Resource from animation found at: <http://www.iris.edu/hq/inclass/search>

**Narration from the animation:**

**Building Resonance: The resonant frequency of different waves**

To understand the resonance of ***buildings*** during earthquakes we will look at other resonant systems. The natural frequency of a swing makes it easy to maintain the motion using little energy. A prolonged wind swung the bridge on the right at *its* natural frequency until it exceeded its structural integrity and tore apart.

The ***frequency*** of a wave refers to the number of waves that pass through a point in one second. A ***period*** is the amount of time it takes ***one*** wave cycle to pass the given point. A frequency of one cycle per second has a one-second period. If the frequency doubles to ***two*** cycles per second, the period is only a ***half*** of a second.

Resonance is the tendency of a system to oscillate with greater amplitude at *some* frequencies than at others. The resonant *frequency* of any given systemis the frequency at which the maximum-amplitude oscillation occurs.

For example the resonant frequency of the one-meter long pendulum is one half of a hertz. If the string were one quarter the length, it would vibrate at twice the frequency. Small amplitudes can be approximated by this equation using length and the gravity constant.

Resonant systems can be used to generate vibrations of a specific frequency to create music. Strings under tension, such as with this cello, have resonant frequencies directly related to the material of the string as well as the mass, length, and tension of the string. The mass of this low C string resonates at 264 hertz, whereas the thinner A string of different material resonates at 440 hertz.

Next we use a simplified analogy of boats at sea. A series of waves, particularly when they hit broadside, can initiate rolling behavior. The smaller boat is affected by short-period low-amplitude waves that slap against the ocean liner with no effect. Small boats, on the other hand, will ride up and over long-period, high amplitude waves as the larger boats begin a long slow rock.

***Now*** let’s look at how buildings are affected by earthquake-induced seismic waves.

All buildings have a natural, period, or resonance, which is the number of seconds it takes for the building to naturally vibrate back and forth. The **ground** also has a specific resonant frequency. Hard bedrock has higher frequencies than softer sediments. If the period of ground motion matches the natural resonance of a building, it will undergo the largest oscillations possible and suffer the greatest damage. Small buildings of one or two stories resonate naturally at much less than one-second periods. A one-second period will affect buildings of about 10 stories. For example, a 30-story building resonates at a period of 3 seconds, and a 50-story building at a period of 5 seconds.

During the 1985 Mexico City earthquake, the ground beneath the city resonated with a two-second period for over a minute thus medium-height buildings with similar natural periods suffered the most damage while short old weak stone buildings and skyscrapers were relatively undamaged.

That proved to be what is called a **resonance disaster,** which is how engineers describe the destruction of a building by seismic vibrations at a system's resonant frequency. It is because of prolonged energy input, that the system swings more and more strongly, until its structural load limit is exceeded.

A key point here is that small buildings on hard rock and large buildings on soft sediments may suffer more damaging ground motion effects from an earthquake than small buildings on soft sediments and large buildings on hard rock. 410

Resonance is one factor that contributes to earthquake damage. Of equal or ***greater*** importance are building design and the quality of construction materials. By determining the resonant frequency of the ground beneath a building site, the building design can be modified so that a resonance disaster doesn’t occur.

The following demonstration shows how to model resonance in the classroom.