Design Analysis of Overhead Crane for Maintenance Workshop

Siva Sitthipong[1,a], Chaiyoot Meengam[2] Suppachai Chainarong[2] and Prawit Towatana[3]

[1]*Physical Testing Laboratory, Thailand Institute of Scientific and Technological Research, Samut Prakan, Thailand*
[2]*Faculty of Industrial Technology, Songkla Rajabhat University, Songkhla, Thailand*
[3]*Marine and Coastal Resources Institute, Prince of Songkla University, Songkhla, Thailand*

Abstract. This research aimed to study the design of the overhead crane of a small fishing boat maintenance factory according to the building and functional requirements of the project based on the ASME B30.2-2005 Standard. The results of the study showed that the design of the runway with steel structure BS: 5950: 2000 grade s460 provided vertical and horizontal deflection values of 4.96 and 16.62 respectively that did not exceed the allowed deflection. It is strong enough for use in construction when the stresses on the beam bridge were analysed by the finite element program compared with the strength of the reinforced steel providing a safety value of 1.83.

1 Introduction

Utilization of the maintenance buildings possesses specification for the overhead crane which has less than 600 square meters in size, 20 meter wide bridge beam and 30 meter running distance as shown in Fig 1. The height of the crane to the floor does not exceed. 15 meters and the crane must be able to carry a load of 20 tons and the design must comply with the requirements. The structure must be strong, stable, and cost-effective.

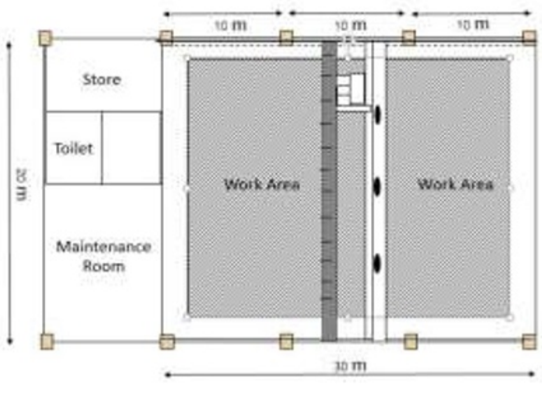

Fig. 1: Install Area of Overhead Crane

2 Crane Design Method

2.1 Design Guidelines

The main structure of the crane is iron with BS: 5950: 2000 grade S460 and has high strength per weight unit. The design is in accordance with ASME B30.2-2005. The figure is shown in Figure 2. The primary data required for the design calculation is shown in Table 1., requirements. The structure must be strong, stable, and cost-effective.

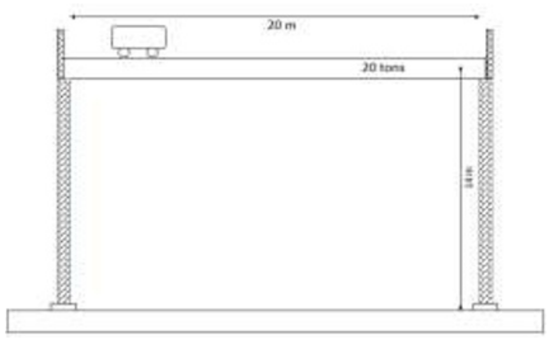

Fig. 2: Overhead Crane

Table 1. Primary data designated in the design

Parameters	Symbol	Value
Crane Capacity	W_{cap}	200 kN
Weight of Crane Bridge and End Carriages	W_c	122 kN
Weight of Crab	W_{cb}	15.6 kN
Span Beetween Crane Rails	L_c	20 m
Minimum Hook Approach	ah	0.92 m
Wheel Centres in End Carriages	s	4 m
No. of Wheel Flanges	-	2
Height of Rail	HR	50 mm
Span of Crane Girder	L	10 m
Self Weight of Crane Girder	W_g	12 kN
Stiff Bearing Length	b1	150 mm
Beam end to Stiff Bearing Edge	be	150 mm
Flange Restrains For Position and Direction	--	1
Design Strength	P_y	440 N/mm^2
Specific Thickness	t	20.2 mm

[a] Corresponding author: siva@tistr.or.th

2.2 Runway Deflection Analysis

The vertical and horizontal actual deflection was calculated from (1) and (2), respectively, which was acceptable only if the result was no more than the permitted deflection as calculated from equation (3)

$$\text{Vertical Actual Deflection} = Wus\ L^3\ [3(a+c)/L - 4(a^3 + c^3)/L^3]/[48E\ Ix] \quad (1)$$

$$\text{Horizontal Actual Deflection} = FR\ L^3/(48E\ Iyfc) \quad (2)$$

$$\text{Permitted Deflection} = \text{Span} / 600 \quad (3)$$

The design of the beam cross-section used for deflection analysis is as follows:
The figure is shown in Fig. 3:

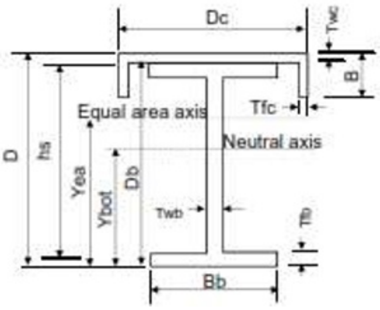

Fig. 3: Overhead Crane.

Table 2. Main Section

Mass	200.9
Ab cm^2	256
Db mm	903
Bb mm	303.3
Tfb mm	20.2
Twb mm	15.1
lxb cm^4	325254
lyb cm^4	9423
Jb cm^4	291
r mm	19.1
d mm	824.4

Table 3. Top Section

Mass kg/m	67.510
Ac cm^2	86
Dc mm	430
Bc,DL mm	20
Tfc mm	0
Twc cm	20
lxc cm^4	13251.167
lyc cm^4	28.667
Jc cm^3	114.667
Cy cm	1

Table 4. Forming a Compound Crane Girder Section.

M kg/m	**A cm^2**	**D mm**	**B mm**	**Ytop mm**	**Ybot mm**	**Ix cm^4**	**Iy cm^4**	**lyfc cm^4**	**lyft cm^4**	**ry cm**
268.410	342.000	923.000	430.000	355.450	567.550	462388	22674	13251	4697	8.142
Zx top cm^3	**Zxbot cm^3**	**Zyfc cm^3**	**Sx cm^3**	**J cm^4**	**hs cm**	**X const**	**DL mm**	**sai**	**N ratio**	
13009	8147	616	10962	405.667	89.280	46.398	20.000	0.385	0.738	

Table 5. Equivalent Area Axis & Plastic Modulus of the Combined Section.

strip	**Width**	**Height**	**y=0**	**Area**	**Dist comp**	**Dist ten**	**Area comp**
A1	430	20	Y=20	8600	20	0	8600
A2	303.3	20.2	Y=40.2	812.66	20.2	0	6126.66
A3	15.1	0	Y=40.2	0	0.0000	0.0000	0
A4	15.1	862.6	Y=902.8	13025.26	146.5317881	716.0682119	221263
A5	303.3	20.2	Y=923	6126.66	0	20.2	0
		923		33878.58		923	16939.29

Area ten	**yc top**	**yt top**	**Sx cm^3**
0	10.000	186.732	-86.000
0	30.100	186.732	-184.412
0	40.200	186.732	0.000
1081263	113.466	544.766	5639.294
6126.66	186.732	912.900	5693.028
16939.29	10.000	186.732	10961.909

2.3. Strength Analysis of Bridge Beam Box

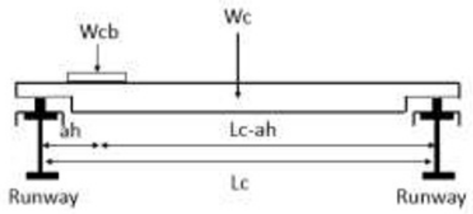

Fig. 4: Bridge Crane.

In processing, the finite element method with the solid work simulation program was employed in the 8 following main steps:

(1) Check the integrity of the CAD file

(2) Define the boundary conditions of the grip and support the actual working conditions.

(3) Determine the force load to determine both position and size. The value derived from the calculation.

(4) Specify the type of material as standard iron steel with BS: 5950: 2000 grade 460.

(5) Determine the type and shape of the elements that are appropriate for the complex structure work.

(6) Create mesh especially using the fine mesh in the complex structure area.

(7) Use the workpiece command and then the obtained results is analyzed for the accuracy.

3 Results and Discussion

3.1 Result of Design Analysis of Runway Overhead Crane

The results obtained from the calculation of the overhead crane design were shown in Table 6. Fig. 5-6 showed the position of the analysis. Fig. 7-10 showed the maximum bending moment. The forces acting on the support points were shown in Fig. 11-12.

Table 6. Result of Design Analysis

Maximum Vertical Moments			
Distances	a = 2 m	S = 4 m	C = 4 m
Due to Dead Load	R_a = 6 kN	R_b = 6 kN	M = 14.4 kNm
Due to Crane Load	R_a = 208 kN	R_b = 138 kN	M = 554.7 kNm
Momement Mx1 = 1.4 Dead Load + 1.6 Crane Load with Impact			M=907.7 kNm
Momement Mx2 = 1.4 Dead Load + 1.4 Crane Load with Impact			M=796.7 kNm
Maximum Horizontal Moments			
Due to Crane Surge	R_a = 6.5kN	R_b = 4.3kN	M = 17.2 kNm
Moment My = 1.4 Crane Load due to Surge			M = 24.1 kNm
Due to Crane Crabbing	My = 1.4FR.L/4		75.8 kNm
Vertical Deflection Check			
Distances	a = 3m	S = 4m	C =3 m
Max Actual Deflection			4.96 mm
Permit Deflection			16.67 mm
Horizontal Deflection Check			
Distances	a = 3m	S = 4m	C =3 m
Surge Deflection			6.99 mm
Crabbing Deflection			16.62 mm
Max Actual Deflection			16.62 mm
Permit Deflection			20.00 mm
Shear, Bending, Compression Check			
Shear			3599.7 kN
Shear Ratio 0.126			452.16
Bending (1.4 Dead Load + 1.6 Vertical Crane Load)			0.483
Maximum Bending 1.4 (Dead Load + Vertical Crane Load + Horizontal Crabbing)			0.703
Compression Under Wheel			101.8 N/mm^2

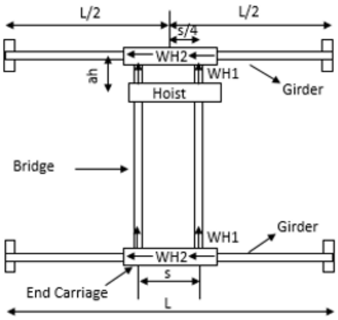

Fig. 5: Crane layout & transverse surge force for maximum horizontal moment

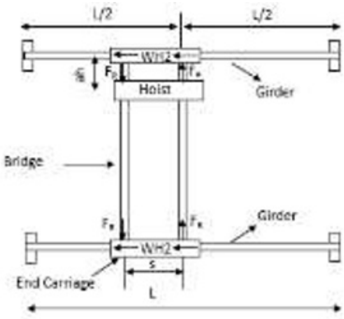

Fig. 6: Crane layout & crabbing forces for maximum horizontal moment

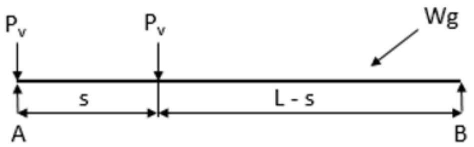

Fig. 7: Vertical Load Positions Causing Maximum Vertical Shear

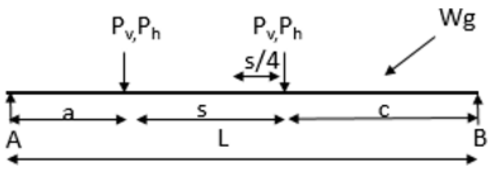

Fig. 8: Load Positions Causing Maximum Vertical & Horizontal Moment

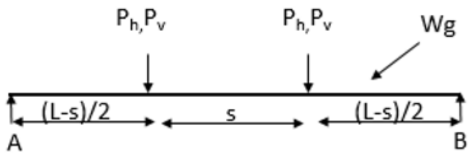

Fig. 9: Load Positions Causing Maximum Vertical & Horizontal Deflection

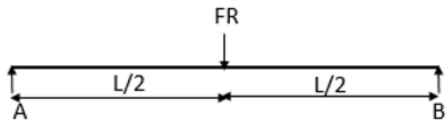

Fig. 10: Crabbing Load Position Causing Maximum Horizontal Moment & Deflection

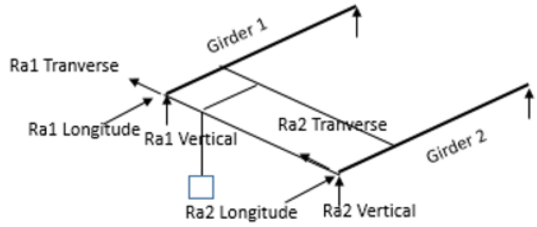

Fig. 11: Reactions on to the Support Structure with Crane Crabbing

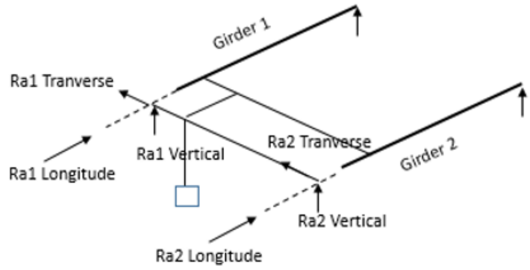

Fig. 12: Reactions on to the Support Structure with Crane Crabbing

3.2 Results of Strength Analysis of Bridge Beam Box

The stress analysis of the beams with finite element method [1-14] is shown in Fig. 13. The maximum stress of 338 MPa gives a safety value of 1.83.

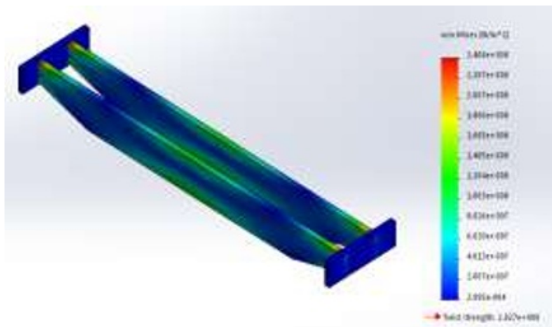

Fig.13: Result of Stress Analysis.

4 Summary

Crane design analysis, which satisfies ASME B30.2-2005 standards, is highly accurate and reliable. Therefore, the cost of construction can be reduced to 1.83., and provides 20 tons of cranes as desired. It is suitable for use within designated areas. The data of this design will be employed to construct the overhead crane of the local fishing boat maintenance workshop.

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