Prepared by **Lambutan Sinaga**
Lifting Coordinator
elsinaga@yahoo.com
https://berthing.wordpress.com/

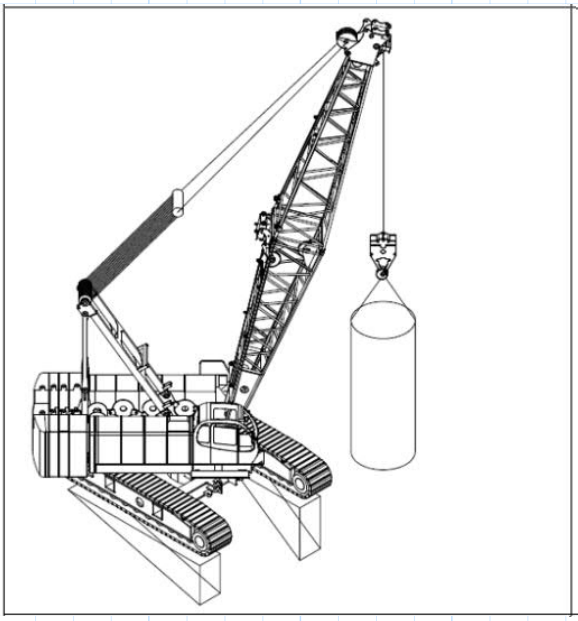
Crawler-Crane Track Pressures Calculation

Lift operation-1 as per case below:

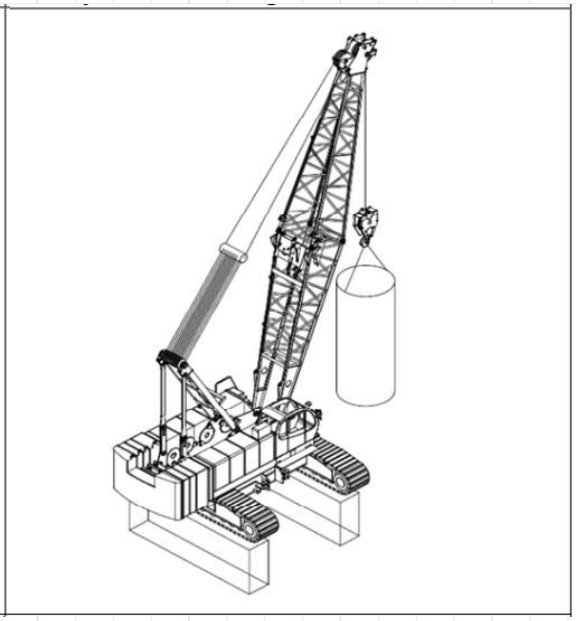
Crawler crane operating over the side while picking up a load including hook block and slings 103.1 ton. The load is on the main hook at 7.3m radius. The crane using 39.6m boom length and has a 15.2-m jib mounted at 0° offset.

Check bearing pressure under the tracks on boom direction
α_{90} (90 deg) and at α_{30} (30 deg).

Crane data:



$\alpha_{30} := 30\ °$



$\alpha_{90} := 90\ °$

NOTATION:

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Solution

Calculation-1:
Find the boom angle.

$$R = t + L \cdot \cos(\alpha)$$

$$\alpha := \operatorname{acos}\left(\frac{R-t}{L}\right) = 81.17\ \textit{deg}$$

Calculation-2:
The boom moment is given by:

$$M_b := W_b \cdot \left(t + L_b \cdot \cos\left(\alpha + \theta_b\right)\right)$$

$$M_b = 394.15\ \textit{kN} \cdot \textit{m}$$

Calculation-3:
The Jib moment + boom moment:

$$M_{bj} := M_b + W_j \cdot \left(t + L \cdot \cos(\alpha) + J_j \cdot \cos\left(\alpha + \mu_j\right)\right)$$

$$M_{bj} = 444.750\ \textit{kN} \cdot \textit{m}$$

Calculation-4:
Calculate superstructure moment.

$$M_u := M_{bj} + \left(W + W_r\right) \cdot R - W_u \cdot d_u$$

$$M_u = 5503.48\ \textit{kN} \cdot \textit{m}$$

Calculation-5:
The vertical load

$$V_u := W_b + W_j + W + W_r + W_u$$

$$V_u = 2062.87\ \textit{kN}$$

Calculation-6:
The moments over the front side (α = 90°) are:

$$M_{nf.90} = M_u \cdot \cos\left(\alpha_{90}\right)$$

$$M_{nf.90} := 0\ \textit{kN} \cdot \textit{m}$$

$$M_{ns.90} := M_u \cdot \sin\left(\alpha_{90}\right)$$

$$M_{ns.90} = 5503.48\ \textit{kN} \cdot \textit{m}$$

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Calculation-7:
Machine vertical load is:

$$V := V_u + W_c$$

$$V = 2637.85\ \boldsymbol{kN}$$

Case-1: Find the track pressures when the horizontal operating angle α = 90°.

Calculation-8:
When Slew boom direction at 90 deg., M_{nf} =0,
therefore e = 0.

$$e_{\alpha.90} := \frac{M_{nf.90}}{V} \qquad e_{\alpha.90} = 0\ \boldsymbol{m}$$

$$l_{\alpha.90} := 3\left(\frac{d_l}{2 - \frac{e_{\alpha.90}}{\boldsymbol{m}}}\right) \qquad l_{\alpha.90} = 10.965\ \boldsymbol{m}$$

$$l_{\alpha.90} > d_l \rightarrow 10.965 \cdot m > 7.31 \cdot m$$

Conclusion:
$l_{\alpha.90} > d_l$ therefore the pressure diagram is trapezoidal. Using Eq. (5.30)

Calculation-9:
Calculate reaction force at heavily side (R_h) and lightly side (R_l)

$$R_{h.90} := \frac{V}{2} + \frac{M_{ns.90}}{d_t}$$

$$R_{h.90} = 2375.26\ \boldsymbol{kN}$$

$$R_{l.90} := \frac{V}{2} - \frac{M_{ns.90}}{d_t}$$

$$R_{l.90} = 262.59\ \boldsymbol{kN}$$

Calculation-10:
Track pressures. With e = 0, pressure will be uniform along each track (p_{max} = p_{min} = p). Track pressures under counterweight side track,

$$p_{l.90} := \frac{R_{l.90}}{w \cdot d_l} \cdot \left(1 + \frac{6 \cdot e_{\alpha.90}}{d_l}\right)$$

$$p_{l.90} = 29.44\ \frac{\boldsymbol{kN}}{\boldsymbol{m}^2}$$

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Calculation-11:
Track pressures under the boom side track,

$$p_{h.90} := \frac{R_{h.90}}{w \cdot d_l}$$

$$p_{h.90} = 266.34 \ \frac{kN}{m^2}$$

NOTE: The pressures calculated are for the loaded lift case case above only, and over the side while picking load at (α=90 deg).

Case-2: Find the track pressures when the horizontal operating angle α = 30°.

Solution

Calculation-12:
Rotation of the superstructure causes a redistribution of upper moments and of track loadings.

$$M_{nf.30} := M_u \cdot \cos\left(\alpha_{30}\right)$$

$$M_{nf.30} = 4766.15 \ kN \cdot m$$

$$M_{ns.30} := M_u \cdot \sin\left(\alpha_{30}\right)$$

$$M_{ns.30} = 2751.74 \ kN \cdot m$$

Calculation-13:
Calculate reaction force at heavily side $\left(R_h\right)$ and lightly side $\left(R_l\right)$ Using Eq. (5.30)

$$R_{h.30} := \frac{V}{2} + \frac{M_{ns.30}}{d_t}$$

$$R_{h.30} = 1847.09 \ kN$$

$$R_{l.30} := \frac{V}{2} - \frac{M_{ns.30}}{d_t}$$

$$R_{l.30} = 790.76 \ kN$$

Calculation-14:
Calculate the eccentricity:

$$e_{\alpha.30} := \frac{M_{nf.30}}{V} \qquad e_{\alpha.30} = 1.8 \ m$$

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$$l_{\alpha.30} := 3 \cdot \left(\frac{d_l}{2} - e_{\alpha.30} \right) \qquad l_{\alpha.30} = 5.545\ m \qquad d_l = 7.310\ m$$

$$l_{\alpha.30} < d_l$$

CONCLUSION:
$l_{\alpha.30} < d_l$ therefore the pressure diagram is triangular.

Calculation-15:
Track pressures under counterweight side track,

$$p_{l.30} := \frac{2 \cdot R_{l.30}}{w \cdot l_{\alpha.30}}$$

$$p_{l.30} = 233.8\ \frac{kN}{m^2}$$

Calculation-16:
Track pressures under the boom side track,

$$p_{h.30} := \frac{2 \cdot R_{h.30}}{w \cdot l_{\alpha.30}}$$

$$p_{h.30} = 546.13\ \frac{kN}{m^2}$$

The pressure diagrams illustrated in below: