Watch it Wiggle: Liquefaction in Your Backyard!

Objectives:

- To test various soils found around your school and neighborhood, using the scientific method, to see how they would react in an earthquake.

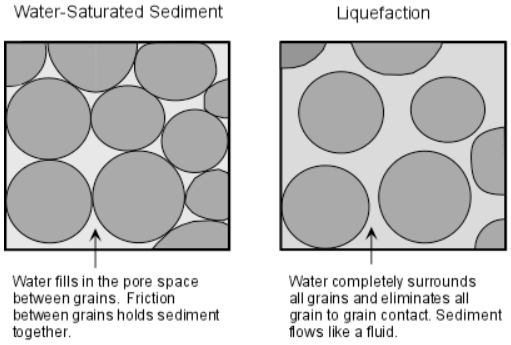
Vocabulary:
liquefaction, earthquake, scientific method, soil, sand, mud

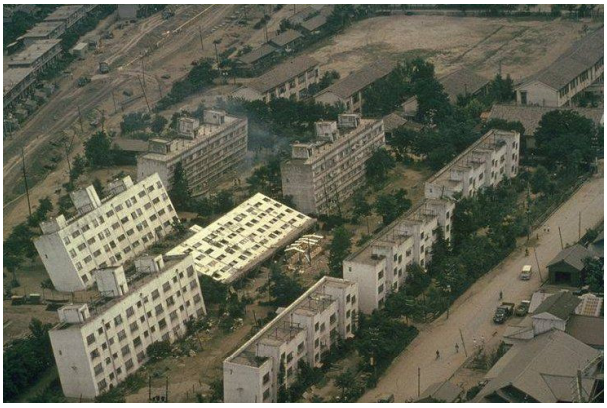
Standards:

- Science (5-8/9-12):
  - Science as Inquiry: Abilities necessary to do scientific inquiry
  - Physical Science: transfer of energy and interactions in energy and matter
  - Earth and Space Science: Changes in the Earth; Energy in the earth system
  - Science in Personal and Social Perspectives: Natural hazards
- Geography
  - World in Spatial Terms: How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information

Skills: Scientific Method, observation, measurement, testing, soil identification, labeling, mapping.

Background:
Earthquakes cause damage as a result of the different waves that they produce as the earthquake energy moves through and on the Earth. The way that the ground responds to the energy of earthquake waves as they pass through depends on the geology of the area. A hard rock, like granite or limestone, may vibrate very quickly with short movements, but not break apart significantly. A wet sand or silt, on the other hand, could be shaken enough that the pressure of the water in the soil builds up enough to make the soil behave like a liquid. This is called liquefaction, and is responsible for much earthquake damage in low-lying wet areas.





Liquefaction: strength of the ground is removed, causing the ground and objects on it to sink.

Any heavy objects sitting on liquefied ground will rapidly sink. This includes all types of natural features as well as structures. Liquefaction can result in depressions, a type of landslide called a lateral spread, and the formation of sand blows. Sand blows are geysers or volcanoes of sand expelled from cracks or holes in the ground due to high water pressure in the saturated sand during earthquake shaking. Sand blows have been known to open large fissures, create large depressions, and cover large areas of land with several inches of sand. This can impact roads and infrastructure, as well as bury large areas of farmland, making it unable to sustain crops.

Activity:
Students should be grouped into pairs or triplets (more than 3 students per team will be difficult).

Overview
Students will test the liquefaction potential of various soils from around their school and home. Students will be asked to gather the soils, examine and describe them (the level of this can be varied depending on the age of the students and interest in soil lexicon of the teacher). Each student will then propose a hypothesis about which soil they think will cause liquefaction when each soil has the same amount of water added to it. The students will then test their soils by adding the same amount of water to each soil (the soils will all be the same amount), placing the pennies upright in the cup, and then carefully tapping the cup on the tap while rotating. After observing and recording their findings, the students will then have the opportunity to make hypotheses about what happens when you add more water, what happens when you tap harder or softer, and which soils will behave in which manner. After recording all of their observations, the class will discuss their findings and begin the inquiry process about earthquakes. The students will write up their lab, complete with the following sections: Introduction, Hypothesis, Methods, Results, Conclusions.

Materials
- Styrofoam or plastic reusable but unbreakable cups
- Measuring cups (if this isn't available, mark a Styrofoam cup or plastic cup into equal fourths).
- Water (any source)
- Pennies
- Pencil and paper for recording observations

Step 1: Collecting your testing materials
Each group of students will need a dry cup for each of the 3 different soil types (more soil types can be obtained – they will need at least 3 however). There are lots of fun and interesting ways to acquire these, but we would recommend that at least one of those cups be of sandbox or beach type sand. Some suggestions for collecting different soils:
- Have each student bring in a cup of soil from their backyard (asking permission from their parents first). [Everything beyond this is extra to

the exercise but could be brought in to incorporate additional national standards.]

- Using a map of the city, mark the location where the soil was obtained.
- Compare the different soil types (grain size, color, amount of moisture, pore space, etc.).
- Have the students look at the map and discuss why the soil types are the same or different. (For more mapping and measuring skills, have the students look at the elevation of the different neighborhoods, measure the distance between the neighborhoods, and plot the shortest distance between neighborhoods as the crow flies and following streets.)
    - For those interested in Social Sciences or History have the students research, by talking to parents, grandparents or "neighborhood locals", to found out the history of the area.
    - For those interested in Creative Writing, have the students write a story about why the different soils might be the way they are or located there (keeping it clear that this is not science, merely a fun creative exercise).

- As a class go around your school and collect different soil types from different locations (larger quantities are needed for this component; discussing it with the groundskeepers so that they can direct you to good locations is a must). [Everything beyond this is extra and not essential to the exercise.]
    - Create a map of your school and grounds with the students. Have them measure distances between major objects, the parking lot, school, etc.
    - Mark on your map where you got the soil samples.
    - Discuss why there are different soils at different locations—perhaps bring in the groundskeeper or a horticulturalist to discuss why the soils are different.
- It is probably a good idea to also have a bag of potting soil and a bag of sand available in case collection is poorer than expected. (Sand must be tested anyhow and so having a bag there would be useful).
- All of the soils must be equally dry before you begin, so measure a cup of each soil into the plastic cups each team will be using and let them sit out somewhere in the room until they are completely dry.

<u>Step 2: Examining your soils</u>

- Students should now examine the soils; depending on the level of the students, this can range from simple color and texture, to detailed examination under a microscope.

<u>Step 3: Scientific Method</u>

1. Discuss the scientific method.
2. Have each student come up with a scientific hypothesis regarding which soil would be most likely to liquefy, whether increasing the

amount of water would increase the likelihood of liquefaction, and what happens when you tap harder or softer (simulating bigger or smaller earthquakes).
3. If you are having the students write up their results, this is a good time for them to start their write up.

Step 4: Liquefaction

1. Each pair of students should have at least 3 cups for the soil in front of them. Each container should contain one cup of soil from 3 different locations, measured using a measuring cup (if you don't have a measuring cup you will need to mark the plastic cups with markings such that the students will be able to measure how much soil and how much water go into the cup—i.e. one measure of soil, 1/2 a measure of water). Have one cup of damp but not saturated sand ready to see what happens to the pennies without liquefaction.
2. Have the students label the different soil types as they describe them (to reuse the cups, students may put a piece of paper with the soil name under the cups or may use a piece of tape on the cup).
3. Students should now pour 1/2 a cup of water into each cup with the soil. They will need to mix it in – the end of a pencil works just fine for this. You may need to test the soils beforehand without the students to determine exactly how much water your soils need, add water until the soil is saturated all the way through but water is not visible on the surface.
4. Now each cup will need its "houses". The students should now place three pennies in each cup. The pennies should be placed vertically and the students should push them gently into the soil so that they are anchored in the vertical position (no more than 1/3 of the way in). The students should be able to pick up the cup without the pennies falling over.
5. Now, the students should select one cup and holding it gently in their hand begin to tap its base against the table and rotate it as they do so. The tapping should be created only by the weight of the cup, no slamming! Students should observe what happens to the pennies as they do so and record their observations. If liquefaction occurs they should see water collecting on the surface of the soil and the pennies will begin to tip and sink.
6. REPEAT FOR EACH CUP.
7. Once all of the cups have been tested the student have the opportunity to experiment more. Students should re-set their pennies before beginning. Students may now try tapping harder with their cups and seeing what happens (you will probably have to put a limit on how hard they are allowed to tap). They may also add more water or let them dry out a bit. Whatever they do, they should do each experiment separately and write down their hypothesis prior to the experiment and record their results.

Step 5: Discussion

- Students should write up their results and then the class as a whole should discuss them. [Suggestion: List all soil types on the board with a box for each team to record their observations]. This is a good time to discuss why scientists do multiple trials and have different scientists perform the same test.