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DESIGN DEVELOPMENT AND OPTIMISATION OF OVERHEAD CRANE

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ABSTRACT

Optimization is one of the techniques used in designing sectors to arrive at the best designing conditions which is a very essential need of the industry toward designing of quality products at low costs. This paper is aimed at finding the optimal conditions using which beam and columns can be designed for crane system manufacturing. The following set of calculations are specific to our industry. For this application we considered various beam sections and found them to be ineffective in terms of cost and material usage. So we did a few iterations using different sections and optimized the design for best material utilization.
KEYWORDS: Overhead Crane, load carrying capacity, beam optimization, column design.

INTRODUCTION

A 'crane' is a type of machine, generally equipped with a hoist, wire ropes or chains, and sheaves, that can be used both to lift and lower materials and to move them horizontally or vertically. It is mainly used for lifting heavy things and transporting them to other places. It uses one or more simple machines to create mechanical advantage and thus move loads beyond the normal capability of a man. Cranes are commonly employed in the transport industry for the loading and unloading of freight, in the construction industry for the movement of materials and in the manufacturing industry for the assembling of heavy equipment. In material handling, the cranes play a vital role in modern manufacturing industries.

MATERIALS AND METHODS

Design of components of the overhead crane system:

The overhead crane consists of the following components:

1. Beam for the chain hoist
2. Columns for the crane
3. The chain hoist mechanism
4. Channel for the chain hoist
5. Channels supporting the beam

Design of beam for chain hoist:

The existing chain hoist will be transferred to a new beam which will move on channels situated over the columns in the workplace.

The beam has to withstand bending and shear forces which will be caused due to the load being lifted by the chain hoist.

The dimensions of the work place are :
Length = 25m
Width = 12m
Height = 5.4m

The beam will be as long as the total width of the workplace and the bearings at the side will facilitate linear movement along the length of the place.

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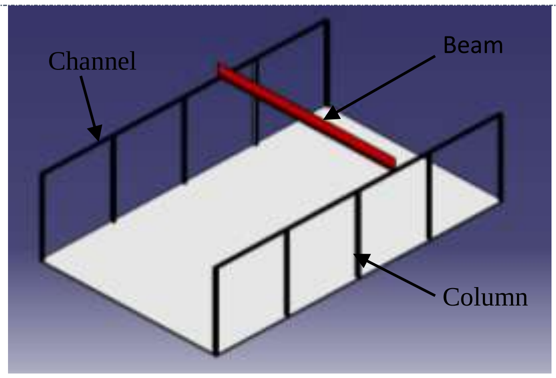


Layout of the workplace

Design of beam :

The material selected for the beam is Fe 410. This material is used in 90% manufacturing works as it is cheap and readily available.

The material properties are :

- Ultimate tensile strength (σu) = 410 MPa
- Yield tensile strengt (σy) = 220 MPa
- Young's modulus (E) = 210 GPa
- Considered FOS over yield = 2
- Allowable bending stress (σb) = 110 MPa

Available Data:

Total weight on beam (W) = 3000kg = 29430N≈30000N

Total length of beam (L) = 12m = 12000mm

Total moment acting(M) = WL/4

= 9x10^6 N-mm

Required section modulus (Z) = M /σ_b

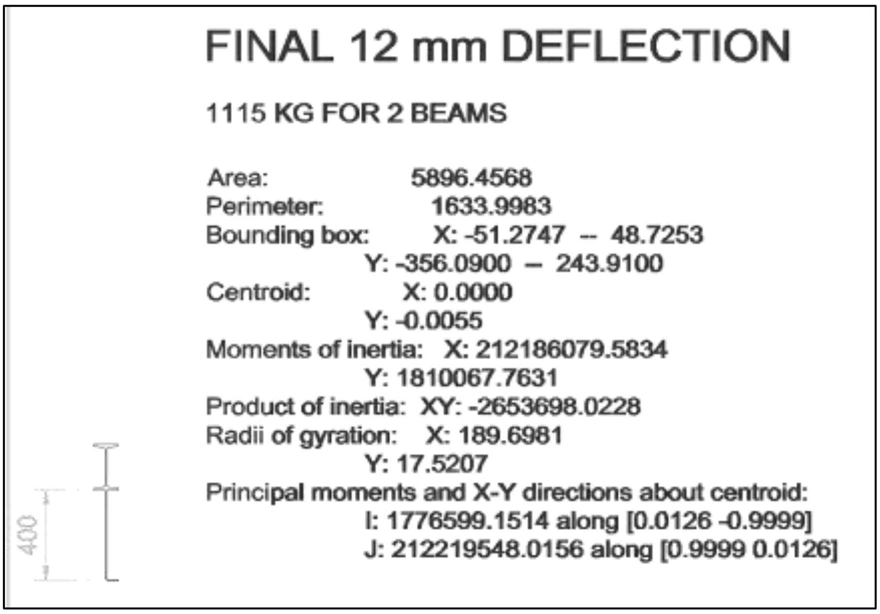
= 818.181 x 10^3 mm^3

For ISMB 200x100 (with plate of dimension 650mmx 20mm welded to it)

I_{xx} = 1.787 x 10^9 mm4

Deflection of beam (δ) = $WL^3/48*E*I_{xx}$

= 12.12 mm



Calculated values for selected beam section in AutoCAD

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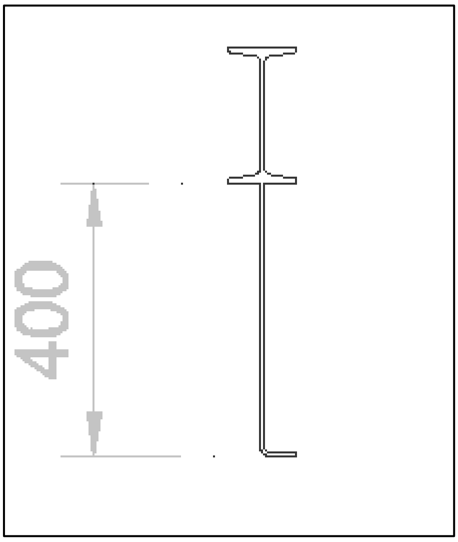

Optimized section of beam selected

Design of column:

By Euler's formula,

For, 1 end fixed and 1 end free column,

$P_c = \pi^2 E * I_c / 4 * L_c^2$

where, P_c = Buckling load,

E = 205 GPa,

L_c = Length of column.

and I_c = Moment of inertia of considered column section.

= 7.88 x 10^6mm^4

$P_c = \pi^2$ x 205 x 10^3 x 7.88 x 10^6/ (4 x 5400^2)

= 136688N

Considering FOS = 5 (as safety is a primary concern , an FOS of 5 is selected.)

Safe load = P_c /FOS = 136688/5 = 27337.6 N

≈ 2.786 tonne

Total maximum load on 1column = (Load on beam /2)+ Beam weight + (Total load of channel/5)

= 3000/2+1000+1000/5

= 2700kg < Safe load

Therefore, The considered I-section is safe and design is proper.

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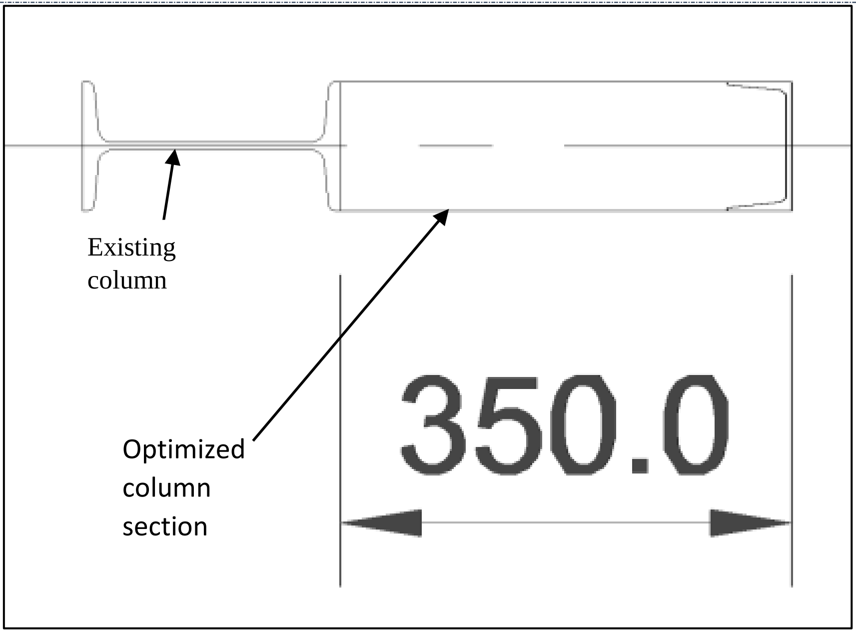

New I section used for columns

RESULTS AND DISCUSSION:

Formulae:

$$M = \frac{WL}{4} \quad (1)$$

$$\delta = \frac{WL^3/}{48*E*I_{xx}} \quad (2)$$

$$W_b = w_b * L \quad (3)$$

$$P_c = \frac{\pi^2 E * I_c}{4 * L_c^2} \quad (4)$$

$$\text{Safe load} = P_c / FOS \quad (5)$$

Iterations for beam design:

Sr.No.	Details	Notation	Units	Iteration I (ISMB 500)	Iteration II (ISMB 450)	Iteration III (ISMB 250)	Iteration IV (cad 400)
1	Load	W	Kg	3000	3000	3000	3000
2	Span	L	Mm	12000	12000	12000	12000
3	Allowable bending stress	σ_b	kg/ mm²	11	11	11	11
4	Moment	M	kg-mm	9000000	9000000	9000000	9000000
5	Moment of Inertia	I_{xx}	mm^4	4.52E+08	3.04E+08	1.03E+08	**4.24E+08**
6	Deflection	Δ	Mm	11.3780025	16.91729323	50.101	**12.12**
7	Weight of the beam/ m	w_b	kg/m	210	72.4	37.3	**37.3**
8	Weight of the beam	W_b	Kg	2520	868.8	447.6	**1115**

CONCLUSION

By selecting single I section we have defelection above safe limit. So ,to reduce deflection we select 2 I section with plate welded on its flange as our beam. By selecting this design we optimize weight of beam as well as size of the beam.

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CATALOGUES

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