Teacher Guide to Student Worksheet 2:
Building the Brooklyn Bridge

Make sure you have the following materials in your group:

6 drinking straws
a roll of pennies
masking tape
small Dixie cup
4 large paper clips
one ruler
one pair of scissors
thread or dental floss (3 4-foot long pieces)
one copy of Roebling's anchorage patent

1. **Building the Towers:** Take one straw and mark 3 cm. on it. Cut the straw at this mark. Now take two whole straws and place them on either side of the standing 3-cm. straw. Tape the top and bottom. This is your first pier. Now repeat the process for your second pier.

2. **Placing the Towers:** Tape each tower at the edge of a desk or the edge of a chair. Move two desks or two chairs so that they are 7 inches apart.

Question: What do you think these 7-inches represent? [The width of the obstacle the bridge needs to connect. Students could imagine it to be the width of a river or valley.]

3. **Building a Bridge Deck:** Place a straw across the 7-inches connecting the two towers. The ends of the straw should rest on top of the 3-cm. straw in the middle of the towers.

Question: Now what type of bridge do you have? [Beam.]

4. At this point in building the suspension bridge, Roebling ran into trouble. He wanted to use his wire cable, but it was too heavy to transport to the site of the bridge.

Question: What do you think Roebling did to overcome this problem?
[He built a special machine so that the wire could be made into cable at the site.]

5. **Creating the Cables:** Take 3 pieces of dental floss/thread 4-foot in length. Wrap two of the pieces tightly around one piece.

Question: What have you just created? [A simple version of a cable.]
What is stronger—a single piece of thread or the cable with strands wrapped around it? Why? [The cable. There is more area in a cable to absorb tension.]

6. **Placing the Cable:** Take your cable and run it up over one tower (inbetween the tops of the two straws taped together), down to the middle of the bridge. Wrap the cable around the middle and take it up to the second tower and through its top. When you are through, your cable should look like an elongated "M."

7. **Anchoring the bridge:** Take each end of your cable and wrap it firmly around the end of a large paper clip. Pull your cable tight and tape to the desk/chair. The paper clips and tape are the anchorages of your bridge.

Note: Roebling invented engineering design improvements to the anchoring for suspension bridges. He experimented with both the qualities of different materials and with the shapes of

surfaces to create a stronger and more enduring system. Take a look a Roebling's patent and answer the following questions:

~ When was his invention patented? [August 26, 1846]

~ What do you think anchorages do in a suspension bridge? [They hold the cables in place, and--since they are connected to the earth--they act to dissipate tension.]

~Did Roebling apply his invention to any bridges before he patented this system? If so, which ones? [Yes. He applied his idea to the Mononghela Bridge in Pittsburgh and a similar concept to the Allegheny Aquaduct Bridge.]

~ If you were inventing something, how would you go about it? What is process called and name the steps? (Hint: Recall yesterday's worksheet about Roeblings' wire rope. What process was mentioned there?)
[Technological Design Process. It is:

- Define the problem.
- Define all aspects of the problem, necessary information and questions that must be answered.
- Propose the best solution.
- Design and propose alternative methods to achieve solutions.
- Apply a solution.
- Explain the results, present improvements, identify and infer the impacts of the solution.]

8. **Creating a Weight to Test our Bridge:** You are going to make a pail with a small Dixie cup and a large paper clip. Bend the paper clip into a "V". Bend the ends of the "V" inward, poking them through the Dixie cup on opposite sides near the rim. Bend the ends of the paper clip up on the inside of the cup. Take a second large paper clip and use it to hang the pail you have made. To do this place the pail on one end of the paperclip and hang it from the middle of the bridge.

9. **Testing our Bridge:** Drop a penny in your pail. If the bridge holds, drop another. See how many pennies your bridge can hold.

Question: What does this weight represent in real life? [It could be man-made forces—traffic, people, etc. It could also be natural forces—winds, rain, ice, etc.]

Final Questions: **[If students need a visual demonstration of this force, see procedure.]**
~When you place a penny in the pail, what part of the bridge is being compressed?
[The towers.]

~What part of the bridge is under tension?
[The cables, the anchorages.]

~How is the pressure being dissipated?
[Through the anchorages and towers attached to the earth.]