Hands-on activity: # Shake It Up! Engineering for Seismic Waves

Contributed by Integrated Teaching and Learning Program, College of Engineering, University of Colorado Boulder

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Grade Level: **8 (6-8)** Time Required: **100 minutes**

Group Size: **4** Expendable Cost per Group: **US $1.50**

Subject areas: **earth and space, physical science, science and technology**

Summary

Students learn about how engineers design and build shake tables to test the ability of buildings to withstand the various types of seismic waves generated by earthquakes. Just like engineers, students design and build shake tables to test their own model buildings made of toothpicks and mini marshmallows. Once students are satisfied with the performance of their buildings, they put them through a one-minute simulated earthquake challenge. *This engineering curriculum meets Next Generation Science Standards (NGSS).*

Engineering Connection

In certain areas of the world, earthquakes are a serious concern. Civil and structural engineers who focus on designing buildings, bridges, roads and other infrastructure for earthquake-prone areas must understand seismic waves and how to construct structures that are able to withstand the forces from the powerful ground motions of the Earth. For testing purposes, engineers design shake tables to simulate (or re-enact) the seismic waves produced by earthquakes and verify the stability and survivability of their structures.

Learning Objectives

After this activity, students should be able to:

- Explain the four different types of seismic waves produced by earthquakes.
- Describe the purpose of shake tables and how engineers use them.

Introduction/Motivation

How many different kinds of waves can you think of? (Listen to student suggestions and add others. For example, electromagnetic [light, radio], sound, ocean [water], seismic, pressure, compression, standing and sine waves.) No matter what kind of wave, what do they have in common? (Draw a wave on the board and identify its parts.) That's right: amplitude, wavelength, crest, trough, frequency.

What types of waves do we associate with earthquakes? That's right, seismic waves. Seismic waves are waves that move through the Earth, and are typically created by earthquakes. For all seismic waves, the amplitude or intensity of the wave is dependent on three things:

1. The depth at which the earthquake took place (the closer to the surface, the greater the amplitude of the wave)

2. The intensity of the earthquake (earthquakes with higher Richter scale ratings produce more intense seismic waves)
3. The composition of the Earth's crust

The people who work in "earthquake engineering" focus on protecting us and the natural and human-built environments from earthquakes. They want to limit our risk of death and damage from earthquakes. How can we possibly make sure that our school or stadium or a skyscraper or a freeway overpass will not collapse in a big earthquake? Well, engineers create shake tables to test the ability of buildings and other structures to withstand the seismic waves produced by earthquakes. To do this, they carefully design and construct shake tables that can accurately re-enact the ground motion of the Earth during earthquakes. Sometimes they test full-size buildings and sometimes they test small-scale model buildings or components. Some shake tables are large enough to put a real-size building on; others are smaller, even tabletop size. By doing this, engineers can test materials, designs, and construction methods to develop building codes and best practices that provide people living in earthquake-prone areas with safe and survivable surroundings.

Engineers must understand everything about the various seismic waves produced during earthquakes and how they cause the Earth to move. Who can tell me the four types of seismic waves that engineers need to simulate? They are:

1. P-waves (or primary waves, a type of body wave)
2. S-waves (or secondary waves, a type of body wave)
3. Love waves (a type of surface wave)
4. Rayleigh waves (a type of surface wave)

What do you know about these different types of seismic waves? How are they different from each other? P-waves and S-waves are body waves, which travel through the body of the Earth. P-waves are the fastest of all the seismic waves and can travel through any medium, although they move through solids faster than through liquids and gases. P-waves vibrate the parallel to Earth or in the direction of their propagation. They are similar to a compression wave moving through a slinky. S-waves are the second fastest type of seismic waves, and they can only move through solids. S-waves are transverse or shear waves and move the Earth perpendicular to the direction of propagation. Both P-waves and S-waves are types of body waves and travel through the interior of the Earth.

Love waves and Rayleigh waves are surface waves, which travel along the surface of the ground. In general, surface waves are slower than body waves—and more destructive. Love waves cause a horizontal shifting of the Earth perpendicular to the wave propagation. Rayleigh waves are a type of sinusoidal wave and move like ocean waves. They are produced by the interaction of P-waves and S-waves. Rayleigh waves are the slowest of all the seismic waves with a speed approximately equal to 3 km/second.

Smart design and testing make buildings resistant to the seismic wave movement of earthquakes. A properly engineered structure does not necessarily have to be extremely strong or expensive, but it must be correctly and intelligently designed to withstand the seismic effects while sustaining an acceptable level of damage. What are your ideas? Let's create our own shaker tables and model buildings to test them.

Aligned Educational Standards

NGSS (2); ITEEA (1); CO science (1)

To see/print the full activity, including the materials list, procedures, specific aligned standards, attachments and assessment click
https://www.teachengineering.org/activities/view/cub_seismicw_lesson01_activity1?utm_source=tpt