Liquefaction demos

Wendy Van Norden:

I fill 3 plastic beakers with sand. One beaker has dry sand, one has totally saturated sand, and the third has sand with Plaster of Paris added ahead of time (aka rock). I place three pencils upright in each. I have kids predict what will happen in an earthquake, then I shake all three equally (usually while exclaiming “Oh no...an earthquake!!!). The one with saturated sand will fall over first. When you repeat the demo, make sure that you have stirred up the saturated beaker, for too much shaking can cause the sand grains to compact.

Gene Williamson:

We used to strap a small electric motor to the side of a juice can. We attached a slightly eccentric weight to the spindle of the motor. When we ran the motor it would vibrate the can much faster than we could accomplish with tapping. We used a variety of objects including fishing weights, marbles, plastic Monopoly hotels, and the like to show how different materials reacted to the liquefaction. We got some interesting results by varying grain size, amount of water, vibration speed, and materials used. I was never sure we were particularly "scientific" in our approach, but we generated some interesting discussions, and when the Marina district in San Francisco suffered considerable damage in the World Series quake, the kids were impressed by their own understanding of what forces were at work.

Bryce Hand:

Liquifaction can occur when an earthquake shakes water-saturated, unconsolidated sediments. Soil that can support the weight of buildings under ordinary conditions can suddenly lose its strength ("liquefy") when shaken. For a short time, the soil actually behaves as a dense fluid, and the consequences for structures built on it can be disastrous.

To demonstrate liquifaction:

> Fill a jar half-way with sand. Add water until the water level stands a couple inches above the sand (but not high enough to completely fill the container).

> Cover the top of the jar with the palm of your hand and shake it until the the sand and water have mixed into a sand/water slurry.

> Let the sand settle for a few minutes.
>> Place the jar on a board supported at each end by a block, and use tape to hold it in place. Carefully place a length of metal rod or tube (your "building") so that it rests on the sand and leans gently against the container rim. The tube I'm using here is a piece of steel electrical conduit.

>> Simulate the shaking of an earthquake by hammering on the board for several seconds. The sand will lose its bearing strength and the rod/tube will suddenly sink downward. Such loss of soil strength can obviously do a lot of damage to foundations; it may even cause buildings to topple.
Liquifaction happened b/c the grains in the original sand bed were loosely packed, with water filling the over-large pores (voids) between grains. When shaking jostled the grains they rearranged themselves into a more compact arrangement, leaving less space for water. The upward escape of this small amount of "now-extra" water and the momentary loss of physical contact between grains, caused the sand to lose strength.

You may be able to repeat the demo a couple times without starting over from Step One, but the effect will be less dramatic as the grains become progressively more stably packed. Of course, if you start over from the slurry stage you can repeat the experiment as many times as you like.

It's true (as Dave Smith says) that silty sands are especially vulnerable to liquifaction. Likewise, fine and very-fine sands generally liquify better than coarse. Angularity of grains and poor sorting probably also enhance the effect. But almost any sand will work, and it doesn't have to come from any particular locality. The demo in these pictures used commercial Sakrete "general purpose" sand (probably from Home Depot)...poured straight from the bag.

Sand volcanoes (as in the photos included in Dave's post) can happen when surface material remains firm while deeper zones are liquified. If you think about it, the existence of sand volcanoes implies that there also must be sand-volcano necks, and dikes and sills... In fact there are.