Performance Analysis of Castellated Beams with Different Web Openings

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Abstract: A castellated beam is a beam which has perforations or openings in its web portion. Generally, steel structures satisfy strength requirements, but the difficulty is that the section has to satisfy the serviceability requirements, i.e., the deflection criteria in safety check. For this it is necessary to use beams with greater depth. Using castellated beam is the best way to overcome this difficulties. With the improvements in materials and techniques of construction, castellated beams have be pushed to span much greater lengths. The castellated beam find use in many varieties of strucutres , in garages,parking lots, steel frames, industrial buildings. In this paper the effect of arrangement of stiffners in castellated beam with different types of openings is investigated. Steel and functionally graded materials are used for stiffners. The structural behaviour of encased castellated beam is also studied in order to check whether it will give a better result than the stiffened castellated beam.

Keywords: Castellated beam, different openings

1.INTRODUCTION

The use of steel for structural purposes in structures is rapidly gaining interest these days. Many of the steel structures require very large spans but comparatively less loading. Generally, steel structures satisfy strength requirements, but the difficulty is that, the section has to satisfy the serviceability requirement, i.e., the deflection criteria in safety check. For this it is necessary to use beams with greater depth. Using castellated beams is the best way to overcome this difficulty. A castellated beam is a beam which has perforations or openings in its web portion. Looking at the history of the castellated beams- as engineers were constantly trying to improve the performance of materials and also the practices of design and construction, a major invention occurred in the mid-1930's. An engineer
Geoffrey Murray Boyd, working in Argentina invented the then called Boyd beam, which later became today's castellated beam. The name castellated beam comes from the appearance of the beam and its similarities with castle battlements. With the improvements in materials and techniques of construction, castellated beams have been pushed to span much greater lengths. The thesis focuses on the determination of structural behavior of castellated beams with different web openings. The study also focuses on the structural behavior of castellated beams with steel stiffeners, functionally graded stiffeners and partially encased beams .In this paper castellated beams with full height rectangular opening is modeled and validated.

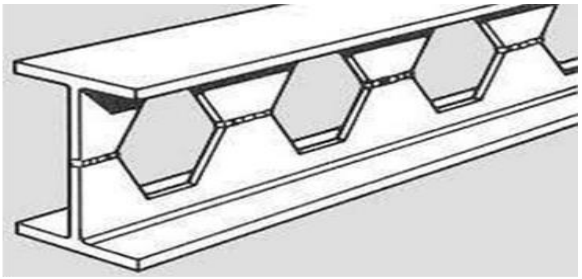

Fig.1.1 Castellated Beam

Castellated beams are made by expanding a standard rolled shape in a manner which creates a regular pattern of holes in the web. Fig 2.1 illustrates the steps in the making of a hexagonal and a circular castellated beam. It is made by separating a standard section into two halves by cutting the web in a regular alternating pattern. The halves are then rejoined by welding after offsetting one portion so that the high points of the cut beams come into contact to form a castellated beam with hexagonal openings. Its depth can be further increased by welding rectangular plates, the increment plates, between the crests of both halves of the original beam. This process of fabrication was originally performed entirely by hand until its automation was initiated by H. Litzka. The manufacturing process, which is now entirely automatic both in cutting and welding has helped to popularize the use of castellated beams.

II. OBJECTIVES

1. To investigate the performance of castellated beam with rectangular opening.

III . METHODOLOGY

The methodology includes study of castellated beam and ANSYS software. The whole thesis work is divided into different sequential steps. Literature survey is conducted on castellated beams. From various researches structural behavior and other parametric behavior of castellated beams were studied. ANSYS software is used for the analysis of castellated beams. ANSYS is a numerical computation program . It is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports

material models and equation solvers for a wide range of mechanical design problems.

A. Modelling

Castellated beams were modeled in ANSYS. Full height rectangular castellated beam for long span is modeled for the validation. Castellated beams with web openings of circular, hexagonal, square and rectangular is modeled . Structural analysis is the process to analyse a structural system to predict its responses and behaviours by using physical laws and mathematical equation. From this analysis structure's deformations, internal forces, stresses, support reactions, accelerations, and stability can be computed. The deformations are calculated for the castellated beams.

B. Dimensional Details

The steel section used is ISMB 100 × 75 mm

Fig.3.1 I section Beam

Table.3.1 Dimensional Details of Steel Section

Original height (h)	150 mm
Width of flange (b_f)	75 mm
Flange thickness(t_f)	7 mm
Web thickness(t_w)	5 mm

Table 3.2 : Dimensional details of castellated beam

Width of hole (B)	130 mm
Height of hole (d)	264 mm
Height of castellated beam	278 mm

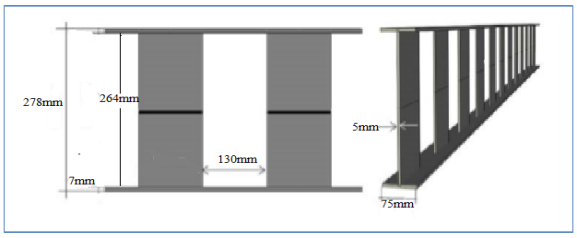

Fig 3.2 : Full height rectangular beam

Table 3.3 : Material properties

Density	7850 kg/m^3
Young's modulus	2×10^5 MPa
Poisson's ratio	0.3
Bulk modulus	1.66×10^{11} Pa
Shear modulus	7.69×10^{10} Pa

C.Meshing And Loading

Two point loading is done in the castellated beam. One end of the beam is hinged and the other end is roller support. When the beam is loaded, the central part of the beam deforms. The meshing is of done as fine meshing.

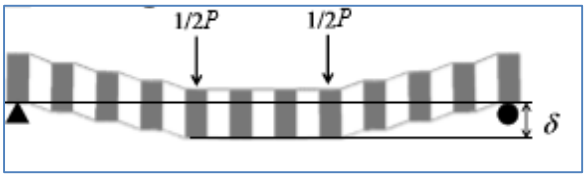

Fig 3.3 : Two point loading

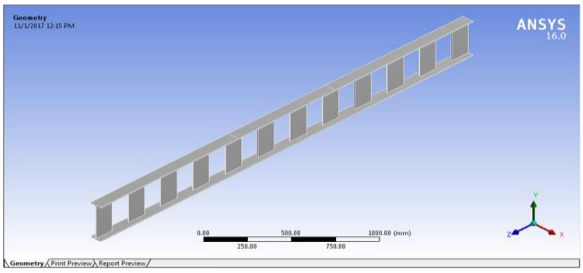

Fig 3.4 : Geometry of castellated beam

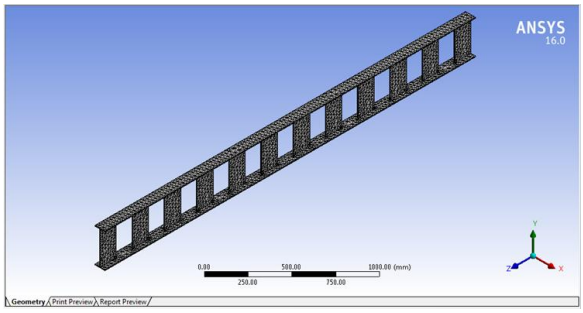

Fig.3.5 Meshing of castellated beam

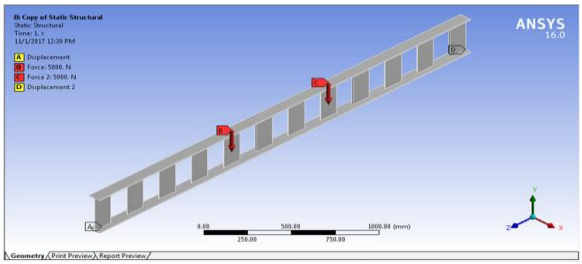

Fig.3.6 Loading of castellated beam

D. Analysis of Sandwich Beam

Analysis was done using ANSYS software. Finite element analysis will provide in depth knowledge about the behavior of the member; it performed with proper boundary conditions and material properties. There are different analyses performed in this study. These include the effects of natural frequencies ,mode shapes ,vibration effects damping effects with point load conditions.

IV RESULTS AND DISSCUSSION

DEFORMATION

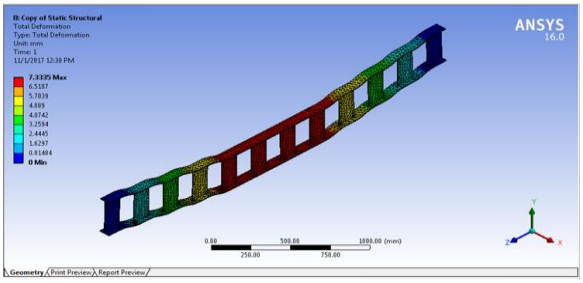

Fig.4.1 Deformation Diagram of Beam

Table 4.1 : Deformation Details

Beam type	Castellated beam
Applied load	10000 N
Deformation	7.33 mm

IV.CONCLUSIONS

Castellated beam is analysed in ANSYS software and the results where compared. This section represents the validation result of finite element model for the rectangular castellated beam. The following conclusions are obtained from the study using this specimen Based on the deformation ;the value is 7.33mm.

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REFERENCES

[1] B. Anupriya and Dr. K. Jagadeesan, "*Strength Study on Castellated Beam*", International Journal on Engineering Research & Technology.
[2] Delphine Sonck and Jan Belis, "*Lateral-torsional buckling resistance of cellular beams*", Journal of Constructional Steel Research.
[3] Ehab Ellobody, "*Interaction of Buckling Modes in Castellated Steel Beams* ", Journal of constructional steel research.
[4] Hideo Takabatake, Shigeru Kusumoto and Tomitaka Inoue, "*Lateral Buckling Behavior of I Beams Stiffened With Stiffeners*", Journal of Structural Engineering.
[5] Iman Satyarno , Djoko Sulistyo and Dina Heldita , "*Full height rectangular opening castellated steel beam partially encased in reinforced mortar*", Department of Civil and Environmental Engineering Universitas Gadjah Mada , Indonesia.
[6] Jamadar A. M. and Kumbhar P.D., "*Parametric Study of Castellated Beam with Circular and Diamond Shaped Openings*", International Research Journal of Engineering and Technology.
[7] Konstantinos Daniel Tsavdaridis and Cedric D'Mello, "*Web Buckling Study of the Behavior and Strength of Perforated Steel Beams with Different Novel Web Opening Shapes*", Journal of Constructional Steel Research
[8] M.R. Soltani, A. Bouchaïr, M. Mimoune, "*Nonlinear FE Analysis of the Ultimate Behavior of Steel Castellated Beams*", Journal of Constructional Steel Research.
[9] Sung C. Lee, M. ASCE; Chai H. Yoo and Dong Y. Yoon, "*Behavior of Intermediate Transverse Stiffeners Attached on Web Panels*", Journal of Structural Engineering.
[10] Wakchaure M.R., Sagade A.V. and Auti V.A., "*Parametric Study of Castellated Beam Varying Depth of Web Opening*", International Journal of Scientific and Publication.