Build a Bridge

Leader Notes

How much weight can a bridge hold? Does the building material affect the results? In this activity, students design a bridge and build two models of it: one using paper and the other using aluminum foil. Then they test the bridges to see which supports the most weight.

Time
45 minutes or less

Careers
Civil Engineering, Materials Science

Topic
Structures, Technology & Materials

Grades
3–5 • 6–8

Materials

Per student or pair:

- Several sheets of plain white paper or heavy-duty aluminum foil, trimmed to the same size as the paper (or regular foil if you don't have heavy-duty foil)
- At least 40 pennies
- Scissors
- Two books of similar thickness
- Ruler
- Lined paper to record their results
- Pencil
- Tape (Note: Can be used in the paper/aluminum foil design only, NOT to tape the sides of the bridge to the stack of the books)

Preparation

1. Watch the Challenge Video. Then decide whether students will complete the activity in a large group setting or independently.
   - If they'll be working in a large group setting, review the Leader Notes.
   - If students will be completing the activity independently, review the Student Activity instructions. Then make enough copies for each student or pair. (Note: The Student Instructions for this activity have been adapted to be used by a student on their own. They are not aligned with the whole-group activity.)

2. Gather the materials and decide how you'll distribute them to the group. Consider setting up a materials table in an accessible area of the room where students can take what they need.

3. Tear sheets of aluminum foil that are approximately the same width as the plain white paper. Trim the extra length so that the foil sheets are the same size as the paper. (A longer piece of foil will affect students' results.) Each student or pair will need several sheets of the material they choose.

Introduction

Background

People have been building and using bridges throughout history in order to cross obstacles such as bodies of water, valleys, or rough terrain. The earliest bridges were constructed using natural resources such as logs, dirt, and stone. But the Roman Empire made huge engineering advancements during the second century BCE. Roman engineers discovered mortar by grinding up volcanic rocks. Mortar enabled them to "glue" stones or bricks together, creating larger and stronger structures. The Pons Fabricius bridge in Rome is an example of an arch bridge. It was built in 62 BCE and is still standing today!

Student Challenge

Select a material—either a single sheet of paper or aluminum foil—and design a bridge that can support as much weight as possible.

Success Criteria

- The bridge is constructed using a single piece of material (paper or aluminum foil).
- The bridge spans a distance of 6 inches.
- The bridge supports at least 40 pennies.

Engineering Constraints

- Use only one sheet (white paper or aluminum foil) per design.

Instructions

Introduce the Challenge

1. Have students think about bridges they've seen in their community, small or large. Ask questions to help them consider the qualities of each one, such as:
    - What is the purpose of the bridge?
    - Who uses it?
    - What does it look like? How long is it?
    - What materials is it made of?

2. Explain that civil engineers design bridges, roads, tunnels, water systems, and other things that people need in towns and cities. Before designing a bridge, they need to think about who will use the bridge and why. They need to consider how much weight the bridge needs to support and what materials they might use.

3. Hold up a single sheet of paper and a same-sized piece of heavy-duty aluminum foil. Ask students to describe the qualities of each one. Then ask them:
    - Which material will make the strongest bridge?
    - Why do you think so?
    - Show of hands: Who wants to build their bridge out of paper? Who wants to use aluminum foil? (Note: The activity will be more interesting if some students build with paper and others with foil. Encourage the use of both materials so the results can be compared.)

4. Tell students that today they will design a bridge to see how many it can hold before collapsing. Explain that they can either use a single sheet of paper or heavy-duty aluminum foil.
    - First, they will brainstorm ideas.
    - Then they'll build prototypes and test them. As they test, they can name or number each prototype and record their results on lined paper. If needed, show students how to create a data table to record their results.
    - Finally, they will evaluate and redesign to create their best bridge.

5. Share the success criteria and engineering constraints.

Brainstorm

1. Point out the materials that students will use to build their bridges. Explain that examining materials can inspire new ideas.

2. If students are working in pairs, have them talk about different design options before they build. Encourage them to sketch their designs or jot ideas, if helpful.

Build, Test, Redesign

1. Give students time to build and test their prototypes. If needed, define *prototype* as a model or something you build that shows your idea.

2. As they work, circulate and provide support as needed. To encourage students to think more deeply about the challenge, ask guiding questions such as:
   - What can you do to your paper or foil to make your bridge stronger?
   - How can you prevent pennies from falling off the bridge?
   - Does it matter where you place the pennies—in other words, how you distribute the weight?

3. Remind students of the engineering constraints and success criteria, as needed.

4. Create a leaderboard where students can list their names, prototypes, and the number of pennies they held.

Reflect

1. Bring students together to discuss their designs and share results. Ask questions such as:
   - Which material built the strongest bridge? Why?
   - Which bridge designs were the most successful?
   - How many pennies did the best design hold? (Reference the leaderboard, if used.)
   - Was there a clear winning design, or were there a variety of designs that held a large number of pennies?

2. Read the success criteria aloud and have students raise their hands if they achieved them.

3. Share your results with DiscoverE! Post photos/videos on social media @DiscoverEorg

Extensions

- Change the constraints. Allow students to use two sheets of paper or foil. Can the bridges hold twice as many pennies? Or have them investigate: How many pieces of foil would you need to hold as many pennies as a paper bridge?
- Have students research a type of bridge (suspension, tied arch, truss, beam, cantilever, floating, etc.) and determine why that type of bridge works well in its location. Students can create a poster or slide displaying images and summarizing their research.

STEM Connections

Engineering & Science Connections

Designing and building bridges connects many different areas of science, engineering, and architecture. Engineers design bridges and buildings to be structurally solid and meet the needs of the people who will be using them. Engineers need to consider several factors when designing bridges, including how the bridge will withstand weight, gravity, wind, earthquakes, corrosion, and temperature. If the bridge spans a body of water, they will also need to think about water flow, tides, and erosion around the footings—all of which can weaken the bridge and cause it to fail!

Modern bridges come in many designs and solve a variety of problems. Some common bridge types include suspension, beam, tied arch, cantilever, floating, and truss. Each one addresses some problems but not others. Suspension bridges, for example, are lightweight, strong, and can span long distances, but they're expensive, difficult to build, and might sway in high winds. In contrast, a beam bridge is easy to build and inexpensive. But longer bridges require many vertical supports, which could make it difficult for people or vehicles to pass underneath.

Image by Doodles43 from Pixabay

The Golden Gate Bridge in San Francisco is a well-known example of a **suspension bridge**. In a suspension bridge, towers hold up the cables, which bear the weight.

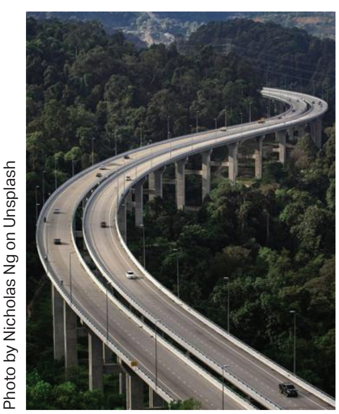

Photo by Nicholas Ng on Unsplash

A **beam bridge** is the most common type of bridge. It's made of a horizontal surface and vertical supports.

Image by Kate Branch from Pixabay

The Sydney Harbour Bridge in Australia is an **arched bridge**. The arch distributes weight along its curve.

Image by Aline Dassel from Pixabay

The Forth Bridge in Scotland is a **railway bridge** and uses triangles, or trusses, for support.

NGSS Standards

Grades 3–5

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Grades 6–8

MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

MS-ETS1-3 Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.