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Design and Static Analysis of I-Section Boom for Rotary Jib Crane

Mr. Subhash N. Khetre
Department of Mechanical Engineering
RSCOE (IInd Shift Polytechnic) Tathawade, Pune, India

Ms. Priyanka S. Bankar
Department of Mechanical Engineering
RSCOE (IInd Shift Polytechnic) Tathawade, Pune, India

Mr. Arun M. Meshram
Department of Mechanical Engineering
RSCOE (IInd Shift Polytechnic) Tathawade, Pune, India

***Abstract*—In this paper, the method of final designing of I-section boom for Material handling jib crane system. The basic functions are determined for certain parameters of jib cranes as yield strength, deflection of I-section using Static stress analysis, displacement analysis .A requirement for movement ,of heavy loads which is correspondingly difficult. Jib crane is design, analyze and develop from three most prevalent material handling devices.**

They are Tower jib crane, free standing Jib crane and jib crane with trusses. Among them the best design, higher strength and greater life span crane has to be designed for future work .

During the analysis, the Solid Works and COSMOS is used the analysis is carried out in two load steps. The total analysis time is approximately two-three hours taken by the software.

***Keywords*— Jib crane; I-section boom; Static analysis; Solid Works and COSMOS.**

I. 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. A jib crane can help to improve material handling efficiency and work flow. Serious consideration should be given to jib cranes for applications requiring repetitive lifting and transferring of loads within a fixed arc of rotation.

The need of continual improvement in material handling technologies is a common feature of many modern engineering endeavors. Engineering structures now encompass 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.

II. ACTION PLAN

Phase 1: Selection Of Crane:

While selecting the crane type, numbers of different factors are taken into account they are capacity, operation requirement, application, design,

Phase 2: Selection Criterion:

Today's industry demands versatile, efficient equipment while at the same time providing more flexibility along with significant savings through increased productivity. A jib crane can help to improve materials handling efficiency and work flow.

Phase 3: Work Requirement:

- Capacity : 2 tons
- Rotation: 360 ^{o}
- Support: floor
- Site : outside weatherized work station
- Height of lift: 6000 mm.
- Boom Length: 6000mm.

According to the above requirements free standing Jib crane is best suitable.

III. DESIGN DETAILS OF BOOM :

A. Selection of I Section:

- Type -I section of "S" type i.e. fillet type
- Size – 500×180 mm^2
- Material – Structural Steel
- Mass per unit length – 86.9 kg/m
- Weight – 564.85 kg.

B. Selection of Material of I Section: Structural steel (M.S.)

Table No. 1 (A) Indian standard medium weight beams

Designation	Area (cm2)	Depth (mm)	Width (mm)	Web Thk. (mm)
	A	H	b	Tw
MB500	110.74	500	180	10.2

Table No. 1 (B) Indian standard medium weight beams

Designation	Root Thik. (mm)	Root radius (mm)	Toe Radius (mm)	MI (cm4)
		R	r	Iz
MB500	10.2	17	8.5	45218.3

C. Properties Of Material Steel:

I. Young's Modulus : 2×10^5 MPa
II. Poisson's Ratio : 0.3
III. Density : 7.85×10-6 kg/mm
IV. Thermal Expansion : 1.25×10^{-5} per °C
V. Tensile yield strength : 250 MPa
VI. Compressive yield strength : 250 MPa
VII. Tensile Ultimate strength : 460 MPa
VIII. Compressive Ultimate strength : 0 MPa
IX. Thermal conductivity :6.05×10^{-2} watt/mm °C
X. Specific Heat : 434 J/kg ° C

D. Loads Defined :

The loads acting on boom are defined as follows:

- Dead Load (DL): The weight of the beam and any other fixed item supported by the beam.
- Trolley/hoist Load (HL) The weight of the hoist and any other equipment attached to the hoist.
- Lifted Load (LL): The weight of the item lifted along with all associated lift devices such as slings, shackles, etc.

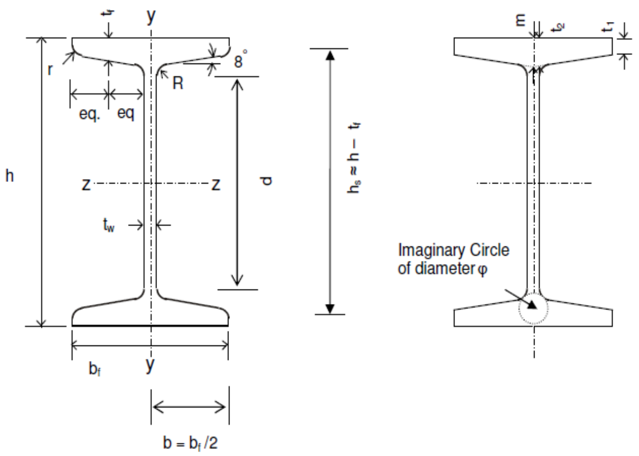

Fig.1- Indian standard medium weight beams with tapered Flanges.

E. Actual load carried by the boom:

1. Lifted Load (LL) = 2000 kg
2. Hoist Load (HL) = 500 kg
3. Dead Load (DL) = 243.10 kg

F. Total load acting on the boom:

= LL+HL+DL = 2000+500+243.10
= 2743.1 kg

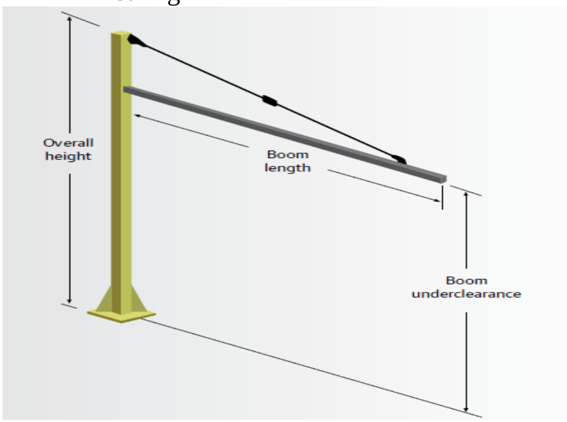

Fig.2 - Dimensioning Of Free Standing Jib Crane

This is the total load carried by the beam. To balance the load and to check the yield strength of I section following calculations are given.

G. Calculatons:

1. Calculations For 300×140 I-Section:

To find reactions,

$R_X = 0$; $\sum M_O = 0$

$R_Y = 442 \times 5.5 + 20 \times 10^3$

$= 22431$ N

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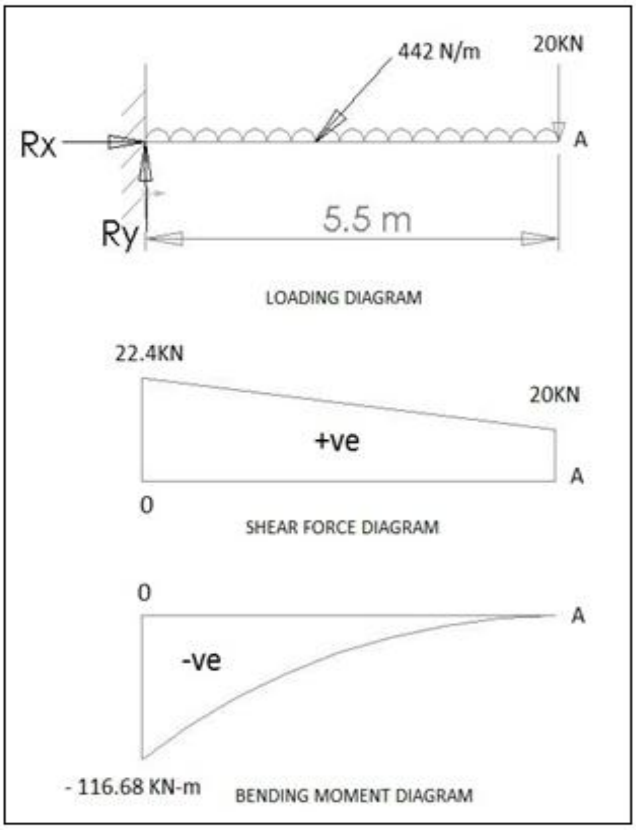

Fig.3. SFD and BMD diagrams for 20 KN loading condition.

Bending Moments: Bending Moment @ A

B.M. at A = 0

B.M. at 0 = - 20 * 103 * 5.5 – 442 * 5.5 * 10^3

M = 116685.25 Nm

By Using Flexure Formula,

M/I = σ / Y = E / R

(11668.25 / 8306.3 * 10^{-8}) = (σ / 125 * 10^{-3})

σ = 175.59 N/m^2

σ = 175.59 MPa

As Yield strength $\sigma_{(yield)}$ = 250 MPa……… (ISO Std.)

2. *Check the Deflection in I Section:*

The Deflection calculated as below

$$\delta l = (wl^3/3EI) + (wl^4/8EI)$$

For Steel, E = 210 * 10^9 N/m^2

E = 210 * 10^9

$$\delta l = \{(20*10^3*5.5) / (3*2.1*10^{11}*5131.6*10^{-8})\} + \{(442*(5.5/2)^4*5.5) / (8*2.1*10^{11}*8603.3*10^{-8})\}$$

δl = 0.006156 m or δl = 6.156 mm

III. Analysis Results of I-Section Boom:

The Static stress analysis is applied to calculation, which address the static analysis and displacement analysis resulting.

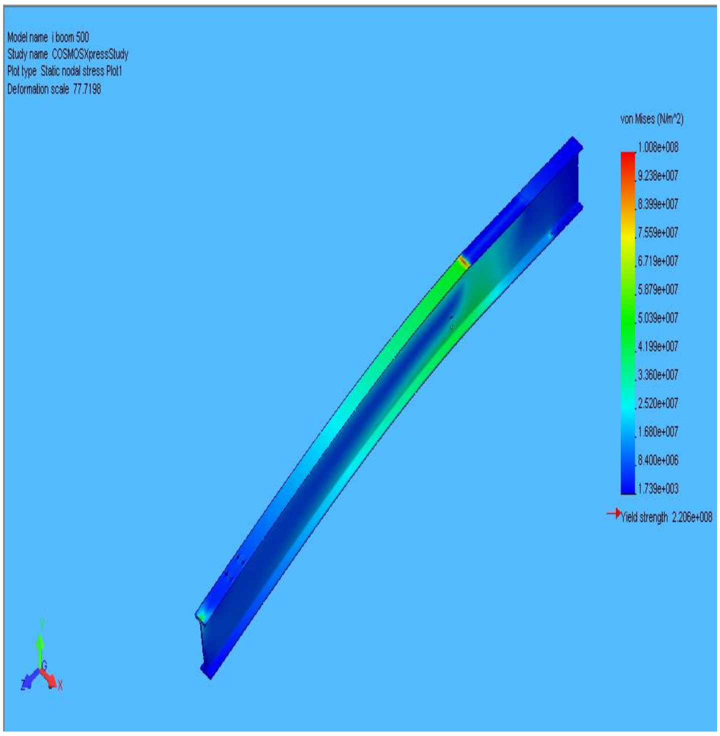

Fig.4-Static stress analysis of I-Section Boom for 20 KN loading condition

The purpose of static analysis is to insure safety of the I – section and supporting structure. Sustained loads are by using self weight and operating conditions. The analysis, the Solid Works and COSMOS is used the analysis is carried out in two load steps.

- Stress (σ): The highest calculated stress will be in the order of 108 MPa.

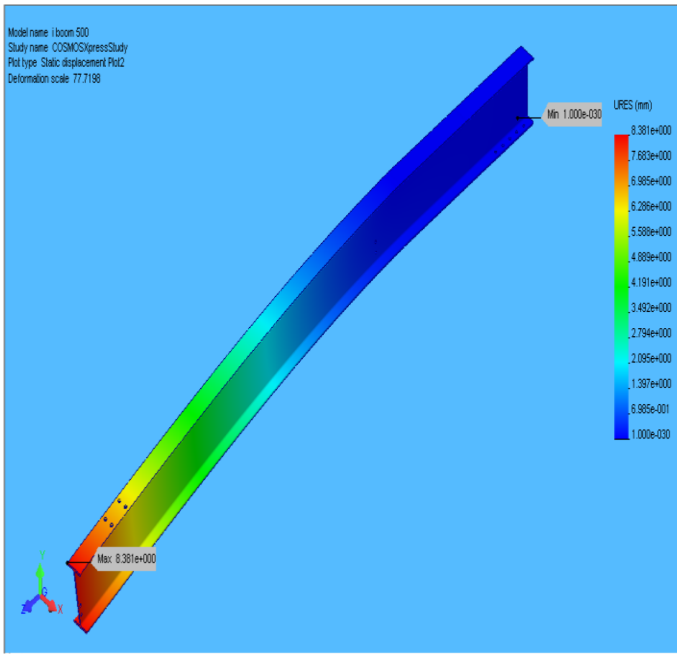

Fig.5-Static displacement analysis of I-section Boom for 20 KN loading condition.

- Deflection (δ): The maximum deflection of the end point will be in the order of 8.38149 mm.
- FOS: 2.5

IV. RESULTS & DISCUSSIONS:

At first point of crane boom the load applied is 20 KN. At this point load is carried with the help of a hook. The maximum displacement is 8.38 mm and maximum 3-D element stress is 175MPa near the upper portion where the assembly is done. In the figure it is shown by red colour.

Table. 2. Static stress analysis by using Analytically for 20 KN loading condition.

1	Minimum	100 MPa
2	Maximum	175 MPa

Table. 3. Static displacement analysis by using Analytically for 20 KN loading condition

1	Minimum	1.91 mm
2	Maximum	6.156 mm

Table. 4. Static stress analysis by using Solid Works and COSMOS for 20 KN loading condition.

1	Minimum	108 MPa
2	Maximum	173 MPa

Table. 5. Static displacement analysis by using Solid Works and COSMOS for 20 KN loading condition.

1	Minimum	1.00 mm
2	Maximum	8.38 mm

During the analysis, the Solid Works and COSMOS is used the analysis is carried out in two load steps. The total analysis time is approximately two-three hours taken by the software.

V. CONCLUSIONS

Jib Cranes vary widely in configuration, capacity, mode of operation, intensity of use, working environment. The variety of forms, operating conditions, environmental factors make the design of jib cranes challenging. Usually a new design need arises when existing cranes do not meet the requirements for a new application. However, in most of the cases the required knowledge on configuration and structure of a jib crane can be obtained from previously accumulated technical information.

The technical information is generally standardized. Besides that, the available jib crane components are also well standardized all over the world and suitable for computer automated design procedures. Since jib Crane design procedures are highly standardized.

Thus it concluded that, we have selected the suitable Design and Static Analysis of I-Section Boom for Rotary Jib Crane.

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