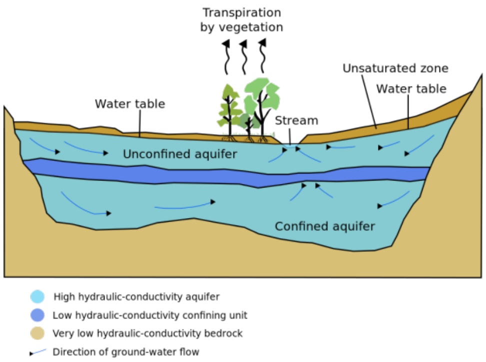
Earthquake Liquefaction - Teacher Notes

In 2011, an earthquake destroyed many of the buildings in the city of Christchurch, New Zealand. However, most of the damage wasn't caused by the shaking from seismic waves; it was the effect the shaking had on the unconsolidated sediments beneath the buildings that caused the most damage.

Many well-built buildings can survive an earthquake if they sit on solid rock, but Christchurch is built over an old river valley, so the ground mostly consists of sand, dirt, and pieces of rocks that are compacted together, but not yet solidified into rock. River valleys fill with loose sediment dropped from the slowing river water. The sediments can be clays, silts, sands, pebbles and boulders. They are often not uniform flat beds, but are lenses depending on the energy and position of the river at the time of deposition. The different sediments will act differently and further disturb the overlying sediments

Additionally, there is a lot of surface water – like streams and rivers – running through the city, and ground water (like aquifers) underneath.



You might think that rivers only flow over the surface of the land, but actually it is more accurate to think of rivers and streams are a place where the land surface cuts into the top of an aquifer. The topography of the water table mimics the topography of the land surface.

Teacher demonstration: River valleys and aquifers

Materials

- 1 take-away container or tray
- Damp sand, enough to fill the container to two thirds
- A book or block
- Water

Method

1. Fill the container with damp sand.
2. Use a stick or hand to carve a valley lengthwise towards one end of the container. Place the other end of the container on a book or block so it tilts towards the "valley".
3. Gently pour "rain water" onto the "uphill" end of the container.

Students will see how the water table rises and the river in the valley extends as it intersects the surface.

An initiative supported by Woodside and ESWA

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Task 1: Shaking sediments → liquefaction

Because river sediments have not been buried into the Earth they have not been compressed or compacted. They are not rock. There are lots of spaces between the broken bits of rock and sand for water to be stored.

Materials per group:

- Two beakers or glasses the same size
- Dry sand
- Water

Method

1. Fill both glasses to the same height with dry sand or dry soil.
2. Add water to one glass until it can absorb no more. The sand should be wet but water should not lie on the surface.
3. Leave the glass of dry sand untouched.
4. On a flat surface, gently slide both glasses back and forth for one minute. This movement replicates the movement due to seismic waves (compression waves) during an earthquake. The effects from the other two types of wave, which result in shaking in other dimensions, is much more destructive.
5. Observe, measure, and report any changes after shaking the glasses, or differences between the glasses.

Observations

A layer of water formed at the top of the container of wet sand. The height of material in both of the glasses was the same as before shaking, but the wet sand had settled (e.g., both glasses started at 8cm, but the wet sand glass afterwards was 7.7cm sand and 0.3cm water on top).

Discussion

Was this a “FAIR TEST”? Explain your answer

Yes. We changed one thing, whether there was water or no water in the sand. We measured one thing, which was the amount of water, which was moved upwards. Everything else we kept the same.

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The sand in the wet glass experienced *liquefaction*. What do you think happened to the sand and water in the wet glass when you shook it?

When you shook the wet sand glass, denser sand shifted downwards, and less dense water was squeezed upwards. The sand in the wet glass is now more compacted than it was before.

Task 2: What happens to buildings on top of liquefied areas?

Materials per group

- Two beakers or glasses of the same size.
- Dry sand
- Water
- Two marbles or solid objects to represent buildings

Method

1. Fill both glasses to the same height with dry sand or dry soil.
2. Add water to one glass until it can absorb no more. The sand should be damp but water should not lie on the surface.
3. Add an object representing houses on top of the sand in each glass.
4. Leave the glass of dry sand untouched.
5. On a flat surface, gently slide both glasses back and forth for one minute. This movement replicates the movement a building would experience during an earthquake.
6. Observe, measure, and report any changes. What happened to the marbles in each glass?

Observations

The marble on the dry sand rolled around but remained on top of the dry sand.
The marble on the wet sand rapidly sank into it.

Extension information

The ground under parts of Christchurch liquefied during the earthquakes in 2011, partially burying houses, disrupting roads and railways, and destroying household services such as sewage, electricity and gas provision. The areas can never be used for building again. During some earthquakes, cattle and humans have been buried in liquefied mud.
In areas like the river flats of California, the old river sediments are full of underground water. Farmers pump the aquifers for irrigation of vines and vegetables. The loss of water between grains of sand causes collapse of the sediments above, resulting in a sinkhole. The collapse is registered as a small earthquake by local seismometers.