Engineering Project

Crossing the Wendella River

The population of Wendella County has been growing. To meet the county's need for transportation, the government has decided to pay for a new bridge across the Wendella River. A site has been chosen, and your engineering firm has been asked to prepare a proposal for the design of the Wendella River Bridge. Your firm is in competition with other firms. The firm with the best proposal will be hired to complete the project.

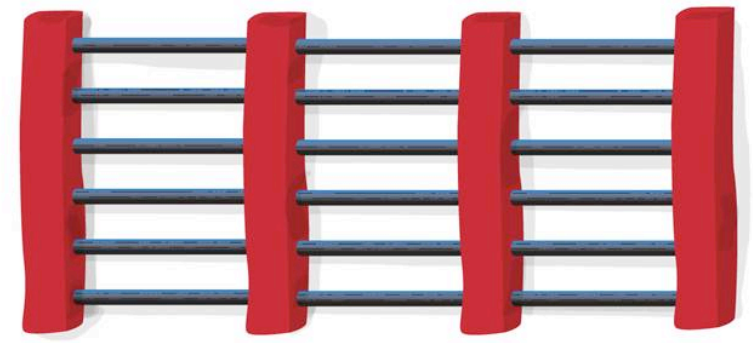
In this project, your goal is to design and build the strongest model or prototype of a bridge for crossing the river. You will use toothpicks to model the steel beams of the bridge. The parts of the bridge will be a deck that you make from blue toothpicks, plus a support structure that you assemble from the white toothpicks and modeling clay. You will then test your bridge and modify it as necessary until the proposal "deadline" when your teacher calls time.

Your teacher will lead a class discussion on what criteria should be used to evaluate the bridge designs. This will help the class determine which proposal wins to construct the Wendella Bridge. Here are some example criteria for evaluating bridge design:

- meets the design constraints
- ability to hold a load distributed along the bridge
- ability to hold a single load in any one place on the deck
- ability to stand up in wind or other natural elements
- aesthetics (this is how nicely your bridge appears in the landscape)

Suggested Materials (per group)

- 18 blue toothpicks (or another color) – for the bridge deck
- 40 white toothpicks (or another color) – for the bridge support system
- two sticks of modeling clay or putty
- ruler
- 6 books of equal thickness, such as textbooks
- 50 pennies or other standard weights



Procedure

Build the Deck

1. Roll four log-shaped strips of modeling clay. Each strip should be about 6 cm. long.

2. Connect the strips of modeling clay with 18 blue toothpicks, as shown in the diagram. This makes a model of a deck of a bridge. On a life-sized bridge, the deck is the part of the bridge that carries vehicles. The model deck should be six toothpicks wide.

3. Make two stacks of three textbooks each. The stacks model the bluffs of the river basin. Separate the book stacks so that the distance between them almost equals the length of the deck.

Design and Build a Support System

4. With your group, discuss ideas for making a support subsystem for the bridge. You could join all of the white toothpicks into piers, or vertical posts, for supporting the deck. Or you could arrange some or all of the white toothpicks diagonally. Make sketches to illustrate your ideas. Keep in mind the criteria for evaluating bridge designs that you discussed as a class.

5. Before agreeing on a plan, make sure you have enough white toothpicks to complete it. Measure the length of one toothpick, the height of the deck above

the floor or table, and the length of the deck. Then estimate the number of toothpicks that you will need to complete a plan, and revise the plan as necessary.

6. When you agree on a plan, share it with the teacher. Your teacher may approve the plan or recommend some changes. Then carry out the plan and build the bridge. If a toothpick breaks, you may replace it. However, the finished bridge may have no more than 18 blue toothpicks and 40 white toothpicks.

7. When the bridge is completed, test the bridge with pennies or other standard weights. Add each penny one at a time, and keep track of the number of pennies on the bridge. Test might include placing the pennies at random points along the deck, or targeting what you think will be the weakest points on the bridge. Record all of your test results, especially the maximum number of pennies that the bridge holds before a toothpick breaks or slips out of position.

8. Improve your design based on your test results. This might include replacing any toothpicks broken in the testing process. If you change the design of your structure, you need to make a new sketch and retest the structure. Again, record your observations and results.

9. Continue to test your design until the teacher says time is up. Then demonstrate your bridge to the class. Your teacher will test all the bridges in the same way to compare which bridge has the most stable construction. You should also observe how each bridge meets the criteria to evaluate the bridge designs.

10. Discuss as a class which bridge should win the proposal to construct the Wendella Bridge. Use the criteria you agreed on as a class to evaluate each design.

Go Further

Choose another type of bridge to test. Try building a suspension bridge or an arch bridge. Or try testing a bridge support system made of craft sticks or drinking straws, or a deck made of cardboard or poster board.

Analysis

1. Compare the different bridges that the class built. Which bridge supported the most weight? Describe this bridge and why you think it succeeded.

2. Which bridge supported the least weight? Describe this bridge. Why was it the least successful?

3. Describe how your bridge failed in Step 8. What do the results of this test show about the strengths and weaknesses of your design?

4. What other forces or causes of stress should you test the bridge for? (Remember that the bridge crosses a river.) How could you test the bridge model to find out how it would respond to these stresses?

5. Do you think that there is one best design for the Wendella River Bridge? Or could engineers and citizens reasonably disagree about the best design?

6. If you were hired to design a real bridge, what are some questions that you would you need to ask?