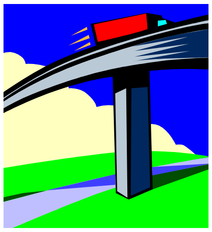
Team Names: ____ **Date:** ______________



Pier (Column) Design Worksheet
Answers

You are engineers working for a structural design company in Colorado. The state of Colorado needs a new transportation bridge to serve as an overpass connecting a highway to a small mining town business district.

1. **Brainstorm a list of questions to be answered before designing the bridge.**

   Examples: What vehicles would be crossing the bridge? How often? How wide is the highway? What is the weather like? Etc.

2. **Make a list of the possible loads that the bridge must withstand.**

   Possible answers: Weight of the bridge itself. Weight and movement of vehicles (cars and trucks). Weight of snow. Forces of wind and earthquake movement. Etc.

3. **Using the given values for loads, calculate the different possible loads for the bridge.**

   a) Dead Load + Live Load + Snow Load
   b) Dead Load + Live Load + Wind Load (or Earthquake Load)
   c) Dead Load + Live Load + Wind Load + (Snow Load ÷ 2)
   d) Dead Load + Live Load + Snow Load + (Wind Load ÷ 2)
   e) Dead Load + Live Load + Snow Load + Earthquake Load

   Load values for a scaled model of this bridge in Colorado:
   Maximum dead load =2 lbs
   Maximum live load =2 lbs
   Maximum wind load =1 lbs
   Maximum snow load =2 lbs
   Maximum earthquake load = 1 lbs

   a = 2 + 2 + 2 = 6 lbs
   b = 2 + 2 + 1 = 5 lbs (or b = 2 + 2 + 1 = 5 lbs)
   c = 2 + 2 + 1 + (2 ÷ 2) = 6 lbs
   d = 2 + 2 + 2 + (1 ÷ 2) = 6.5 lbs
   e = 2 + 2 + 2 + 1 = 7 lbs

   Which is the maximum load (force) that the bridge must be able to hold? 7 lbs

4. **Choose one of the available materials for your model and calculate the cross-section area required for a pier (column) to support the maximum load. Use the following information and equation, and show your work.**

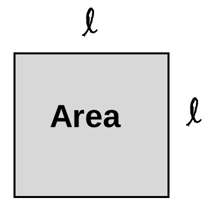
   The compressive strength (F_y) of clay is 7 lb/in^2.

   The compressive strength (F_y) of large marshmallows = 5 lb/in^2

   The compressive strength (F_y) of foam = 3 lb/in^2

   Force = maximum load, as calculated in #3.

   Solve for the area using the following equation: **Area = Force ÷ F_y.**



   For clay: 7 lbs ÷ 7 lb/in^2 = 1.0 in^2
   For foam: 7 lbs ÷ 3 lb/in^2 = 2.3 in^2
   For marshmallows: 7 lbs ÷ 5 lb/in^2 = 1.4 in^2

5. **Using a calculator, find the length (ℓ) of each side of your cross-section area of the pier (column) from #4. Show your calculations.**

   Hint: For a rectangular pier, take the square root of your area to find the length of the sides.

   Hint: For a cylindrical pier, divide the area by 3.14, and then take the square root of your answer to find the radius of the end of the column.

   For clay: square root of 1.0 in^2 = 1.0 in
   For foam: square root of 2.3 in^2 = 1.52 in
   For marshmallows: 1.4 in^2 ÷ 3.14 = 0.45 in^2; the square root of 0.45 in^2 = 0.67 in

6. **Double-check that your length dimensions are correct. Show your work. Does it match your area answer from #4?**

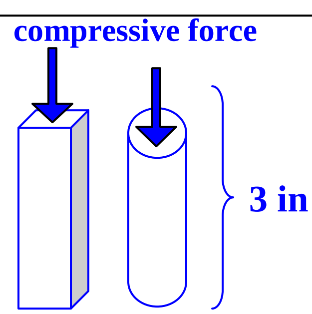
   Hint: For a rectangular pier, multiply the length of one side by the length of the other side to find the area.

   Hint: For a cylindrical pier, multiply the radius by itself, and then multiply by 3.14 to find the area.

   For clay: 1.0 in x 1.0 in = 1.0 in^2 (yes, it matches)
   For foam: 1.52 in x 1.52 in = 2.31 in^2 (yes, it matches, close enough)
   For marshmallows: 0.67 in x 0.67 in x 3.14 = 1.41 in^2 (yes, it matches, close enough)

7. **Build your model pier (column) using the materials you chose. Draw a sketch of your pier below, using the length of sides you just calculated and a height of 3 inches. Write the measurements on your drawing and indicate forces using arrows.**

   cross-sectional area = __ x __ in ➔



   Pier drawing designs will vary…
   Make sure measurements and forces are noted.

8. **Test your pier model by adding the weight of books to equal the force you calculated in #3. Record each book weight as you add it. Total the book weights to find the total load at each stage. Record your observations on how the column is withstanding the applied load.** **Your pier (column) material:** <u>**Clay or foam or marshmallows**</u>

Book #	Book Weight	Total Load	Pier/Column Observations & Measurements
0	None	None	Column begins 3 inches high.
1	**Ex. 2 lbs**	**2 lbs**	
2	**3 lbs**	**5 lbs**	
3			**Answers will vary.**
4			
5			
6			
7			
8			
9			

9. **Describe what happened to your column during testing.**

Answers will vary. Some columns collapse or fall over right away, such as foam. Those that remain standing usually compress. Some compress quickly down to an inch tall; others compress more slowly and stop at about two inches.

10. **Was the material you chose for your model effective? Why or why not?**

Answers will vary.

11. **What could you do to improve the design of your column?**

Possible answers: Use a stronger material. Make the cross section of the pier/column larger so it can support more force.