LIQUEFACTION

Wake Forest University

Natural Hazards Engineering Research Infrastructure (NHERI)

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Lesson Details

Grades This lesson has been designed for a high school level (9 – 12), but it can be adapted to lower grades by simplifying the information provided.

Key Words Liquefaction, Large-Scale Mobile Shaker, Sand, Soil

Topics Liquefaction, Soil Characterization, Soil Natural Hazards, Soil Texture

Objectives

After this activity, students should be able to:

- Explain the difference between soil that has experienced liquefaction versus soil that has not and how the two different soils can either sustain a structure or destroy it.
- Infer how soil liquefaction affects the integrity of structures in urban locations.
- Determine whether there is anything that can be done to a structure to mitigate the damage that may occur due to liquefaction and create a solution for mitigation.

Essential Questions

- What is liquefaction?
- How can knowledge of liquefaction help mitigate the damage of earthquakes on structures?
- How can one know if an area may be susceptible to liquefaction?

Introduction

Throughout the world, there are many areas where liquefiable soils can cause significant damage in urban areas when earthquakes occur. Being able to determine where liquefiable soil is, how it occurs, and how to mitigate damage from it is imperative to keep people safe. In this lesson, students will learn about liquefaction, the effects of liquefaction on structures, and mitigation techniques to lower the amount of damage that occurs on structures.

The Lesson

When sandy soil that is not tightly packed and is saturated with water experiences an earthquake or strong ground shaking, the voids within the soil can collapse and push the liquid up to the surface (see Figure 1). This phenomenon is called “liquefaction.” Liquefaction has caused significant damage around the world, as shown in Figure 2, and while damage can be mitigated, it cannot be stopped.

Scientists, engineers, and local communities must pay particular attention to these areas when considering placement of structures to ensure the safety of the public. Within this lesson, students will be able to observe potential effects of liquefaction on a home, observe the types and levels of potential ground shaking that must occur for liquefaction to happen, and create a design to mitigate the damage that occurs on the home.

At the University of Texas-Austin, the mobile shaker, “T-Rex,” (See Figure 1) is used to create seismic waves, as an earthquake would, to test different liquefiable soils and give researchers an opportunity to further study the effects of liquefaction on structures and surrounding

Image 1. T-Rex Mobile Shaker. (UT Austin, n.d.)

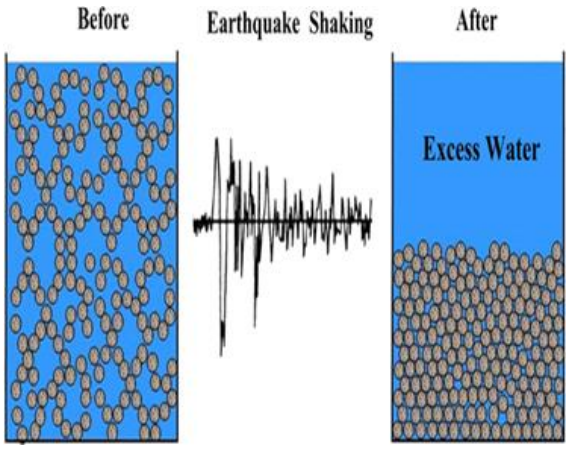

Image 2. Depiction of soil with water in videos prior to earthquake shaking and the voids collapsing and water moving up to the surface after. (Xue, X., & Liu, E., 2017)

Image 3. Liquefaction-induced damage observed in (a) Niigata, Japan 1964 (From http://civilenggseminar.blogspot.cl), (b) Alaska, USA 1964 (http:// en.wikipedia.org), (c) Maule, Chile 2010 (Provided by CGMI Consultants) and (d) Christchurch, New Zealand 2010 (From http://www.news.com.au)

Here is a 2:38 video (https://www.youtube.com/watch?v=RJCidfj-x9M) that provides a firsthand look at soil liquefaction occurring during an earthquake in Japan. You can see the water bubbling up out of the ground. This water coming up is the water displaced as the sandy soil settles during the earthquake shaking.

Materials

Each group needs:

· 1- 500 gram weight (example- Amazon.com: TEXALAN M2 Chrome Scale Calibration Weight (500G) : Industrial & Scientific – this will be used to represent a building)

· Small storage bin (used in images- Hefty 6.5 Qt. Stackable Bin with Latch, Teal/Clear, Case of 6 Bins - Walmart.com)

· 1-lb of sand

· Cup

· Wooden dowels (cut approximately 3” in length, or similar to the depth of the sand in the bin)

Procedure

1. Divide the class into groups of four (4) students. Less students per group will work, however there should be no more than six (6) students per group, due to a lack of “hands-on” space.

2. Have students in each group measure out one (1) lb. of sand and place it into a small storage container.

3. Using the measuring cup, students will pour the water directly into the sand, using their hands to mix it until the sand is fully saturated. (If the water pools or puddles at the top of the sand after mixing, too much has been used- just add more dry sand until the puddle is gone and the newly mixed sand is saturated.)

4. Place a weight into the center of the container on top of the saturated sand.

5. Have each group do “drum rolls” on the desk to simulate surface waves from an earthquake. (They may need to use force when doing this so liquefaction occurs.)

6. Observe what happens to the weight as liquefaction occurs.

7. Have each small group come up with ideas on how to mitigate or completely stop the destruction caused by the liquefaction during the earthquake using wooden dowels (and any other materials teachers prefer).

8. Reset the saturated sand by mixing it up again by hand and flatten it.

9. Have students repeat steps 4-6 using the mitigation technique they created using the wooden dowels.

10. Discuss observations as a class.
11. Have students complete the “Making Sense Assessment” provided within this document.

Assessment

Have students reflect on the science concepts they explored and/or the science and engineering skills they used by completing the Making Sense Assessment.

References

- UT Austin. (n.d.). *UT Austin NHERI Experimental Facility*. DesignSafe. https://utexas.designsafe-ci.org/equipment-portfolio/

- Xue, X., & Liu, E. (2017, February). Schematic of soil liquefaction | download scientific diagram - researchgate. https://www.researchgate.net/figure/Schematic-of-soil-liquefaction_fig1_314036703

- YouTube. (2013, April 2). *Soil liquefaction in Japan*. YouTube. https://www.youtube.com/watch?v=RJCidfj-x9M