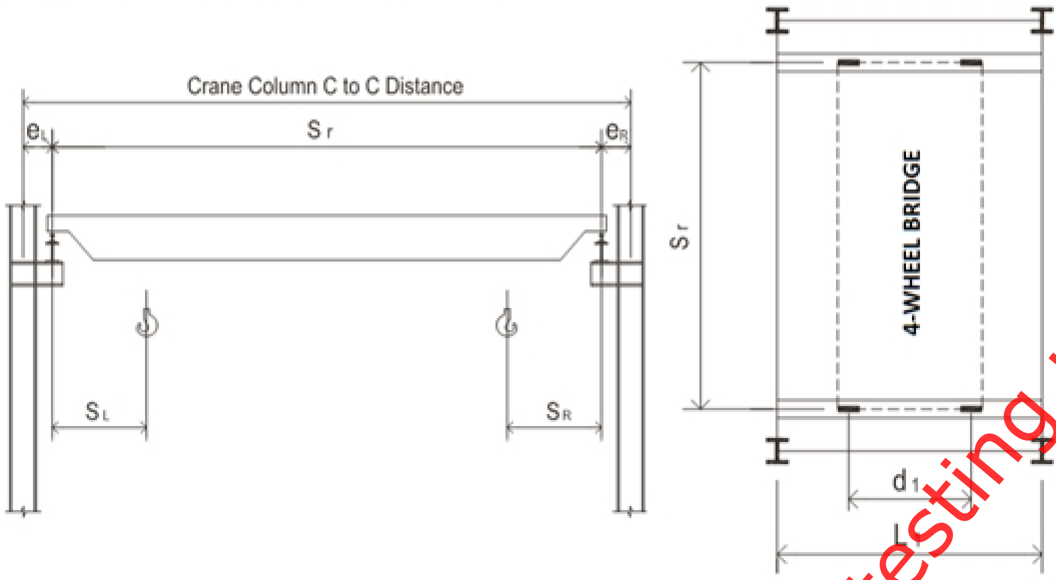
CRANE RUNWAY BEAM DESIGN: AISC360-16

Crane Information



Crane Data		Value	
Capacity	W_{rc}	100	kN
Bridge Weight	W_{br}	74.1	kN
Trolley + hoist weight	W_{th}	12.7	kN
Max static wheel load	$P_{max\text{-}v}$	83.8	kN
Bridge span	S_r	20	m
Min. hook approach	S_{min}	0.0	m
Bridge wheel spacing	d_1	3.15	m
Crane runway beam span	L_1	6	m
Runway CL to column CL dist	e	0.0	m
Crane rail size		No Rail	
CMAA crane service class		Class C	
Vertical impact factor	α	1.25	
Crane type		Top Running	
Crane runway beam size		H:363:10:200:15+UPN240	
Crane runway beam steel		S235	
Beam F_y	F_y	235000	kN/m²

Conclusion

Runway Beam Design Using AISC360-16

Local buckling	ratio =	
Biaxial Bending on Top Flange	ratio = 0.83 Satisfactory	✔ o.k.
Shear along Y−Y Axis	ratio = 0.28 Satisfactory	✔ o.k.
Web Sidesway Buckling	ratio = 0.40 Satisfactory	✔ o.k.
Runway Beam Vertical Deflection	ratio = 0.23 Satisfactory	✔ o.k.
Runway Beam Lateral Deflection	ratio = 0.83 Satisfactory	✔ o.k.
OVERALL	ratio = 0.83 Satisfactory	✔ o.k.

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Runway beam linear self weight $U_{rb} = 1.06\ kN/m$

Crane rail linear self weight $U_{cr} = 0.0\ kN/m$

Crane runway + rail self weight

$$R_{sw} = (U_{rb} + U_{cr})L \Longrightarrow R_{sw} = (1.06 + 0.0) \cdot 6 = 6.34\ kN$$

Wheel load by bridge self weight

$$P_{br} = W_{br}/(2\ or\ 4\ wheels\ x\ 2\ sides) \Longrightarrow P_{br} = 74.1/(4) = 18.5\ kN$$

Option 1 $H_s = \quad 0.2(lifted\ load + trolley/hoist\ Wt) = 0.2(100 + 12.7) = 22.5\ kN$

$$H_{s2} = 0.2\ (lifted\ load + trolley/hoist\ Wt) = 0.2(100 + 12.7) = 22.5\ kN$$

$$H_{st} = H_{s2}/wheel\ count = 22.5/4 = 5.63\ kN/\ per\ wheel$$

Tractive Load

$$H_{tr} = 0.2\ P_{max} = 0.2 \cdot 83.8 = 16.8\ kN$$

Min. hook aproach $S_{min} = min(S_L, S_R) = 0.0\ m$

Max wheel load by calc

$$P_{max-c} = \frac{(W_{rc} + W_{th})(S_r - S_{min})}{no\ of\ wheel\ x\ S_r} + P_{br}$$

$$P_{max-c} = \frac{(100 + 12.7) \cdot (20 - 0.0)}{2 \cdot 20} + 18.5 = 74.9\ kN$$

Max wheel load by vendor $P_{max-v} = 83.8\ kN$

Max static wheel load

$$P_{max} = max(P_{max-v}, P_{max-c})$$

$$P_{max} = max(83.8, 74.9) = 83.8\ kN$$

Min static wheel load

$$P_{min} = \frac{(W_{rc} + W_{th})S_{min}}{no\ of\ wheel\ x\ S_r} + P_{br}$$

$$P_{min} = \frac{(100 + 12.7) \cdot 0.0}{2 \cdot 20} + 18.5 = 18.5\ kN$$

Moment by moving wheel load

$$M_{cr} = 136.76\ kN.m$$

$$M_{sw} = (U_{rb} + U_{cr})L^2/8$$

$$M_{sw} = (1.06 + 0.0) \cdot 6^2/8 = 4.75\ kN.m$$

Shear by moving wheel load

$$V_{cr} = 23.63\ kN$$

$$V_{sw} = (U_{rb} + U_{cr})L/2$$

$$V_{sw} = (1.06 + 0.0) \cdot 6/2 = 3.17\ kN$$

Vertical load impact factor $\alpha = 1.25$

Runway beam + rail selfwei $U = U_{rb} + U_{cr}$

$$U = 1.06 + 0.0 = 1.06\ kN$$

Max ver.load/wheel(no impact) $P_{max} = 83.8\ kN$

Max hor.load/wheel $P_h = 9.01\ kN$

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Wheel load by bridge selfwei

$$P_{br} = W_{br} / (no\ of\ wheel \cdot 2\ sides)$$

$$P_{br} = 74.1 / (4) = 18.5\ kN$$

Wheel load by lift load + trolley

$$P_{lt} = P_{max} - P_{br} \implies P_{lt} = 83.8 - 18.5 = 65.3\ kN$$

Max factored ver. load/wheel

$$P_{v-f} = 1.2 P_{br} + 1.6 P_{lt}$$

$$P_{v-f} = 1.2 \cdot 18.5 + 1.6 \cdot 65.3 = 126.69\ kN$$

Max factored hor. load/wheel

$$P_{h-f} = 1.2 P_{br} + 1.6 P_{lt}$$

$$P_{h-f} = 1.2 \cdot 18.5 + 1.6 \cdot 65.3 = 9.01\ kN$$

Factor Bending moment x−x axis

$$M_x = M_{cr} P_{v-f} \Big/ P_{max} \alpha(impact) + M_{sw} 1.2$$

$$M_x = 136.76 \cdot 126.69 / 83.8 \cdot 1.25 + 4.75 \cdot 1.2 = 264.11\ kN.m$$

Factor Bending moment y−y axis

$$M_y = M_{cr} P_{h-f} \Big/ P_{max}$$

$$M_y = 136.76 \cdot 9.01 / 83.8 = 14.7\ kN.m$$

Factor Shear along y−y axis

$$V_y = V_{cr} P_{v-f} \Big/ P_{max} \alpha(impact) + V_{sw} 1.2$$

$$V_y = 123.63 \cdot 126.69 / 83.8 \cdot 1.25 + 3.17 \cdot 1.2 = 237.39\ kN$$

Reaction On the Side Far to Hook
Reaction by moving wheel load

$$R_{cr-c} = -155.91\ kN$$

Reaction by crane beam self wt

$$R_{sw} = 0.5(U_{rb} + U_{cr})(L_1 + L_2)$$

$$R_{sw} = 0.5 \cdot (1.06 + 0.0) \cdot (6 + 6) = 6.34\ kN$$

Sum $R_1 = R_{cr-c} + R_{sw}$

$$R_1 = -155.91 + 6.34 = -183.64\ kN$$

Reaction On the Side Far to Hook
Reaction by moving wheel load

$$R_{cr-f} = R_{cr-c} P_{min} \Big/ P_{max}$$

$$R_{cr-f} = -155.91 \cdot 18.5 \Big/ 83.8 = -34.5\ kN$$

Reaction by crane beam self wt

$$R_{sw} = 0.5(U_{rb} + U_{cr})(L_1 + L_2)$$

$$R_{sw} = 0.5 \cdot (1.06 + 0.0) \cdot (6 + 6) = 6.34\ kN$$

Sum $R_2 = R_{cr-f} + R_{sw}$

$$R_2 = -34.5 + 6.34 = -28.1\ kN$$

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Side thrust load per wheel H_{st} (*side thrust load calc using*) *Option1*

Max static wheel load $P_{max} = 83.8 \ kN$

Side thrust load $H_s = R_{cr-c} H_{st} / P_{max}$

$$H_s = -155.91 \cdot 5.63 / 83.8 = -10.5 \ kN$$

Tractive load per wheel $H_{tr} = 0.2$ *Max wheel load*

Max static wheel load $P_{max} = 83.8 \ kN$

Tractive load $H_t = R_{cr-c} H_{tr} / P_{max}$

$$H_t = -155.91 \cdot 16.8/83.8 = -31.2 \ kN$$

Point moment to Building Column Center

$M_1 = R_1 e_R \quad M_1 = -183.64 \cdot 0.0 = 0.0 \ kN.m$

$M_2 = R_2 e_L \quad M_2 = -28.1 \cdot 0.0 = 0.0 \ kN.m$

$\Phi = 0.85 (LRFD)$

When $(h/t_w)/(L_b/b_f) \le 1.7 \Rightarrow (0.313/0.01)/(Lb/0.2) \le 1.7$

$$R_n = \frac{C_r t_w^3 t_f}{h^2} \left[0.4 \left(\frac{h/t_w}{L_b/b_f} \right)^3 \right] \qquad (J10-7)$$

$$R_n = \frac{6.620E+9 \cdot 0.01^3 \cdot 0.015}{0.313^2} \cdot \left[0.4 \cdot \left(\frac{0.313/0.01}{Lb/0.2} \right)^3 \right] = 460.75 \ kN$$

Check Runway Beam Deflection

CMMA crane service class: $Class-C$

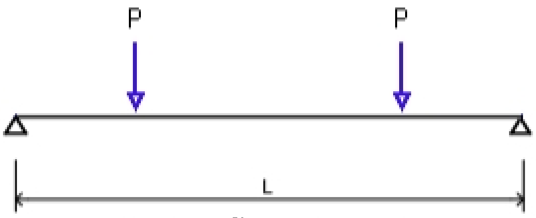
Vertical deflection Limit $B_v = L/600 = 6/600 = 0.01\ m$

Horizontal deflection Limit $B_h = L/400 = 6/400 = 0.015\ m$

Runway Beam Span $L = 6\ m$

Bridge Wheel Spacing $s = 3.15\ m$

Bridge Wheel Spacing $a = (L-s)/2 = 1.43\ m$



Max Deflection Case

Maximum vertical deflection at center

$P_{max} = 83.8\ kN\ /\ per\ wheel$ *Impact factor not included*

$$\Delta_{max,ver} = \frac{P_{max} \cdot (3L^2 - 4a^2)}{24EI_x} = \frac{83.8 \cdot (3 \cdot 6^2 - 4 \cdot 1.43^2)}{24 \cdot 2.000E{+}8 \cdot 0.000299} = 0.00831\ m$$

$ratio_{ver} = \Delta_{max,ver}/B_v = 0.00831/0.01 = 0.831$ *Satisfactory* ✔ *o.k.*

For top running crane, only top flange moment of inertia is considered for deflection check

$P_h = 5.63\ kN\ /\ per\ wheel$

$$\Delta_{max,hor} = \frac{P_h \cdot (3L^2 - 4a^2)}{24EI_f} = \frac{5.63 \cdot (3 \cdot 6^2 - 4 \cdot 1.43^2)}{24 \cdot 2.000E{+}8 \cdot 5.74E{-}05} = 0.00351\ m$$

$ratio_{hor} = \Delta_{max,hor}/B_h = 0.00351/0.015 = 0.234$ *Satisfactory* ✔ *o.k.*

H:363:10:200:15+UPN240 Properties :

$b = 0.2\ m$ $t_f = 0.015\ m$

$h = 0.0\ m$ $t_w = 0.01\ m$

$A = 0.0137135\ m^2$

$I_x = 0.000299141\ m^4$

$I_y = 5.73518E\text{-}05\ m^4$

$S_x = 0.00127659\ m^3$

$S_y = 0.000477932\ m^3$

$Z_x = 0.00168815\ m^3$

$Z_y = 0.000833494\ m^3$

$i_x = 0.147694\ m$

$i_y = 0.0646695\ m$

$C_w = 1.76201E\text{-}06\ m^6$

$J_c = 7.56656E\text{-}07\ m^4$

Material Properties: S235

F_y :Yield stress $= 235000\ kN/m^2$

F_u :Ultimate stres $= 360000\ kN/m^2$

E :Elasticity modulus $= 2.000E+8\ kN/m^2$

G : Shear modulus $= 7.692E+7\ kN/m^2$

Classification

Flange Slenderness

Compact Limit $\lambda_p = 0.38\sqrt{\dfrac{E}{F_y}} = 0.38\sqrt{\dfrac{2.000E+8}{235000}} = 11.1$

$F_L = 0.7F_y$

Non compact Limit $\lambda_r = 0.95\sqrt{\dfrac{k_c \cdot E}{F_L}} = 0.95\sqrt{\dfrac{0.708 \cdot 2.000E+8}{164500}} = 27.9$

$b/f = 0.1/0.015 = 6.67 \Longrightarrow Compact$

Web Slenderness

Compact Limit $\lambda_p = 3.76\sqrt{\dfrac{E}{F_y}} = 3.76\sqrt{\dfrac{2.000E+8}{235000}} = 109.69$

Non compact Limit $\lambda_r = 5.7\sqrt{\dfrac{E}{F_y}} = 5.7\sqrt{\dfrac{2.000E+8}{235000}} = 166.29$

$h/tw = 0.319/0.01 = 31.9 \Longrightarrow Compact$

Flange Slenderness

Compact Limit $\lambda_p = 0.38\sqrt{\dfrac{E}{F_y}} = 0.38\sqrt{\dfrac{2.000E+8}{235000}} = 11.1$

Non compact Limit $\lambda_r = 1\sqrt{\dfrac{E}{F_y}} = 1\sqrt{\dfrac{2.000E+8}{235000}} = 29.2$

$b/f = 0.085/0.013 = 6.54 \Longrightarrow Compact$

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Web Slenderness

Compact Limit $\lambda_p = 3.76\sqrt{\frac{E}{F_y}} = 3.76\sqrt{\frac{2.000E+8}{235000}} = 109.69$

Non compact Limit $\lambda_r = 5.7\sqrt{\frac{E}{F_y}} = 5.7\sqrt{\frac{2.000E+8}{235000}} = 166.29$

$h/tw = 0.24/0.0095 = 25.3 \implies Compact$