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Analysis of Steel Beam with Web Openings Subjected To Buckling Load

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ABSTRACT
As we know that, due to limitations on maximum allowable deflection. The high strength properties of structural steel cannot always be utilized to best advantage. As a result several new methods have been aimed at increasing the stiffness of the steel members without any increase in weight of the steel required. Steel beams with web opening are combine beauty, versatility, economy in steel design. These are mainly designed to reduce weight and at the same time increase the efficiency in structural performance. The principle advantage of castellation is the increase in vertical bending stiffness. Beam with web opening have proved to be efficient for moderately loaded longer span where the Design is controlled by moment capacity or deflection. In this paper a steel beam is selected and is analyzed for different loading and support condition by using Ansys Software. The deflection pattern at the Center distance of the beam is studied for different parametric condition by same depth of web opening to the depth of beam ratio and also for various combinations of shapes of opening.
Keywords: Web Opening, support Condition.

I. Introduction

Steel beam with web opening are combine beauty versatility, economy in steel design. These are fabricated from standard rolled section & are engineered to save time of construction. Many attempts have been made by Structural Engineers to find way to decrease the cost of steel structures.[1] Due to limitation on maximum allowable deflection the high strength properties of structural steel cannot always be utilized to best advantages. As a result several new methods have been aimed at increasing the stiffness of steel members without any increasing in weight of the steel required. Beam with web opening were one of these one solution. The shape of the web opening will depend upon the designer's choice & the purpose of the openings. The scope of study deals with Aspect ratio, Deformation characteristics, Load caring capacity and Buckling load on beam. The introduction of an opening in the web of the beam alters the stress distribution within the member and also influences its collapse behavior. Thus, the efficient design of beams and plate girder sections with web openings has become one of the important considerations in modern structures.

Application of beams with web openings Steel beams with web opening find wide use in light to medium construction and medium to long spans. They are used in structures like commercial and industrial building, warehouse and portal frames.

These are also used in cranes, crane girders, towers, secondary members and deck stiffeners in bridges.

These beams are effectively uses as ring beams in pressure vessels and storage tanks, under-carriages of railway wagons and as light duty automobiles chassis frames.

These beams can also be used for platforms and temporary structures for off shore sores and for marine oil drilling rig etc.

Figure1.1 Application of beams with web openings [2]

II. Methodology

ANSYS Workbench provides an excellent platform for analysis of various structural systems. ANSYS Workbench easily modeled steel beam and steel beam with web opening using the geometry modeler in ANSYS Workbench. Present study focuses on the calculation of buckling load on steel beam by various sizes of beam and providing the web opening on the beam using ANSYS Workbench software. Based on the results of ANSYS Workbench.

2.1 Finite element method (Ansys) – analysis

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Although originally developed to study stresses in complex airframe structures, it has since been extended and applied to the broad field of continuum mechanics. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and in industry.[3] The resourcefulness of the analyst usually comes to the rescue and provides several alternatives to overcome this dilemma. One possibility is to make simplifying assumptions to ignore the difficulties and reduce the problem to one that can be handled. Sometimes this procedures works; but, more often than not, it leads to serious inaccuracies or wrong answers. Now that computers are widely available, a more viable alternative is to retain the complexities of the problem and find an approximate numerical solution. [4]

2.2 Steps Followed while Analysis of Beam with and without web openings

A finite element model of a simply supported ISMB 300 of actual span length 5.0 m and a pressure of 20 Pa acting on the beam is shown in figure. Material properties are given in table.

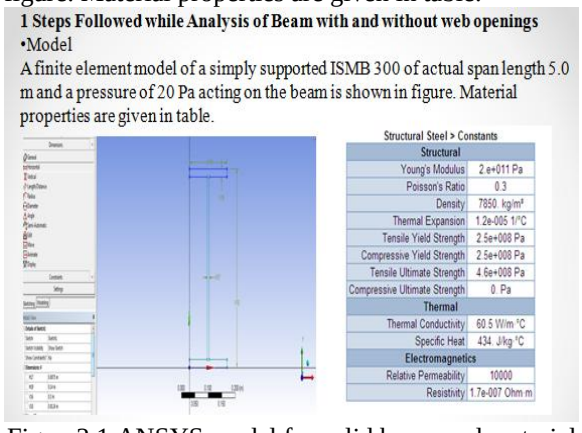


Figure2.1 ANSYS model for solid beam and material properties

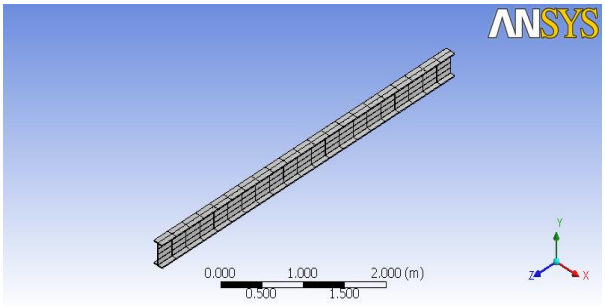


Figure 2.2 Meshing ISMB 300

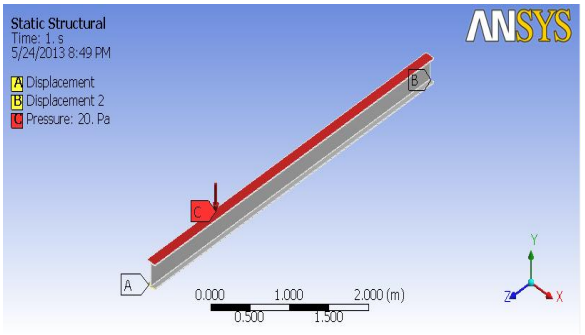


Figure2.3 load acting on the beam and support condition [5]

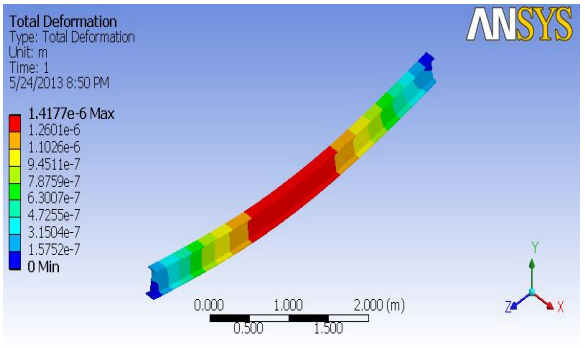


Figure 2.4 Total Static Deformations

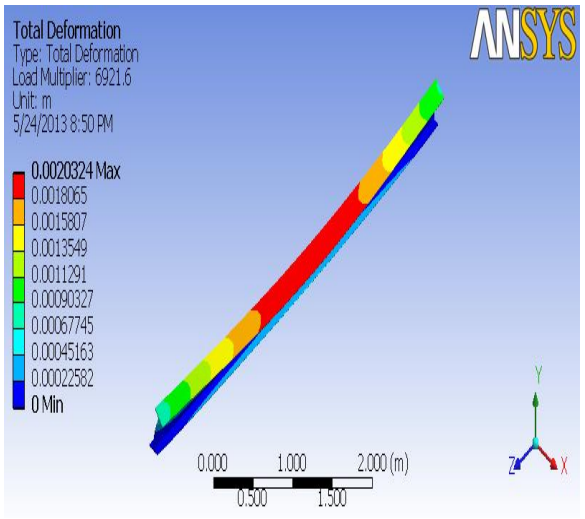


Figure 2.5 Total Buckling Deformation and load Multiplier[6]

III. Figures and Tables

Steel beam of ISMB 300 of span 5m acting 20N/m^2 pressure on it, having circular, hexagonal and square web opening of restrained, unrestrained and simply supported condition having d/d ratio 0.5. Fig. 3.1 shows different end conditions of beam. Table 3.1, Table 3.2 and Table 3.3 shows ISMB 300 for 20n/m^2 pressure on it having restrained, unrestrained and simply supported condition for circular, *square and hexagonal* opening [7]

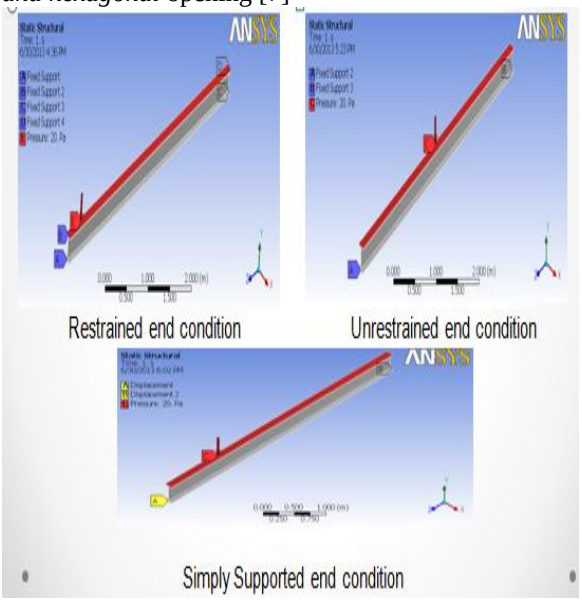


Figure 3.1 Different end conditions of beam

Table 3.1 ISMB 300 for 20N/m^2 pressure on it having restrained, unrestrained and simply supported condition for *circular* opening.

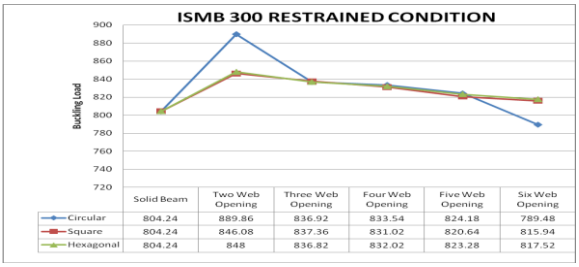
S.N.	Section	Restrained Condition		Unrestrained Condition		Simply Supported Condition	
		Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)
	1	2	3	4	5	6	7
1	Solid Beam	3.391 ×10^{-7}	804.24	7.716×10^{-7}	142.1	1.417×10^{-6}	138.42
2	Two Web Opening	3.356 ×10^{-7}	889.86	7.798×10^{-7}	177.456	1.422×10^{-6}	172.84
3	Three Web Opening	3.336 ×10^{-7}	836.92	7.228×10^{-7}	159.88	1.345×10^{-6}	156.16
4	Four Web Opening	3.523 ×10^{-7}	833.54	7.993×10^{-7}	151.76	1.434×10^{-6}	148.25
5	Five Web Opening	3.554×10^{-7}	824.18	8.088×10^{-7}	150.68	1.438×10^{-6}	147.27
6	Six Web Opening	3.664 ×10^{-7}	789.48	7.599×10^{-7}	151.89	1.375×10^{-6}	148.73

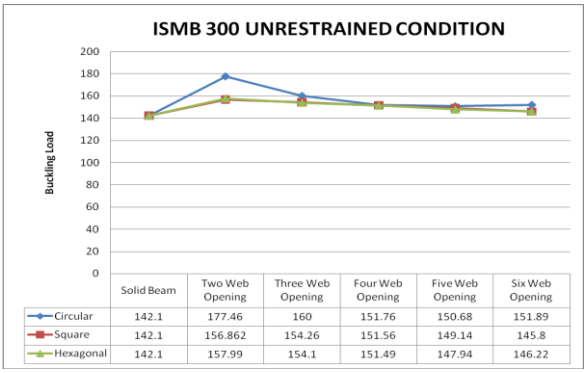
Table 3.2 ISMB 300 for 20n/m^2 pressure on it having restrained, unrestrained and simply supported condition for *square* opening [8]

S.N.	Section	Restrained Condition		Unrestrained Condition		Simply Supported Condition	
		Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)
	1	2	3	4	5	6	7
1	Solid Beam	3.391×10^{-7}	804.24	7.716×10^{-7}	142.1	1.417×10^{-6}	138.42
2	Two Web Opening	3.466×10^{-7}	846.08	7.898×10^{-7}	156.82	1.431×10^{-6}	153.04
3	Three Web Opening	3.563×10^{-7}	837.36	8.068×10^{-7}	154.26	1.440×10^{-6}	150.79
4	Four Web Opening	3.678×10^{-7}	831.02	8.211×10^{-7}	151.56	1.454×10^{-6}	148.11
5	Five Web Opening	3.763×10^{-7}	820.64	8.342×10^{-7}	149.14	1.463×10^{-6}	145.88
6	Six Web Opening	3.885×10^{-7}	815.94	8.494×10^{-7}	145.80	1.476×10^{-6}	142.70

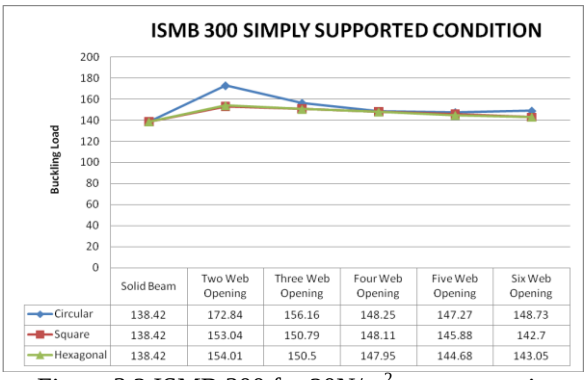
Table 3.3 ISMB 300 for 20N/m^2 pressure on it having restrained, unrestrained and simply supported condition for *hexagonal* opening.

S.N.	Section	Restrained Condition		Unrestrained Condition		Simply Supported Condition	
		Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)	Static deflection (m)	Buckling load (KN)
	1	2	3	4	5	6	7
1	Solid Beam	3.391×10^{-7}	804.24	7.716×10^{-7}	142.1	1.417×10^{-6}	138.42
2	Two Web Opening	3.428×10^{-7}	848	7.848×10^{-7}	157.99	1.425×10^{-6}	154.01
3	Three Web Opening	3.484×10^{-7}	836.82	7.956×10^{-7}	154.10	1.430×10^{-6}	150.50
4	Four Web Opening	3.541×10^{-7}	832.02	8.045×10^{-7}	151.49	1.438×10^{-6}	147.95
5	Five Web Opening	3.585×10^{-7}	823.28	8.140×10^{-7}	147.94	1.444×10^{-6}	144.68
6	Six Web Opening	3.647×10^{-7}	817.52	8.231×10^{-7}	146.22	1.451×10^{-6}	143.05





	Solid Beam	Two Web Opening	Three Web Opening	Four Web Opening	Five Web Opening	Six Web Opening
Circular	142.1	177.46	160	151.76	150.68	151.89
Square	142.1	156.862	154.26	151.56	149.14	145.8
Hexagonal	142.1	157.99	154.1	151.49	147.94	146.22



	Solid Beam	Two Web Opening	Three Web Opening	Four Web Opening	Five Web Opening	Six Web Opening
Circular	138.42	172.84	156.16	148.25	147.27	148.73
Square	138.42	153.04	150.79	148.11	145.88	142.7
Hexagonal	138.42	154.01	150.5	147.95	144.68	143.05

Figure 3.2 ISMB 300 for 20N/m^2 pressure on it having Restrained, Unrestrained and Simply Supported Condition for circular, square and hexagonal opening.

IV. Conclusion

The Buckling load Analysis and deflection calculation of different section of beams with different support condition and different loadings with circular, square and hexagonal web openings is done and the results obtained are:

- If the section of beam increases buckling load will also be increases and it will be decreases as the web opening are provided in the section.
- Value of buckling load is nearer same for square and hexagonal web opening of same section of beam but different for circular web opening of the same section.
- Value of buckling load is nearer same for Unrestrained and simply supported end condition but higher in Restrained end condition for same section of beam.
- If number of web opening in the beam is increases buckling load will be decreases.
- If number of web opening in the beam is increases deflection of beam will also be increases.
- Cellular beam subjected to mid span concentrated load provide higher moment carrying capacity than those supporting uniformly distributed loadA conclusion might elaborate on the importance of the work or suggest applications and extensions.

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