

Soil and Natural Hazards 2021 NHERI Mobile Shakers REU

Audience

Middle school (7-8th grade)

Concepts

Soil mechanics

- Define pipes
- What natural hazard affect pipes in the ocean?
- How does soil friction cause pipes to break?
- How does the soil density affect how the soil behaves (porosity)?

Introduction/Motivation

The motivation for this plan is to connect natural hazards to the understanding of soil mechanics; how soil affects natural hazards.

Learning Activities

- Begin with how soil behaves and its effects on natural hazards. Next, discuss an application such as pipelines.
- **Remember**
 - **I. Slide 1: A picture of a landslide and an oil spill**
 - Talk about natural hazards and our motivations to prevent them (i.e., landslides, oil spills, etc.)
 - **II. Slide 2: A picture of soil**
 - Explain the importance of soil and how there is a connection of natural hazards to the way that soil behaves
 - Explain basic concepts of soil mechanics such as the structure of soil (i.e., soil grains)
- **Understand: How does “bad” soil or pipes cause a disaster?**
 - **III. Slide 3/4: Oil spills and pipes and soil friction**
 - Define friction/frictional resistance and drained/undrained behavior (refer to #7 for detailed definitions)
 - Explain how friction affects the strength of soil
 - **IV. Slide 5: Comparison of different states of density to show that density can change the characteristics of something**
 - Define saturation, density, porosity, surface tension, and buoyancy (refer to #7 for detailed definitions)

- At low saturations (meaning the amount of water in a soil sample is relatively low). The force of water tension overcomes the force of buoyancy for each soil grain.
 - The water acts to pull on soil grains and create a suction force. This suction pulls soil grains together with proportional force. This extra force puts stress on the soil grains and increases the force of friction between the grains. This extra friction then acts to limit movement of soil grains and increases the integrity of the soil.
- **Apply: demonstrate the concept of drained/undrained behavior and how it will affect the frictional strength of the soil**
 - **V. Slide6: A picture of a pile of soil and a pitcher of water next to it.**
 - Pose the question —“If I pour this pitcher of water over the pile of soil, will the soil be *drained* or *undrained*?” Answer: undrained
 - Follow up question: We know the soil will be undrained because it has water throughout it. Will this weaken or strengthen the soil?” Answer: Weaken it
 - Follow up comment: Therefore, this weakened and undrained soil will not provide a surface for strong friction. We want the soil to be strong so that it can provide strong friction to hold a pipe in place.
- **Analyze: Pose a situational question (word problem)**
 - Here is a picture of a pipe and soil. We want to make sure that the pipe stays in place because the currents will be very strong tonight. What are some ways to make sure the pipe stays in place? Do we want the soil to be drained or undrained? How would you place the pipe onto the soil?”
 - Answer#1: The soil should be undrained so that there is no water in the soil and therefore, the soil is stronger and keeps the pipe in place.
 - Answer#2: Think about embedment depth. The pipe will be more secure if it is embedded further into the soil.

Objectives

Students will . . .

- Recall information about natural hazards
- Classify soil properties and understand basics of soil
- Recognize how soil and pipes cause natural hazards such as an oil spill or landslide
- Differentiate between the different saturated/drainage states of soil

Background and Vocabulary

The students need to know how soil grains interact with each other and how that affects the overall soil and with other objects, such as pipes.

- **Friction/Frictional Resistance**- a force that is experienced in an interaction between two objects that resist the movement of one another; the force that may slow down or halt the movement of an object. This is an important term to know for this research project because the objective is to find ways to increase the friction so that the pipe(object) stays in place and therefore, its movement halts.
- **Drained/Undrained Behavior**-This refers to the amount of water that is present in the soil. Under drained conditions, we can assume that most, if not all, of the water drains out of the soil. Alternatively, under undrained behavior, we assume that there is water in the soil. Another way to think about it in your head might be using the terms “hydrated soil” or “dehydrated soil.” Even though these terms are not used, it is an easier way to think about it.
- **Density**- Density is the amount of matter within a certain volume. For example, imagine a cotton ball and a ball of steel of equal size. The heavier, or more massive, object would obviously be the steel ball. The reason it is heavier is because it has much for ‘stuff’ in it, despite filling the same volume as the cotton ball. For soils, soil density is almost exactly the same. It is defined by how much room the soil occupies in a certain amount of space. If soil takes up a larger portion of the volume, then the soil sample itself is more massive while still occupying the same space.
- **Porosity**-Much like density is the amount of matter in a certain space, porosity is how much empty space is in a region of space. In soil, this would be the amount of space between soil grains.
- **Saturation**- The saturation is how “full” something is of something else. In soils, we focus on how water fills the space. When water fills up all the space in between the soil grains, then the soil is 100% saturated. Likewise, if there is no water in the soil sample, then it is 0% saturated. This is like “drained/undrained” above except this term is used in understanding smaller scales (e. g., individual soil grains and not the soil sample as a whole) and can be numerically expressed.
- **Unsaturated Soil**- Soil that has a certain water content but is not 100% nor 0% saturated.
- **Water (surface) tension**- At the surface of any liquid, molecules attract each other. This is why you can fill a cup of water a little bit over what the cup can hold and the water won’t spill and will instead form a shallow dome that holds all the liquid.
- **Buoyancy**- When you place an object in water (really any liquid), it will displace an equivalent mass of water. The water has a certain pressure, and because of that, the more water displaced, the more upward force applied to the object. This is why boats can float, because they can displace large amounts of water to the point that they can float.

Assessment

We will know if the students have met the objective if they can understand the soil properties, the differences in saturated/drainage behavior, and the importance of frictional strength in soil in supporting the stability of a pipe and how all of these concepts ultimately connect to the prevention of natural hazards.

Conclusion

After looking at how water affects the structure of soil from the demonstration of the pouring water over the pile of soil, we now understand that the water weakens the soil. Knowing this, we want to find ways to prevent the soil from weakening. This is because we want the soil to be a strong source of friction for the pipe that it may support. We want the pipe supported so that it does not move around and break. If the pipe break, the oil that it holds within it would spill out and cause damage to the marine life and to the surrounding human life. Now we understand how important soil is in preventing natural hazards.