Loads of Steel - Student Activity Sheet - Solutions

1. Each diagonal brace must support the sum of all lateral forces at or above the brace; for example, the total force acting on F2 must also include the force acting on F3. What would be the lateral force, measured in kips, exerted at each level?

   $F_3 = 110$ kips
   $F_2 = 100 + 110 = 210$ kips
   $F_1 = 90 + 100 + 110 = 300$ kips

2. The force in each diagonal brace is found by dividing the lateral force (found in question 1) by the ratio of the horizontal beam length to diagonal brace length. What force is being applied on the diagonal brace at each level?

$$\text{Force in Brace 3} = \frac{lateral\ force}{horizontal\ beam\ /\ diagonal\ beam} = \frac{110}{30\ /\ \sqrt{1125}} = 122.9837 \approx 123 \text{ kips}$$

$$\text{Force in Brace 2} = \frac{lateral\ force}{horizontal\ beam\ /\ diagonal\ beam} = \frac{210}{30\ /\ \sqrt{1125}} = 234.7871 \approx 235 \text{ kips}$$

$$\text{Force in Brace 1} = \frac{lateral\ force}{horizontal\ beam\ /\ diagonal\ beam} = \frac{300}{15\ /\ \sqrt{450}} = 424.264 \div 2 \approx 212 \text{ kips}$$

3. Find P_{CR} in terms of t.

$$P_{CR} = \frac{\pi^2(29{,}000)\left(\frac{18t^3}{12}\right)}{24^2}(18t) = 13{,}416.49t^4$$

4. For safety precautions, SteelFab, Inc. assumes a factor of safety of 2.0 to ensure the structure is much stronger than it needs to be for an intended load. Take the critical load and divide the coefficient by 2 to find the revised P_{CR}, in terms of t, after taking the safety measures into consideration.

$$P_{CR} = \frac{13{,}416.49t^4}{2} = 6{,}708.25t^4$$

5. Steel plates are designed with various plate thicknesses: 0.25 inches, 0.375 inches, 0.50 inches, 0.625 inches. Using Euler's Equation and the forces you calculated in question 2, determine what plate thickness is required for each diagonal brace.

Thickness (t) in inches	Euler's Equation	Compression Force (P_{CR})
0.25 inches	$P_{CR} = 6708.25(0.25)^4$	26.2 kips
0.375 inches	$P_{CR} = 6708.25(0.375)^4$	132.7 kips
0.50 inches	$P_{CR} = 6708.25(0.50)^4$	419.3 kips
0.625 inches	$P_{CR} = 6708.25(0.625)^4$	1023.6 kips

Force in Brace 3 $\approx$ 123 kips $\rightarrow$ 0.375 inch thickness
Force in Brace 2 $\approx$ 235 kips $\rightarrow$ 0.50 inch thickness
Force in Brace 1 $\approx$ 213 kips $\rightarrow$ 0.50 inch thickness

6. Write a statement summarizing your final recommendations for the plate thicknesses and explain how you came to this conclusion.
   answers will vary
   Sample response: F3 brace should be 0.375 inches thick because the compression force is greater than 26.2 kips but less than 132.7 kips. F2 brace should be 0.05 inches thick because the compression force is greater than 132.7 kips but less than 419.25 kips. F1 brace should be 0.05 inches thick because the compression force is greater than 132.7 kips but less than 419.25 kips.

7. Write a statement summarizing the costs of the project. If SteelFab, Inc. is competing for a bid, in what area(s) could you cut costs to reduce the budget? In what area(s) can costs <u>not</u> be changed? Discuss the pros and cons of making these types of adjustments.
   answers will vary
   Sample response: The total cost of the parking structure is $57,663.39. Areas where you could cut costs would be: finding cheaper deck squares, steel materials for the plates and bolts, and paint; hiring cheaper labor; adjusting the markup percentage. Areas where you cannot cut costs would be: square footage and amount of supplies required. When considering how/where to cut costs, it is important to remember that cheaper is not always better! We do not want cheap supplies/labor that may compromise the quality of the structure.