Liquefaction

Lab Related Activity: *Engineering for Earthquakes*

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This activity is meant to extend your students' knowledge of the topics covered in our Engineering for Earthquakes lab. Through this activity, your students will simulate liquefaction to see the dangers the San Francisco Bay Area faces with every earthquake.

Grade Levels: 4-12
Estimated Time: 45-60 minutes (This activity is meant for students to work as teams of four or five)

Student Outcomes:

1. Students will be able to model the act of liquefaction during an earthquake.
2. Students will be able to determine the liquefaction susceptibility of their hometown.

Common Core ELA Standards
Grade 4: *Speaking and Listening* 4.SL.1b-d
Grade 5: *Speaking and Listening* 5.SL.1b-d
Grades 6-12: Writing W.7; *Speaking and Listening* SL.1b-e

Next Generation Science Standards
Earth Sciences:
Grade 4: 4-ESS2-2, 4-ESS3-2
Grades 6-8: MS-ESS3-2; **Grades 9-12:** HS-ESS2-5, HS-ESS3-1

California State Science Standards
Earth Sciences:
Grade 4: 4.5.a; **Grade 6:** 6.2.d, 6.3.a
Grades 9-12: 9.b,d
Investigation and Experimentation:
Grade 4: 4.6.c-d; **Grade 5:** 5.6.b-c, g-h;
Grade 6: 6.7.a, d, e; **Grade 7:** 7.7.c-e
Grade 8: 8.9.a-b; **Grades 9-12:**1.a, c-d, f-g

Vocabulary:

- Earthquake: A shaking of the ground caused by the sudden movement of the earth's crust or by volcanic activity.
- Liquefaction: A phenomenon in which the strength and stiffness of a soil is weakened by an earthquake or other high load activity such as construction blasting.
- Soil saturation: A point at which a soil can no longer take on any additional water. All spaces between soil particles are filled with water.

Materials (one set per group of 4-5 students):

- Medium sized clear plastic bin (approx. shoebox size)
- Sand or sandy type soil
- Water
- 2 bricks or large stones
- Red marker
- Plastic film canister or small pill bottle (empty)
- Rubber mallet/hammer

Procedure:

1. *Set-up:* Fill the plastic bin a little more than half way with sand. Slowly pour water over the sand while mixing to ensure complete saturation. Make sure there is no standing water on top of the sand. If too much water is added, try adding more sand or scooping out some of the water.
2. *Discussion:* Begin with a discussion about liquefaction. Ask students what they think liquefaction is and why it is dangerous.
    a. Liquefaction is a dangerous phenomenon that occurs when saturated soil is weakened during an earthquake or high load activity.
    b. Liquefaction only occurs in soil that is fully saturated.
    c. A large part of the bay area is at risk for liquefaction. Show students the following map (http://geomaps.wr.usgs.gov/sfgeo/liquefaction/susceptibility.html) and ask them to determine the risk

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factor for liquefaction in your area. If not from the bay area, ask about locations such as South San Francisco, San Jose, Palo Alto, etc.

d. Many areas in the bay area are at high to moderate risk of liquefaction due to high water table and man-made landfill as a structural foundation.

3. Before simulating liquefaction, ask students to touch the saturated sand. What does it feel like? How much pressure can be put on it (use a fist to push down on it)? What happens when pressure is applied? Does it feel strong or weak? Would it make a good soil type to build a structure on?

Liquefaction simulation:

4. First have students take the two bricks and place them in the saturated sand. One should be vertical and pushed into the sand as far as possible. The other should be horizontal and pushed about half-way into the sand.
5. Using the red marker, have students draw a line on the brick at the soil line.
6. The small film canister or pill bottle will represent a septic tank or other underground utility line. Have students push the canister all the way into the sand so that it is completely covered.
7. Before simulating the earthquake, have students make predictions on what they think will happen to the two structures.
8. To simulate the earthquake, tap the side of the container with the rubber hammer rapidly and firmly, but not so hard that the container breaks. Earthquake simulation may also be done by shaking the desk or table that the container is sitting on or by shaking the container. Make sure the rest of the team is making observations while the earthquake is taking place.
9. Simulate the earthquake for about 30-40 seconds. Have students make observations and compare with other teams. Which structure held up best? Why? Did the sand rise above the red line? What does that represent? What happened to the "septic tank?

   a. So what exactly happens during liquefaction??

   - Prior to the earthquake, all spaces between soil granules are filled with water. When a load is put on the soil, it the water increases the pressure within the soil. When this occurs, the water attempts to move to an area of lower pressure such as the surface. The sand or soil then becomes impacted. (This could be demonstrated by having students push their fist into the saturated sand.)
   - When the load is put on the soil repeatedly and at a fast rate, such as an earthquake, the pressure builds to a point where the soil particles can no longer stay in contact with one another and the water molecules can't reach the area of lower pressure. When this occurs, the soil and water act together as a liquid, hence *liquefaction*.

10. As a class, discuss what this demonstration means for the bay area. Is it safe to build on this type of land? Why or why not? Why do people do it if it is not safe? Are there ways to make it safe?

Extended Learning:

- Take the next step in this activity by having student teams design and engineer their brick structure to withstand the dangers of liquefaction. *(Hint: structures built in high risk liquefaction zones are typically on stilts…).* If doing this extension, you could also have students try making their own structures out of other classroom materials such as pencils, popsicle sticks, etc.