Instruction 3-6
How to Measure Earthquakes?

In our last Instruction, we told you about the seismic waves that result when energy is released in an earthquake.

Detecting, recording and measuring these waves is how scientists measure earthquakes. (Seismic wave vibrations are not electromagnetic vibrations.)

There are two different kinds of seismic waves, which we told you about in our last Instruction. They are *body waves* and *surface waves*.

Body waves are also called compressional waves, primary waves or P waves. They travel quickly from the earthquake's point of origin to the Earth's surface.

The *first sign* of an earthquake is usually a *sharp thud*, which is how these P waves announce their arrival.

Surface waves are also called shear waves, secondary waves or S waves. They travel through the Earth's upper and lower mantles and arrive *after* the P waves.

It is these S waves that cause the *ground roll* associated with earthquakes.

Seismic (and Other) Measurement

The instrument that measures seismic wave vibrations is called a *seismograph*.

The zig-zag line it makes is called a *seismogram*.

The seismogram reflects changing seismic vibrations by recording the motion of the ground beneath the seismograph.

By studying this data, scientists can determine the time, epicenter, focal depth and amount of energy released by an earthquake.

For example, if an earthquake's P wave arrives at a seismograph station at 2 hrs 40 minutes 00 seconds, and its S wave arrives 2 minutes later, they know that the epicenter of the quake is approximately 2400 km from the seismograph station.

Earthquakes are measured in two different ways.

They are either measured by *magnitude* -- which means the amount of energy released -- or by *intensity.*

Magnitude is measured on something called the Richter Scale.

Magnitude / The Richter Scale

The Richter Scale was developed in the 1930's by Dr. Charles F. Richter of the California Institute of Technology.

It rates the magnitude (size) of an earthquake on a scale of 1 through 10 -- as follows:

Magnitude 1 - 2.9	Very Minor
Magnitude 3 - 3.9	Minor
Magnitude 4 - 4.9	Light
Magnitude 5 - 5.9	Moderate
Magnitude 6 - 6.9	Strong
Magnitude 7 - 7.9	Major
Magnitude 8+	Great

The Richter Scale is *logarithmic*. In other words, an increase of one whole number indicates a 10-fold increase in magnitude.

For example, a level 7 earthquake is

10 times bigger than a level 6 earthquake

100 times bigger than a level 5 earthquake, and

1,000 times bigger than a level 4 earthquake.

Historic (and Other) Earthquakes

The biggest earthquake ever recorded measured 9.5 on the Richter Scale. It took place in Chile on May 22, 1960, and caused damage as far away as Japan.

The second biggest earthquake on record measured 9.2 on the Richter Scale.

This 9.2 earthquake took place on Good Friday, 1964, in Prince William Sound, Alaska. This earthquake and its resulting tsunami (seismic ocean wave) caused death and destruction as far away as Hawaii.

To see what happened in these and other major earthquakes, click:

http://ibs.howstuffworks.com/ibs/elp/earthquake6.htm

Most earthquakes register less than 3 on the Richter Scale. They are called *microquakes.* Scientists estimate that about 9000 of them take place every day.

Humans almost never feel them.

Usually, an earthquake registering less than 4 doesn't cause much damage.

Which brings us to the other way earthquakes are measured -- by their *intensity.*

Intensity is closely related to the *destructiveness* of an earthquake.

Intensity / The Mercalli Ratings

Richter ratings don't give you a complete picture of the impact of an earthquake.

An earthquake's intensity (destructiveness) depends on factors beside magnitude, which is all that Richter measures.

These factors include the composition of the ground where the earthquake took place and the design and placement of the manmade structures on it.

An area with unstable ground underneath (like sand or clay) will experience much more damage than an area with granite under it.

The intensity (destructiveness) of an earthquake is measured location by location by both objective and subjective criteria. These include visual inspection and interviews with survivors.

Unlike Richter ratings, which are instantaneous, this data takes time to assemble.

The mechanism for doing so is called *The Modified Mercalli Intensity Scale*.

The Modified Mercalli Intensity Scale

On the Modified Mercalli Intensity Scale, the intensity of an earthquake is given a value of from one to twelve (I to XII), as follows:

I	felt by almost no one
II	felt mostly by people lying down
III	felt by people indoors on upper floors
IV	felt indoors by many people; walls crack
V	felt by almost everyone; unstable objects fall
VI	felt by all; heavy furniture moves
VII	little damage in well-designed buildings; considerable damage in poorly built structures
VIII	considerable damage even in substantial buildings; partial collapse of chimneys and columns
IX	considerable damage in even the best-designed and substantial structures
X	destruction of all wooden structures and most masonry and frame structures; rails bent
XI	few (if any) masonry structures left standing; bridges and underground pipelines destroyed
XII	total devastation; lines of sight and levels distorted; objects thrown into the air

Sometimes an earthquake will rank high on both the Richter and Mercalli Scales.

The 1964 Alaskan earthquake is a good example. It had a Richter magnitude of 9.2 and a Mercalli intensity (destructiveness) value of X (10).

But there can also be big differences.

In 1989, an earthquake centered at Loma Prieta Peak in Northern California measured 7.1 on the Richter Scale. But it caused Mercalli-value damage of 10 (X) in the Marina District of San Francisco, 70 miles away.

That was because the houses and apartment buildings were built on loose sand originally used to fill in San Francisco Bay.

For more on the Mercalli Scale, click:
http://www.seismo.unr.edu/ftp/pub/louie/class/100/mercalli.html

Liquefaction

In some areas, severe earthquake damage is caused by *liquefaction* of the soil.

Under certain conditions, the violent shaking of an earthquake can cause loosely packed sediment and soil to behave like a liquid. When buildings are constructed on this type of soil, they are apt to collapse more easily.

Liquefaction can also cause mudslides, like the ones that took so many lives in El Salvador in January 2001.

Predicting Earthquakes

Although scientists understand earthquakes better than they used to, they still don't know how to predict them.

After the first seismic waves, geologists know that aftershocks are on their way. But this only gives victims a few minutes' warning.

Earthquake prediction has been popular with psychics and pseudo-scientists for centuries. They claim success by using everything from tidal forces to unusual behavior in animals to predict upcoming earthquakes.

These techniques have not been verified scientifically. But scientific earthquake-prediction experiments **are** going on all over the world -- especially in the United States since the Earthquake Hazards Reduction Act of 1977.

All along the San Andreas fault, for example, a wide variety of monitoring instruments are in place, since new earthquakes are more likely to happen in established earthquake areas.

Protecting Yourself

Even if we can't predict earthquakes, there are things that can be done to lessen their damage.

In 1973, the Uniform Building Code was adopted by a number of countries.

This is set of international construction standards which include ways to fortify buildings against seismic waves. But this code only affects new construction -- and it doesn't apply in every country.

Where adopted, tougher building codes and better building methods are very helpful. So is not building near known fault lines.

There are also things you can do *yourself* -- before, during and after an earthquake.

These are things can help protect you, your family and your pets (who are of special concern since they are usually not allowed in emergency shelters).

Here is a list of suggestions:
http://www.fema.gov/hazards/earthquakes/quakef.shtm