Bridge the Gap

Summary

In this activity, students will use the engineering design process to design and build a bridge using available materials that meet specific design criteria. Once the bridge is built, students will test their designs to determine how well the bridge functions. Students will also learn about different types of bridge designs.

After completing this activity, students should be able to:

- Explain how a bridge transfers load
- Describe different types of bridges
- Describe the relationship between the load and deflection
- Develop and use a mathematical model and graphical representation of data
- Apply the engineering design process

Setting the Stage

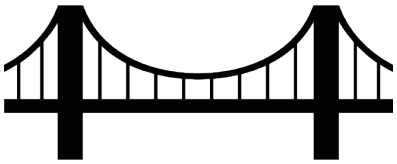
Before the students start working, initiate discussion about the topic using some of the following open-ended questions.

1. Why are bridges important?
2. What would we do if we did not have bridges or if a bridge was out of service?
3. What are some examples of bridges in our community?
4. Draw a picture of a bridge with as much detail as you can.
5. What are some different types of bridges?
6. How does a bridge carry the load of traffic without failing?
7. How could a bridge fail?

Materials

- Two containers of sand (or other type of soil)
- Building materials can be anything you may have available, such as:
    - Straws, wooden craft sticks, etc.
    - String, yarn, wire, etc.
    - Toothpicks
    - Tape and/or rubber bands
- Loading container that will fit on the bridge (cup, box, etc.)
- Loose material to weigh (weights, sand, rocks, marbles, washers, pennies, etc.)
- Scissors
- Ruler
- Engineering Notebook Pages

Types of Bridges

Bridge Type	How It's Built	What do you think? Pros and Cons
Suspension Bridge 	Uses cables attached to huge anchors to hold up the weight of the bridge and traffic. This type has materials such as tension cables, concrete, and steel.	
Arch Bridge 	An arch only works if all the members are in a perfect circle so the load with balance. This type needs a firm foundation to push up on the base.	
Truss Bridge 	Trusses use beam members to divide the load. Each member is in compression or tension. Trusses are made of materials such as steel and wood.	
Beam Bridge 	Beam bridges are supported by a straight line of beams that support the bridge deck. They are shorter than other types of bridges because, they don't have additional support members like others.	

Test Procedure

Test Set-up

1. Space two containers of sand apart using a wooden blue spacer representing a river as shown in Figure 1.
2. Using the materials available design a bridge to span the river that meets the following criteria:
    a. No part of the bridge can touch the plastic containers, the river, or anything else but the sand in the container.
    b. o. Students/instructor will add more weight to figure out the maximum load that their designed bridge supports.
    c. Optional: Minimum unsupported horizontal main span of 15 in.
    d. Optional: Minimum vertical clearance between the top of the river and the bottom of the bridge of 6 in at the center of the bridge span.

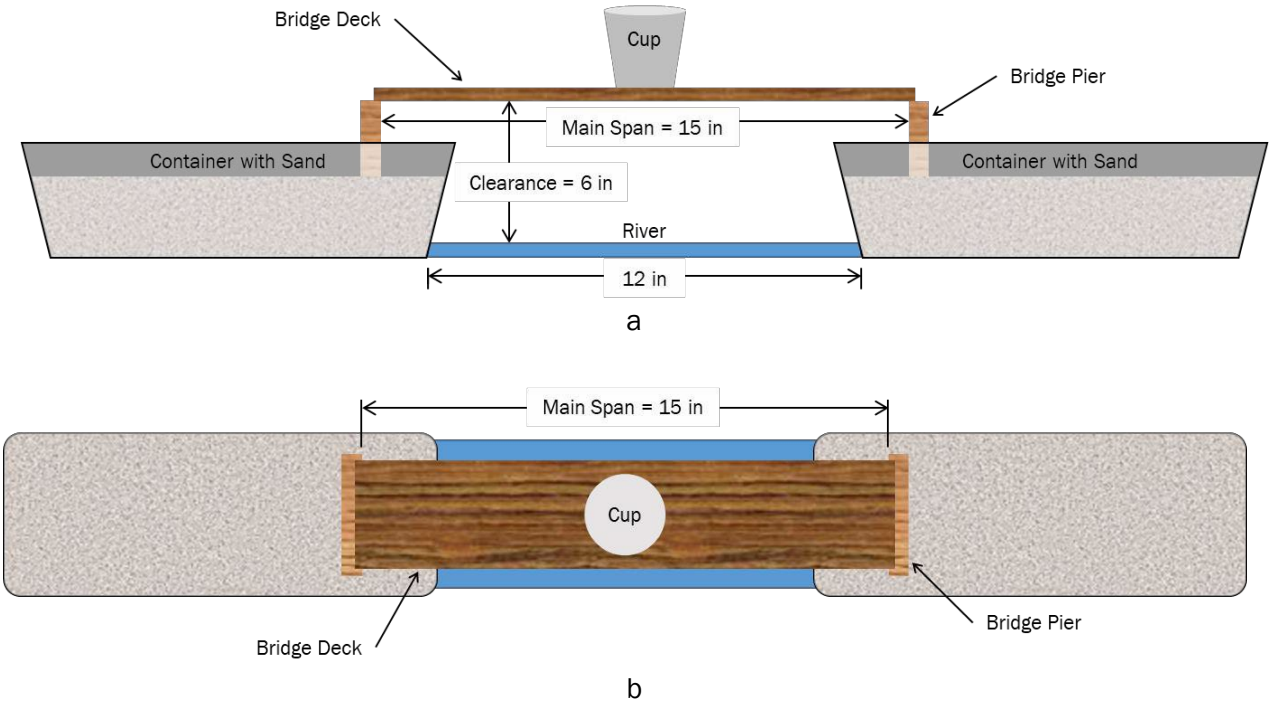


Figure 1. Sketch of bridge construction set-up (a) elevation view and (b) top view

1. Measure the following dimensions to ensure it meets the specifications:
    a. Clear horizontal span
    b. Vertical clearance
2. Place the empty load cup on the bridge at the center of the span and record the vertical clearance at mid-span. Record this in Data Table 1 (Mass = 0 g).
3. Add 50 g of material (sand, rocks, marbles, etc.) to the load cup and measure the vertical clearance at mid-span. Record this in Data Table 1.
4. Continue to add 50 g of material to the cup and measuring the vertical clearance each time load is added until the cup is full. Record your data in Data Table 1.
5. Add weigh in 50/100 g increments until bridge fails. Bridge fails is consider when cup falls, bridge brakes or any part of the bride touches the container or the river. Record the maximum load supported.
6. Calculate the deflection at each load and record the value in Data Table 1.

Development of the Deflection Curve

1. Plot the load vs. deflection data points on Graph 1.
    a. Which is the independent variable and which is the dependent variable?
    b. Label your axes appropriately.
    c. Use as much of the graphing area as you can.
2. Draw a best-fit curve (or line) through the data points.
3. If the curve is linear, determine the equation for the line.
4. Explain what this graph means.

Calculations

Deflection

$$\Delta_i = h_0 - h_i$$

h_0 = vertical clearance with no load, mm
h_i = vertical clearance with load i, mm
Δ_i = deflection under load i, mm

Follow-up questions

1. Did your bridge meet the design criteria?
2. How did your bridge perform?
3. What type of bridge did you design and build? Why did you choose this type of bridge?
4. What would you change to improve the performance of your bridge?
5. What could you use the deflection curve for?

Extra Resources

1. Watch video about: What makes bridges so strong? (3:44)
2. Watch video about the 1940 Tacoma Narrows Bridge Collapse (2:36)
3. Watch video about: the most amazing bridges ever built (7:47)
4. Watch video about bridge design and analysis: Arches and chains (9:26) Suspension bridge (7:01) Trusses (17:41). Watch as appropriate as these videos can go in too much detail.

Vocabulary

- Abutment – a mass supporting the arch, beam, truss, etc. at each end of a bridge.
- Beam – long piece of metal, wood, concrete, etc., designed for use as rigid members of a structure.
- Cable – a very strong rope made of strands of metal wire.
- Clearance – the distance between two objects (e.g., the water and a bridge).
- Deflection – the difference between the vertical clearance under load compared to the clearance with no load.
- Foundation – the lowest portion of a structure that is in partly or entirely below the surface of the ground.
- Load – the weight supported by a structure or part.
- Span – the distance between two supports of a bridge.
- Truss – a type of structural frame based on the geometric rigidity of the triangle having straight members subjected to compression, tension, or both.