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Static and Dynamic Analysis of Cellular Beams

C.Rajendra Prasath, P.M.Dhureen Karthik, P.Muthanand

Abstract — Utilization of castellated beam has become extremely well known nowadays because of its beneficial auxiliary applications. The chief preferred position of castellated beam is increment in vertical twisting solidness, simplicity of administration arrangement and appealing appearance. Anyway one outcome of essence of web opening is the advancement of different neighborhood impacts. This is because of expanded profundity of area with no extra weight, High solidarity to weight proportion, their lower upkeep and painting cost. In this work steel I area was chosen. To break down the static and dynamic conduct of castellated steel beams having different openings were displayed by limited component programming bundle ABAQUS 6.14. Investigation was completed on the beams with consistently circulated burden and their closures are essentially bolstered. The avoidance at focus of beam different disappointment examples are examined. In this investigation of castellated beam having different web openings are dissected by ABAQUS (Finite component analysis).From the Finite component examination results compelling model is recognized.

Keywords — ABAQUS Castellated beam, Circular opening, Finite Element Modelling.

I. INTRODUCTION

CASTELLATED BEAM

Castellated beams are assortments of supports with commonly roundabout or hexagonal web openings, appropriated along the beams with customary interims. The way toward assembling castellated beams, by cutting the web in crisscross example along its centerline and afterward rejoining the two parts by welding, leads into an expansion in bowing limit and a decrease of the heaviness of the beam enabling this sort of beams to be utilized for medium to long traverses developments. For the most part, steel areas fulfill quality prerequisite, the trouble is that, segment need to fulfill functionality necessity for example avoidance criteria in security check. This requires the utilization of beams with more prominent profundity to fulfill this prerequisite. Utilization of castellated beams is the best answer for conquered this trouble. The beams with roundabout openings are called as cell beams. The benefit of utilizing such beams is that it causes decrease in all out weight of the structure and henceforth requires less amount of steel.

ADVANTAGES OF CASTELLATED BEAM

Castellated steel beams fabricated from standard hot-rolled

I-sections have many advantages including

- Greater bending rigidity
- Larger section modulus
- Optimum self-weight–depth ratio
- Economic construction

TERMINOLOGY IN CASTELLATED BEAM

Before going to see the structure norms for castellated beam it is imperative to comprehend the some of fundamental wordings utilized in the plan of castellated beam, these terms are shown in the accompanying

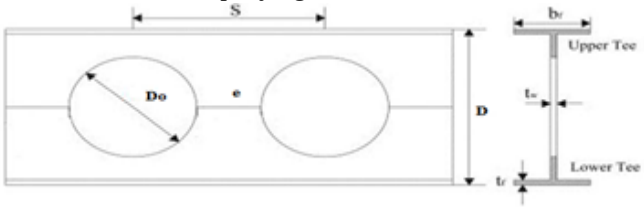

Figure 1: Typical cross section of the beam

Where,
D = Depth of opening.
S = Centre to Centre spacing between the openings
e = Clear distance between the openings
b = Flange width
tf and tw = Flange and web thickness of I beam

II. PRESENT STUDIES AND THEORIES

From the accompanying diaries we removed the center topic of the examination. Parcel of examination had been done in the territory of castellated beam yet roundabout opening is not very many .They tried progressively number of beams with various size of opening, for example, hexagonal, jewel, and so forth, for finding the beam is in safe in redirection under different bowing tests. There is no all around acknowledged plan technique for castellated beam as a result of unpredictability in geometry joined by complex method of disappointment. At present, there are potentially six disappointment methods of castellated beam in particular, development of flexure system, horizontal torsional clasping, arrangement of Vierendeel instrument, break of welded joint, shear clasping of web post and pressure clasping of web post.

Peijun Wang et al (2016)

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Shear fastening practices of web-post in a Castellated Steel Beam (CSB) with hexagonal web openings under vertical shear were investigated using constrained segment method. Differentiated and the solid web steel pillar, the CSB may bomb in new modes, for instance, the improvement of plastic turns at parts of the deals portions above and underneath the web opening [1]–[3], and the catching of the web post under vertical shear control [4]. Constrained segment reenactment results showed that the closeness of web distortional catching caused a noteworthy decreasing in the failure stack of the dainty CSB.

Ismail .R. E. S (2015)

An effective nonlinear 3D limited component model has been created utilizing ABAQUS programming mulling over the underlying geometric flaw and material nonlinearities, and the outcomes were contrasted and distributed exploratory information, where a decent understanding was found in both flexible and plastic extents. Expanding the web thickness leads by and large to an expansion in a definitive burden, the underlying firmness, and the malleability for the beams that its disappointment is administered by clasping, so it tends to be a powerful instrument for upgrading the conduct of the beams.

B.Anupriya, Dr.K.Jagadeesan (2014)

Examination conduct of shear quality of castellated beam with and without stiffeners. They gain its bit of leeway because of its expanded profundity of area with no extra weight. Anyway one outcome is the nearness of web opening which prompts different neighborhood impacts like shear and miss happening. The beam is broke down utilizing Finite Element Analysis (ANSYS 14).Two point burdens is applied and stress dissemination is contemplated. Stress focus increments at the gap corners along the shear zone and at load application point. Diversion of the beam with and without stiffeners is examined. From the outcomes got from ANSYS14 it is presumed that shear quality of castellated beam can be improved by giving corner to corner stiffeners along the web opening.

Peijun Wang et al (2014)

The fastening modes and catching cutoff of the web-post in the castellated pillar with filet corner hexagonal web openings are differentiated and those having indirect and extended indirect openings. The effects of the opening detachment, the opening stature, and the web thickness on the fastening behavior of the web-post are looked into. The constrained part programming ABAQUS was used to examine the kicking behavior of the web-post. The ribs and the web post were corresponded using the shell segment, S4R, in ABAQUS. A parametric examination shows that the shear furthest reaches of the web-post is affected by the opening shape, the opening estimation, the opening partition, and the web thickness.

M.R.Wakchaure, A.V. Sagade (2012)

Investigates the effect of web openings on various helper parts of castellated column, various strategies for dissatisfactions, and effect on redirection with increase in the significance of web openings are analyzed with the help of restricted segment assessment programming ANSYS 14. Significance of bar extended in methodology of castellation by 40, 50 and 60%, with hexagonal shaped openings of edge 600. Since the castellated columns are decently flimsy and have web openings, which affect their obstacle. The huge dissatisfaction techniques for castellated bars are web post fastening [1]-[2] and parallel torsional catching. The failure modes dominatingly endless supply of openings, zone of opening, length of the tee-section above and underneath the opening, opening significance, sort of opening and kind of stacking. The test testing on steel columns with web opening of various shapes and sizes was moreover finished. The Castellated steel shaft continues pleasingly as for usefulness requirements up to a biggest web opening significance of 0.6h. Castellated beams have holes in its web, which lead to close by impacts in the bars.

III. FINITE ELEMENT MODELLING

Castellated beams was modelled and analyzed y ABAQUS software is carried out and the results are verified with the results of the similar beam illustrated in Indian Standard Codes. The details of modelling and analysis was done by ABAQUS.

A. Problem Definition

In this work for castellated beams are given round molded openings. The new area with openings will have a profundity in any event half more and its segment modulus expanded by 2.25 occasions the first segment. The Castellated beam considered for displaying is gotten from Parent steel I beam (ISMB450). Consequently, the profundity of castellated beam after aperture becomes 675 mm. The diversion and consolidated hub bowing worries under Uniformly Distributed Load and considering straightforward backings at their closures are contemplated. The geometrical subtleties of the castellated beam as appeared in Fig. 2 (All Dimensions are in mm)

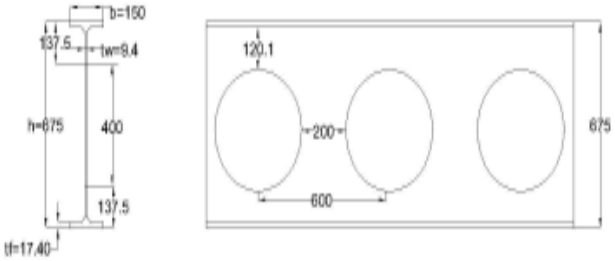

Fig 2: NCB 450 with 400 mm opening

Rolled steel section ISMB450 which is converted into a castellated section of NCB450 with circular opening having dia of 400 mm.

Span of Castellated beam = 16 m.
Type of material = Steel
Young's Modulus = 2 x 105 N/mm2
Poisson's ratio = 0.3
Self-Weight = 11.36 kN
Live load = 160 kN
Total load = 257.04 kN
Spacing of lateral beams = 4m
Using ISMB 450, flange width = 0.15m

TABLE 1: Detailing of Castellated beam

D_0(mm)	D (mm)	S (mm)	D/D_0	S/D_0
250	675	375	2.70	1.5
300	675	450	2.25	1.5
350	675	525	1.93	1.5
400	675	600	1.69	1.5

The table.1 shows that the detailing of castellated beam having various web openings (D0). Here, (S) is the Centre to Centre spacing of openings. The beam having S/D0 ratio less than 1.8 is taken into consideration. In our case all four having ratio 1.5. Hence it is ok.

B. Modelling of Castellated Beam in ABAQUS

Modelling of castellated beams was done by ABAQUS software using Solid element. The modelled castellated beams are shown in fig 3 and 4 with loading details and support conditions.

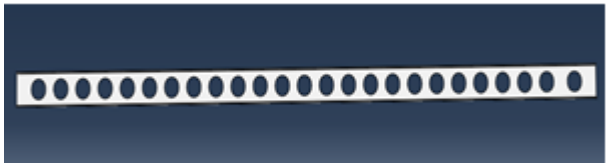

Fig. 3: Modelling of Castellated Beam

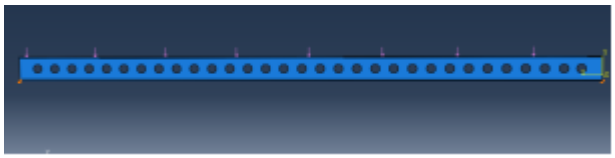

Fig.4: Loading and Support Condition

Finite Element Analysis - procedure (ABAQUS):

- Initially the required element is created in part area with its proper dimensions.
- Then properties are given with respect to the material used.
- After that they are assembled to the element.
- In order to assign the loads step is created. For static analysis step is Static General.
- Then boundary conditions and magnitude of loads are given.
- Next step is meshing the element in to number of sub elements since it is a finite element analysis.
- Final step is to create the job to run the analysis for getting the results

IV. RESULTS AND DISCUSSION

The results of the deflection and combined axial bending stresses obtained by analyzing the beam by ABAQUS software are discussed below.

A. Deflections of the beams

The values of deflections as obtained by ABAQUS software and by IS 800 are tabulated. The deflected shapes of castellated beams are represented in Fig. 4,5,6,7 and 8. The Limiting value of deflection as per formula given below:

δ = (span/240)

δ =16000 / 240 = 66.67 mm

TABLE 2: Comparison of deflection Values

Size of web Opening (mm)	Maximum Deflection of castellated beam obtained from		Limiting value of deflection as per IS 800 (mm)
	Theoretical analysis (mm)	ABAQUS analysis(mm)	
250	61.85	63.41	66.67
300	62.73	62.37	66.67
350	62.61	61.37	66.67
400	63.42	58.33	66.67

Size of web Opening (mm) Maximum Deflection of castellated beam obtained from Limiting value of deflection as per IS 800 (mm)

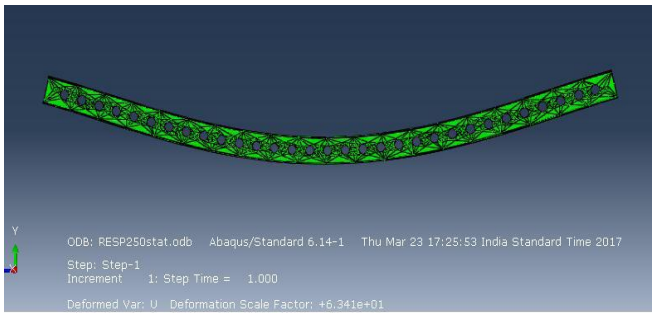

Fig. 5: Deformed shape for 250 mm Opening

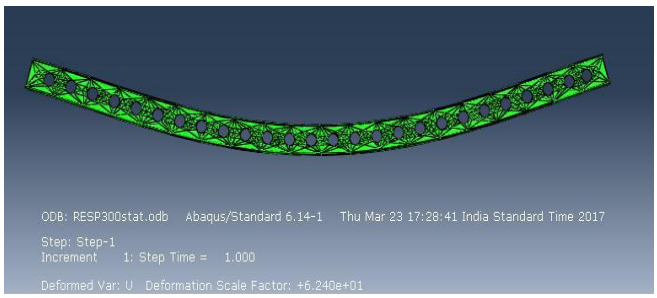

Fig.6: Deformed shape for 300 mm Opening

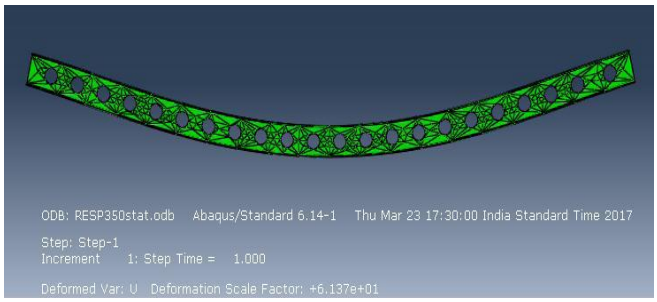

Fig.7: Deformed shape for 350 mm Opening

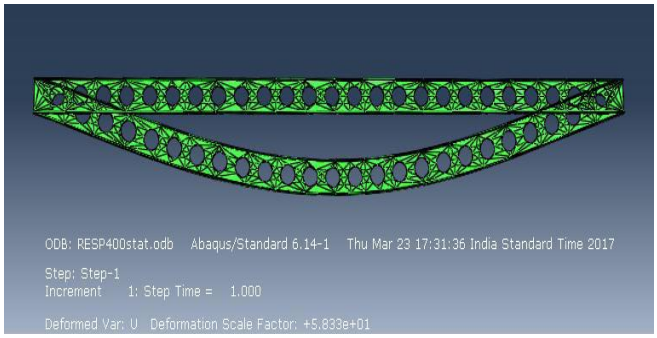

Fig.8: Deformed shape for 400 mm Opening

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The above table and figures shows that the deflection of Castellated beams having various web openings. From these observations shows that 400 mm opening will have more effective as compared with other shapes.

B. Combined and axial bending stresses

The values of combined bending and direct stresses as obtained by ABAQUS software and by IS: 800 are tabulated in Table.3 and the deflected shapes of castellated beams are represented in Fig 9, 10, 11 and 12

TABLE 3: Comparison of Bending and Direct stress

Size of web opening (mm)	Bending and Direct stress (N/mm^2)		Limiting value of stress as per IS 800 (N/mm^2)
	From Theoretic analysis	From ABAQUS	
250	206.86	103.4	227.3
300	224.87	118.3	227.3
350	225.63	128.2	227.3
400	226.94	139.4	227.3

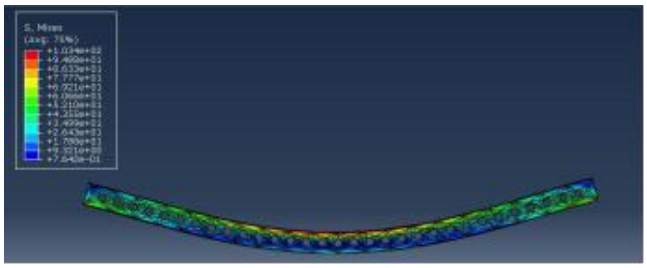

Fig 9: Von Mises Plot for 250 mm Opening

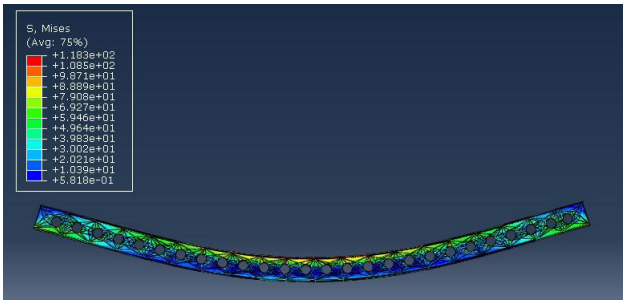

Fig 10: Von Mises Plot for 300 mm Opening

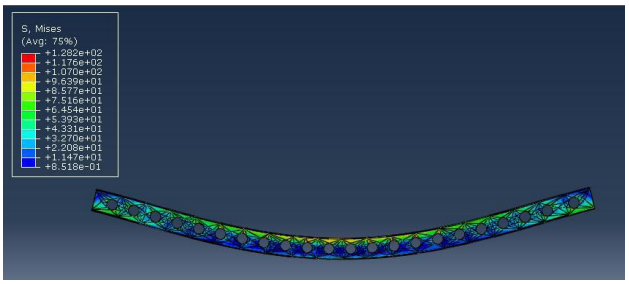

Fig 11: Von Mises Plot for 350 mm Opening

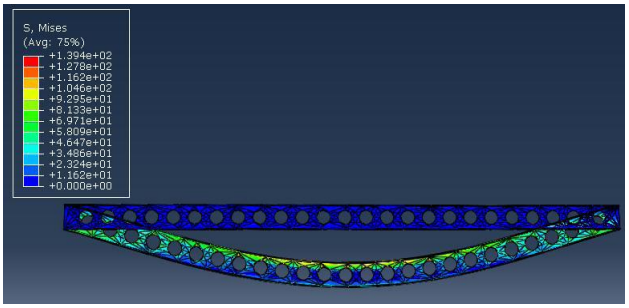

Fig 12: Von Mises Plot for 400 mm Opening

The above figures shows that the Von Mises Plot for Castellated beams having various web openings. From these observations shows that obtain mixed mode stress intensities of castellated beams. In that 400 mm opening will have the maximum bending and direct stress of 139.4 N/mm2 and more effective section as compared with other openings.

C. DYNAMIC ANALYSIS

An analytical model investigated the Natural Frequencies are tabulated in Table.4 and the mode shapes of castellated beam having 400 mm web opening are represented in Fig 13. Frequency value of each mode shape of all the four models was taken from ABAQUS (in cycle/time). By comparing all these values we can concluded that the castellated beam having web opening of 400 mm is effective one.

TABLE 4: Comparison of Natural frequencies of various web openings

Mode shape	Natural Frequency			
	(250 mm opening) (cycle/time)	(300 mm opening) (cycle/time)	(350 mm opening) (cycle/time)	(400 mm opening) (cycle/time)
1	1.7550	1.8725	1.8414	1.8885
2	4.9828	5.2435	5.1696	2.2395
3	5.3750	6.4150	5.9089	5.2367
4	10.440	10.926	10.749	5.6760
5	11.276	11434	11.092	6.2330

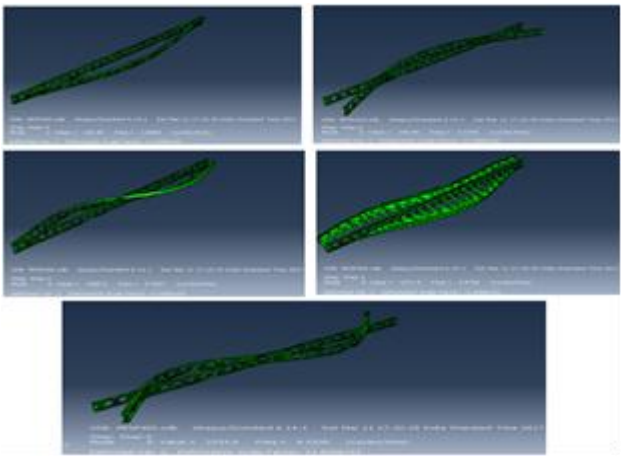

Fig 12: Mode Shape

V. CONCLUSION

From finite element analysis, the following points are to be drawn:

- The castellated beams with circular shaped openings give better shear transfer area and hence the optimization of castellated beams was done.
- From this examination, it was considered that to be the significance of opening extends, stress obsessions increases at the hole corners (Vierendeel sway) and at load application point. It is gathered that, the Castellated steel beam continues adequately concerning usefulness requirements up to a most outrageous web opening significance of 0.5h
- When comparing the finite element analysis results of all the four models, the castellated beam having opening of 400 mm is an effective one.

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