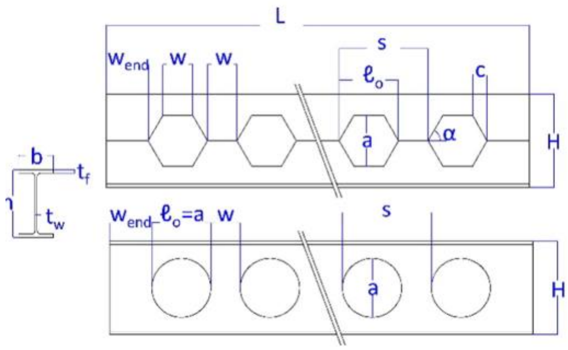

Figure 4 Dimensions Of The Castellated And Cellular Members, As Well As Their Parent Sections

✓ **Design of Castellated Column**

Given: Column section:

Height of column, L=6 m, End Conditions: One end: held in position and direction, Other end: held in position but not restrained in direction., Grade of steel: Fe 410

To find: Design Compressive load

Properties of Given section:

$A = 1500\,mm^2$, $I_{zz} = 5350000\,mm^4$, $I_{yy} = 428125\ mm^4$, $\square = 150\,mm$, $b_f = 80\,mm$, $t_w = 5\,mm$, $t_f = 5\,mm$, $r_{yy} = 16.894\,mm$, $r_{zz} = 59.722\,mm$, $d = 140\,mm$, $b = 40\,mm$

Classification of section:

(Table 2.1, page 18)

For $f_y = 250\,N/mm^2$, $\in = 1$

$$\frac{b}{t_f} = \frac{40}{5} = 8 < 15.7\ \in \therefore Flange\ is\ semi-compact$$

$$From\ steel\ table\ d = 140\,mm$$

$$\frac{d}{t_w} = \frac{140}{5} = 28\ < 84 \in\ Web\ is\ plastic$$

$$\therefore Section\ is\ semi-compact$$

Buckling class of cross section:

(Table 10, page 44)

$$\frac{\square}{b_f} = \frac{150}{80} = 1.875$$

$$t_f = 5\,mm\ \leq 100mm$$

$$\therefore Buckling\ class\ about\ z-z\ axis\ is\ b$$

Buckling class about y-y axis is c.

Design Compressive stress about z-z axis:

a. Effective length;

For one end fixed and other is pinned

KL = 0.8 L = 0.8×1750 = 1400 mm

b. Slenderness ratio:

$$\frac{KL}{r_{zz}} = \frac{1400}{59.72} = 23.44$$

c. Design Compressive stress:
(Table 9b, page 41)

KL/r	Fcd
20	225
30	216
23.44	x

$$\therefore\ f_{cd} = x = 225 - \frac{225-216}{30-20} \times (23.44-20)$$

$\therefore (f_{cd})_z$ = 221.90
Design compressive stress about y-y axis:
a. Effective length:
KL = 0.8 × 1750 = 1400 mm
b. Slenderness ratio:

$$\frac{KL}{r_{yy}} = \frac{1400}{16.89} = 82.88$$

c. Design Compressive stress:
(Table 9c, page 42)

KL/r	Fcd
80	136
90	121
82.88	x

$$(f_{cd})_y = x = 136 - \frac{136-121}{90-80} \times (82.88-80) = 131.68\ Mpa$$

Design Compressive strength:
Design compressive strength = Least of $(f_{cd})_z$ and $(f_{cd})_y$

$$\therefore\ f_{cd} = (f_{cd})_y = 131.68\ Mpa$$

$$\therefore Design\ Compresive\ strength = f_{cd} \times A$$

$$P_d = 131.68 \times 1500 = 197.52\ KN$$

IV. RESULT AND DISCUSSION

4.1. Load Capacity of Castellated Steel Column With Tapered Shape Normal Column

Table 1: Result For Castellated Steel Column With Tapered Shape Column

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		Mm	Kl/R	Kn
1	Without Opening	600	6.36	580.84
2		700	7.42	431.96
3		800	8.48	351.95
4		900	9.54	286.19
5		1000	10.60	244.75
6		1100	11.66	196.23
7		1200	12.72	170.89
8		1300	13.78	146.28
9		1400	14.85	130.95
10		1500	15.91	138.16
11		1600	16.97	102.12

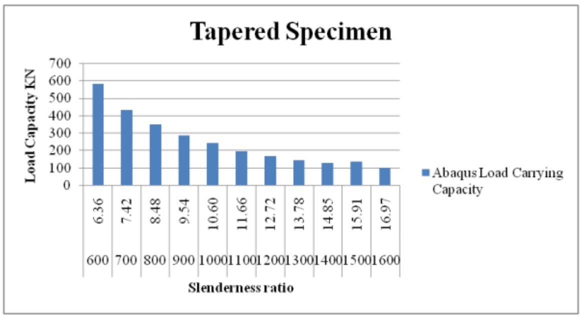

Figure 5 Castellated Steel Column With Tapered Column

4.2. Load Capacity of Castellated Steel Column With Square Opening

Table 2: Result For Castellated Steel column With Tapered Shape Square Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		Mm	Kl/R	Kn
1	Square Opening	600	6.36	425.85
2		700	7.42	331.09
3		800	8.48	268.31
4		900	9.54	219.18
5		1000	10.60	185.6
6		1100	11.66	156.58
7		1200	12.72	135.85
8		1300	13.78	123.3
9		1400	14.85	104.27
10		1500	15.91	92.48
11		1600	16.97	82.682

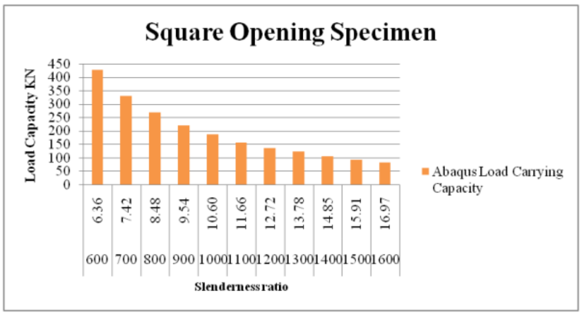

Figure 6 Castellated Steel Column With Square Opening

4.3. Load Capacity of Castellated Steel Column With Rectangular Opening

Table 3: Result For Castellated Steel column With Rectangular Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		mm	KL/r	KN
1	Rectangular Opening	600	6.36	413.72
2		700	7.42	323.66
3		800	8.48	263.05
4		900	9.54	190.84
5		1000	10.60	220.31
6		1100	11.66	155.01
7		1200	12.72	150.44
8		1300	13.78	122.84
9		1400	14.85	103.87
10		1500	15.91	82.425
11		1600	16.97	92.487

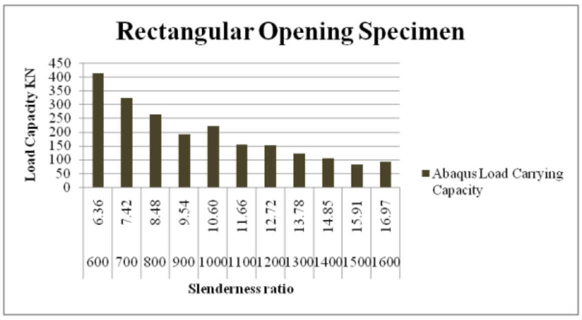

Figure 7 Castellated Steel Beam With Rectangular Opening

4.4. Load Capacity of Castellated Steel Column With Circular Opening

Table 4: Result For Castellated Steel column With Tapered with Circular Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		mm	KL/r	KN
1	Circle Opening	600	6.36	410.69
2		700	7.42	313.57
3		800	8.48	260.37
4		900	9.54	195.64
5		1000	10.60	179.7
6		1100	11.66	152.46
7		1200	12.72	132
8		1300	13.78	115.21
9		1400	14.85	97.554
10		1500	15.91	96.89
11		1600	16.97	80.696

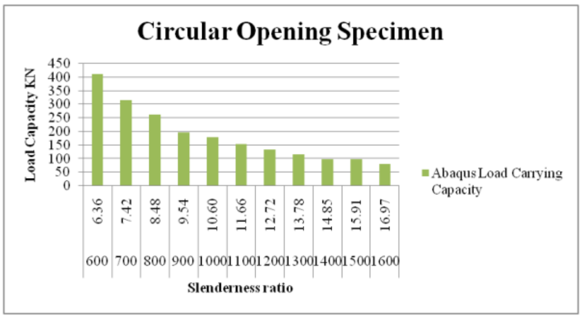

Figure 8 Castellated Steel column With Circular Opening

4.5. Load Capacity of Castellated Steel Column With Rhombus Opening

Table 5: Result For Castellated Steel Column With Rhombus Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		mm	KL/r	KN
1	Rhombus Opening	600	6.36	473.84
2		700	7.42	366.74
3		800	8.48	281.54
4		900	9.54	230.18
5		1000	10.60	180
6		1100	11.66	172.41
7		1200	12.72	132.56
8		1300	13.78	129.51
9		1400	14.85	102.22
10		1500	15.91	100.68
11		1600	16.97	90.103

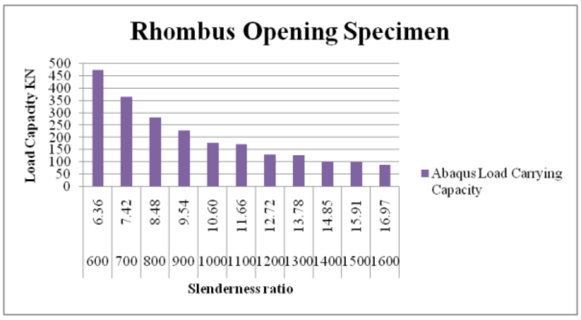

Figure 9 Castellated Steel column With Rhombus Opening

4.6. Load Capacity of Castellated Steel Column With Pentagon Opening

Table 6: Result For Castellated Steel column With Pentagon Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		mm	KL/r	KN
1	Pentagon Opening	600	6.36	410.34
2		700	7.42	375.17
3		800	8.48	256.95
4		900	9.54	218.39
5		1000	10.60	178.17
6		1100	11.66	155.89
7		1200	12.72	132.59
8		1300	13.78	117.63
9		1400	14.85	102.18
10		1500	15.91	92.344
11		1600	16.97	80.851

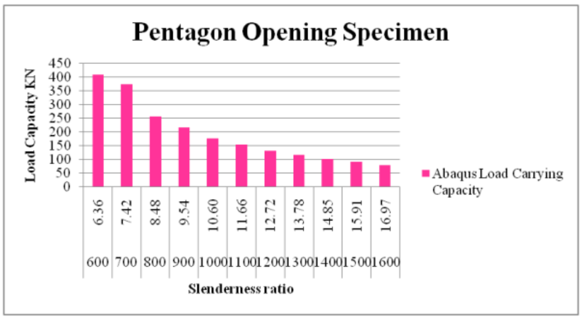

Figure 10 Castellated Steel column With Pentagon opening

4.7. Load Capacity of Castellated Steel Column With Hexagonal Opening

Table 7: Result For Castellated Steel column With Hexagonal Opening

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity
		mm	KL/r	KN
1	Hexagonal Opening	600	6.36	361.51
2		700	7.42	285.95
3		800	8.48	232.47
4		900	9.54	192.47
5		1000	10.60	162.64
6		1100	11.66	138.8
7		1200	12.72	120.53
8		1300	13.78	105.57
9		1400	14.85	93.153
10		1500	15.91	82.966
11		1600	16.97	74.45

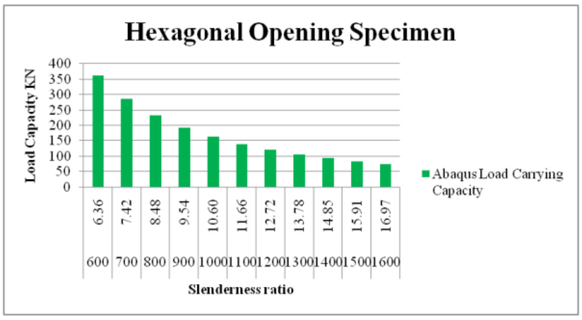

Figure 11 Castellated Steel Column With Hexagonal Opening

4.8. Decrease In Load Capacity With All Type of Opening

Table 8: Decrease In Load Capacity In 600 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	600	6.36	580.84	0	
2	Square	600	6.36	425.85	154.99	36.40
3	Rectangular	600	6.36	413.72	167.12	40.39
4	Circular	600	6.36	410.69	170.15	41.43
5	Rhombus	600	6.36	473.84	107	22.58
6	Pentagon	600	6.36	410.34	170.5	41.55
7	Hexagon	600	6.36	361.51	219.33	60.67

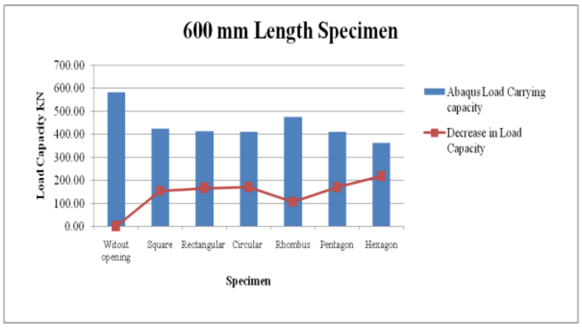

Figure 12 Decrease in Load Capacity of 600 mm Length Of Specimen

Table 9: Decrease In Load Capacity In 700 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	700	7.42	431.96	0	
2	Square	700	7.42	331.09	100.87	30.47
3	Rectangular	700	7.42	323.66	108.3	33.46
4	Circular	700	7.42	313.57	118.39	37.76
5	Rhombus	700	7.42	366.74	65.22	17.78
6	Pentagon	700	7.42	375.17	56.79	15.14
7	Hexagon	700	7.42	285.95	146.01	51.06

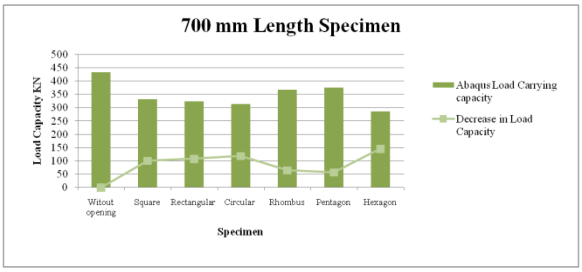

Figure 13 Decrease in 700 mm Length Of Specimen

Table 10: Decrease In Load Capacity In 800 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
15	Without opening	800	8.48	351.95	0	
16	Square	800	8.48	268.31	83.64	31.17
17	Rectangular	800	8.48	263.05	88.9	33.80
18	Circular	800	8.48	260.37	91.58	35.17
19	Rhombus	800	8.48	281.54	70.41	25.01
20	Pentagon	800	8.48	256.95	95	36.97
21	Hexagon	800	8.48	232.47	119.48	51.40

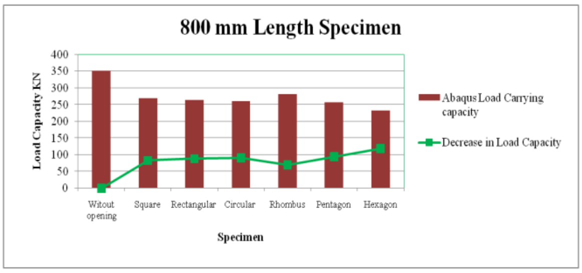

Figure 14 Decrease in 800 mm Length of Specimen

Table 11: Decrease In Load Capacity In 900 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	900	9.54	286.19	0	
2	Square	900	9.54	219.18	67.01	30.57
3	Rectangular	900	9.54	190.84	95.35	49.96
4	Circular	900	9.54	195.64	90.55	46.28
5	Rhombus	900	9.54	230.18	56.01	24.33
6	Pentagon	900	9.54	218.39	67.8	31.05
7	Hexagon	900	9.54	192.47	93.72	48.69

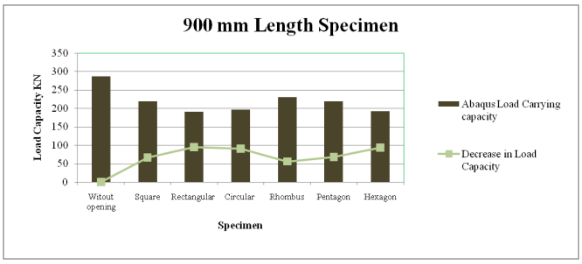

Figure 15 Decrease in 900 mm Length Of Specimen

Table 12: Decrease In Load Capacity In 1000 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	1000	10.60	244.75	0	0.00
2	Square	1000	10.60	185.6	59.15	31.87
3	Rectangular	1000	10.60	220.31	24.44	11.09
4	Circular	1000	10.60	179.7	65.05	36.20
5	Rhombus	1000	10.60	180	64.75	35.97
6	Pentagon	1000	10.60	178.17	66.58	37.37
7	Hexagon	1000	10.60	162.64	82.11	50.49

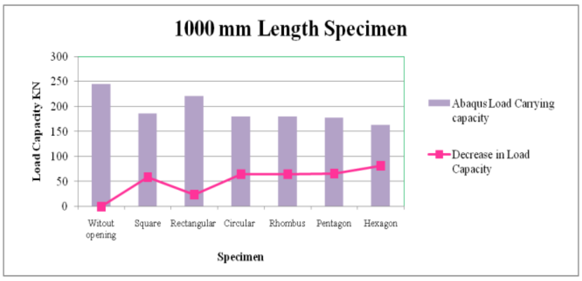

Figure 16 Decrease in 1000 mm Length Of Specimen

Table 13: Decrease In Load Capacity In 1100 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	1100	11.66	196.23	0	
2	Square	1100	11.66	156.58	39.65	25.32
3	Rectangular	1100	11.66	155.01	41.22	26.59
4	Circular	1100	11.66	152.46	43.77	28.71
5	Rhombus	1100	11.66	155.89	40.34	25.88
6	Pentagon	1100	11.66	155.89	40.34	25.88
7	Hexagon	1100	11.66	138.8	57.43	41.38

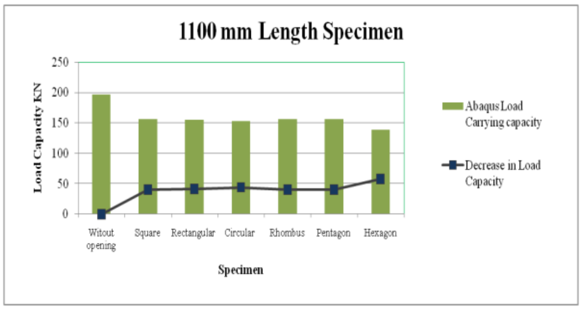

Figure 17 Decrease in 1100 mm Length Of Specimen

Table 14: Decrease In Load Capacity In 1200 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	1200	12.72	170.89	0	
2	Square	1200	12.72	135.85	35.04	25.79
3	Rectangular	1200	12.72	150.44	20.45	13.59
4	Circular	1200	12.72	132	38.89	29.46
5	Rhombus	1200	12.72	132.56	38.33	28.92
6	Pentagon	1200	12.72	132.59	38.3	28.89
7	Hexagon	1200	12.72	120.53	50.36	41.78

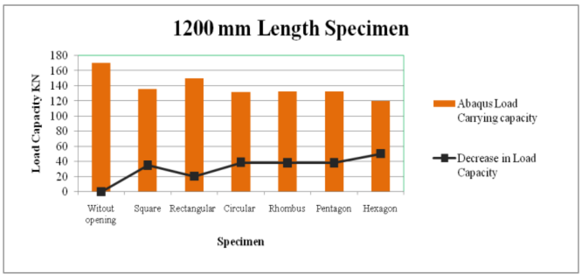

Figure 18 Decrease in 1200 mm Length Of Specimen

Table 15: Decrease In Load Capacity In 1300 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	1300	13.78	146.28	0	
2	Square	1300	13.78	123.3	22.98	18.64
3	Rectangular	1300	13.78	122.84	23.44	19.08
4	Circular	1300	13.78	115.21	31.07	26.97
5	Rhombus	1300	13.78	129.51	16.77	12.95
6	Pentagon	1300	13.78	117.63	28.65	24.36
7	Hexagon	1300	13.78	105.57	40.71	38.56

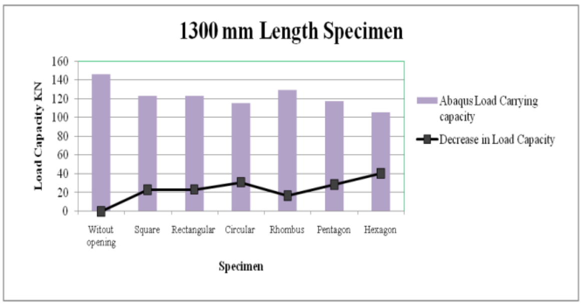

Figure 19 Decrease in 1300 mm Length Of Specimen

Table 16: Decrease In Load Capacity In 1400 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without Opening	1400	14.85	130.95	0	
2	Square	1400	14.85	104.27	26.68	25.59
3	Rectangular	1400	14.85	103.87	27.08	26.07
4	Circular	1400	14.85	97.554	33.396	34.23
5	Rhombus	1400	14.85	102.22	28.73	28.11
6	Pentagon	1400	14.85	102.18	28.77	28.16
7	Hexagon	1400	14.85	93.153	37.797	40.58

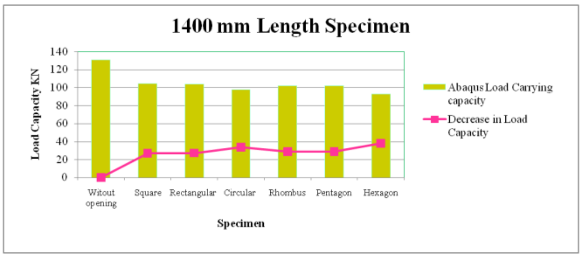

Figure 20 Decrease in 1400 mm Length Of Specimen

Table 17: Decrease In Load Capacity In 1500 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without Opening	1500	15.91	138.16	0	
2	Square	1500	15.91	92.48	45.68	49.39
3	Rectangular	1500	15.91	82.425	55.735	67.62
4	Circular	1500	15.91	96.89	41.27	42.59
5	Rhombus	1500	15.91	100.68	37.48	37.23
6	Pentagon	1500	15.91	92.344	45.816	49.61
7	Hexagon	1500	15.91	82.966	55.194	66.53

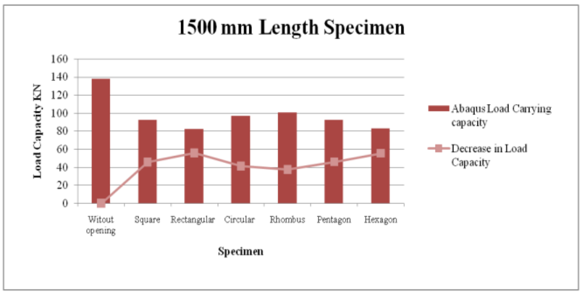

Figure 21 Decrease in 1500 mm Length Of Specimen

Table 18: Decrease In Load Capacity In 1600 Length Specimen

Sr. No	Specimen	Length	Slenderness Ratio	Abaqus Load Carrying Capacity	Decrease In Load Capacity	Load Capacity In Term Of Ratio
		mm		**KN**	**KN**	
1	Without opening	1600	16.97	102.12	0	
2	Square	1600	16.97	82.682	19.438	23.51
3	Rectangular	1600	16.97	92.487	9.633	10.42
4	Circular	1600	16.97	80.696	21.424	26.55
5	Rhombus	1600	16.97	90.103	12.017	13.34
6	Pentagon	1600	16.97	80.851	21.269	26.31
7	Hexagon	1600	16.97	74.45	27.67	37.17

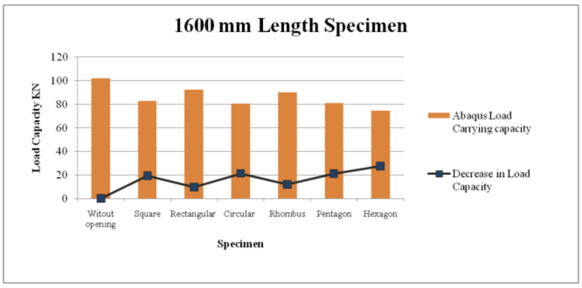

Figure 22 Decrease in 1600 mm Length Of Specimen

4.9. Load Vs Deflection

1. Load Vs Deflection in Without Opening

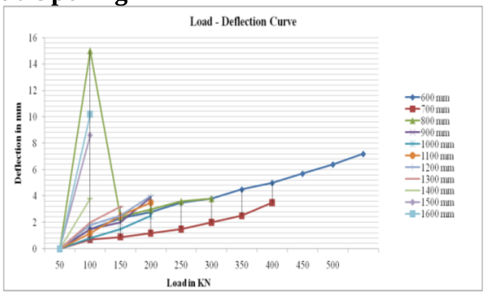

Figure 23 Load Deflection Curve for Tapered Shape without Openings

2. Load Vs Deflection in Square Opening

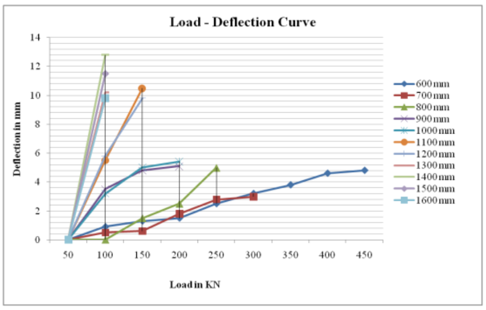

Figure 24 Load Deflection Curve for Tapered Shape with Square Openings

3. Load Vs Deflection in Rectangular Opening

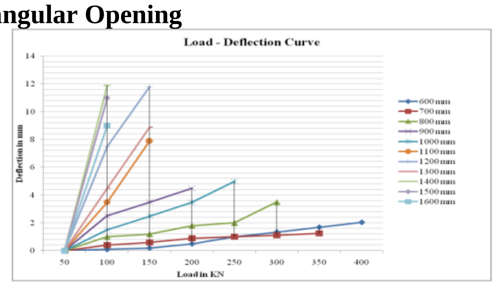

Figure 25 Load Deflection Curve for Tapered Shape with Rectangular Openings

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4. Load Vs Deflection in Circular Opening

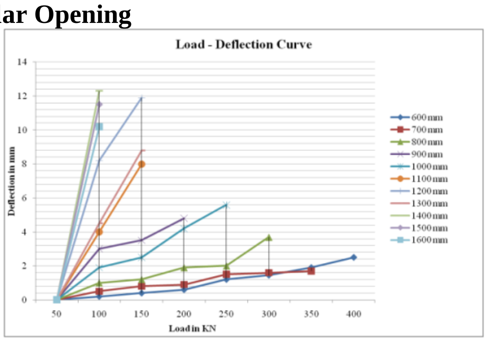

Figure 26 Load Deflection Curve for Tapered Shape with Circular Openings

5. Load Vs Deflection in Rhombus Opening

Table

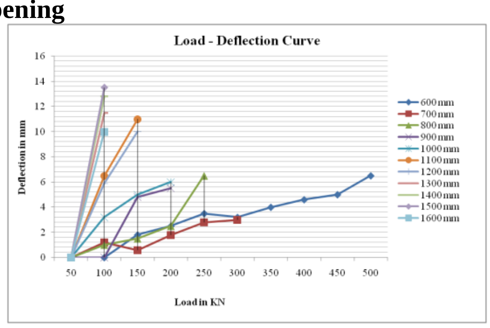

Figure 27 Load Deflection Curve for Tapered Shape with Rhombus Openings

6. Load Vs Deflection in Pentagonal Opening

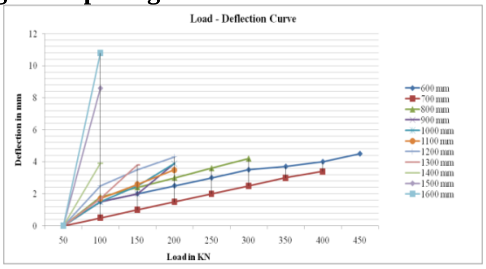

Figure 28 Load Deflection Curve for Tapered Shape with Pentagon Openings

7. Load Vs Deflection in Hexagonal Opening

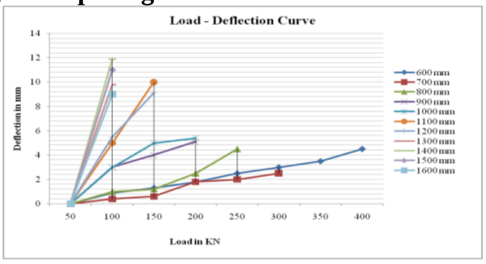

Figure 29 Load Deflection Curve for Tapered Shape with Hexagonal Openings

V. CONCLUSION

Following conclusion can be listed below:

1 The obtained results from the analyses of steel columns show that the maximum load capacity of castellated steel columns is considerably higher than that of the common steel columns and the difference between the load increment percentages in castellated and common sections increases as the columns' slenderness goes up.

2 The equation for the prediction of load capacity in castellated cruciform steel columns under axial compression was proposed. Furthermore, numerical results obtained from the nonlinear analyses are in line with the analytical formulas reported in the current study

✓ **Decrease in Load Carrying Capacity due to Increase in Length**

❖ **600 mm Length of Castellated Column**

In the 600 mm length castellated column the maximum decrease in load carrying capacity is 219.33 KN and minimum for 107.0KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 60.67% rhombus shape of opening column are minimum capacity is 22.58% as compare to without opening specimen.

❖ **700 mm Length of Castellated Column**

In the 700 mm length castellated column the maximum decrease in load carrying capacity is 146.01 KN and minimum for 56.79 KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 51.06% and pentagonal shape of opening column are minimum capacity is 15.4% as compare to without opening specimen.

❖ **800 mm Length of Castellated Column**

In the 800 mm length castellated column the maximum decrease in load carrying capacity is 119.48 KN and minimum for 70.41 KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 51.48% rhombus shape of opening column are minimum capacity is 25.01% as compare to without opening specimen.

❖ **900 mm Length of Castellated Column**

In the 900 mm length castellated column the maximum decrease in load carrying capacity is 95.35KN and minimum for 67.01KN as compare to normal Specimen. Result is conclude that rectangular shape of opening in castellated column are maximum decrease in capacity is 49.96% square shape of opening column are minimum capacity is 30.57% as compare to without opening specimen.

❖ **1000 mm Length of Castellated Column**

In the 1000 mm length castellated column the maximum decrease in load carrying capacity is 82.11KN and minimum for 24.44KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 50.49% square shape of opening column are minimum capacity is 11.09% as compare to without opening specimen.

❖ **1100 mm Length of Castellated Column**

In the 1100 mm length castellated column the maximum decrease in load carrying capacity is 57.43KN and minimum for 40.34KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 41.38% pentagon and rhombus shape of opening column are minimum capacity is 25.88% as compare to without opening specimen.

❖ **1200 mm Length of Castellated Column**

In the 1200 mm length castellated column the maximum decrease in load carrying capacity is 50.36KN and minimum for 20.45KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 41.78% rectangular shape of opening column are minimum capacity is 11.59% as compare to normal specimen.

❖ **1300 mm Length of Castellated Column**

In the 1300 mm length castellated column the maximum decrease in load carrying capacity is 40.71KN and minimum for 16.77KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 38.56% rhombus shape of opening column are minimum capacity is 12.95% as compare to without opening specimen.

❖ **1400 mm Length of Castellated Column**

In the 1400 mm length castellated column the maximum decrease in load carrying capacity is 37.797KN and minimum for 27.08KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 40.58% rectangular shape of opening column are minimum capacity is 26.07% as compare to normal specimen.

❖ **1500 mm Length of Castellated Column**

In the 1500 mm length castellated column the maximum decrease in load carrying capacity is 55.194KN and minimum for 37.48KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 66.53% rhombus shape of opening column are minimum capacity is 37.23% as compare to without opening specimen.

❖ **1600 mm Length of Castellated Column**

In the 1600 mm length castellated column the maximum decrease in load carrying capacity is 27.67KN and minimum for 9.63KN as compare to normal Specimen. Result is conclude that hexagonal shape of opening in castellated column are maximum decrease in capacity is 37.17% rectangular shape of opening column are minimum capacity is 10.42% as compare to without opening specimen.

✓ **Load Deflection Curve**

- Load deflection of without opening column are maximum deflection is 10.2 mm and ultimate load is 102.12 KN. In this result load carrying capacity decrease also increase in deflection.
- Load deflection of square opening column are maximum deflection is 12.8 mm and ultimate load is 82.882KN. In this result load carrying capacity decrease also increase in deflection.
- Load deflection of circular opening column are maximum deflection is 12.3 mm and ultimate load is 80.696KN. In this result load carrying capacity decrease also increase in deflection.
- Load deflection of rectangular opening column are maximum deflection is 11.9 mm and ultimate load is 92.487KN. In this result load carrying capacity decrease also increase in deflection.
- Load deflection of pentagon opening column are maximum deflection is 10.8 mm and ultimate load is 80.851KN. In this result load carrying capacity decrease also increase in deflection.
- Load deflection of rhombus opening column are maximum deflection is 13.5 mm and ultimate load is 90.103KN. In this result load carrying capacity decrease also increase in deflection.

Load deflection of hexagonal opening column are maximum deflection is 11.9 mm and ultimate load is 74.15KN. In this result load carrying capacity decrease also increase in deflection.

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