Study on Flexure Behavior of Castellated Beam

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Abstract- *This study presents an experimental & analytical study on behavior of steel beam with web openings& also by providing vertical &horizontal stiffeners to check effectiveness. After performing experimental study, the beam is analyzed by the finite element method by using general finite element analysis software ANSYS & the results were compared with those obtained experimentally. This paper is highlighting the Study of Structural Behavior of Castellated Beam in various loading. By providing vertical & horizontal stiffeners in web portion of castellated beam help in increasing the strength and also minimizing the buckling.This paper is focused on the investigation behavior of shear strength of castellated beam with increase in web thickness. Castellated beams are steel beams with web openings and they gain its advantage due to its increased depth of section without any additional weight. However, one consequence is the presence of web opening which leads to various local effects like shear and deformation. In this paper steel I section ISMB 250 is selected and castellated beams are fabricated such that depth of the beam is 1.5 times greater than the original depth and web thickness increases by 10%, 20% and 30%.The beam is analyzed using Finite Element Analysis (ANSYS 16). Two-point loads is applied and stress distribution is studied.*

Keywords- Experimental analysis, Castellated beam, ANSYS,Finite element method, Stiffeners.

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.

Fig.1 Application of beams with web openings.

II. OBJECTIVE OF STUDY

- To Study Structural Behaviour of Castellated Beam under Various Loading
- To study the behaviour of castellated beam under the influence of flexure load.
- To check influence of duct/voids on the structural response of castellated beam under flexure loading.
- To check effectiveness of increment in web thickness to improve the performance of castellated beam.
- To compare the Software & Analytical results of castellated Beam under shear buckling behaviour

III. SYSTEM OF DEVELOPMENT

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. Castellated beam is generally considered as a solid plain strain structure. Its thickness is much greater than its other two dimensions; therefore, it has been analyzed as 2D plain strain structure. But in this work, it is analyzed as three-dimensional problem Castellated beam is subjected to various forces like hydrostatic pressure, uplift pressure etc. due to which it causes stress concentration within its body. Such stress concentration leads to localized failure zones in the structure. Though the stress concentration is to belocalized can leads to drastic damage to important structure like dam. The dam structure failure is analyzed using tools like Finite Element Method & ANSYS 16.

1 FINITE ELEMENT MODELLING

The following elements of ANSYS.16are used for validation and modeling of castellated beam.

SOLID186 Element Description:

SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behaviour.

The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity,

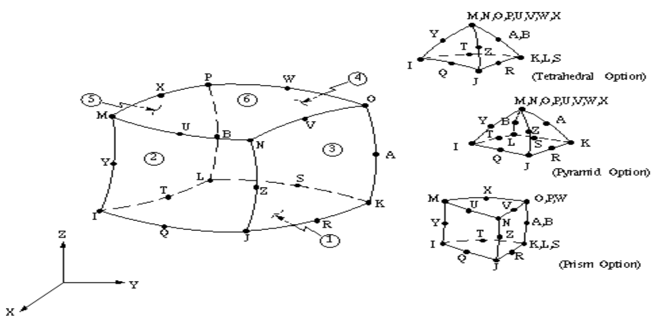


Fig.2 Solid 186 geometrical representation.

SURF 151:

SURF 151 may be used for various load and surface effect applications. It may be overlaid onto a face of any 2-D thermal solid element (except axisymmetric harmonic elements PLANE75 and PLANE78). The element is applicable to two-dimensional thermal analyses. Various loads and surface effects may exist simultaneously. The element is defined by two to four node points and the material properties. An extra node (away from the base element) may be used for convection or radiation effects. The element x-axis is along to the I-J line of the element also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

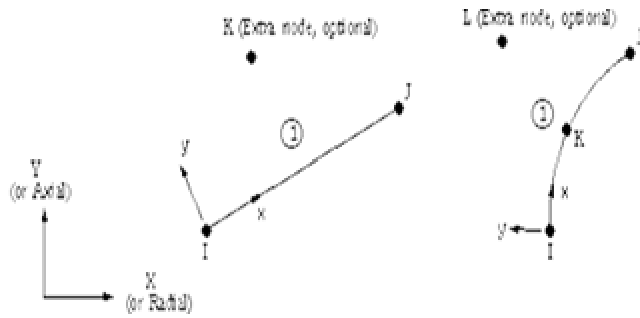


Fig.3 SURF 151.

CONTA174: CONTA174 may be used to represent contact and sliding between two surfaces (or between a node and a surface, or between a line and a surface) in 2-D or 3-D. The element is applicable to 2-D or 3-D structural and coupled field contact analyses. This element is located on the surfaces of solid, beam, and shell elements. 3-D solid and shell elements with mid side nodes are supported for bonded and no separation contact. For other contact types, lower order solid and shell elements are recommended. Contact occurs when the element surface penetrates one of the target segment elements (TARGE169, TARGE170) on a specified target surface. Coulomb friction, shear stress friction, and user defined friction with the USERFRIC subroutine are allowed. This element also allows separation of bonded contact to simulate interface delamination.

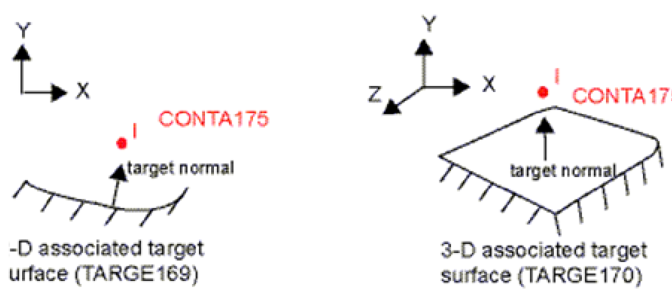


Fig.4 Geometrical representation of CONTA175.

TARGET170: TARGE170 is used to represent various 3-D "target" surfaces for the associated contact elements). The contact elements themselves overlay the solid elements describing the boundary of a deformable body and are potentially in contact with the target surface, defined by TARGE170. This target surface is discretized by a set of target segment elements (TARGE170) and is paired with its associated contact surface via a shared real constant set. You can impose any translational or rotational displacement on the target segment element. You can also impose forces and moments on target elements. See Section 14.170 of the ANSYS Theory Reference for more details about this element. To represent 2-D target surfaces, use TARGE169, a 2-D target segment element.For rigid target surfaces, these elements can easily model complex target shapes. For flexible targets, these elements will overlay the solid elements describing the boundary of the deformable target body.

IV. PROBLEM STATEMENT

Design a suitable ‘I’ beam for a simply supported span of 3 m and carrying a dead or permanent load of 17.78 kN/m and an imposed load of 40 kN/m. Assume full lateral restraint and stiff support bearing of 100 mm

Design load calculation:

in this example the following load factors are chosen.
LD γ and LL γ
are taken as 1.50 and 1.50 respectively.
γ_{LD} – partial safety factor for dead or permanent loads
γ_{LL} – partial safety factor for live or imposed loads
Total factored load = 1.50× 17.78 + 1.50 × 40.0 = 86.67 kN/m.
Factored bending moment = 86.67 × 1.82 /8 = 97.504 kN – m
Z – value required for fy=250 MPa ;γm =1.10 ; Z_{reqd} = 429.02 cm^3.

Try ISMB 250

D = 250 mm
B = 125 mm
t = 6.9 mm
T = 12.5 mm
Izz = 5131.6 cm^4
Iyy = 334.5 cm^4

V. COMPARATIVE ANALYSIS

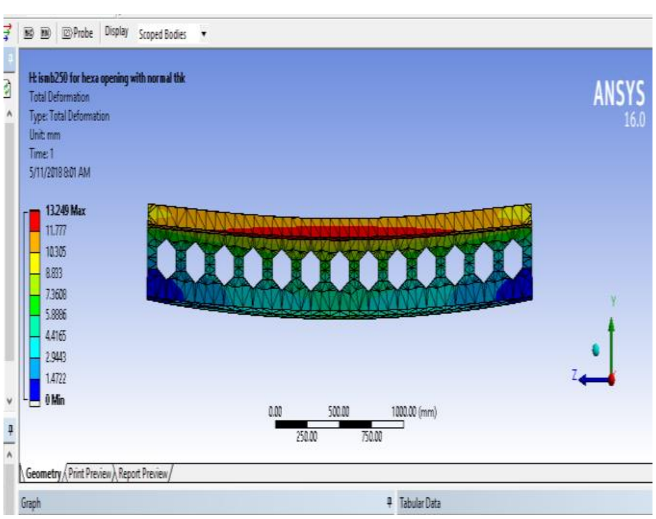
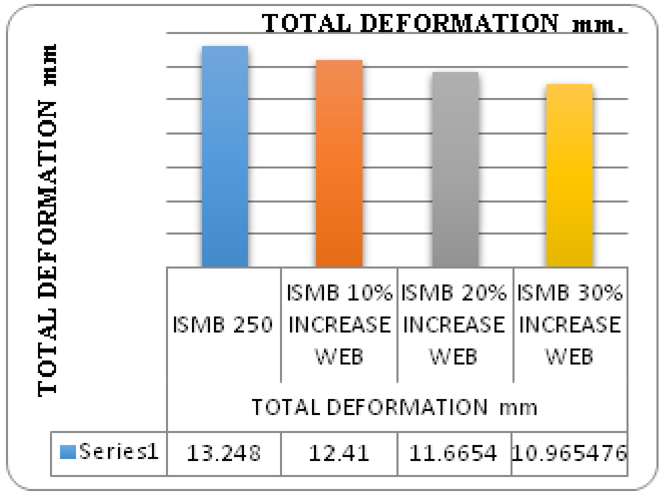
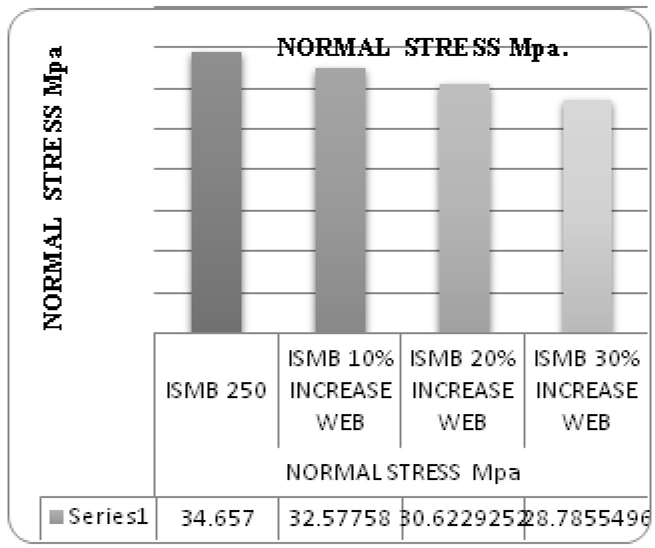


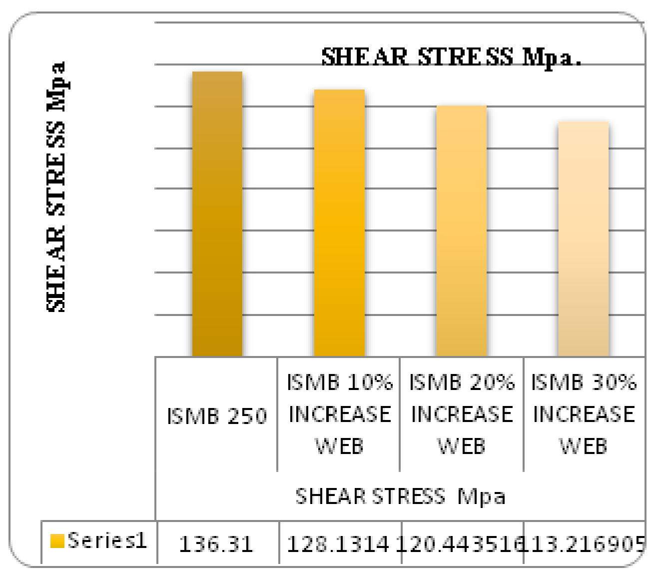
Fig.5 ISMB 250 ANSYS.



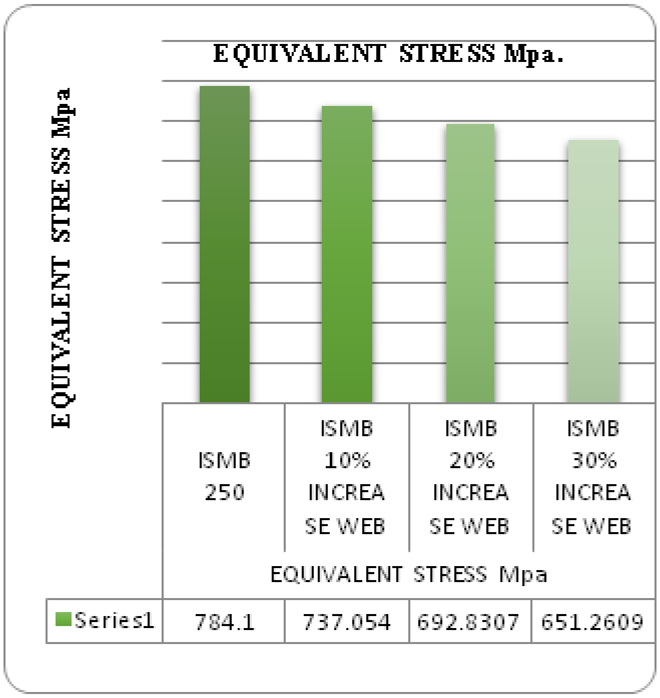
Graph 1 Total deformation mm.



Graph 2 Normal stress mpa.



Graph 3 Shear stress mpa.



Graph 4 Equivalent stress mpa.

VI. CONCLUSION

From the finite element analysis results, it is concluded that, the Castellated steel beam behaves satisfactorily with regards to serviceability requirements up to a maximum web opening depth of 0.6h and it gives better result with increment in web thickness. Castellated beams have holes in its web, which lead to local effects in the beams. This causes the beams to fail in different local failure modes, which reduces their virgin load carrying capacity. Hence, it is irrational to compare the structural behavior of beams having different modes of failure, based only on strength criteria.

- The finite element analysis effectively captured the different failure modes of all the beams. From this analysis, it was observed that as the depth of opening increases, stress concentrations increases at the hole corners (Vierendeel effect) and at load application point.
- The results also confirm that the flexural stiffness of castellated beams decrease as the depth of opening increases.
- The normal stress, bending stress, total deformation decreases in castellated beam as the web thickness of web increases.

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