Keeping You in Suspens(ion)

Areas of Science	Civil Engineering (http://www.sciencebuddies.org/science-fair-projects/project-ideas/civil-engineering)
Difficulty	
Time Required	Very Short (≤ 1 day)
Prerequisites	None
Material Availability	Readily available
Cost	Very Low (under $20)
Safety	No issues

Abstract

Suspension bridges, with their tall towers, long spans, and gracefully curving cables, are beautiful examples of the work of civil er
carry the *load* that is on the bridge? Can a suspension bridge carry a greater load than a simple beam bridge? This science proje

Objective

Compare the strength of two simple bridge designs: a beam bridge vs. a suspension bridge.

Credits

Edited by Andrew Olson, Ph.D., and Teisha Rowland, Ph.D., Science Buddies

Sources

The experiment procedure for this science project idea is from:

- WGBH Educational Foundation. (2001). *Building Big: Bridges.* PBS Online. Retrieved June 13, 2006, from http://www.pbs. (http://www.pbs.org/wgbh/buildingbig/bridge/index.html)

Cite This Page

General citation information is provided here. Be sure to check the formatting, including capitalization, for the method you are using and upd

MLA Style

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APA Style

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Introduction

The Akashi-Kaikyo Bridge, shown in Figure 1, is the longest *suspension bridge*. in the world, at the time of this writing (January, 2 overall, with a central span of 1991 m. The bridge is in Japan, where it connects the city of Kobe (on the large island of Honshu) w island in Japan). In addition to the sheer length of the bridge, the engineers who designed it also had to consider the environmen and the potential for earthquakes in the area.

Figure 1. The Akashi-Kaikyo Bridge, in Japan, is the longest suspension bridge in the world. (Image cre

In a **suspension bridge**, the **bridge deck** (the part of the bridge that supports the *load*, such as cars and their passengers) hang *cables*. These cables stretch between the bridge's *towers*, and are securely anchored at each end. The cables are thus under **te** while the bridge towers are under **compression** (they are being compressed, or pressed down on).

For long spans, the suspension bridge is usually the most economical choice, because the amount of material required per unit le However, since suspension bridges are relatively flexible structures, stress forces introduced by high winds can be a serious prob Tacoma Narrows Bridge, captured on film, is a pointed example. You can watch the video below to find out more about the Tacon 1940.

This video gives background on, and shows the collapse of, the Tacoma Narrows Bridge, w was in Washington state.
https://www.youtube.com/watch?v=dTEeECS7_Ow (https://www.youtube.com/watch?v=dTEeECS7_Ow

In this engineering science project, you will use simple construction materials to build and test two types of bridges: a simple susp **beam bridge** is the simplest type of bridge, and is supported by a raised part on either end. For example, a beam bridge could be cross a stream. Which type of bridge do you think can support a heavier load?

Terms and Concepts

- Suspension bridge
- Bridge deck
- Tension
- Compression
- Beam bridge

Questions

- In a suspension bridge, which parts of the bridge are under compression?
- Which parts of a suspension bridge are under tension?
- How is a suspension bridge different from a beam bridge? Why might they be used in different situations?
- How does an engineer decide which type of bridge to use for a particular site?

Bibliography

This science project idea came from the PBS website, "Building Big." Their page on bridges is a good place to start your backgro

- WGBH Educational Foundation. (2001). *Building Big: Bridges.* PBS Online. Retrieved June 13, 2006, from *http://www.pbs.* *(http://www.pbs.org/wgbh/buildingbig/bridge/index.html)*

On this website, you can learn about different types of bridges (arch, beam, suspension, and cable-stayed), and then play "Build description, and you have to decide which bridge type would work best there.

- NOVA Online. (1997). *Super Bridge.* WGBH. Retrieved June 13, 2006, from *http://www.pbs.org/wgbh/nova/bridge/* *(http://www*

What can happen when the design is not quite right:

- Ketchum, M. (n.d.). *Mark Ketchum's Bridge Collapse Page.* Retrieved June 13, 2006, from *http://www.ketchum.org/bridge* *(http://www.ketchum.org/bridgecollapse.html)*
- Youtube, CalPolyPomonaDemos. (2013, July 8). *Tacoma Narrows bridge collapse*. Retrieved October 27, 2017, from *https* *v=dTEeECS7_Ow* *(https://www.youtube.com/watch?v=dTEeECS7_Ow)*

Check out this Science Buddies resource on building materials and forces:

- Pruitt, B., T. Bailey, and A. Tung. (2006). *Stress, Strain, & Strength: An Introduction to Materials Science* *(http://www.sciencebuddi* *strength-an-introduction-to-materials-science)*. Department of Mechanical Engineering, Stanford University (published by Science Buddi

Materials and Equipment

- Box of drinking straws
- Masking tape or painter's tape
- Thread
- Scissors
- Paperclips (4). At least two of the paperclips should be large ones.
- Paper cup, at least 8-oz.
- Pennies (at least 350). Alternatively you could use other coins, such as quarters (at least 150), as long as you use all of th
- Metric ruler or tape measure
- Chairs, tables, or desks that you can arrange to build a bridge between (2)
- Optional: Scale, accurate to 1 g, such as the digital pocket scale available from Amazon.com (https://www.amazon.com/Weigh-MS-600 Scale/dp/B004O792H2/ref=dp_ob_title_kitchen?ie=UTF8&tag=sciencebuddie-20)
- Lab notebook

Figure 2. To do this science project, you will need materials likes the ones shown here. *Note:* At least two of the paperclips shou
coins instead of quarters.

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https://www.sciencebuddies.org/science-fair-projects/project-ideas/CE_p007/civil-engineering/suspension-bridges (http://ww
ideas/CE_p007/civil-engineering/suspension-bridges)

PDF date: 2020-03-06

Experimental Procedure

1. If your straws are the flexible type, cut the flexible part off (so that you are left with a long, straight, non-bendable straw pie
this way. Make sure they are all the same length; trim some using the scissors if necessary.

Figure 3. If you are using flexible straws, cut off the short flexible part so you are left with the long, straight piece

2. Cut two short pieces of straw, each 3 centimeters (cm) long, as shown in Figure 4.

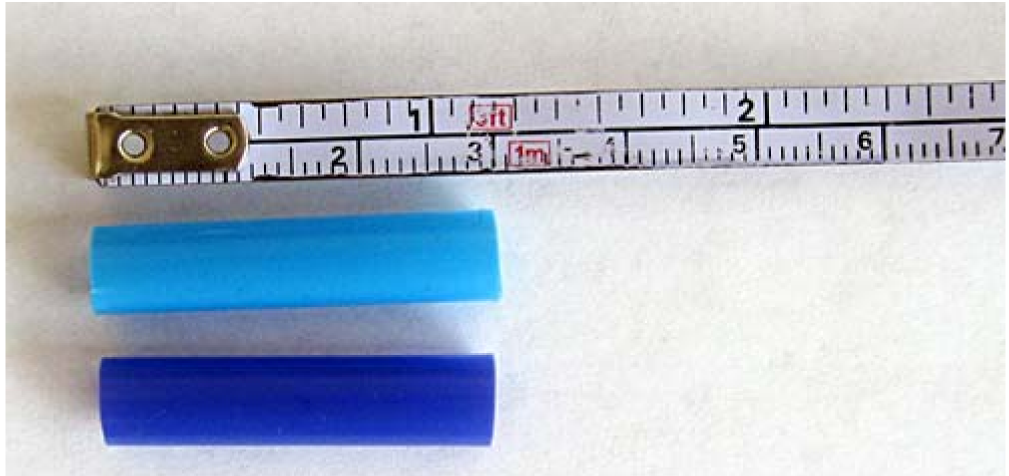

Figure 4. Cut two short pieces of straw, each 3 cm long.

3. Tape two long straws on either side of one of the short pieces of straw. Do this at one end of the long straws. Then, tape th as shown in Figure 5. This is a tower for your suspension bridge.
    a. If you are using flexible straws, the "long" straws will be the ones you prepared in step 1, above. If you are using no long straws.
4. Repeat step 3 to create a second tower.

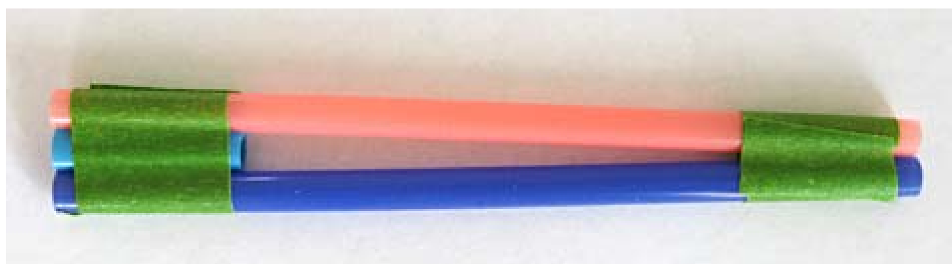

Figure 5. Create a bridge tower by taping two long straws together around a short straw piece on one end. Make t

5. Tape one tower to the edge of a desk, table, or chair, as shown in Figure 6. Tape the second tower to a second piece of fu towers far enough apart so that you could fit a straw between them, as shown in Figure 7.
    a. If you are using flexible straws, you may need to position the towers about 13 cm apart.
    b. If you are using non-flexible straws, you may need to position the towers about 17 cm apart.

Figure 6. Tape a tower to the edge of a chair, desk, or table.

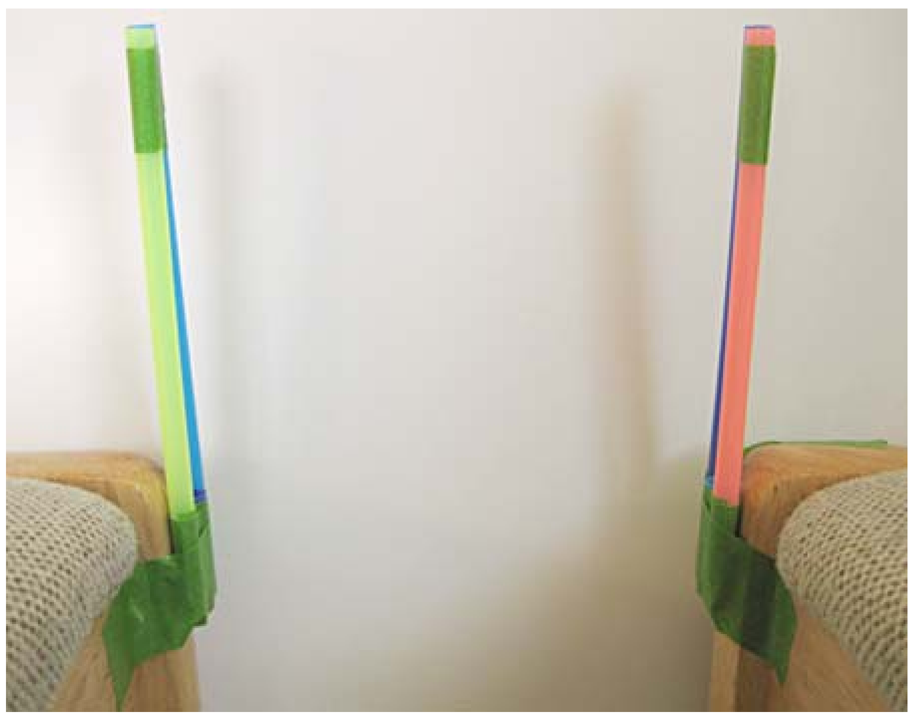

Figure 7. Tape the other tower to a different piece of furniture that is the same height. Move the tower positions so that you could fit one long straw between them.

6. Place another straw between the towers so its ends rest on the short pieces, as shown in Figure 8. This straw is the bridge bridge.
    a. If you are using flexible straws, use one of the straws you cut in step 1, above, as the bridge deck.

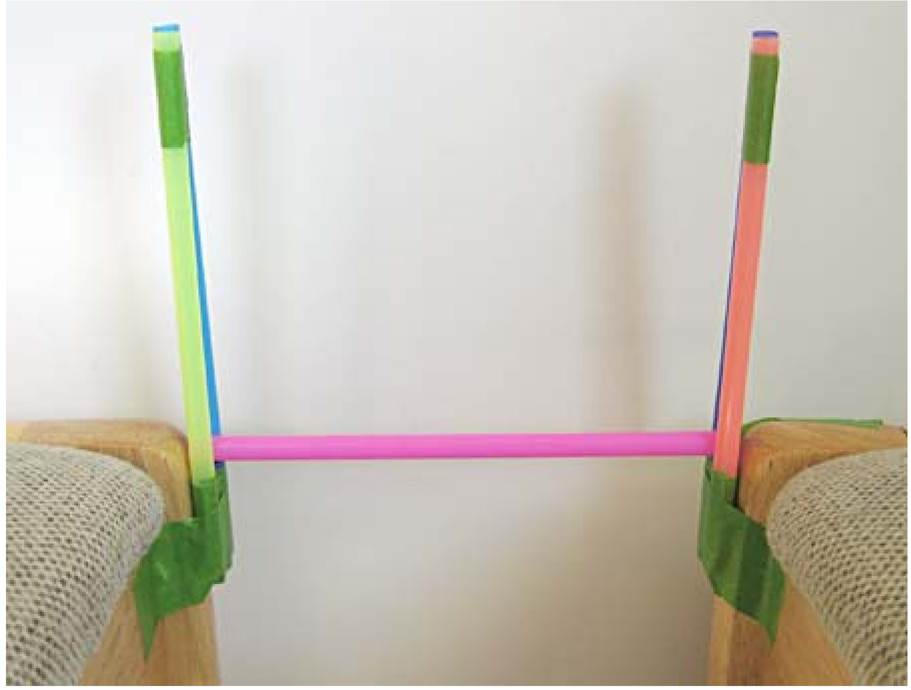

Figure 8. Place a straw between the towers. This straw (in pink here) is the bridge deck and should rest on top c
You now have a simple beam bridge.

7. Make a *load tester* by unbending a large paperclip into a V-shape. Poke the ends of the paperclip into opposite sides of a
shown in Figure 9.

Figure 9. Make a load tester by bending a large paperclip into a V-shape and poking the ends into a paper cup, on op

8. Use a second large paperclip to hang the load tester over the bridge deck. Do this by attaching the two large paperclips to
around the bridge deck straw, as shown in Figure 10.

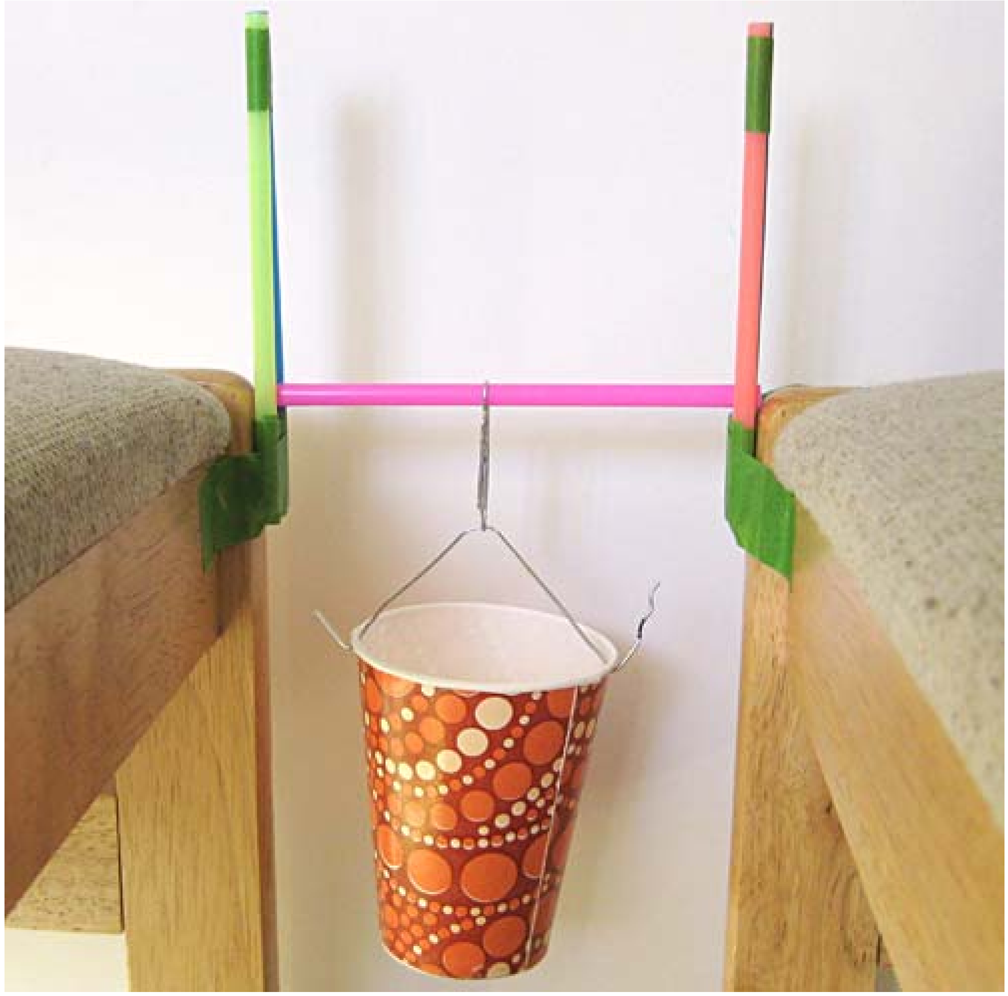

Figure 10. Attach the load tester (paper cup) to the bridge deck (the pink straw here) by using a seconc

9. In your lab notebook, make a data table like Table 1. You will be recording your results in this data table.

Bridge Design	Trial	Number of Pennies	Average Number of Pen
Beam Bridge	1		
	2		
	3		
Suspension Bridge	1		
	2		
	3		

Table 1. In your lab notebook, make a data table like this one to record your data. If you use coins other than pennies, be sure to change the words in your data table.

10. Add pennies (or other coins, all of the same type) one at a time into the load tester cup. In your data table, record how mai the bridge fails. This will be trial 1. Record any other observations you make, such as *how* the bridge failed, in your lab not

   a. If you have a scale, you could also weigh the mass (in grams [g]) of all of the pennies together that caused the bridg
   data table like Table 1 in your lab notebook but instead of "Number of Pennies" label the columns "Mass of the Load

11. Replace the straw that was the bridge deck with a new straw.
    a. If you are using flexible straws, this would be one of the other ones you cut in step 1.
    b. You are replacing the bridge deck straw because it likely became bent and damaged when the bridge failed.
12. Repeat steps 10–11 at least two more times so that you have done a total of at least three trials using the beam bridge des
13. Now change the beam bridge into a suspension bridge. Tie the center of a 100 cm piece of thread (acting as your bridge c deck straw. Place the straw between the towers. Pass each end of the cable over a tower and down the other side.
14. To anchor the suspension bridge, tie each end of the cable around a paperclip. Slide the paperclips away from the towers paperclips firmly to the furniture, as shown in Figure 11. Overall, the suspension bridge setup should look similar to Figure

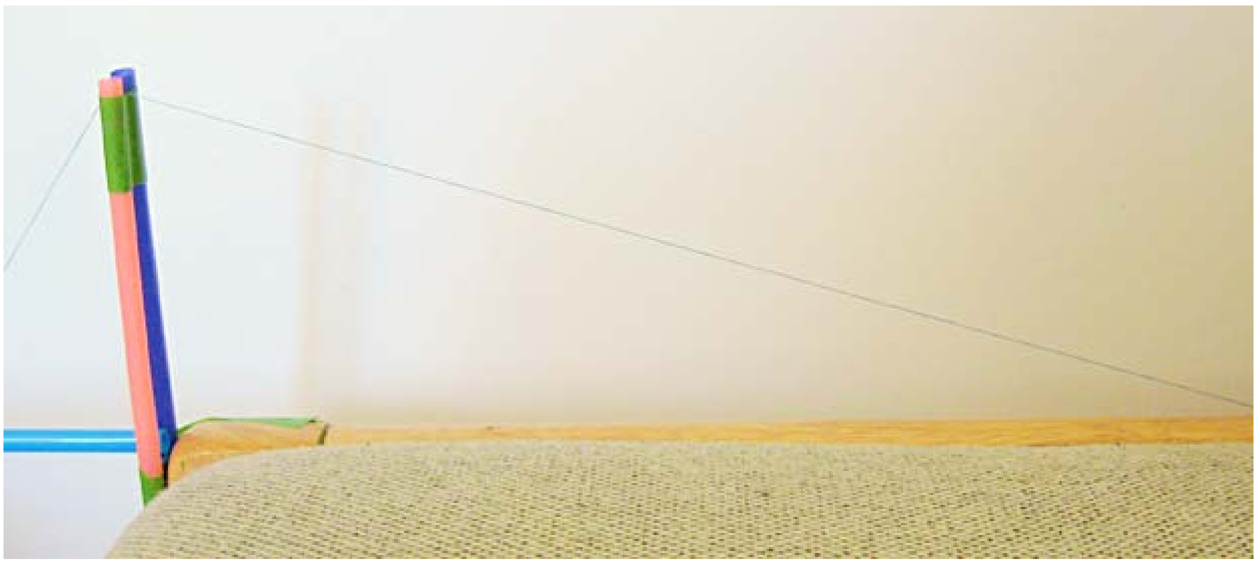

Figure 11. Attach each end of the cable to a paperclip and tape the paperclip to the furnitu as shown here (for only the right side of the bridge), so that the cable is tight..

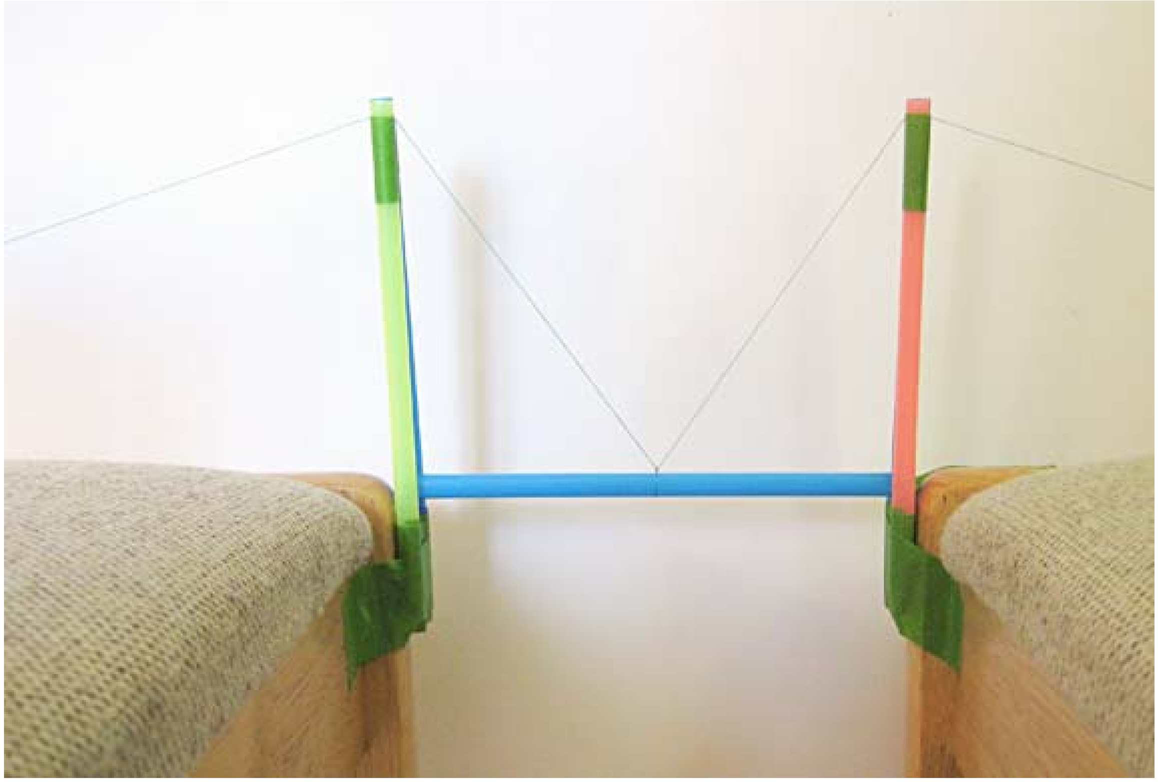

Figure 12. In this picture you can see the middle part of the suspension bridge. The cables are taped to the furniture outside of the picture, to the right and left sides.

15. Attach the load tester cup, as shown in Figure 13, and repeat steps 10-12 so that you have tested the suspension bridge c record your results in your data table.

Figure 13. Attach the load tester (cup) to the bridge deck (the blue straw here) as you did be

16. Calculate the average number of pennies needed to make each bridge design fail and record your results in your data tabl
    a. For example, if for the beam bridge it took 180 pennies in trial 1, 190 pennies in trial 2, and 195 pennies in trial 3 to of pennies needed to make the bridge beam fail would be 188 (since 180 + 190 + 195 = 565, and divided by 3 equa
17. Make a bar graph of your results. On the x-axis (the horizontal axis) put the name of the bridge design and on the y-axis (t of pennies needed for that design to fail.
18. If you weighed the mass of the pennies, you can repeat steps 16 to 17 to calculate the average mass of the load (in grams then make a bar graph of your results.
19. Analyze your results. Looking at your data and graph(s), which bridge design could hold more pennies? Which bridge desi lot stronger? Why do you think you got the results that you did?

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If you like this project, you might enjoy exploring these related careers: