Bridge Building

Author(s): Kevin Dilley *(updated by Mark Walsh)*

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Subject: Physics

Grade Level: Upper Elementary/Middle School

Standards: *Next Generation Science Standards (www.nextgensciecne.org)*

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.

MS-PS2-2 Plan an investigation to provide evidence that the change in a object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS2-4 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.

Schedule: Two to three 40-minute class periods

CCMR Lending Library Connected Activities:

Objectives:	**Vocabulary:**
Understand how bridges work and what forces are acting on them. Identify the advantages and disadvantages of each bridge type.	Compression, Tension, Torsion, Shear, Bending, Truss, Beam, Suspension, Arch
Students Will: · Learn about different kinds of bridges by doing experiments and website activities. · Learn and identify the forces acting on the different kinds of bridges. Build an appropriate bridge for a span using given materials.	**Materials:** **For Activities:** Wood blocks, Plastic ruler, Wood ruler, Sponge w/notches, Matchbox cars, Long wood blocks, Cardstock, Wooden arch pieces, Popsicle sticks w/holes, Screws w/nuts, Paper, Rope w/velco handles **For Competition:** Straws, Tape, Scissors **For Students:** Workbook **For Teachers:** Activity Sheets, Google Presentation
Safety	There are no safety concerns for this activity

Science Content for the Teacher:

Introduction:
In the US alone, there are almost 600,000 bridges. People rely on them every day to cross over things like lakes, streams, rivers, valleys, gorges, railroad tracks, or even other roads. You've probably passed over many bridges yourself and seen even more. If you've ever laid a board over a creek to keep from getting wet, you've even built one. From all the bridges you've seen, you've probably noticed that they are not all the same. Some bridges are flat and some are curved. Some have cables and some don't. Do you know why all bridges are not built the same? If you don't know the answer to this question right now, don't worry. You will by the end of this lesson.

When designing a bridge, engineers have to consider many things, such as what will be crossing over the bridge, where it's being built and what materials are available, just to name a few. One very important thing to consider is how far the bridge has to span. This will help decide what

type of bridge they would want to build.
In this lesson, students will find out how bridges work and what forces are acting on them. They'll also learn about the four basic types of bridges and what advantages and disadvantages they have. They will even get an opportunity to build ther own bridge and test how strong it is.

BRIDGE BASICS
Bridges have all sorts of forces acting on them. A good bridge will be designed to withstand all these forces and even use them to its advantage. The bridge types deal with these forces differently which is why. Here are a few of the forces that act on bridges:

Compression is a force that pushes together or shortens the thing it's acting on.
Tension is a force that pulls apart or lengthens the thing it's acting on.
Torsion is the twisting of an object due to

TYPES of BRIDGES
In Engineering terms there are only four main types of bridges: beam bridges, arch bridges, truss bridges, and suspension bridges.

Beam bridges
Beam bridges are horizontal beams supported at each end by piers. The earliest beam bridges were simple logs that sat across streams and similar simple structures. In modern times, beam bridges are large box steel girder bridges. Weight on top of the beam pushes straight down on the piers at either end of the bridge.

Arch bridges
Arch bridges are arch-shaped and have abutments at each end. The earliest known arch bridges were built by the Greeks and include the Arkadiko Bridge. The weight of the bridge is thrust into the abutments at either side. Dubai in the United Arab Emirates is currently building the largest arch bridge in the world, which is scheduled for completion in 2012.

Truss bridges
Truss bridges are composed of connected elements. They have a solid deck and a lattice of pin-jointed girders for the sides. Early truss bridges were made of wood, and later of wood with iron tensile rods, but modern truss bridges are made completely of metals such as wrought iron and steel or sometimes of reinforced concrete. The Quebec Bridge, mentioned above as a cantilever bridge, is also the world's longest truss bridge.

Suspension bridges
Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams. The caissons or cofferdams are implanted deep into the floor of a lake or river. The longest suspension bridge in the world is the 12,826 feet (3,909 m) Akashi Kaikyo Bridge in Japan.

Preparation:

Bridge Stations:
Prepare 4 bridge stations in the room by having these materials ready:

Station 1 (Beam Bridge): Activity card, 3 wooden blocks, 2 rulers (one flimsy, one wooden), sponge w/notches
Station 2 (Arch Bridge): Activity card, 2 long wooden blocks, 2 pieces of cardstock, Wooden arch pieces
Station 3 (Truss Bridge): Activity card, 20 popsicle sticks w/holes at each end, 15 screws w/nuts
Station 4 (Suspension Bridge): Activity card, 2 long wooden blocks, paper, Adjustable length rope with velcro handles

Bridge Building Competition:
Each kid gets 10 straws, scissors, and a length of tape (about 4 ft)

Classroom Procedure:

Split the students into groups and have them spend about 10 minutes at each of the 4 stations. Plan on taking about 20 minutes to go over the bridges and review ideas/questions the groups had for each one.

Station 1:
Have them follow the activity card to make a simple bridge with the flimsy ruler and two blocks. They will demonstrate a car "driving" over the bridge; the flimsy ruler will tend to bow a lot in the middle. They will then come up with ideas to make the bridge stronger and test them out.

Additional supports:
Most students come up with the idea of adding another support. Add another support in the middle of the flimsy bridge and drive the car across it. It bows much less this time. This is one of the benefits of ***Beam Bridges***, you can keep making them longer and longer by adding additional supports. This is also one of the drawbacks of beam bridges, because all the supports could disrupt boat traffic.

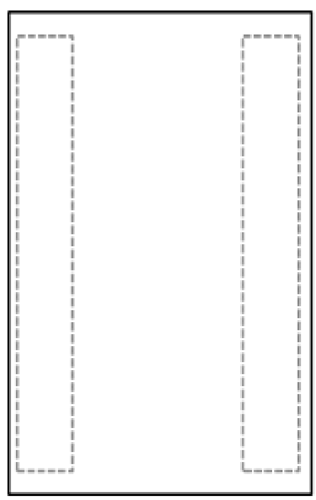
eg: The Chesapeake Bay bridge is an example of a bridge that addresses both of these ideas, it is a beam bridge then then turns into a tunnel to allow boat traffic to go through uninterrupted, then turns back into a beam bridge.

Stronger materials:
Go back to the original design (2 supports and a flimsy ruler), ask if there is anything else we can change. Not many students come up with the idea to change the material; You might have to prompt them. Replace the flimsy ruler with a wooden one. Now have the car drive across; the bridge does not bow.

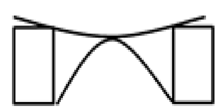
Have the sponge span two blocks.
As you put force on the sponge by having the car drive across it, you'll notice the notches at the top pushing towards each other and the notches at the bottom pushing away from each other. The top is in compression, the bottom is in tension.

Station 2:
Have them follow the activity sheet to make a simple bridge. A piece of cardstock span two long blocks (the longer sides of the paper should be lined up with the longer sides of the wooden blocks). Again, they will demonstrate a car "driving" over the bridge; the cardstock will bow a lot in the middle. They will be ask to come up with ways to improve the bridge.

Arches:
From the previous station, many will try to add supports or strengthen the material. Explain that they only have one extra piece of paper this time. Most students will not guess the arch; they will need prompting. Put the second piece of cardstock as an arch between the wooden supports, and then put the first piece of cardstock over top. Drive the car over again; it will not bow.



Side View: Bridge #1



Side View: Bridge #2 (Arch)

Have the students build a wooden arch to see how the forces are compression along the sides that meet. The most rectangular pieces go on the bottom, the more triangular ones go toward the peak of the arch. If having trouble, use the guide that is included in that station

eg: Arch Bridges have been around for a long time; you can see examples of them in the ancient Roman aqueducts.

Station 3:

Station 3:
Have the students build some 2 dimensional shapes (triangle, square, pentagon, and hexagon), using the popsicle sticks and screws. They will then stand and hold the structures up, with one edge on the table. Have them push down on the structure to see if they will hold a load (they won't very well). Ask the students if that is a safe bridge. If it is one they would want to drive across.Ask the students how they would strength the bridge with the materials in front of them. (hing: they should add popsicle sticks between corners to make a much more stable structure - no additional nuts needed). Once you've added all the supports you can, ask the students what shapes they see. They should see triangles, explain that the triangle provides the most stability to the structure.

NOTE: This is the main bridge the students will be using ideas from for the building competition

Station 4:
This first demo teaches the kids about anchoring. Have them set the blocks up with the paper spanning, and put a car on it. The bridge will collapse. Explain that suspension bridges require supports to be anchored to the ground at the ends of the bridge.
This second demo teaches the kids about where the forces are. Get a student to volunteer to act like a bridge. Have the student hold their arms out. Push down on one of their arms, it will fall a bit. Ask where they felt the force (it should be on their arm). Now give the student the rope. Have the student put the end of the rope in each hand, and rest the middle of the top on top of their head and push down on their arm, it shouldn't fall much. Ask where they felt the force (it should be on their head). Explain that the supports (the student's head/body) feel a compressive force. The rope experiences a tension; if the rope compresses it just falls into a pile.

Before the competition, you can review the different bridge types and the forces acting on them with the presentation that can be found at this link:

https://docs.google.com/presentation/d/13czrm7_HBz6Os6wDqQ6CK84VRpwr9JMboFovfgKwcS0/edit?usp=sharing

Bridge Building Competition:
The competition is outlined in the middle of their workbooks.
There are three rules:
1) Come in on budget (can't ask for extra materials)
2) Free standing (can't tape it to the table) – this eliminates arch and suspension
3) Must span the distance between two tables (5 inches)
4) Must support at least the bucket.

Allow the students to build their bridges, and then test them using the bucket provided. The kids can put their own washers in, but teacher should help place the bucket and choose the location that would make the bridge the strongest.

Assessment:

The following rubric can be used to assess students during each part of the activity. The term "expectations" here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.

1= exceeds expectations
2= meets expectations consistently
3= meets expectations occasionally
4= not meeting expectations

	Explore	Explain	Expand/Synthesis
1	Student works well with partner(s). Student is very involved with testing each bridge.Student shows leadership in activity. Student completes activity for each bridge type.	Student takes leadership in discussion. Student contributes in the discussion and accepts other opinions. Student is able to determine advantages and disadvantages of different bridge types.	Student worked well on bridge competition. Student came up with a plan for the bridge. Student was planning and working the entire time.
2	Student works with partner(s). Student is involved with testing each bridge. Student completes activity for each bridge type.	Student contributes to discussion. Student may not accept other opinions. Student is able to determine advantages and disadvantages of different bridge types.	Student worked well on bridge competition. Student came up with a plan bridge design. Student was distracted during this time and did some off topic talking.
3	Student does not work well with partner(s). Student is not very involved with testing each bridge. Student does not complete activity for each bridge type.	Student contributes little to the discussion. Student refuses to accept other opinions. Student may still be unsure what advantages and disadvantages bridge type has.	Student sometimes worked well on bridge competition.. Student was easily distracted and often talked off topic. Student did not do much planning.
4	Student does not work with partner(s). Student does no testing of bridges. Student does not complete activity for each bridge type..	Student does not contribute to the discussion. Student will not accept other opinions. Student does not understand the advantages and disadvantages of different bridge types.	Student did not work. Student did not plan their bridge and did not do anything towards the project during this time.

Other Resources:

PBS site on Bridge Building: http://www.pbs.org/wgbh/buildingbig/bridge/