BEHAVIOUR OF SIMPLY SUPPORTED CASTELLATED BEAM UNDER GRAVITY LOADING

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ABSTRACT: As we know that, though there is no provision for the castellated beam in Indian standard, though the use of castellated beam is increased day by day for the industrial buildings because of the economical advantages of the castellated beam like decrease the weight of the beam cause decrease floor weight. And decrease of floor weight causes decrease in size and weight of the columns and foundations which reduces overall cost of construction.

A study on the effect of the behavior of the castellated beam is described in this paper. Finite element method is used using ANSYS 11 to determine the behavior of the simply supported castellated beam under gravity loadings.

As it has been already discussed that, the analysis of simply supported castellated beam is performed by ANSYS 11, the von mises stresses, deformation and displacements are studied for structural stability under gravity loadings. Analysis of ISMB 300 is used for making of castellated beam of overall depth of 700 mm. the dimensions of which have been shown in figure 1. One can find the shear stress and flexural stress diagram at any isotropy section for given shear force and bending moment. But for castellated beam, it is not easy to draw the shear stress and bending stress diagram as there is an openings at some part for which cross section of openings also change from section to section. Hence it is easy to utilize the finite element method for drawing shear stress and bending stress diagram for castellated beam. For preparing model of simply supported castellated beam, both bottom edges of the flanges are to be considered as fixed or restrained against displacements in all three dimensions i.e. x,y and z. and also rotation is to be restrained in x, y, and z directions. All other points of castellated beam have been considered to be free to deform in x,y and z directions and also free to rotation in all x,y and z directions. For preparing model, mashes are to be considered as polygon. So numbers of nodes in one element is more than 3. Also fine mash have been utilized so, large numbers of elements are analyzed and result have been plotted in the form of graphs.

Key words: Castellated beam, von mises stresses, deformation, displacement.

I. INTRODUCTION

As analysis of castellated beam is difficult, hence there is ambiguity in design procedures. Researchers who reported results using experimental data suggested approximate procedures for design of castellated beam. However, these procedures did not always covers all aspects of design and behavior of castellated beams. This leds to several authors to proceeds design recommendations based on the research carried out by researchers based on experimental analysis or finite element analysis. Now a days to reduce manual calculations, some software are successfully utilized and results have been compared with experimental result data. One of the most powerful tool now a days utilized is ANSYS. In which all kinds of problems can be solved using finite element method. The early papers by Bazile, Faltus and Boyer responded and treated castellated beam as plain-webbed beams. It is interesting to know that only Boyer and McCormick have considered design for lateral buckling. They suggested using existing code of practice recommendations for plain webbed beam.

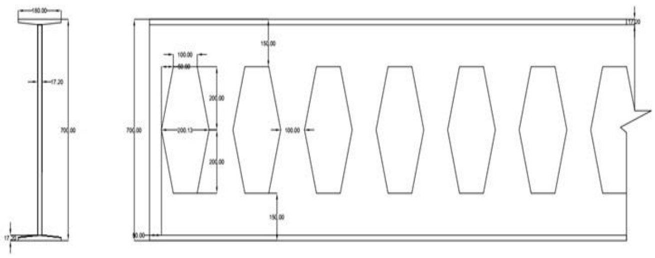

Figure 1: Castellated beam and opening geometry.

Fabrication:
Profile cutting is done in web of I – section in zig-zag manner as shown in fig.2. than these two halves are separated and slid by the length equal to half the width of hollow portion, so as both throat are coincide each other. In this position these two separate parts are joined using weld as shown in fig.2. Remaining portion at the ends are considered as a wastage, which is shown by hatch lines as shown in fig.2.

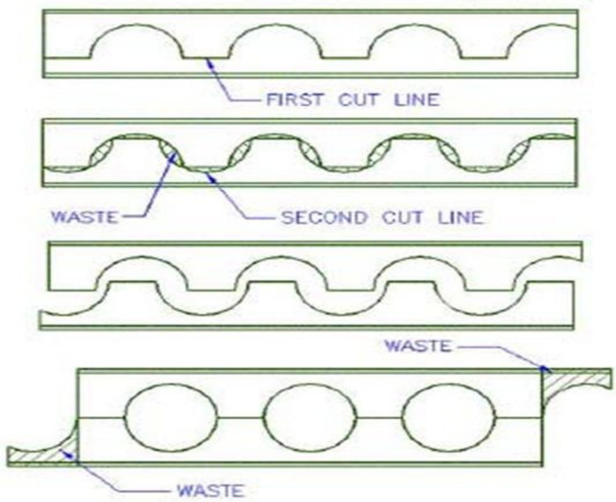

Figure 2 : Fabrication of castellated beam

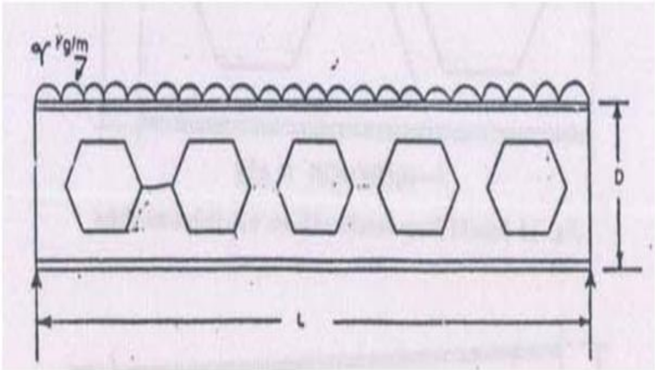

Figure 3: Typical castellated beam under uniformly distributed superimposed loading.

In the open portion of the web, vertical shear divides equally between the upper and lower tees.

For bending moment in the T-section due to shear, point of contra lecture is assumed to exist in the vertical centre line of the open section.

Fiber stresses varies linearly and the maximum stress in the open section is computed as an algebraic sum of both primary and secondary stresses which are due to shear in the T-section respectively

A typical section of a castellated beam is shown in the fig. 4(a)

The stress distribution diagram is shown in fig. 4(b).

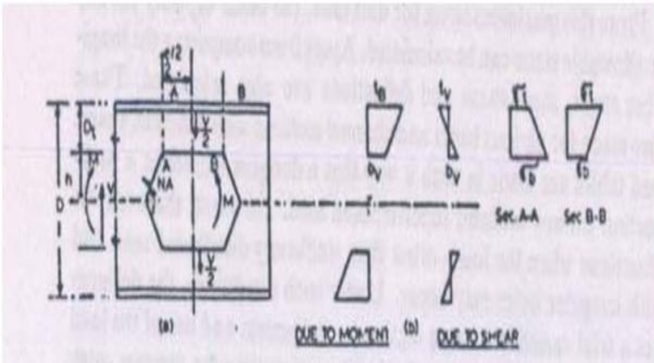

Figure 4: Typical section and distribution of stresses of castellated beam.

Maximum fiber stress at section A-A.

$$б_b = b_B + b_V = \frac{M_A}{I_g}\ X\,h + \frac{V.e}{4S_g} \quad \ldots\ldots(1)$$

Maximum fiber stresses at section B-B.

$$б_t = t_B + t_V = \frac{M_B D}{2I_g} + \frac{V\,e}{4\,S_f} \quad \ldots\ldots(2)$$

The maximum longitudinal fiber stresses can occur at inner edge of the tee web i.e. bending stress at top fiber of the tee i.e. maximum bending stress would occur at section A-A and is computed by the equation 1. The maximum bending stress would occur at section B-B and is computed by equation 2. A castellated beam section is most efficiently used when bending stress at section B-B is governing stress. However, this is not always possible particularly on the short spans.

For analysis, the castellated beams have considered to be loaded with uniformly distributed loadings of 10 kn/m. This load is also distributed along flange width. So the load is 10/0.18 = 55.56 kn/m^2 is applied for analysis.

II. RESULT AND DISCUSSIONS

Problem & Definition

For analysis, the castellated beams have considered to be loaded with uniformly distributed loadings of 10 kn/m. This load is also distributed along flange width. So the load is 10/0.18 = 55.56 kn/m^2 is applied for analysis by ANSYS WORKBENCH 11.

The problem is taken as a 10m. span of castellated beam with both bottom edges of flanges are being restrained against rotation, displacement and deformation in x, y and z directions. And top flange is loaded with 55.56 kn/m^2. Which is considered as gravity loading. The section of the castellated beam is as shown in figure 1. And the parent section property from Indian standard steel table is as mentioned below.

ISMB 500 @ 86.9 Kg/m.
Sectional area a = 110.74 cm^2.
Depth of the beam D = 500 mm.
Width of the beam B_f = 180 mm.
Thickness of the web t_w = 10.2 mm.
Thickness of the flange t_f = 17.2 mm.
Slope of flange = 98˚.
Radius at root Y_1 = 17.0 mm.
Radius at toe Y_2 = 8.5 mm.
Moment of inertia I_{xx} = 45218.3 cm^4.
Moment of inertia I_{yy} = 1369.8 cm^4
Radius of gyration r_{xx} = 20.21 cm.
Radius of gyration r_{yy}= 3.52 cm.
Section modulus Z_{xx} = 1808.7 cm^3.
Section modulus Z_{yy} = 152.2 cm^3.

Results & Discussions:

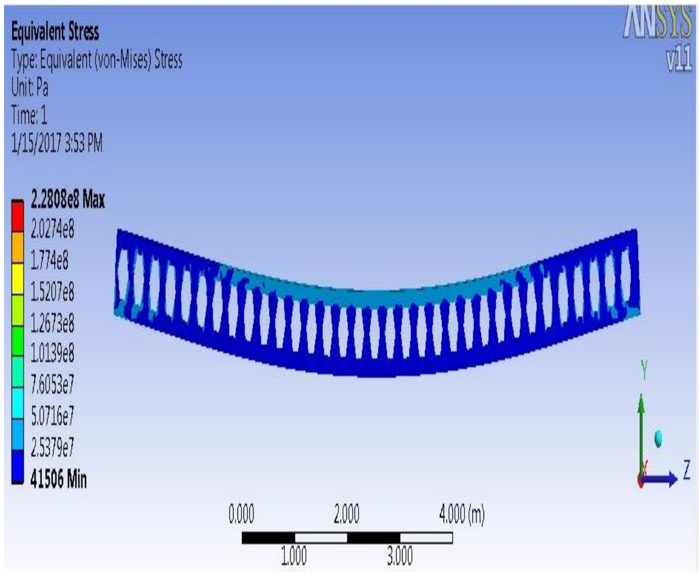

Figure 5 : Results obtained from ANSYS 11 for Equivalent stresses in castellated beam under gravity loading.

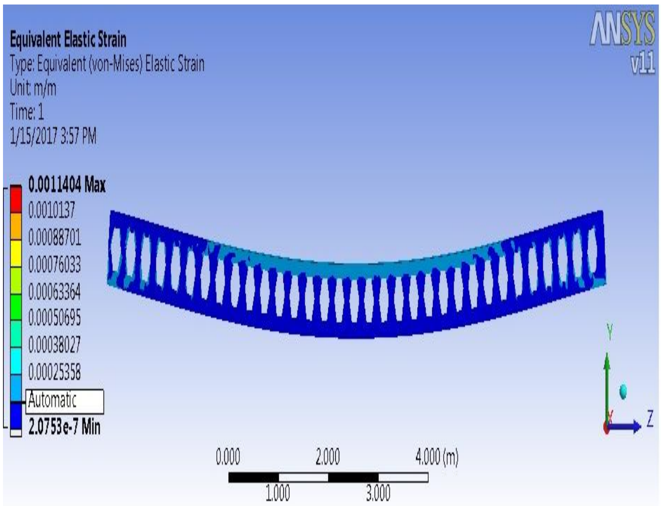

Figure 6 : Results obtained from ANSYS 11 for Equivalent strain in castellated beam under gravity loading.

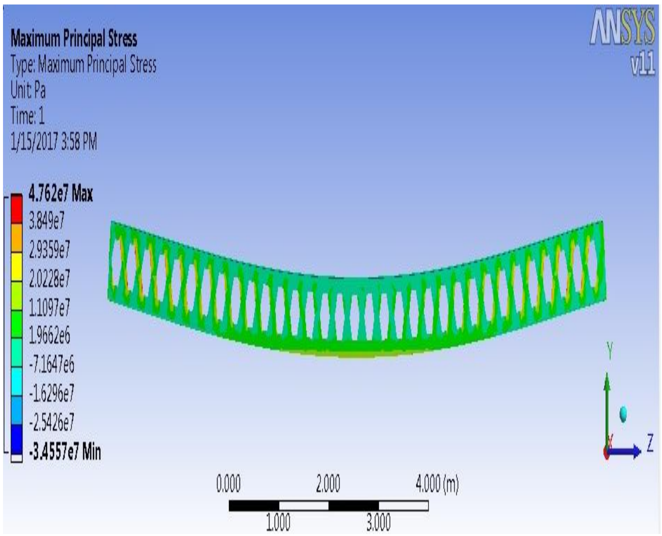

Figure 7 : Results obtained from ANSYS 11 for Maximum principal stresses in castellated beam under gravity loading.

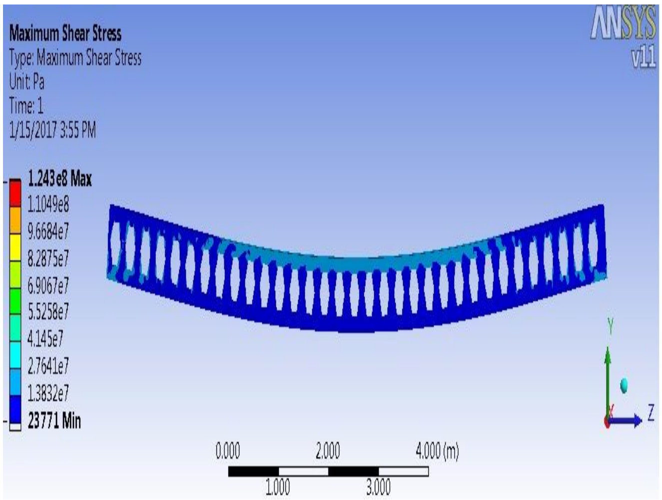

Figure 8 : Results obtained from ANSYS 11 for Shear stresses in castellated beam under gravity loading.

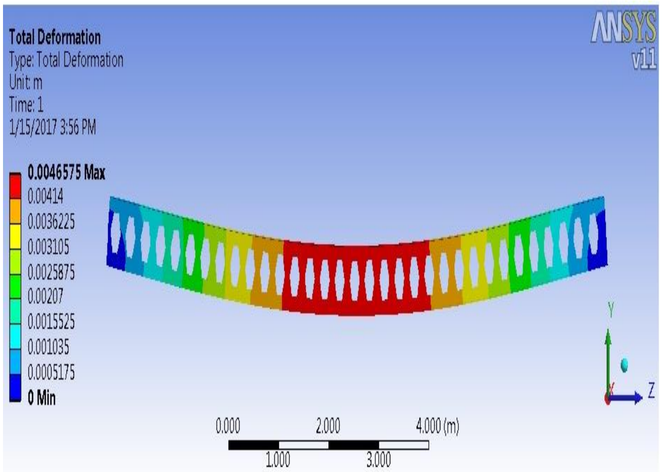

Figure 9 : Results obtained from ANSYS 11 for Total deformation in castellated beam under gravity loading.

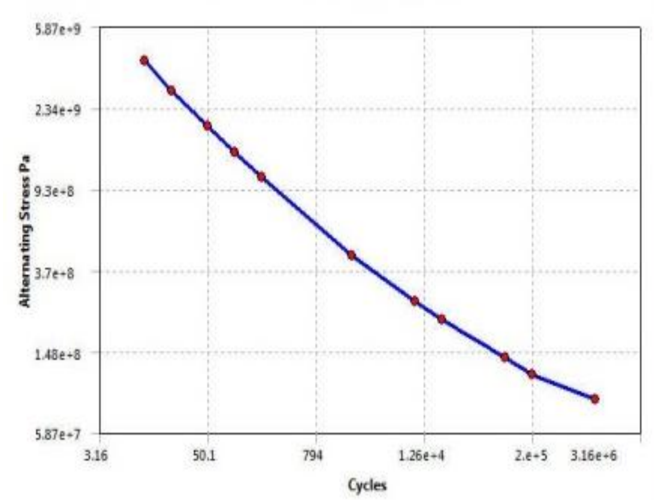

Figure 10 : Results obtained from ANSYS 11 for graph alternating stress v/s cycles in castellated beam under gravity loading.

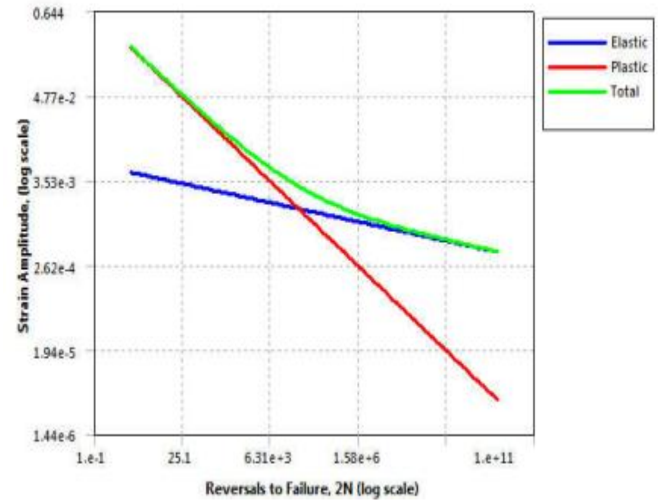

Figure 11: Results obtained from ANSYS 11 for graph strain altitude v/s reversals to failure in castellated beam under gravity loading.

All figures above shows the nature of simply supported castellated beam under gravity loading only for the theory purpose. As it is not possible to provide restriction against rotations and deformations in all directions at the bottom edge of flanges. In practice, the bolted or riveted connections are used to provide pinned or hinged supports. Also, the use of gusset plates is also there in practice. So for this particular paper, this all parameters are ignored.

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