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Finite Element Analysis of Castellated column with and without stiffener

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Abstract - Utilization of steel as structure material is done from old age. Steel gives various advantages with respect to concrete structure like speedy work, low cost etc. Researchers and academician continuously doing work and research on steel to improve performance and cost effective ness of section. Hollow flange Perforated web are example are of this research. Practice of providing web opening is done from and studies from age of 1940. Many researchers have contributed to this idea. In castellated section depth of section is increased without increasing section weight which provided good moment of inertia and slenderness ration which increases strength of section, But much research is concentrated to utilization of castellated section as beam only in this paper attempt was made to study effect of axial load on castellated column. It was found that maximum stress developed at section where depth of opening are large so to overcome this problem and strengthen these cross section stiffener are provided and effect of stiffener on stress and deformation is studies.

***Key Words*:** Stiffener , Castellated Column,

1.INTRODUCTION *(Size 11, Times New roman)*

Steel structure possess various advantages over other construction material like high tensile strength , high strength to weight ration can be easily fabricated , very flexible , relatively cheap as compare to other construction material and most important steel section can fabricated off site and can be erected on site easily. From 1940 many researchers are working on steel structure and take effort to make structure more effective and efficient. D. Kerdal 1984 studied failure modes of castellated beam. K.F. Chung 2001 investigates Vierendeel mechanism in steel beams with circular web openings using analytical and numerical studies. A. Kaveh 2016 studied castellated beams using tug of war optimization algorithm and solve problem of assessment of robustness and efficiency. Ashraf M. Abou-Rayan 2020 try to strengthen I beam with hollow tubular flange. Kaustubh V Raut 2020 et. Al. studied flexural behavior of light steel beam with stiffening arrangement. Samadhan G. Morkhade et al 2020, 2021 studied behavior of castellated beam with and without providing stiffener and found that by providing stiffener 40 % strength of beam can be increased. Steel structure also used as column and many researcher has contributed toward study of steel, lite steel as column. Young Bong Kwon et al 2009 carried out compression tests on channel cold-formed section with and without intermediate stiffener fabricated with high yield strength steel. Fan Shenggang et al. 2014 studied Capacity of stainless steel lipped C-section stub column under axial compression. But from this research it was found that study of castellated section or perforated web section as column is not carried out intensively. Wei-bin Yuan 2014 study simply supported castellated columns and gives analytical solution for calculating the critical buckling load of when they buckle about the major axis. As till date use of castellated section as column is not studied intensively in this paper attempt was made to do analytical study of castellated section as column.

Experimental study

For analytical this study Standard I section of ISMB 100 is taken and converted into castellated section as shown in fig.1. Dimension of standard I section and dimension of section after converting in to castellated section as shown in fig

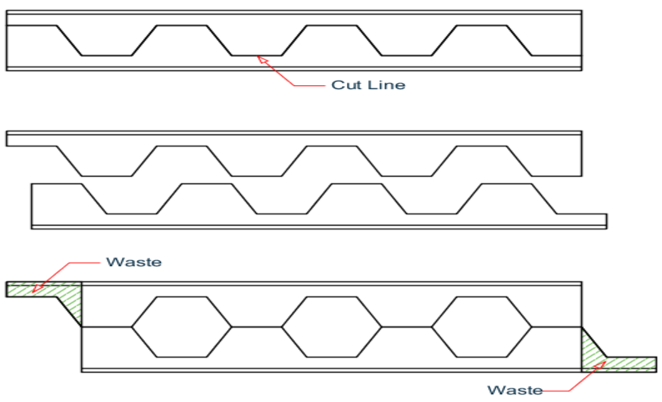

Fig. 1 Procedure of Conversion of standard I section into Hexagonal Castellated section.

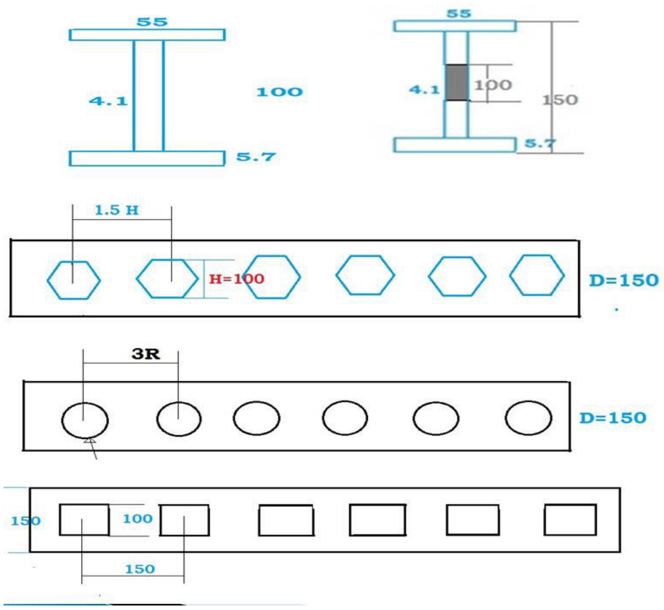

Fig. 2 Dimension of standard ISMB 100 dimension after corrugation

The standard material properties of steel have been considered in the analysis (yield strength σy = 250 N/mm2, ultimate strength σu = 410 N/mm2, modulus of elasticity E = 210 GPa, strain hardening modulus ET = 5000 N/mm2 and Poisson's ratio

μ = 0.30). For column at bottom fix support and top pin support is provided. Axial load at center was applied as shown in Fig. 3.

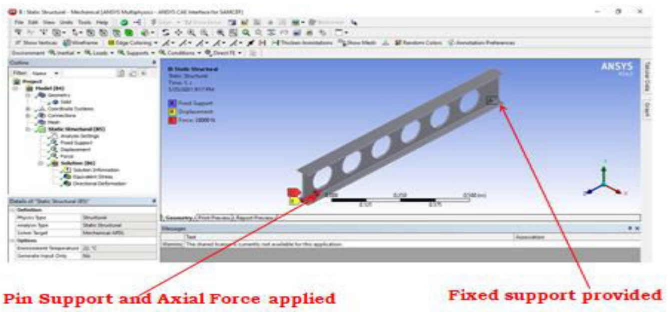

Fig. 3 support and load provided on section.

Initially load of 10 kN. Is applied and deformation and maximum stress was noted down. To determine maximum load carrying capacity point load were maximum stress goes beyond 250 MPa in noted as yield strength of section. After analysis of section without stiffener cross section where maximum stress/maximum deformation is generate is found and stiffener of 5mm thickness plate is provided to check effect of stiffener on strength deformation and stress generate in section.

Stress developed in Circular opening section

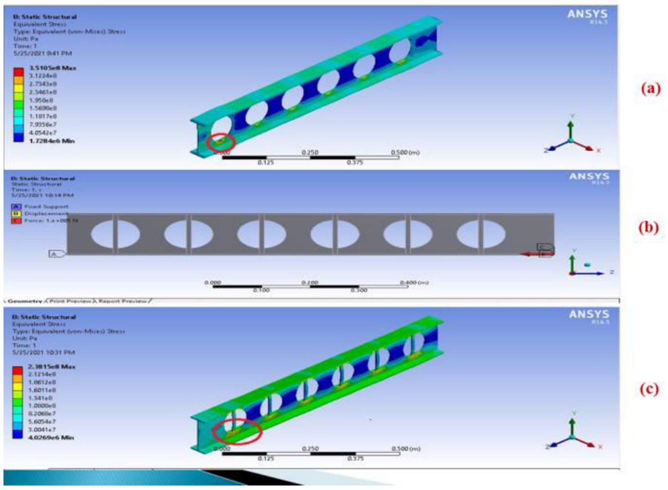

Fig. 4 stress developed and stiffener provided for circular opening section

In fig 4.a it can be observed that at cross section where net cross section area is less and opening is large stress developed at that cross section is large so stiffener provided at that cross section. Still stress developed at that section is maximum but reduced drastically. Location of stiffener provided can be observed in fig 4.b and effect can be of stiffener can be observed in fig. 4 c.

From fig 5 a stress development pattern can be observed and location of stiffener and stress pattern after providing stiffener can be observed

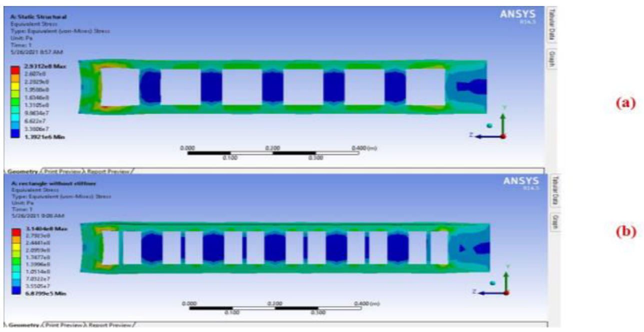

Fig. 5 stress developed in rectangular opening column without and with stiffener

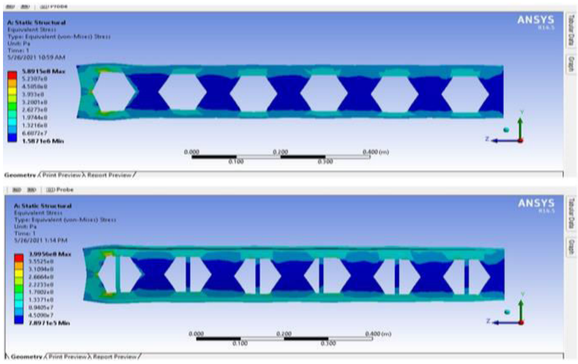
(a)
(b)

Fig. 6 stress developed in hexagonal opening column without and with stiffener

Results obtained from analytical study are as below. Point when maximum stress goes beyond 250 MPa load is considered as yield load. This result of yield strength as below.

Table -1: Result of yield strength

C	CWS	H	HWS	R	RWS
71	107	41	50	84	80

Table -1: Deformation corresponding to loading

LOAD (KN)	DEFORMATION (10^-3 mm)					
	Circular opening		Hexagonal opening		Rectangular opening	
	Without stiffener	With stiffener	Without stiffener	With stiffener	Without stiffener	With stiffener
20	1.0843	0.0160	1.1617	0.0327	1.1294	0.0628
30	1.6260	0.0241	1.7426	0.0490	1.6941	0.0265
40	2.1687	0.0322	2.3234	0.0654	2.2587	0.0354
50	2.8708	0.0403	2.9043	0.0818	2.8234	0.0442
60	3.2530	0.0483	3.4852	0.0981	3.3881	0.0531
70	3.7920	0.0564	4.0666	0.0114	3.9528	0.0619
80	4.3373	0.0644	4.6469	0.0130	4.5175	0.0708
90	4.87	0.0	5.22	0.01	5.082	0.079

	95	725	78	47	2	6
100	5.4217	0.0805	5.8086	0.0163	5.6469	0.0885

Table -3 Stress corresponding to loading is below

Load (kN)	Stress (MPa)					
	Circular opening		Hexagonal opening		Rectangular opening	
	Without stiffener	With stiffener	Without stiffener	With stiffener	Without stiffener	With stiffener
20	70.211	47.63	117.83	99.89	58.62	62.80
30	105.32	71.445	176.75	149.84	87.93	94.21
40	140.42	95.26	235.66	199.78	117.25	125.62
50	175.73	119.08	294.58	249.732	146.56	157.02
60	210.63	142.89	353.49	299.67	175.87	188.43
70	245.74	166.71	412.41	349.62	205.18	219.83
80	280.84	190.52	471.32	399.56	234.49	251.23
90	315.95	214.34	530.24	449.51	263.81	282.64
100	351.05	238.15	589.15	499.55	293.12	314.40

Graphical representation of yield strength of section will be as below

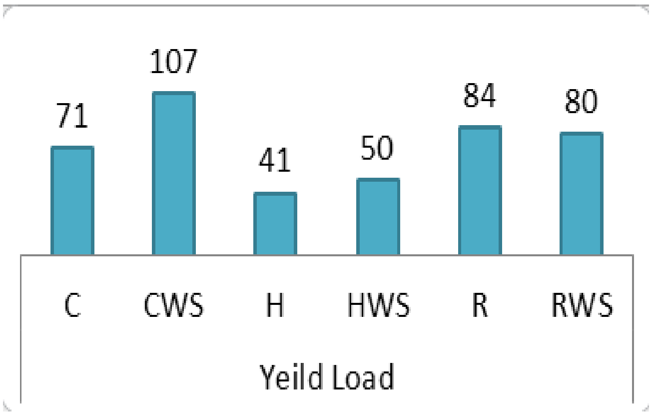

Fig. 7 Graphical representation of yield strength

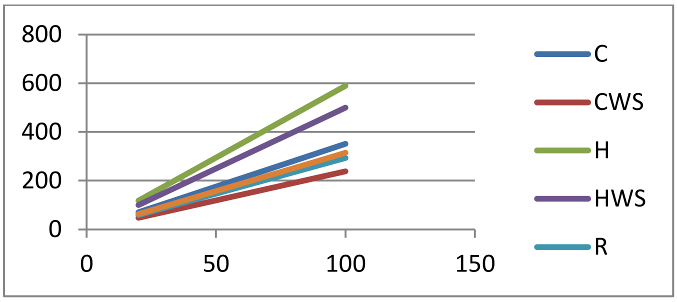

Fig 8 Graphical representation of stress vs load

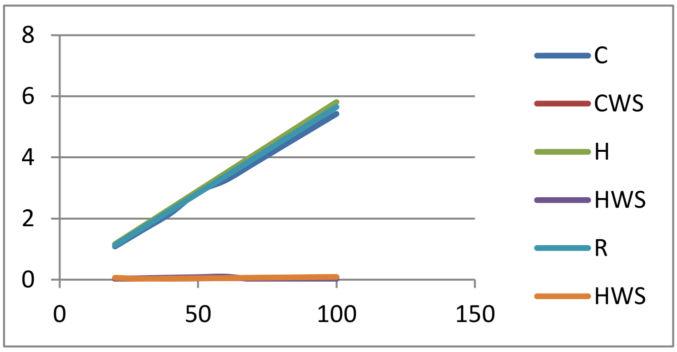

Fig 9 Graphical representation of stress vs load

CONCLUSION:

FEM study was performed to study the effect of shape and stiffener on a castellated column. From an analysis of the result following conclusion can be drawn

1.

a) Stress developed in a circular section is 40 % less as compare to hexagonal section and in rectangular section 50 % less as compare to hexagonal section.

b) Maximum Deformation in the circular opening section is 6.66 % less as compared to the hexagonal section and 2.87 % less as in the rectangular section.

2. Yield strength of Circular shape of the section is more as compared to other section and hexagonal shape of opening provide least strength. Normally rectangular and hexagonal shape of the opening failed at a vertex.

3. In the circular section stiffener increases strength by 32.68 % in hexagonal opening strength increases by 17 % and in the rectangular opening, stiffener increases strength by 19.46 %.

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