SHAKY GROUND

GOAL

With a simple battery, kids realize a safe and stable building depends on more than the visible structure.

GRADE LEVEL

Middle School

MATERIALS *(For each group)*

sand
D, C or 9-volt battery
(not AA or smaller)
3 paper cups, 5 – 8 ounce size
water
spoon
drinking straws, toothpicks

DISCUSSION

Many buildings are built on landfill, sand, or mud that can liquefy. Liquefaction caused much of the damage during the 1989 Loma Prieta earthquake in California. It has also been responsible for major destruction in other quakes, including Kobe, Japan, in 1995, and Mexico City in 1985. Engineers are working to develop techniques to protect buildings and tunnels in earthquake-prone areas.

ACTIVITY

Step 1

Each group starts with a paper cup of dry sand. DO NOT shake the sand in the cup.
Stand a battery up on top of the sand.

Step 2

Try to knock the battery over by drumming gently with a spoon about halfway up the side of the cup. Not easy, right?

Step 3

Each group gets a new cup of sand and a cup of water. Add the water to the cup of sand in small amounts, pausing to let the sand absorb it. You may see bubbles on the sides of the cup. This means the sand is still absorbing water. When the sand no longer absorbs the water, it means nearly all the spaces between the grains are full of water. But the sand still looks solid.

Step 4

Stand a battery on top of the wet sand and try to tip it over the same way as before. What's the difference?

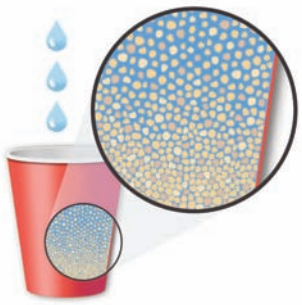
WHAT HAPPENED?

In dry sand, air trapped in the spaces between the grains absorbed the drumming vibrations. In the water-sand mixture, the drumming vibrations caused grains of sand at the bottom of the cup to compact (fit more closely together). This forced the water upward toward the surface, causing the grains near the surface to become supersaturated with water, or to liquefy. When an earthquake shakes the ground, the soil can liquefy, just like in the cup, leaving buildings without firm ground beneath them.

FURTHER EXPLORATION

One method engineers use to stabilize buildings is driving piles into the ground. Experiment by pushing straws and toothpicks into the sand; make sure they reach to the bottom of the cup without touching the battery.

SO WHAT?



If the mixture of sand and water sits for a while, the sand particles will settle until they touch each other. There will be water in spaces between the particles, but the mixture will behave as a solid. But during a quake (the vibrations caused by the spoon), the squeezing done by the seismic waves happens very quickly, and the water doesn't have time to flow out of the way of the sand particles. So as the particles try to move into a denser configuration, they push on the water, causing an increase in water pressure. If the water pressure is high enough, for a brief time, the sand particles are suspended in the water. This is liquefaction. The soil's loss of strength occurs because there's no contact between the particles of sand.

CONNECT TO ENGINEERING

In earthquake prone areas, engineers make sure structures can withstand this liquefaction process. One technique was developed by engineer Sergio Brena in Mexico City. He discovered methods to use a glue-like "wallpaper" on existing buildings and bridges to strengthen them.

Other techniques can be incorporated directly into new construction. Earthquake loads push and pull horizontally on a structure. Solid walls of reinforced concrete or masonry — called "shear walls" — have great stiffness in the horizontal direction. The First Interstate World Center in Los Angeles, the tallest building in the world in a major earthquake zone, has a solid concrete core right up the center of the building. This design allows it to withstand an earthquake with a magnitude of 8.3 on the Richter scale.

This activity is from the American Society of Civil Engineers.
See www.asceville.org for more engineering experiments.