EXPERIMENTAL STUDIES OF LATERAL TORSIONAL BUCKLING ON CASTELLATED BEAMS

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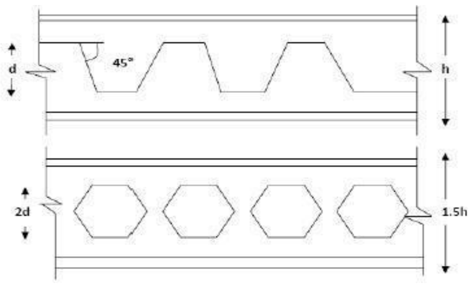
Abstract:- *The Construction of Industrial structures needs to be safe as well as to maintain economy in the planning analysis design and fabrication. In this scenario application of pre-engineered structure play a vital role in the construction of innovative and naval shape in construction industries. To cater this situation castellated beam offered new and elegant and economy one. Castellated beam are formed by cutting and rearranging the I section into regular hole patterns of different shapes in the web. Experimental testing is carried out on beam*

1. Introduction

Castellated beam are formed by cutting and rearranging the I section into regular hole patterns of different shapes in the web. Castellated beam gets its name for its web holes which looks like a castle. The two halves are re-joined by welding, after rearranging one portion so that the high points of the web pattern come into contact. This is done by adding web plates between high points of the tee sections. The overall beam depth is increased by 50% without any increase in weight for improved structural performance against bending.



with two point load with simply supported condition. The deflection at center of beam and various failure patterns are studied. The shear carrying capacity of castellated beam is reduced near the perforations which can be increased by introducing stiffeners near the openings. So deflection of beam can be reduced. In this study, a brief study of castellated beam with stiffener and without stiffeners and their properties and behaviour are compared and discussed.

KEYWORDS: *Castellated beam, lateral torsional buckling, Failure modes, Experimental studies.*

2. Failure modes of castellated beams

- Formation of a Vierendeel mechanism.
- Lateral- torsional buckling occurs at web portion.
- Rupture occurs in welded joint of web portion.
- Lateral-torsional buckling of an entire span.
- Formation of a flexure mechanism.
- The web post may buckle.

2. Experimental studies

2.1 Fabrication of castellated beam

Castellated beams are structural members, which are made by flame cutting a rolled beam along its centerline and then rejoining the two halves by welding so that the overall beam depth is increased by 50% without any increase in weight for improved structural performance against bending.

IC 225 is fabricated from ISMB 150 by increasing the depth of the section by 1.5 times for the same weight of the section. The properties of ISMB 150 are, A= 19.0 cm^2, B = 80mm, tf=7.5 mm, tw= 5mm, Ixx= 726.4 cm^4 , Iyy = 52.6 cm^4, Zxx = 96.9 cm^3, Zyy = 13.1 cm^3

Where 'A' is the area of the section, 'B' is the breath of the flange, 'tf' is the thickness of flange, 't' is the thickness of web , Ixx, Iyy is the moment of inertia about 'x' and 'y' axis respectively. Zxx and Zyy represents the section modulus about 'x' and 'y' respectively.

2.2 Distribution of stresses in I section

The nature of shear distribution in an I – beam In an I- Section the value of Q which is zero at the extreme fibre increases to a high value at top flange- web interactions and attain maximum value at the neutral axis.

From the bending stress distribution diagram it can be seen that flanges carries most of the bending stress.

Flange carrying the major portion of the flexural load is observed, whereas the shear load is carried by the web.

The primary modes of failure of the beam are the local buckling of compression flange and shear buckling of web.

Castellated *beam* depends on web post buckling. That is at high shear locations, normally near the supports and neutral axis; the principal planes would be inclined to the longitudinal axis of the member.

The diagonal tension and diagonal compression of the principal stresses along the principal planes, causes the web to buckle in the perpendicular direction to its action.

By reducing the depth to thickness ratio of the web this problem can be solved and also by providing stiffeners at the web develops tension field action which resists the diagonal compression.

3. Stiffeners

When the web has an inadequate capacity to carry the loads, Stiffeners are provided which are in a wide variety that can make the web portion stable and strong

3.1 Stiffeners along the Shear Zone

The disadvantage of castellated beam is due to the presence of opening in the web of the beam which alters the stress distribution within the member and it also influences in the collapses behavior.

The major disadvantage of castellated beam is the introduction of an opening in the web of the beam alters the stress distribution within the member and also influences its collapse behavior. These openings decrease the stiffness of the beams resulting in larger deflection (Chapkhanea N.K et al -2012). Hence to improve the shear strength of castellated beam and to reduce the deflection stiffeners are introduced on the web.

Stiffeners are introduced, vertical stiffeners on the solid portion of the web along the shear zone.

3.2 Different Types of Sections Adopted

Stress concentration is more near the opening than in the solid portion, hence stiffeners are introduced on the web opening and also on the solid portion of the web. To study the stiffeners effect along the shear zone following cases are considered.

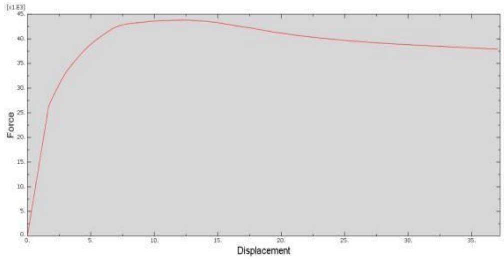
The following are the different types of cases that are used for the experimental and analysis work,

a) Case I –Castellated beam Without Stiffeners (WOS)

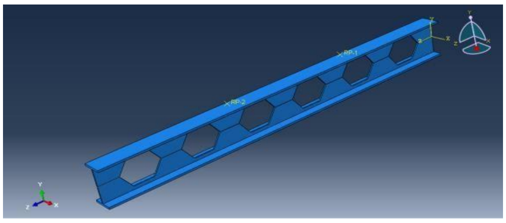
b) Case II –Castellated beam With Vertical Stiffeners on the solid portion of the web along the shear zone (WVS)

4. Finite Element Analysis

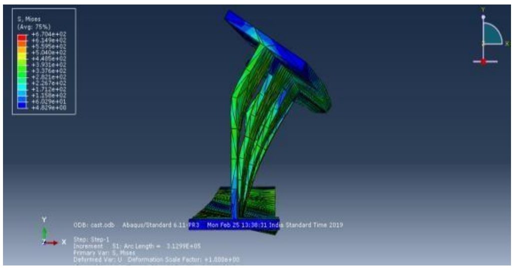
The finite element method provides approximate solutions to variety of engineering problems which is a numerical analysis technique. Many engineering problems needs approximate numerical solutions rather than closed form solution. Infinite element analysis the structure is divided into a finite number of elements which have finite dimensions and reduces the structure into infinite degrees of freedom to finite degrees of freedom. The original body of structure is then considered as an assemblage of these elements connected at a finite number of joints called Nodes or Nodal points. The advantage of this analysis is to take care of the loading and boundary conditions.



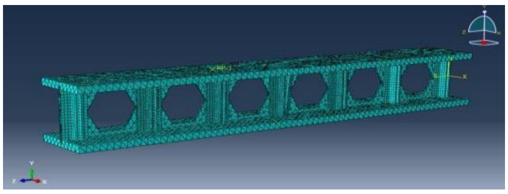
Force displacement curve



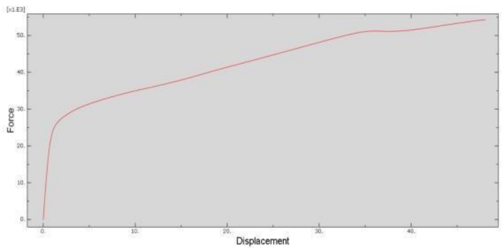
IC 225 model without stiffener



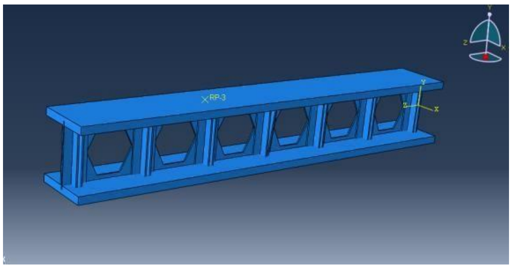
Lateral torsional buckling



IC 225 mesh with stiffener



IC 225 With stiffener –Result graph



IC 225 with vertical stiffener

7. Results and discussions

Beam analyzed using ABAQUS	Load carried by the beam without stiffener	Load carried by the beam with stiffener
IC 225	44 KN	55 KN

Load carried by the beam with and without stiffener.

From the observation made, we can conclude that the beam without stiffeners carries less load than beam with stiffener. The load carrying capacity of the beam with stiffener is 25% more than the beam without stiffener.

6. Conclusion

The studies made from software modeling, the deflection of the beam with stiffeners is lesser than the beam without stiffener. The stress pattern of the beam without stiffener is higher than the beam with Stiffener. The failure pattern in beam without stiffener is earlier than beam with stiffener. The ductility of beam with stiffener is greater than beam without stiffener.

7. Scope for future work

- Easy fabrication of castellated beam.
- Comparing the results obtained from the experimental study and analytical study of the beam.

Reference

1. Delphine Sonck and Jan Belis "lateral torsional buckling resistance of cellular beams" ELSEVIER-Journal of constructional steel research, VOL-105 (2015), 119-128

2. Amin Mohebkhah, Mojtaba and G.Azandariani "Lateral torsional buckling resistance of unstiffened slender-web plate girders under moment gradient" ELSEVIER- Thin walled structures 102 (2016) 215-221

3. B.Anupriya and Dr. K. Jagadeesan "Strength Study on Castellated Beam", ELSEVIER- International Journal on Engineering Research & Technology, 12(2014)2278-0181

4. EhabElloboby "Interaction of buckling modes in castellated steel beams" ELSEVIER-Journal of constructional steel research 67 (2011)814-825.

5.Sandhi Kwani and Paulus Karta Wijaya "Lateral Torsional buckling of castellated beams analyzed using the collapse analysis " ELSEVIER- Journal of constructional steel research 171 (2017) 813-820

6.Jin song lei and Long-yuan li "Combined Web distortional and Lateral Torsional buckling of partially restrained I-sections beams "ELSEVIER- international Journal of mechanical sciences 131-132 (2017) 107-112.

8. Tadehzirakian,"Lateral Distortional buckling of I-beams and the extrapolation techniques" ELSEVIER- Journal of constructional steel research 64 (2008) 1-11 800

9. Peijunwang, kangruiguo, meiliu and lulu zhang ,"Shear buckling strength s of web-posts in a castellated steel beam with hexagonal web openings "ELSEVIER -Journal of constructional steel research 121 (2016) 173-184

10. Ilkerkalkan and alperbuyukkaragoz, "A numerical and analytical study on distortional buckling of doubly – symmetric steel I-beams " ELSEVIER -Journal of constructional steel research 70 (2012) 289-297