Narration from animation “Earthquake Intensity—What Controls the Shaking You Feel?”

<https://www.iris.edu/hq/inclass/animation/earthquake_intensity>

[voice over from KTLA footage] “Ginger, thank you. Coming up, more troubles for a…” “Earthquake! We’re having an earthquake!”

Have you ever felt an earthquake or witnessed the effects of one?

Seismic intensity, which is the shaking you experience, can be gentle or severe, short or long, jerky or rolling. Unlike Earthquake magnitude, which is a measure of the ***energy*** released and is the same for all locations. the seismic intensity you feel depends on where you are. Intensity is controlled by three main factors:
***Magnitude****: how big was the earthquake?*
 ***Distance from the hypocenter****: Intensity varies from place to place, and*

***Local rock and soil conditions****:*

Before we address each factor, let’s clarify the difference between magnitude and intensity by comparing a lightbulb to an earthquake. The lightbulb represents the location within the Earth called the hypocenter where the earthquake begins.

*The* ***magnitude****, or size, of an earthquake is like the wattage of a lightbulb. Just as the wattage represents the amount of power of the lightbulb, the magnitude is related to the total amount of energy released by the earthquake source.*

*The* ***intensity****, or shaking level, is like the amount of light from a lightbulb that is received at any spot in a room. A small lightbulb in one area of a room will make that area bright with high intensity light, but it will leave the distant areas of the room dim with low intensity light*.

So a given earthquake has only one magnitude but will produce different intensities of ground shaking at different locations as shown on a ShakeMap. But where did Shake Maps come from?

After the 1906 magnitude 7.8 San Francisco earthquake, an intensity map was created using reports by California residents. Numbered colors represent the Modified Mercalli Intensity Scale, which reflects the *effects* of an earthquake.In zone V moderate shaking was felt, houses rocked cracking plaster, and some water tanks toppled over. In zones VIII and IX, people, horses, and cattle were thrown off their feet, bridges wrecked, and wood-frame buildings slid off their foundations. The lower numbers generally dealt with how the earthquake was felt by people. The higher numbers were based on observed structural damage.

Human observations still help scientists understand earthquake ground shaking but intensity is now measured by seismometers and illustrated by USGS’ ShakeMaps like this modern reconstruction for the 1906 earthquake. Colors represent peak ground acceleration. That is, *how quickly the ground shook and how swiftly it changed direction*. The red zones reached 1G acceleration, or 100% of gravity, a violence of shaking illustrated in this shake-table experiment. In the green zone, moderate shaking occurred with accelerations up to 10% of gravity.

Let’s examine how intensity of ground shaking is controlled by earthquake magnitude.

We understand that a **one hundred-**watt lightbulb produces more light everywhere than a **25-watt** lightbulb. Similarly increasing earthquake magnitude also means greater intensity of shaking everywhere. To see this principle at work, let’s examine two earthquakes that occurred at the same depth beneath Kumamoto, Japan but had different magnitudes. On April 14, 2016, a magnitude 6.2 earthquake generated strong shaking up to forty km from the epicenter. The next day, a magnitude 7.0 earthquake released twenty times as much energy in the same location. Strong ground shaking extended to **one hundred km** from the epicenter. The larger magnitude earthquake “lit up” the surrounding area with stronger ground shaking just like a larger wattage lightbulb casts brighter light everywhere in a room

Let’s now examine how intensity of ground shaking is controlled by distance from the earthquake. This ShakeMap for a magnitude 7.0 earthquake in Mozambique nicely illustrates a bullseye map pattern with intensity decreasing with distance along the surface away from the epicenter just like the light from a lamp is less bright the farther away we are from the lamp. By analogy, we expect shaking to decrease as distance increases away from the earthquake.

Remembering that earthquakes occur in the Earth, not on Earth’s surface, let’s consider the effect of earthquake depth on ground shaking intensity.

To see this principle applied to earthquakes, let’s examine two earthquakes of the same magnitude with nearby epicenters but with hypocenters at different depths. In 2015, the magnitude 7.5 Hindu Kush earthquake occurred 212 km below Afghanistan. Although strong shaking was distributed over a broad area only 399 lives were lost. The hypocenter of the 2005 magnitude 7.5 Kashmir earthquake was only 23 km deep. Severe ground shaking was concentrated near the epicenter causing extensive damage to buildings with over 87,000 fatalities.

In 1989, the magnitude 6.9 Loma Prieta earthquake occurred on the San Andreas Fault system near Santa Cruz, California. Ground shaking intensity and resulting damage was strongly influenced by local rock and soil conditions. In fact, the most severe damage occurred in Oakland and San Francisco’s Marina District, 100 kilometers from the epicenter, where violent intensity IX shaking was greater than that experienced by many areas closer to the epicenter. Both are built on mud substrate.

A dramatic and tragic example of shaking amplification is the double-decker Nimitz Freeway, constructed on Bay Mud. Four seconds after drivers felt the earthquake, the Nimitz Freeway shook and swayed, and sections collapsed taking 42 lives. Seismograms from nearby stations document that seismic waves are amplified by a factor of two as they pass from bedrock to sand and gravel deposits and the amplitude of ground shaking of soft and water-saturdated Bay Mud is five-times larger than on bedrock. The section of the Nimitz Freeway that collapsed was built on Bay Mud.

The Marina District was constructed on loosly compacted Bay Mud. In addition, debris from the 1906 earthquake had been dumped into the Bay to make more land for city expansion. This weak ground experienced both amplification of ground shaking and liquefaction of water-saturated sediment that caused differential settling of buildings, and ruptured gas lines resulted in major fires.

So the soil and rock that your house is built on has a major influence on earthquake intensity and potential damage due to ground shaking.

Following the earthquake and during aftershocks over 1,000 landslides were reported mostly near the epicenter in the steep terrain of the Santa Cruz Mountains and along rocky bluffs of the Pacific Ocean.

In closing, If you feel the bump of an earthquake, it is important to know that the first waves may not be the strongest. Taking immediate actions to "Drop, Cover, and Hold On", before strong shaking arrives. can save lives and reduce the risk of injury.