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A review paper on structural analysis of cantilever beam of jib crane

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Abstract -The study includes an investigation of the stresses, deflections, shear capacity and lateral-torsional buckling behavior of regular I section cantilever beam of jib crane subjected to a uniformly distributed load (self-weight) and a concentrated load at the free end. The lateral torsional buckling is the main failure mode that controls the design of "slender" beams. Different shapes of cantilevers are proposed in this study with different cross section, web shapes and materials. Finite element analysis and experimental study are carried out on both types (i.e. Regular and proposed beam) to calculate and validate results. An optimization technique is used to optimize the solution from proposed different designs. The thickness of the web and flange is constant for all specimens with length 3 to 6 m and tested for 250 Kg and 500 Kg load lifting capacity. Structural analysis is done to examine the influence of the section dimension due to point load at the free end and uniformly distributed load on cantilever. Using the study it is observed that not only the web thickness, but also the shape of web and sectional cross section of cantilever beam influences the resistance to lateral torsional buckling and bending.

Keywords - Slender, bending, shear capacity, lateral torsional buckling, sectional cross section, web shape.

INTRODUCTION

Today's industry demands versatile, efficient and cost effective equipment while at the same time providing more flexibility along with significant savings through increased productivity, there are several equipment used in industry for material handling, a jib crane is one of them [1].

The need for continual improvement in material handling technologies is a common feature of many modern engineering endeavors. Engineering structures now encompasses a wide range of technologies from structure development, analysis, design, testing, production and maintenance. Advances in material handling technologies have been largely responsible and major performance improvements in many engineering structures and continue to be key in determining the reliability, performance and effectiveness of such structures [2].

Beams are essential components of steel construction. A satisfactory design should ensure that the beam is stable and has enough strength and stiffness against the applied loads. For steel beams having an I-shaped cross section, global buckling and local buckling are typical modes of instability [3]. When symmetrical beams are loaded on the plane of symmetry they may deflect in the symmetry plane. However, at a certain level of the applied load, the beam may buckle laterally, while the cross sections of the beam rotate simultaneously about the beam's axis. This phenomenon is called lateral-torsional buckling, and the value of the load at which buckling occurs is called the buckling load or critical load [4].

In study and investigations or regular beam of jib crane, it is observed that (a) lateral shift of cantilever I-type beam or misalignment of the axis of cantilever I-type beam with respect to the axis of mounting and because of that movement of the trolley is restricted, (b) bending at free end stuck the trolley at tip position, (c) bending caused damage to the bearing.

The use of variable cross section beam has been increasing in the steel construction industry. This is because of their ability to increase stability of structure, and sometimes to satisfy architectural and functional requirements in many engineering structures [5]. Tapered beams are widely used in modern constructions, mainly due to their structural efficiency [6].

LITERATURE REVIEW

1. A Parametric Study on Lateral Torsional Buckling of European IPN and IPE Cantilevers ---- By H. Ozbasaran

In this paper, a simple equation is presented to calculate lateral torsional buckling load of IPN and IPE section cantilever beams. First, differential equation of lateral torsional buckling is solved numerically for various loading cases. Then a parametric study is conducted on results to present an equation for lateral torsional buckling loads of European IPN and IPE beams. ABAQUS software is utilized to

generate finite element models of beams. It can be suggested that presented formula can be safely used to calculate critical lateral torsional buckling load of European IPN and IPE section cantilevers.

2. Lateral torsional buckling of rectangular beams using the variational iteration method ---- By Seval Pinarbasi

This paper shows that complex beam, buckling problems, such as lateral torsional buckling of narrow rectangular cantilever beams whose minor axis flexural and torsional rigidities vary exponentially along their lengths, can successfully be solved using the variational iteration method (VIM). The paper also investigates the effectiveness of three VIM algorithms, two of which have been proposed very recently in solving lateral torsional buckling equations. Analytical results show that alliteration algorithms yield exactly the same results in all studied problems. As far as the computation times and spaces are concerned, however, one of these algorithms, called variational iteration algorithm II, is found to be superior than the others, especially in lateral torsional buckling problems where the beam rigidities vary along the beam length.

3. Bending and buckling of tapered steel beam structures ---- By N.S. Trahair

Tapered finite element formulations are developed by numerical integration instead of the closed forms often used for uniform elements. Difficulties in specifying the load positions for tapered mono-symmetric members caused by the variations of the centroidal and shear center axes are avoided by using an arbitrary axis system based on the web mid-line. The program's predictions of the elastic out-of-plane flexural–torsional buckling of a large number of uniform and tapered doubly and mono-symmetric beams and cantilevers under various loading and restraint conditions are generally in close agreement with existing predictions and test results.

4. Lateral–torsional buckling of steel web tapered tee-section cantilevers --- By Wei-bin Yuan, Boskun Kim, Chang-Yi Chen

To validate the present analytical solutions, finite element analyses using ANSYS software is also presented. It is found that web tapering can increase or decrease the critical lateral–torsional buckling loads, depending on the flange width of the beam. For a beam with a wide flange (width/depth = 0.96) the critical buckling load is increased by 2% by web tapering, whereas for a beam with a narrow flange (width/depth = 0.19) web tapering reduces the buckling load up to10% and 6% for the tip point loading and the uniformly distributed load respectively.

5. The study of lateral torsional buckling behavior of beam with trapezoid web steel section of experimental and finite element analysis ---By Fatimah Denan, Mohd Hanim Osman & Sariffuddin Saad

In the experimental work, sections with nominal dimension 200 x 80 mm and 5 m length were loaded vertically while the lateral deflection were unrestrained to allow for the lateral torsional buckling. In the analytical study, eigenvalue buckling analysis of the finite element method was used to determine the critical buckling load. It is concluded that steel beam with trapezoidal corrugated web section have higher resistance to lateral torsional buckling compared to that of section with flat web. The result shows that corrugation thickness influences the resistance to lateral torsional buckling.

6. Effect of Triangular Web Profile on the Shear Behavior of Steel I-Beam ---- ***By Fatimah De'nan, MusniraMustar, Adzhar Bin Hassan and Norbaya Omar***

This paper develops a three-dimensional finite element model using LUSAS 14.3 to study on the effect of the triangular steel beam web profile (T WP) in the shear buckling behavior of different thickness compared RI to that of the normal flat beam (FW). Eigenvalue buckling analysis was used in analyzing the buckling load of the flat plate model and triangular web profile (TRIWP). Results showed that the web thickness gave a significant impact on the shear buckling of the TRIWP. In addition, the corrugation thickness of the web was also effective in increasing the shear buckling capacity of the profile.

7. The Effect of Web Corrugation Angle on Bending Performance of Triangular Web Profile Steel Beam Section ----- By Fatimah De'nan, Nor Salwani Hashim

Two sizes of flat webs (FW) as control specimens and two sizes of TRIWP which are 200×100×6×3 mm and 180×75×5×2 mm section were used. Each of beam section was modeled using several spans such as 3 m, 4 m and 4.8 m and different corrugation angles (15^0,30^0,45^0,60^0 and 75^0). It was noted that deflection of 45^0 and 75^0 web corrugations angle is the lowest deflection value either in the

minor or major axis of the TRIWP steel section. The TRIWP steel section has a higher resistance to bending in the minor and major axis when the web is used in both corrugation angles.

PROPOSED WORK

The proposed system of design with varying cross sectional shape with trapezoidal web is shown in figure 1. It recognizes top and front view of the proposed cantilever beam. 3D models for each case have to be created in CATIA and FEA is to be done for bending, shear capacity and lateral torsional buckling. Suitable cases can be considered and manufactured for experimental analysis. The result should be validated through FEA, and experimental setup.

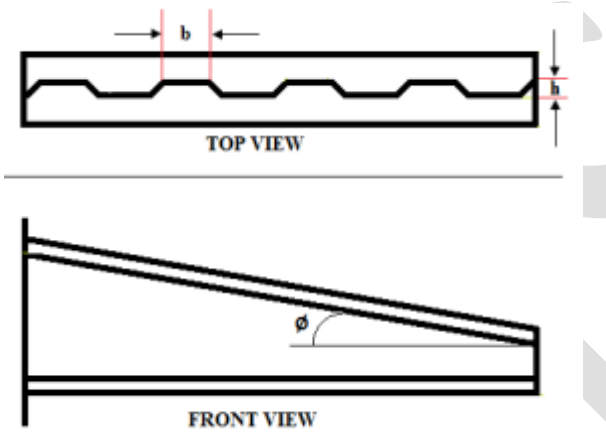

Figure 1: Proposed I Section Beam

CONCLUSION

This paper investigates a promising structural analysis of cantilever beam of jib crane. A new design approach of beam shape is proposed to tackle the problems of deflection, shear capacity and lateral torsional buckling of cantilever beam due to loading. Discussions of this paper show that how the web tapered cantilever beam is more capable of resisting the lateral torsional buckling and bending with high shear capacity for a given load, if compared to regular I section cantilever beam. From the study it is observed that not only the web thickness, but also the shape of the web and cross section of cantilever beam influences the resistance to bending, lateral torsional buckling and shear capacity.

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