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FINITE ELEMENT ANALYSIS OF JIB CRANE

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***Abstract*— A "crane" is a machine for lifting and lowering a load and moving it horizontally, with the hoisting mechanism an integral part of the machine. Jib cranes are simplest type & widely used in the small scale industries. In this research work, finite element analysis column mounted jib crane is done. Software ANSYS is used for modeling & analysis. During the work, effect of variation of web thickness, web height on deflection of beam & Von Mises stresses is studied.**

Index Terms*— *finite element analysis, jib crane, Von Mises stresses, deflection

I. INTRODUCTION

Cranes are widely used to transport heavy loads and hazardous materials in shipyards, factories, nuclear installations, and high-building construction and play an important role in production process and serve to transfer loads from one place to another. Cranes are the best way of providing a heavy lifting facility covering virtually the whole area of the industry.

Finite element analysis is a powerful tool in the field of engineering. Initially, finite element analysis was used in aerospace structural engineering. The technique has since been applied to nearly every engineering discipline from fluid dynamics to electromagnetics. With the recent increases in the speed and processing power of computers, finite element analysis has become a practical way to solve many problems.

Following table gives details of the dimensions of the crane of which analysis is done.

Table 1 Dimensions of jib crane

Name of part	Parameter	Value
Beam	Length of Beam	2500 mm
	Height of Beam	125 mm
	Thickness of flange	6.5 mm
	Width of flange	75 mm
	Thickness of web	4.4 mm
Column	Inner diameter	120 mm
	Outer diameter	150 mm
Material Properties	Young's Modulus	2.1 x 10^5 N/mm^2
	Poisson's Ratio	0.3

II. ANALYTICAL SOLUTION FOR DEFLECTION OF BEAM

To choose the proper element size during model meshing in finite element analysis, analytically deflection of beam is calculated. Load applied at the end of the beam is 100 x 9.81 N.

The deflection of beam considering one end rigidly fixed is calculated by using formula,

$\delta = (WL^3)/(3\ E\ I) = [9.81 \times 100 \times 2500]^3/(3 \times 2.1 \times 10^5 \times 65088 \times 62.5) = 5.98$ mm

This value will be used as reference for finite element analysis.

III. FINITE ELEMENT ANALYSIS OF BEAM

Following figure shows the meshed model of beam with load condition & boundary condition. Solid 45 is the element used for meshing. An element edge length of 30 is used.

Meshing: For meshing of the model, 8 Node Brick 45 (SOLID45) elements are used. The geometry of this element is as shown in the figure 1.

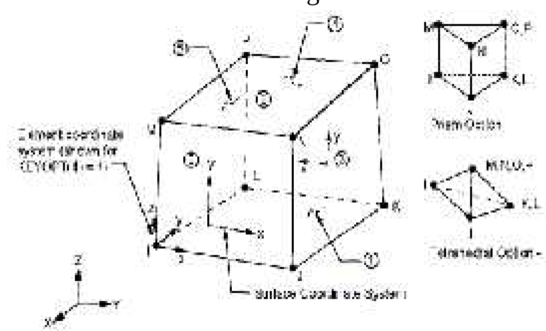

Figure 1 Geometry of SOLID45 element

The tetrahedral option is used for the present problem. Solid 45 is used for the 3-D modeling of solid structures.

Load condition: At right end of the beam load is applied in vertical downward direction.

Boundary condition: Movement of left end of the beam is restricted in all direction.

Deflection of beam: The deflection at the end of the beam is noted & variation in element edge length is done to correct element size. It is found that an element edge length of 30 is sufficient to give the deflection near to the analytical value.

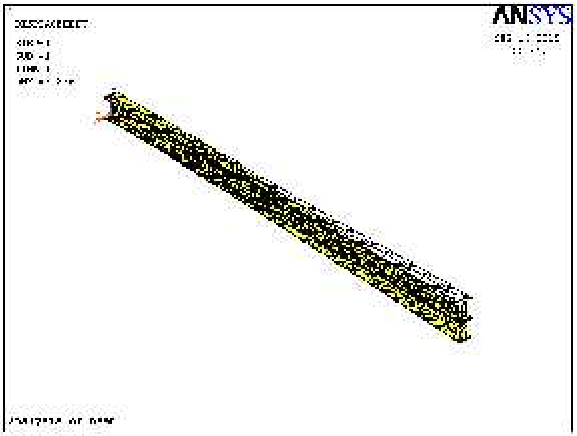

Figure 2 Deformed shape

Value of deflection (Analytical) = 5.98 mm

Value of deflection (Finite element analysis) = 5.85 mm

Error = (5.98-5.85) x 100 /5.98 = 2.17 % which is very less & hence the same element size is used throughout the analysis. Total number of elements is 4687 & total number of nodes is 1754. Figure 2 shows the deformed shape of the beam.

IV. FINITE ELEMENT ANALYSIS OF JIB CRANE

Model of jib crane: A simplified model of the jib crane is prepared using the facilities in ANSYS software. Here the inner & outer diameter of the mast is 120 mm & 150 mm respectively. The beam dimensions are as in earlier case.

Meshing: Model is meshed with same element & edge length of the element is same as in the case of beam.

Boundary condition: The bottom surface of the mast or column is constrained in all directions (rotary & linear) as it is fixed with foundation & will not move at all.

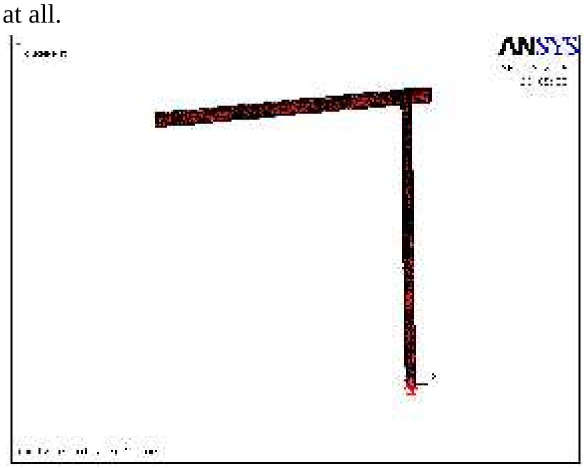

Figure 3 Meshed model with boundary condition

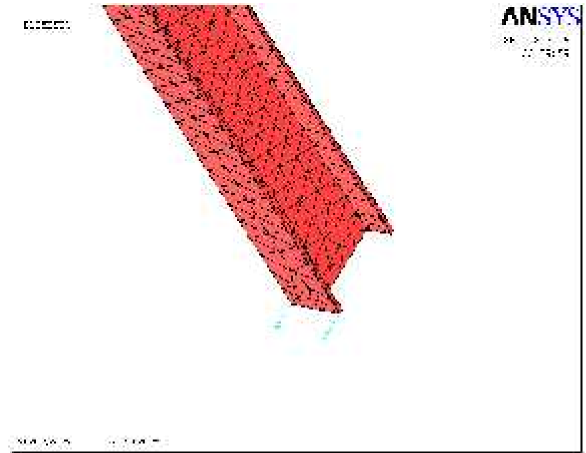

Figure 4 Load applied to model

Load conditions: At the end of the beam, load is applied at two points. Value of this load is 9.81 x 100 x 1.15/2. Here weight of trolley is 15% of the capacity of the crane.

V. RESULTS & DISCUSSIONS

Deflection of the beam & stresses in the crane are observed during the post-processing.

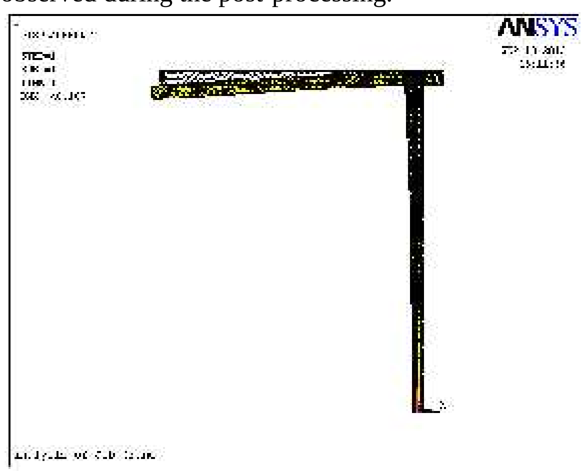

Figure 5 Deformation of crane

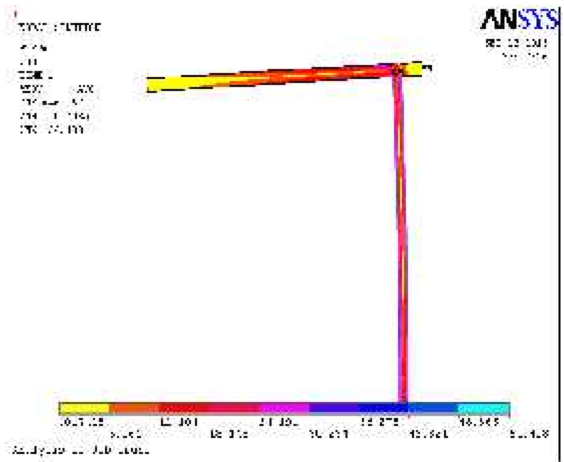

Figure 6 Von Mises stresses in crane

Effect of web thickness: As web is the part which takes the load in the beam, effect of web thickness is studied keeping the load constant & equal to 1.15 x 9.81 x 100 Newton.

Table 2 Effect of web thickness on deflection & stresses

Web thickness (in mm)	Max. Von Mises Stress (in MPa)	Deflection (in mm)
4.4	46.789	14.123
4.6	46.634	14.077
4.8	46.28	14.028
5.0	46.26	13.992
5.2	45.909	19.951
5.4	45.622	13.91

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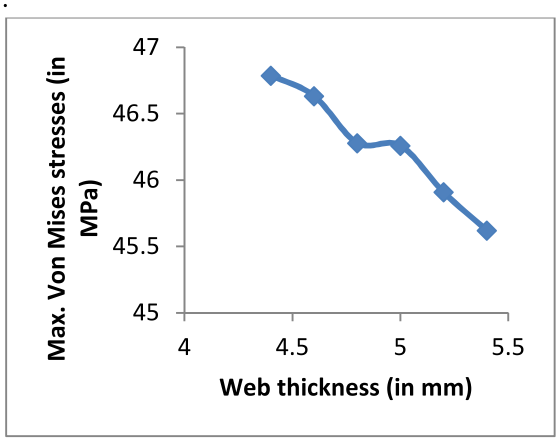

Figure 7 Effect of web thickness on stresses

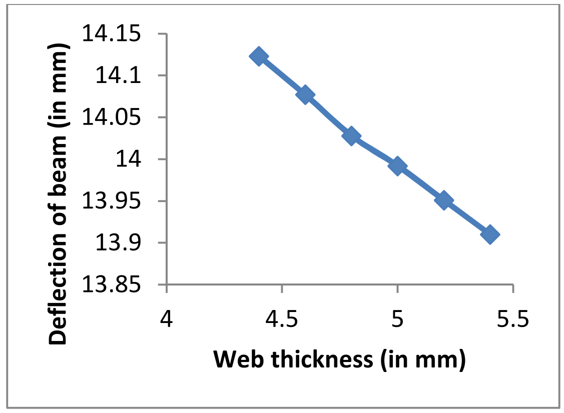

Figure 8 Effect of web thickness on deflection

Here it is seen that as with increase in the web thickness there is decrease in maximum Von Mises stresses initially. Afterwards it remains constant. Then again it decreases with web thickness. As thickness of web increases, deflection of beam decreases continuously. Deflection is inversely proportional to web thickness.

Effect of web height: During the study variation in web height is also done.

Table 3 Effect of web height on deflection & stresses

Web height (in mm)	Max. Von Mises Stress (in MPa)	Deflection (in mm)
112	46.789	14.123
117	44.309	13.532
122	62.751	13.192
127	42.643	12.808
132	41.052	12.505
137	39.505	13.193

Figure 9 & 10 show relation between web height & maximum Von Mises stresses & deformation.

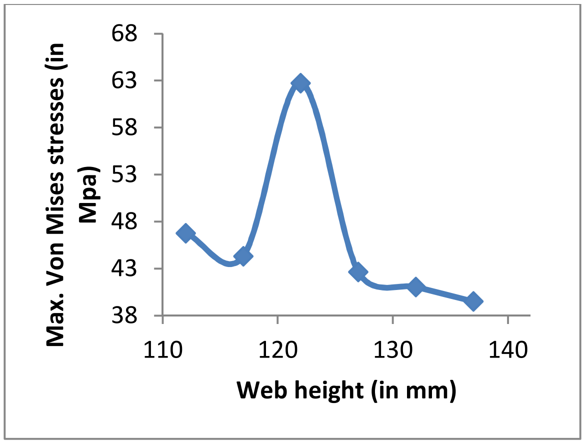

Figure 9 Effect of web height on stresses

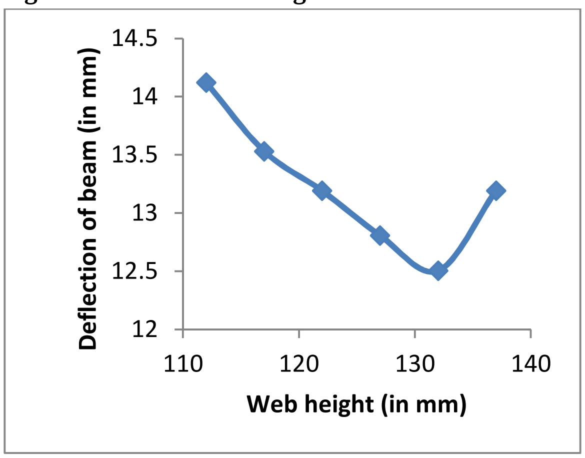

Figure 10 Effect of web height on deflection

Here it is seen that with increase in web height initially there is decrease in maximum Von Mises stresses but afterwards it starts increases & reaches a peak value. Again it starts decreasing & at the end it nearly remains constant. With increase in web height, there is decrease in the deflection of the beam for a larger part initially. But at the end, again it starts increasing.

VII. CONCLUSIONS

Analysis of jib crane is performed during this dissertation work. Following conclusions can be drawn from the same.

- ✓ The maximum Von Mises Stress occurs at the junction of at the beam & column or mast & at the free end of the beam, highest deformation has occurred leading to lower stresses.
- ✓ As thickness of web increases, deflection of beam decreases continuously. Deflection is inversely proportional to web thickness. There is also decrease in maximum Von Mises stresses.
- ✓ With increase in web height initially there is decrease in maximum Von Mises stresses but afterwards it starts increasing & reaches a peak value. Again it starts decreasing & at the end it nearly remains constant.
- ✓ With increase in web height, there is decrease in the deflection of the beam for a larger part initially. But at the end, again it starts increasing.

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