International Journal on Recent Researches in Science, Engineering & Technology (IJRRSET)

A Journal Established in early 2000 as National journal and upgraded to International journal in 2013 and is in existence for the last 10 years. It is run by Retired Professors from NIT, Trichy. Journal Indexed in JIR, DIIF and SJIF.

Research Paper

Available online at: www.jrrset.com

ISSN (Print) : 2347-6729
ISSN (Online) : 2348-3105

Volume 7, Issue 4
April 2019.
JIR IF : 2.54
SJIF IF : 4.334
Cosmos: 5.395

Received on: 04.04.2019 Published on: 28.04.2019 Pages : 58 - 63

STUDY AND ANALYSIS OF CONNECTING POSITION ON THE VIBRATION CHARACTERISTICS FOR BEAM

M.Sathyaseelan[1], M.Mohammed Shafeeque[2], A.K.S.Ansari[3]

[1]Assistant Professor, [2] Assistant Professor, [3]Associate Professor

Department of Mechanical Engineering, Dhanalakshmi Srinivasan College of Engineering, Coimbatore.

ABSTRACT

This study proposes an investigation into the effect of stiffeners where local stiffness varies on the vibration characteristics of I beams. The main focus is to finding out the proper perforation for reducing the deflection that is caused by vibration characteristic of the beam. Based on the study, considering a castellated beam with hexagonal opening is taken as an example to locating the stiffeners where the local stiffness is reduced in the beam. The castellated beam with web openings and they gain its advantage due to its increased depth of section by cutting the beam into two pieces and welded it together to make hexagonal web openings. Hence, due to increase in depth of beam, variable load carrying capacity of the beam is getting increased. The increase in depth of castellated beam leads to local residual stresses in web openings and lateral torsional buckling failure when these beams are subjected to loading. There are many modes of failure like shear buckling, flexural failure, and rupture of the welded joint in a web post. In order to avoid all these failures stiffeners were introduced in the hexagonal castellated beam.

I.INTRODUCTION

Beams are very common types of structural components and it can be classified according to their shapes of uniform or taper and slender or thick. If practically analyzed, the non-uniform beams provide a better distribution of mass and strength than uniform beams and can meet special functional requirements in architecture, aeronautics, robotics, and other innovative engineering applications. Design of such structures is important to resist dynamic forces, such as wind and earthquakes. It requires the basic knowledge of natural frequencies and mode shapes of those structures. Design of such structures to increase the resistance to earthquakes and wind, requires a knowledge of their natural frequencies and the mode shapes of vibration.

A. Castellated beam

A castellated beam is a beam style where can I beam is subjected to a longitudinal cut along its web following a specific pattern in order to divide it, and reassemble the beam with a longer web by taking advantages of the cutting pattern. However presence of web openings which causes to various local effects likes residual stress and shear, which causes out-of plane deformations and constitutes the first source of torsional stiffness for these cross-section types.

B. Fabrication of castellated beam

Castellated beam is made by separating a standard rolled shape into two halves by cutting the web in a regular alternating pattern as shown. The halves are rejoinder by welding, after offsetting one portion so that the high points of the web pattern come into contact. Some design conditions make it advantageous to increase the depth even more. This is done by adding web plates between high points of the tee sections. These added plates are called increment plates.

C. Castellated beam with hexagonal opening

Use of castellated beam with hexagonal opening is very common in recent years because of the simplicity in its fabrication. Castellated beams are fabricated by cutting flange of a hot rolled steel I beam along its center line and then welding the two halves so that the overall beam depth gets increased for more efficient structural performance against bending.

D. Castellated hexagonal beam with stiffeners

Stiffener are those secondary plates which are used to attached with beams along the longitudinal, transverse and along the edge of opening But if the castellated beams are subjected to concentric loading in such case castellated beam prove to be inappropriate. In such cases castellated beams must be reinforced at the places where these load concentrations occur. For example by inserting plates called as stiffeners, into one or more of the web openings by additional fitting and welding work.

II.REVIEW FROM PREVIOUS STUDY

In recent times, analysis and design of castellated beam has been carried out by research work, especially with hexagonal openings. There is no universally accepted design method for castellated beam because of complexity in geometry accompanied by complex mode of failure. At present, there are possibly six failure modes of castellated beam namely, formation of flexure mechanism, lateral torsional buckling, formation of Vierendeel mechanism, rupture of welded joint, shear buckling of web post and compression buckling of web post. Various research studies carried out for analysis and design of castellated beams are presented in the following section.

The load carrying capacity of optimally designed castellated beam with various numbers of holes and spacing. Finite element analysis of same beams is also carried out under the application of centrally applied point load and failure patterns are studied and verified using ANSYS. Study shows that, even though the members are relatively of shorter spans, lateral supports are governing factor for the analysis of beams due to torsional buckling. It is concluded that, the beam fails in Vierendeel mode when the load is applied above the openings while it fails in web post buckling when load is applied in between space of the openings [1].

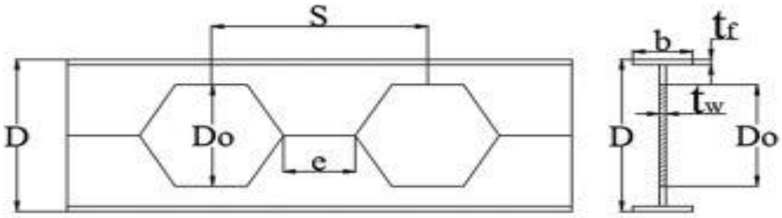

Fig 1- typical cross section of a beam

Where,

Do	=	Depth of opening provided.
D	=	Overall depth of the opening.
S	=	C/C spacing between the two opening
e	=	Clear distance between two opening
b	=	Width of flange of I beam
tf	=	Thickness of flange of I beam
tw	=	Thickness of web of I beam

A. Guidelines for Perforations in Web

The perforations made in the beam plays a vital role in structural performance of the beam. Therefore, some logical and practical considerations need to be observed while providing perforations in the beam. Following are the general guidelines based on the field or practical considerations.

1. $1.08 < S/Do < 1.5$
2. $1.25 < D/Do < 1.75$
3. $Do \leq 0.8\ D$
4. $e \leq 0.4\ Do$
5. Width of end post $\leq 0.5Do$
6.

III.DESIGN OF CASTELLATED BEAM

In this section, design standards provided by universal beam (UB) for designing of castellated beam are illustrated.

a) Moment (flexural) capacity of the beam

In this check, we have to ensure that maximum moment induced in the beam due to external loads should be less than moment capacity of the upper and lower Tee.

$$M_u < M_{pTee}$$
$$M_{pTee} = A_{Tee} \times P_y \times z$$

Where,

M_u = Maximum moment induced in the beam as per loading conditions.

Mp_{Tee}= Moment capacity of the upper or lower Tee.

A_{Tee}= Area of upper or lower Tee.

Py = Yield stress of steel.

z = Lever arm (Distance between the centroid of upper and lower Tee).

b) Shear Capacity of the Beam

Maximum horizontal and vertical shear induced in the beam due to external loading should be less than horizontal and vertical l shear capacities of the beam respectively.

$$V_{vmax} < P_v$$
$$P_v = 0.6 \times P_y \times A_v$$
$$V_{vmax} = P_{vh}$$
$$P_{vy} = 0.6 \times 0.9 \times A_{wt}$$
$$V_{Hmax} < P_{vh}$$
$$P_{vh} = 0.6 \times P_y \times A_{mwt}$$
$$V_H = T_{i+1} - T_i$$

Where,

V_{max}= Maximum vertical shear.

H_{max}= Maximum horizontal shear.

P_v= Shear strength of castellated beam.

A_v= Shear area (shear area of whole cross section)

P_{vy}= Vertical shear capacity.

A_{wt}= Shear are of Tee

P_{vh}= Horizontal shear capacity.

A_{mwt}= Horizontal shear area = e × tw

V_H= Horizontal shear.

T = Axial load at different point.
M = Bending moment at different point

c) Vierendeel bending of Tee

Vierendeel bending moment of the lower or upper Tee should be less than the local bending resistance of respective Tee.

$$M_{pTeeLocal} = \frac{A_{tee} \times P_y \times z_{tee}}{2}$$

$$M_{pv} = V_{max} \times l_{eff}$$

Where,
$M_{pTeeLocal}$ = Bending resistance of Tee of beam.
M_{pv}= Vierendeel bending moment.
l_{eff}= Effective length of opening.
Effective length of opening is depends on the type of opening provided.

d) Fracture in welding

Strength of weld should be more than maximum horizontal shear force in the section,

Shear strength of the weld > V_{hmax}

e) Deflection Check

Deflection of beam is calculated as per standard formulae for perforated depth of the beam. Additional deflection due to openings is obtained by adding 25% to 35% deflection in above calculated deflection.

Sr. No.	Do (mm)	D (mm)	D/Do	S/Do	S (mm)	e (mm)
1	115	150	1.30	1.4	182	52
2	105	145	1.38	1.4	168	48
3	95	140	1.47	1.4	154	44
4	85	135	1.58	1.4	140	40
5	75	130	1.72	1.4	126	36
6	65	125	1.92	1.4	112	32

Table-1 parameters considered for hexagonal castellated beam

Analysis of three models of plate girder without stiffener using software program. And the same model providing with three plates stiffener are evaluated. The post buckling behavior of shear web panel was explained using model called as shear analogy It was found that the transverse stiffeners are not subjected to compression force. But the strength of the intermediate transverse stiffener is very important parameter as it provides strength to the web of the beam [3].

Studied on the interaction of buckling modes in castellated beam with hexagonal opening analytically as well as experimentally. 62 models of castellated beam were developed with all nonlinear material properties in Finite Element programming software. The parametric study was extended in order to study the effects on the beam when the geometries of the specimen is changed also the length of the beam was considered [4].

IV.FINITE ELEMENT ANALYSIS OF CASTELLATED BEAM WITH HEXAGONAL OPENINGS

FEA of all castellated beams is carried out in ANSYS software to determine the optimum section which fails at greater load. The beam is modeled as 3D shell element the various dimensions of openings along with their loads, deflections by FEA and their respective deflections are given in

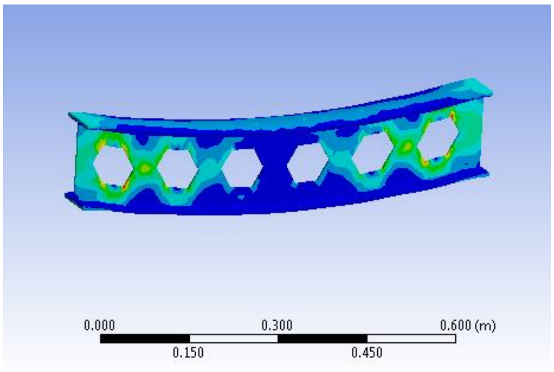

Fig 2.ANSYS analyzed model without stiffeners

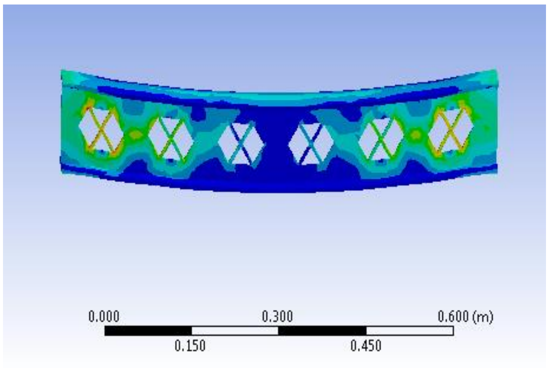

Fig 3.ANSYS analyzed model with diagonal stiffeners

V.RESULTS AND DISCUSSIONS

Sr. No.	Do (mm)	D (mm)	Load (KN)	Deflection (mm)	
				Without stiffeners	With diagonal stiffeners
1	115	150	20	0.174	0.091
2	105	145	20	0.183	0.099
3	95	140	20	0.191	0.113
4	85	135	20	0.198	0.147
5	75	130	20	0.211	0.172
6	65	125	20	0.229	0.197

Table 2. Results obtained from ANSYS for castellated beam with and without stiffeners

From the result of above analysis it is observed that the beam with diagonal stiffeners along hexagonal openings gives more satisfying results than the castellated beam without stiffeners.

VI.CONCLUSION

Study and optimization of the castellated beam is done by many researchers. From the research gap it have been concluded that study of the behavior of the castellated beam with stiffener is not yet understood. But on the other hand the day by day use of the castellated beam is increasing widely and demand of good performance of the beam under point loading is increasing. This will also give a rise to a new area of optimizing the design of stiffener. Analysis and design of castellated beam with hexagonal openings carried out by using stiffeners along the openings of the beam in order to minimize vibrational characteristics. Optimization of castellated beams with stiffeners by varying the parameters namely, size and positions in web portion is obtained.

VI.REFERENCES

[1]Jamadar A. M.1, Kumbhar P. D.2 1 PG Scholar, Department of Civil engineering, RIT Islampur, Maharashtra, India

[2]Siddheshwari. A. Patil1, Popat. D. Kumbhar2 1PG Scholar, Department of Civil Engineering, RIT Rajaramnagar, Maharashtra, India 2 Associate Professor, Department of Civil Engineering, RIT Rajaramnagar, Maharashtra, India

[3]B.Anupriya and Dr. K. Jagadeesan, “Strength Study on Castellated Beam”, International Journal on Engineering Research & Technology, Vol.2, pp 3853-3859. 2013.

[4]Konstantinos Daniel Tsavdaridis and Grigorios Galiatsatos, “Assesment of Cellular Beams with Transverse Stiffeners and Closely Spaced Web Openings”, Thin-Walled Structures, vol.94, pp 636-650. 2015.

[5]Indian Standard code of practices for General construction in steel, IS 800-2007, third revision, bureau of Indian standards.