



Drexel-SDP GK-12 ACTIVITY

Toothpick Bridges

Subject Area(s): Math, Physics, Engineering

Associated Unit: None

Grade Level 6 (6-10)

Activity Dependency: None

Time Required: 65-165 minutes (Note: 1 30 minute Session and 1-3 45 Minute Sessions)

Group Size: 1-4

Expendable Cost per Group: \$3

Summary: The goal of this lesson is to not only educate students about the types of bridges that exist and how they hold weight but also to have the students think critically about how they can construct a bridge using a very limited set of materials. In this case the limits are not budget or amount of each material but simply the type of materials that can be used. They can use an unlimited amount of those materials but absolutely nothing supplemental.

Engineering Connection: Bridges are an important civil engineering device. Without bridges we would not be able to span water of any variety. In order to understand how bridges work and hold weight students will attempt to construct their own bridge. This gives younger students a basic understanding of some physics and allows older students to employ physics they know to solve a problem.

Keywords: Bridge, math, physics.

PA Educational Standards

3.1.7ABCE, 3.2.7ABC, 3.4.7AC, 3.6.7BC, 3.7.7E

Pre-Requisite Knowledge

- None required for this lesson for younger students
- Older students need a cursory knowledge of physics

Learning Objectives

After this lesson, students should be able to:

- List and draw the different types of bridges constructed by engineers
- Talk about strengths and weaknesses of different bridges
- Discuss how each type of bridge supports weight
- Build a bridge out of toothpicks and glue

Materials List

Each student/group needs:

- 1 box of regular, round toothpicks
- 1 container of white glue (Elmer's is ideal)

To share with the entire class:

- Some type of weights to test the bridges ability to hold weight.

Introduction / Motivation:

Bridges have been around since the dawn of time. The very simplest bridges are logs that fell across water. Later through history bridges have been constructed by all civilizations to provide a means to cross large bodies of water. Modern day bridges are designed and built by civil engineers and the type of bridge is chosen based on how long the bridge needs to be and how much weight it can support. There are 4 main types of bridges; truss bridges, beam bridges, suspension bridges and arch bridges.

Beam bridges are the simplest type of bridge. They involve place large beams across the area that needs to be crossed. The typical distance for beam bridges is 10m-200m but they rarely span more than 250 feet. The weight in this case presses down on the beams and is distributed down through the supports on either side of the bridge. The longer a beam bridge is the less weight it can support at its center.

The second type of bridge is an arch bridge. These bridges were constructed by the Romans out of stones. Now they are made of steel and concrete instead. These bridges can span up to about 800 feet and are extremely strong. The weight is distributed along the arch in the bridge and because an arch is part of a circle it is capable of handling a great deal of weight. The downside to these bridges is they are extremely expensive to build.

Next we have a truss bridge. Truss bridges are formed by a series of triangle shapes. The Betsy Ross Bridge between New Jersey and Pennsylvania is a great example of a truss bridge. Triangles are an extremely strong shape and the weight on the bridge is distributed along the

many triangular sides so these can hold more weight than a standard beam bridge. In addition they are more cost effective to build than an arch bridge. Typical spans for these bridges are about 40-500m.

Finally we have the suspension bridge. Suspension bridges can span the longest distances and hold the most weight due to their ability to distribute the weight through the man steel cables that run from the top of tall towers on the bridge down to the bridge bottom. These bridges can span 70-over 1000 meters and hold enormous amounts of weight. One great example of this bridge is the Golden Gate Bridge in San Francisco. The steel cables used for these bridge can be expensive and so can the construction of the bridge itself making it the most expensive type of bridge.

When Civil Engineers are asked to design a bridge they consider how far it needs to span as well as how much traffic will likely cross it at once. Bridges that span short distances, like foot bridges are often constructed of beams. Bridges like the Golden Gate that span very far distances need to be suspension bridges because other types cannot be that long. These types of design criteria are important for engineers and need to be considered when building a bridge.

Vocabulary / Definitions

Word	Definition
Truss Bridge	a bridge composed of connected elements (typically straight) which may be stressed from tension , compression , or sometimes both in response to dynamic loads
Beam Bridge	a rigid, horizontal structure that rests on two end supports, and carries traffic loads by acting structurally as a beam.
Suspension Bridge	a bridge with its deck supported by large cables hung from towers
Arch Bridge	an arch bridge is a bridge supported by a concrete or steel arch underneath the bridge that directs pressure and weight of the bridge outward to the supports along the arch.

Procedure

Background

- Discuss the 4 different types of bridges outlined above with the entire class. Detail good and bad things about each type of bridge including length, amount of weight, ideal conditions for building those bridges, cost, etc. Also discuss how each bridge supports weight and where the stresses are on each bridge due to cars or people traveling over them. All of this information is detailed above in the Introduction/Motivation section. In addition to this obvious information about bridges perhaps it is relevant to discuss materials and how they have different throughout time. For instance the Romans had mostly stones with which to build their large bridges. This was a major driving force for most of their bridges being arches. As we have progressed through history our available materials have changed. We now have steel beams to build bridges but this was not always the case. This will give relevance to the design constraint that the students have to build their own bridges.

Sometimes we simply do not have access to certain materials either due to cost or because they simply have not been invented yet.

With the Students

1. Each student should draw a blueprint of their bridge and make a guess about how much weight they think it could hold. It's also sometimes interesting to have them estimate how many toothpicks it will require to build their bridge (though it's difficult to keep track of how many they actually use to build it)
2. Students can work individually or in groups. Group students accordingly
3. Give each student some type of surface covering to work on. Wax paper works well because the glue will not stick to this too much.
4. Give each student/group toothpicks and glue
5. Students can have anywhere from 1-3 45 minute sessions to build their bridge. Keep in mind the glue takes a good amount of time to dry. 2 or 3 sessions are ideal because it gives them a bit of time to experiment with their bridge
6. Allow all bridges to dry for a few days.
7. Set the bridges up on 2x4 blocks across stacked books. Put weight on each bridge started with a low amount to see how much weight each bridge holds.
8. Ask the students to make a table showing the type of bridge and how much weight it held.
9. Have the students find an average weight for each type of bridge
10. Have the students find an overall average weight held by all the bridges.
11. Students should answer the investigation questions in their engineering journal.

Attachments

None

Safety Issues

- Glue or toothpicks in the eyes. Monitor students and make sure they are not throwing toothpicks

Investigating Questions

1. What type of bridge did you construct?
2. Why did you choose that type of bridge?
3. How much weight do you hypothesize it will hold?
4. What made this activity difficult?
5. What would have made this much easier?

Assessment

Pre-Activity Assessment

Students should draw a blueprint of their bridge and make a hypothesis about how much weight it will hold

Activity Embedded Assessment

Students will be building their bridges and investigating how to glue the toothpicks together in different configurations.

Post-Activity Assessment

Have students write a paragraph in their journal discussing the different types of bridges in their area. Have the students try to determine what type of bridge each one is and discuss which of the bridges are shorter/longer and seem to have the most traffic driving across them. Given what they have learned have the students discuss which bridge they would feel the safest crossing.

Activity Scaling

- For lower grades, only perform the activity as stated in this lesson.
- For upper grades, this lesson can be extended to include more detailed physics discussion and bridges can be built with those ideas in mind.
- In addition to make this activity easier for younger student Legos or K'nex can be used in place of toothpicks and glue.

References

Owner

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