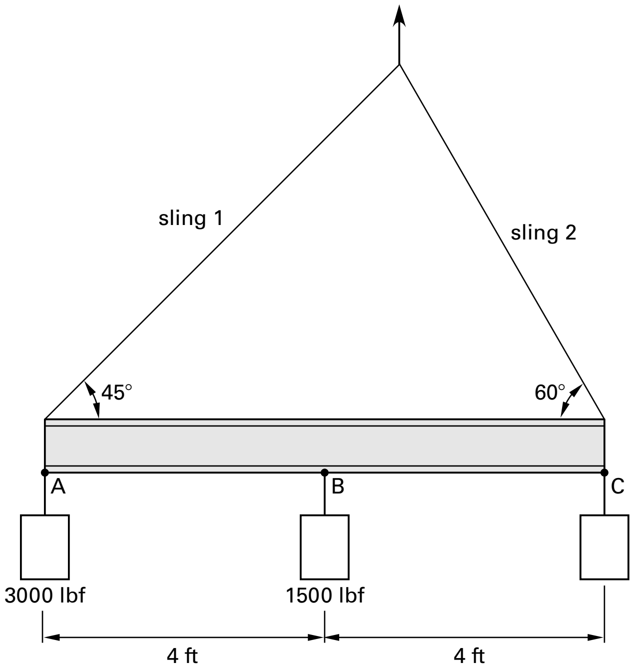
3 Construction Operations and Methods

LIFTING AND RIGGING

PROBLEM 1

Two slings are arranged asymmetrically to lift three objects as shown. Object A weighs 3000 lbf, and object B weighs 1500 lbf. The mass of the spreader beam is negligible. When the slings are pulled up at the point where they meet, the three objects are raised and remain horizontally aligned. What does object C most nearly weigh?



(A) 3000 lbf

(B) 5300 lbf

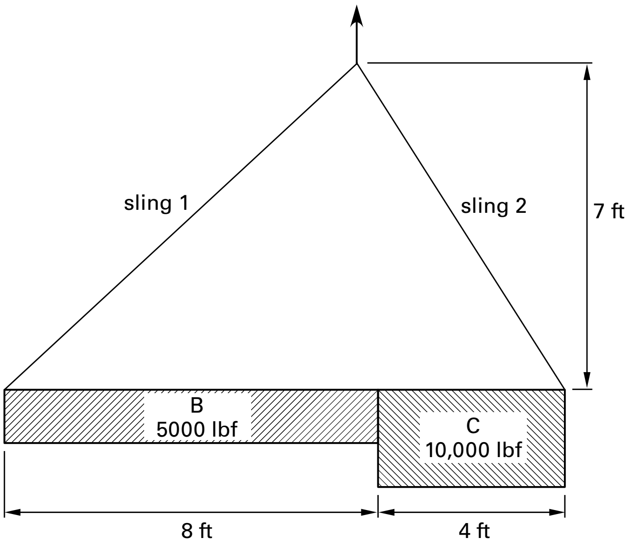
(C) 5700 lbf

(D) 7500 lbf

Hint: Find the weight of object C using principles of static equilibrium.

PROBLEM 2

Two different materials make up the object shown. Material B weighs 5000 lbf, and material C weighs 10,000 lbf. The master link is properly placed. What is most nearly the length of sling 1?



(A) 8.1 ft

(B) 9.2 ft

(C) 11 ft

(D) 19 ft

Hint: Find the horizontal center of gravity of the object.

CRANE STABILITY

PROBLEM 3

A tower crane is equipped with a 246 ft boom, as well as load handling accessories (e.g., slings and spreader bars) that have a combined weight of 2000 lbf. The crane's load capacities are given in the table provided. What is the approximate maximum lift radius for a 15,000 lbf load?

Construction Operations

Find the weight of object C, W_C, by taking the moment around point A. Assume counterclockwise moments are positive.

$$\begin{aligned} M_A &= -W_B d_B - W_C d_C + (T_2 \sin 60°) d_C = 0 \\ W_C &= \frac{(T_2 \sin 60°) d_C - W_B d_B}{d_C} \\ &= \frac{(7498 \text{ lbf})(0.8660)(8 \text{ ft}) - (1500 \text{ lbf})(4 \text{ ft})}{8 \text{ ft}} \\ &= 5743 \text{ lbf} \quad (5700 \text{ lbf}) \end{aligned}$$

The answer is (C).

Why Other Options Are Wrong

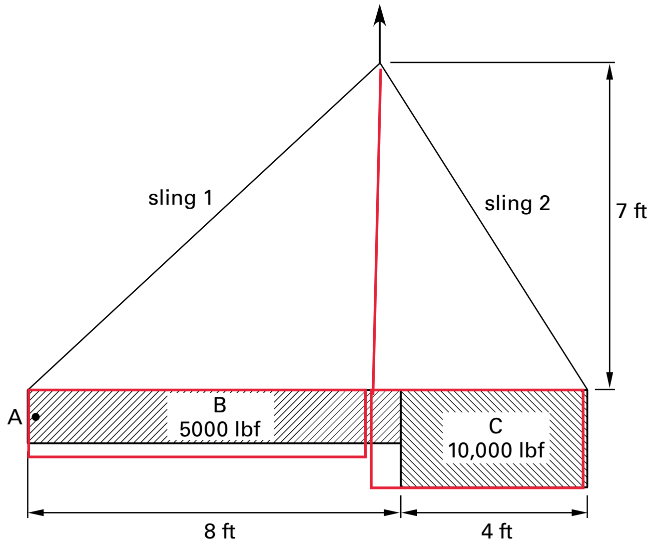
(A) This incorrect option analyzed the system as though the slings were symmetrical.

(B) This incorrect option found the tension force in sling 1, not the weight of object C.

(D) This incorrect option found the tension force in sling 2, not the weight of object C.

SOLUTION 2

If the horizontal center of gravity of each material (d_B and d_C, measured from point A) is multiplied by that material's weight (F_B and F_C), these two products added together will equal the horizontal center of gravity of the entire object (x_{cg}) multiplied by the weight of the entire object.



That is,

$$\begin{aligned} F_B d_B + F_C d_C &= (F_B + F_C) x_{cg} \\ x_{cg} &= \frac{F_B d_B + F_C d_C}{F_B + F_C} \\ &= \frac{(5000 \text{ lbf})(4 \text{ ft}) + (10{,}000 \text{ lbf})(10 \text{ ft})}{5000 \text{ lbf} + 10{,}000 \text{ lbf}} \\ &= 8 \text{ ft} \end{aligned}$$

The object's horizontal center of gravity is 8 ft from point A, which is where the materials are connected. The master link should be aligned vertically. The length of sling 1 can therefore be calculated using the Pythagorean theorem, with the center of gravity and the height of the system as the other two sides of the triangle.

$$\begin{aligned} L_1 &= \sqrt{x_{cg}^2 + h^2} = \sqrt{(8 \text{ ft})^2 + (7 \text{ ft})^2} \\ &= 10.63 \text{ ft} \quad (11 \text{ ft}) \end{aligned}$$

The answer is (C).

Why Other Options Are Wrong

(A) This incorrect option calculated the length of sling 2.

(B) This incorrect option assumed the center of gravity is in the middle of the system.

(D) This incorrect option calculated the total length of sling 1 and sling 2.

SOLUTION 3

The total weight the crane must lift is

$$15{,}000 \text{ lbf} + 2000 \text{ lbf} = 17{,}000 \text{ lbf}$$

From the table provided, for a boom length of 246 ft, the load capacity closest to 17,000 lbf is 18,440 lbf, which corresponds to a lift radius of 150 ft.

The answer is (A).

Why Other Options Are Wrong

(B) This incorrect option interpolated the maximum lift radius from the table values.

(C) This incorrect option measured the maximum lift radius for a 15,000 lbf load.

(D) This incorrect option measured the maximum lift radius for the load from lifting accessories only.

SOLUTION 11

Taking the cycle time and swing-depth factor from Table 49.1 and Table 49.2 given in the problem, the production of the excavator is

$$\begin{aligned} P &= (\text{cycle time})(\text{swing-depth factor})\,V_{\text{bucket}} \\ &\quad \times(\text{bucket factor})(\text{efficiency}) \\ &= \left(160\ \frac{\text{cycles}}{\text{hr}}\right)(1.10)\left(2\ \frac{\text{yd}^3}{\text{cycle}}\right)(0.9)\left(\frac{50\ \text{min}}{60\ \text{min}}\right) \\ &= 264\ \text{yd}^3/\text{hr} \quad (260\ \text{yd}^3/\text{hr}) \end{aligned}$$

The answer is (B).

Why Other Options Are Wrong

(A) This incorrect option did not include the swing depth factor in the calculation.

(C) This incorrect option did not include the bucket factor in the calculation.

(D) This incorrect option did not include the work efficiency in the calculation.

SOLUTION 12

Convert the production, P, of the static compact roller into cubic yards per hour. w is the width of the roller, v is the speed of the roller, B is the depth of the lift, and n is the number of passes.

$$\begin{aligned} P = \frac{w\text{v}B}{n} &= \frac{(8\ \text{ft})\left(\left(5\ \frac{\text{mi}}{\text{hr}}\right)\left(5280\ \frac{\text{ft}}{\text{mi}}\right)\right)\left(\frac{24\ \text{in}}{12\ \frac{\text{in}}{\text{ft}}}\right)}{(2)\left(27\ \frac{\text{ft}^3}{\text{yd}^3}\right)} \\ &= 7822\ \text{yd}^3/\text{hr} \end{aligned}$$

The total volume to be compacted is

$$\begin{aligned} V = Ldh &= \frac{(200\ \text{ft})(300\ \text{ft})(2\ \text{ft})(2)}{27\ \frac{\text{ft}^3}{\text{yd}^3}} \\ &= 8889\ \text{yd}^3 \end{aligned}$$

Therefore, the time that it requires to compact two lifts of soil is

$$\begin{aligned} t_{\text{required}} = \frac{V}{P} &= \frac{8889\ \text{yd}^3}{7822\ \frac{\text{yd}^3}{\text{hr}}} \\ &= 1.14\ \text{hr} \quad (1.2\ \text{hr}) \end{aligned}$$

The answer is (D).

Why Other Options Are Wrong

(A) This incorrect option did not convert the depth of the lift from inches to feet when calculating the production of the roller per hour.

(B) This incorrect option did not divide the production volume by 2 to account for the second pass. Furthermore, it included only one lift.

(C) This incorrect option did not divide the production volume by 2 to account for the second pass.

SOLUTION 13

From the table, the cycle time of a single pusher using the chain method is 1 min. The number of scrapers, n, one pusher can serve in a cycle, t, is

$$n = \frac{t_{\text{scraper}}}{t_{\text{pusher}}} = \frac{5\ \text{min}}{1\ \text{min}} = 5$$

Find the number of pushers required to serve eight scrapers.

$$n_{\text{required}} = \frac{8}{5} = 1.6 \quad (2)$$

The answer is (B).

Why Other Options Are Wrong

(A) This incorrect option rounded down the number of pushers required rather than rounding up.

(C) This incorrect option only solved for the number of scrapers one pusher can serve.

(D) This incorrect option assumed that one pusher services each scraper separately.

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1.Five ring soil samples are recovered with a total mass of 879 g. The following measurements are taken.

average mass of a single ring, m	44 g
average diameter of a single ring, D	2.42 in
average height of a single ring, H	1 in
dry unit weight of the soil, Y_d	98 lbf/ft^3

Most nearly, the moisture content of the sample is

(A) 10%

(B) 11%

(C) 12%

(D) 15%

1. Calculate the total mass of the soil sample from the mass of the field sample and the mass of the five rings.

$$\begin{aligned} m_{\text{soil sample}} &= m_{\text{field sample}} - (\text{no. of rings})m_{\text{ring}} \\ &= 879 \text{ g} - (5)(44 \text{ g}) \\ &= 659 \text{ g} \end{aligned}$$

Calculate the volume of the five rings.

$$\begin{aligned} V_{\text{rings,total}} &= \left((\text{no. of rings})\pi\left(\frac{D}{2}\right)^2\right)H \\ &= 5\pi\left(\left(\frac{2.42 \text{ in}}{2}\right)\left(2.54 \ \frac{\text{cm}}{\text{in}}\right)\right)^2\left((1 \text{ in})\left(2.54 \ \frac{\text{cm}}{\text{in}}\right)\right) \\ &= 377 \text{ cm}^3 \end{aligned}$$

Calculate the density of the recovered soil sample.

$$\begin{aligned} \rho_{\text{soil sample}} &= \frac{m_{\text{soil sample}}}{V_{\text{rings,total}}} \\ &= \frac{659 \text{ g}}{377 \text{ cm}^3} \\ &= 1.75 \text{ g/cm}^3 \end{aligned}$$

Convert soil sample density to total unit weight.

$$\begin{aligned} Y_t &= \left(\frac{1.75 \ \frac{\text{g}}{\text{cm}^3}}{453.6 \ \frac{\text{lbf}}{\text{g}}}\right)\left(28{,}316.8 \ \frac{\text{cm}^3}{\text{ft}^3}\right) \\ &= 109.2 \text{ lbf/ft}^3 \end{aligned}$$

The moisture content, w, is

$$\begin{aligned} w &= \frac{Y_t}{Y_d} - 1 = \left(\frac{109.2 \ \frac{\text{lbf}}{\text{ft}^3}}{98 \ \frac{\text{lbf}}{\text{ft}^3}} - 1\right) \times 100\% \\ &= 11\% \end{aligned}$$

The answer is (B).

Why Other Options Are Wrong

(A) This incorrect option is the total unit weight, obtained by failing to convert to dry unit weight.

(C) This incorrect option is obtained by subtracting the mass of one ring instead of five rings in determining the total mass of the soil sample. This dry unit weight value is high compared to the correct answer.

(D) This incorrect option fails to subtract the mass of five rings before determining the total unit weight. This dry unit weight value is very high compared to the correct answer.

The answer is (B).