Building Bridges

Overview: What keeps buildings from toppling over in the wind? Why are some earthquake-proof and others not? We're going to look at how engineers design buildings and bridges while making our own.

What to Learn: Objects near the Earth fall to the ground unless something holds them up.

Materials

- index cards
- blocks
- straws
- clay
- cups, disposable

Lab Time

1. Grab an index card and place it across two blocks.
2. Roll up a lump of clay and place it on the card. This represents your person on the bridge.
3. Try adding another lump of clay, representing another person. Does that work as well?
4. Now, put the card between the two blocks so that it forms an arch in the middle. What happens when you load this new bridge?
5. Spread out the arch a bit and add another index card on top. Test it with your clay again – how many clay lump "people" can you add to this bridge?
6. Make lengthwise accordion folds in an index card and place it on top of the blocks. Place another, unfolded card on top. How many clay lumps can you add now?
7. Use the straws and clay to make bridge supports for your pleated bridge.
8. Continue to experiment with your materials to perfect your bridge. Remember to simulate weather conditions and even earthquakes to test your structures.

Building Bridges Data Table

Draw a Picture of your Bridge Design and/or Describe it in Words	How Much Weight Did it Hold?

Reading

There are different kinds of forces, and they act in different ways on things like buildings, chairs, bridges, fences, frames, and more. We'll be dealing with a static load in this lab, which is like holding a stack of heavy books. You're not moving, but you're keeping the books from falling to the floor by holding them up. A stack of books on anything non-moving, like a chair, table, desk, or counter is a static load.

For comparison, I'll list a few more different kinds of forces so you can get a feel for how they differ from each other.

A dynamic load is when you're moving with the load. If you place the books on a skateboard, or walk with them across the room, now you're dealing with a dynamic load.

Tension is the pull an object feels when you try to pull it apart. Two kids playing tug-of-war puts tension in the rope. A chandelier hanging from the ceiling has tension in the cable. A kid on a swing puts tension on the chain. This stretching puts the object in tension.

Compression is what you feel if you lift a heavy weight over your head. You feel compressed as the weight pushes down on your arms. When you sit in a chair, you are compressing the chair's legs. If you sit on a balloon, you are compressing it into a smaller shape.

Torsion is the force an object feels when you twist it along its length. If you hold a ruler or stick at opposite ends and twist in opposite directions, the ruler feels a twist (torsion). Crankshafts use torsion to spin the wheels of your car from the engine.

Shear force happens when forces are applied in two different directions to an object. When you squeeze a pair of pliers, you are applying a shear force on the pin that holds the piers together. If you rub a piece of paper between your hands as you rub your hands together, you are applying a shear force to the paper.

How do you design something to be earthquake proof? In 1989, a massive earthquake caused structural engineers to redesign the Bay Bridge in San Francisco, California with three distinct elements: shear link beams, hinge pipe beams, and piles. The shear link beams are steel beams in the central tower designed to shear under excessive loads and will absorb the damage. The hinge pipe beams are 20 60-foot-long tubes that connect sections of the bridge's road. The soft centers of the tubes are like a fuse, and during an earthquake are designed to fail so they can easily be replaced. Part of the bridge sits on top of mud, which turns to liquid during an earthquake, so engineers drove 160 angled piles down 300 feet into the mud to get a more solid foundation for the bridge.

Exercises Answer the questions below:

1. What are three different kinds of forces?

2. Using only blocks, what kind of wall design is the weakest?

3. Why does the bridge seem stronger when a card is arched underneath?

Answers to Exercises: Building Bridges

1. What are three different kinds of forces? (Shear, static, and tension.)
2. Using only blocks, what kind of wall design is the weakest? (When you stack them in independent stacks and place them side by side.)
3. Why does the bridge seem stronger when a card is arched underneath? (The card provides additional support in the vertical direction.)