Factors Affecting a Structure's Ability to Support a Load

SKILLS MENU

- ☐ Questioning
- ■ Hypothesizing
- ■ Predicting
- ☐ Planning
- ■ Controlling Variables
- ■ Performing
- ■ Observing
- ■ Analyzing
- ■ Evaluating
- ■ Communicating

Imagine that you have to design a bridge to span a stream. What design provides enough strength but the least mass of materials? How can you perform a fair test to discover how factors affect the strength of a beam? In this investigation, you will develop answers to these and other questions.

Testable Question

How do the mass, shape, and form of a beam affect the beam's ability to support a load?

Hypothesis/Prediction

SKILLS HANDBOOK 2.B.3.

Read the Experimental Design and Procedure, and examine the figures to see the different beam designs you will be testing. Make and record a hypothesis about which design will be the strongest and which will be the weakest. Your hypothesis should include a prediction and reasons for your prediction.

Experimental Design

Your group will build six different beam "bridges." Four have the same mass, while the remaining two have twice as much mass. You will test each beam's strength by pulling down on its centre with a spring scale. Use as little masking tape as possible, and recycle the cardboard after completing the investigation.

Equipment and Materials

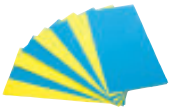
- ruler or metre stick
- scissors
- spring scale
- 2 stools or movable desks
- 8 pieces of file-folder cardboard
- masking tape
- string


ruler or metre stick


scissors


spring scale


stools or movable desks


pieces of file-folder cardboard


masking tape


string

Be very careful when using sharp objects.

Procedure

SKILLS HANDBOOK 6.A.3., 6.D.1.

1. Mark and cut out eight pieces of cardboard, 24 cm long × 12 cm wide. Draw lines on five of the pieces of cardboard, and fold the cardboard as shown in Figure 1 on the next page. Tape the edges together to close the beam. Make three flat beams, one triangular beam, one cylindrical beam, and two rectangular beams.

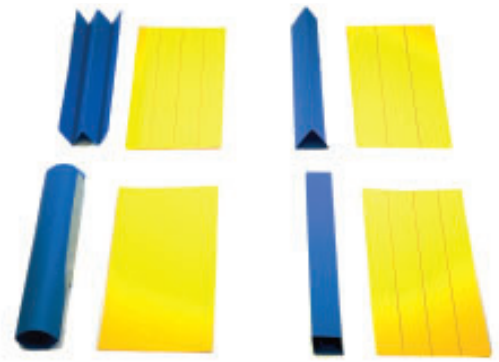


Figure 1 The four beam designs

2. Design a table to record the measurements taken during the tests you will be performing.
3. Set up a single flat beam as a bridge supported at the ends by two stools or desks separated by 18 cm. The overlap at the ends of the beam should be equal. Tie a loose loop of string around the middle of the beam. Suspend the spring scale from it. As you read the force on the scale, very gently pull straight down until the beam fails (Figure 2). Record the force that caused the failure.

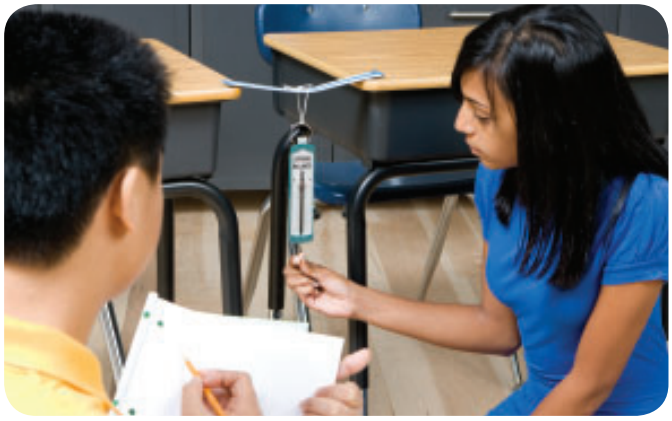


Figure 2 Setup for testing the strength of a beam bridge

4. Tape two flat beams together to double the mass. Repeat the test in step 3.
5. Repeat step 3 for the triangular beam, the cylindrical beam, and a rectangular beam.
6. Mark and cut the last piece of cardboard into four equal strips 24 cm long and 3 cm wide. Fold these strips width-wise. Tape them together to form a corrugated row about 24 cm long. Place this row into the second rectangular beam (Figure 3). Use tape to secure it to the ends of the beam. Close the sides of the beam, and tape the edges that meet. Test this beam as you did in step 3.

Figure 3 Reinforcing a rectangular beam

Analyze and Evaluate

(a) Rank the beams in order of weakest to strongest.

(b) Describe three independent variables you tested in this investigation. State how each variable affected the beam's ability to support a load.

(c) Answer the Testable Question.

(d) About how many flat (or solid) beams would be needed to provide the same strength as a single reinforced rectangular beam? How would the masses compare?

Apply and Extend

(e) If you were allowed four 24 cm × 12 cm pieces of cardboard, what design would you use to maximize a beam's strength? Draw a sketch of your design.

(f) Metal support beams are made in the shape of a capital L or a capital I. Describe the advantages of this design.