IS-325 -Earthquake Basics

This course is expected to take 30 minutes to complete. The course uses graphics, text, video, and knowledge checks to present the information.

After completing the course, participants should be able to

- Describe what causes earthquakes
- Differentiate between hazard and vulnerability
- Identify potential vulnerabilities in their homes or businesses
- Take further steps toward reducing their overall risk

Have you ever wondered about earthquakes, how they might affect you, and what you can do to safeguard your family, your home, your business?

This presentation will give you some of the basics about why the earth moves, what happens when it moves, and how you can be prepared for when it does.

This presentation is intended for everyone. No technical skill or training is required.

This presentation is not a comprehensive guide to earthquake safety. Links to additional resources are given at the end of the presentation.

Science: Earthquake Basics Earthquake Mechanics

The surface of the earth is divided into separate pieces, like a cracked shell of the hard-boiled egg. These pieces, called “tectonic plates,” are in constant, but slow, motion as they float on the surface of the molten interior of the earth. As they drift, they tend to get stuck at the jagged boundary between plates, and stress builds up year after year. At some point, the stress is high enough to cause the plates to slip, releasing a tremendous amount of energy, which causes ground shaking, ground rupture, and other effects, including tsunamis and landslides.

Ground Ruptures

Faults can occur along plate boundaries, such as in coastal California, or within plates, such as in the New Madrid fault zone.

We can see the physical effects of faults when the ground ruptures, or breaks apart, at the surface. Buildings should not be located over active fault traces, lest they be torn apart, as shown below.

Ground Shaking

The motion that most people associate with earthquakes – the shaking of the earth – is usually what causes the vast majority of the destruction, injury, and death in an earthquake. When the earth moves, buildings are pulled along with it, which causes them to sway. The taller a building, the more it will tend to sway in an earthquake. Think of what happens when you slide a plate of jello. If you move it slowly, nothing perceptible will happen; however if you jerk it quickly, it will vibrate.

The following link shows two houses experiencing an earthquake simulation. One of these houses is a typical house, and the other is the same house, but it has been strengthened or retrofitted. (There are two houses on a shake table. When the table shakes, the un-retrofitted house on the left collapses.) To see the video, click here. (Source: Special Project for Earthquake Disaster Mitigation in Urban Areas, Testing and Analysis of wood structure by MEXT, NIED, BRI and University of Tokyo.)

Magnitude vs. Intensity

People tend to judge an earthquake's severity by its Richter magnitude, as that is what is usually reported in the news. Shaking intensity is a different concept. An earthquake has a single magnitude, but the shaking intensity varies, generally decreasing with distance from the epicenter. Shaking intensity is directly responsible for earthquake damage, while earthquake magnitude is a measure of the total energy released.

You might think of a flood. While the quantity of water involved in the flood can tell you about the extent of the damage, the water level at your house will tell you more about the damage at a local level.

[The map at right is the "shake map" for the 2011 Virginia earthquake (Magnitude 5.8), showing how it was felt in the surrounding areas.] The shaking generally decreases as you get away from the epicenter (marked with a star).

Science: Past Earthquakes

Structural Damage

Structural damage can include:

- "Soft stories," where one story (usually the bottom story) of a building is weaker than the rest of the building and can collapse
- Excessive movement of the building to one side or another ("racking")
- Damage to structural elements, such as walls, columns, beams, braces, etc.
- Failure of the structural system to maintain stability of the building.

Related Damage

Earthquakes can trigger cascading failures by severing power and gas lines and disrupting fire alarm and water-supply systems. Post-earthquake fires are a major concern. Much of the damage in the 1906 San Francisco earthquake was caused by fire.

Perspectives on Economic Losses

Economic losses from an earthquake come not just from the damage to a building, but also from things like:

- damage to inventory or equipment
- necessary materials or supplies not being available
- employees not being able to work due to injury or inability to get to work
- damage to shipping facilities

Regional Impacts

Even if your own business isn't damaged, the regional impacts of an earthquake can still affect you. For instance, after the 1995 Kobe earthquake, the Port of Kobe, Japan's largest shipping facility, was out of commission for more than two years, leading to huge economic losses for many local businesses. Even three years after the earthquake, the Port was only handling about half of its pre-quake traffic.

Consider the effects if the California Ports of Long Beach, Los Angeles, or Oakland were nonfunctional for a similar length of time --they are three of the four busiest ports in the United States.

Risk: Earthquake Hazard

Regional seismicity

Earthquakes are generally concentrated around faults, which are generally located around tectonic plate boundaries. Areas with faults are therefore said to have a higher "seismicity," or probability of experiencing an earthquake. The magnitude of the earthquake is determined by the type of fault present.

Geologists have mapped many of the earth's faults, but occasionally an earthquake reveals a previously unknown fault. Sometimes people don't even realize they've been living in a seismically active area because it's been so long since an earthquake. A great example of this is the New Madrid Fault Zone, between Memphis and St. Louis.

Two recent earthquakes have occurred in areas not typically considered "earthquake country."

On August 23, 2011, Virginia experienced the most widely-felt earthquake in U.S. history, with a magnitude of 5.8. The epicenter was in Mineral, Virginia, but it was felt over 600 miles away, all the way from Canada to northern Florida.

On November 5, 2011, the Oklahoma City region experienced a magnitude 4.7 and a magnitude 5.6 earthquake. Dozens of aftershocks followed.

Return Periods

One way of talking about risk is using the return period of an earthquake of a given magnitude. For example, in a certain area, one might expect to see a magnitude 7.0 earthquake every 500 years. This doesn't mean that 7.0 earthquakes happen *exactly* every 500 years, so it can't be used as a precise prediction tool.

Think of rolling a die. You have a 1 in 6 chance of rolling a certain number each time, so the return period for that number is 6 rolls of the die.

Putting it in Perspective: Other Hazards

We hear a lot about disastrous earthquakes in the news. In the 2011 Christchurch earthquake, there were 181 casualties. In the 2010 Chile earthquake, there were 562 casualties. In the 2011 Japanese earthquake and tsunami, more than 15,000 people died.

Luckily, devastating earthquakes are rare events compared to hurricanes, tornados, and floods. Nevertheless, mitigation of earthquake risk makes sense and can save lives. Without mitigation, the consequences of a severe earthquake could be devastating. Furthermore, earthquakes can be extremely costly (4 out of 5 of the costliest disasters in history have been earthquakes), so mitigation does save money.

Risk: Earthquake Myths

Prediction

As long as earthquakes have been felt, people have tried to predict when the next one will arrive. Unfortunately, even with highly sensitive seismic monitoring equipment around the world, there has yet to be a successful earthquake prediction. Some people claim that the relative position of the moon and tides can put extra pressure on faults and cause them to rupture, but this theory has never been confirmed by an actual prediction.

Others believe earthquakes can be predicted by observing animals behaving unusually; however this theory has also never been confirmed.

There has never been any conclusive correlation found between the weather and earthquakes. Earthquakes can occur in all seasons, in all climate zones, at any time of day.

Earthquake Immunity

Earthquakes don't just occur in California! Every state has experienced some level of earthquake shaking.

Some people believe that having several smaller quakes relieves the stress on a fault and “lets off the steam,” so there is no need to worry about a large earthquake. In fact, the amount of energy let off by small earthquakes is negligible compared to that released in a major earthquake. In fact, a small quake can sometimes be the precursor, or “foreshock,” to a larger earthquake.

The fact that a building has "survived" a significant earthquake does not mean the building is "earthquake proof." Remember, the intensity of the shaking at the building site may have been much smaller than the intensity nearer the earthquake epicenter. Another earthquake might produce significantly higher levels of shaking at that site.

Risk

Risk = Hazard x Vulnerability

The likelihood that an earthquake will strike is the earthquake *hazard*. *Vulnerability* means the consequences of that damage: what happens if that earthquake occurs. Together, hazard and vulnerability make up *risk*. The more likely an earthquake is and the more severe the consequences to you (your home, your business, etc.), the higher your earthquake risk.

The hazard at a given location cannot be changed, and every building is subject to earthquake hazard all the time. However, the amount of vulnerability you or your community has *to* that hazard is controllable.

Understanding your own risk is important, because it can help you decide what steps to take to protect yourself, your business, your home, and your family --your future.

Risk: Vulnerability

Structure

In earthquake-prone regions, modern buildings designed by an engineer are designed to take a certain amount of shaking. Single-family houses are generally not designed by an engineer, but there are ways of lessening the vulnerability of the house to earthquake damage. If a structure is damaged during an earthquake, it will likely need to be repaired or rebuilt. More information on how to strengthen homes is coming later in the lesson.

Nonstructural systems

Nonstructural systems, if they fail during an earthquake, can injure the occupants and cause economic damage. These include things like the gas lines, plumbing, and electrical lines, or even something as simple as the ceiling tiles.

Contents

The contents of a business or home are also vulnerable to damage during an earthquake. This includes inventory, supplies, and operating equipment for a business, and treasured or otherwise valuable possessions in a home.

Risk: Performance

Building performance during an earthquake is important. While newer building codes are more strict, they tolerate some earthquake damage. If the building is severely damaged or collapses, there is a risk of fatalities, economic losses in the form of repairs or rebuilding, and losses associated with not being able to use the building.

Continued operation

Building codes do not require most buildings to be designed to remain operational after an earthquake. Building to code does not mean your building will be undamaged by an earthquake. However, hospitals and other critical facilities designed using modern seismic codes are expected to be operational after an earthquake.

Shelter in place

Ideally people should be able to return to their homes after an earthquake and “shelter in place” (if it is safe to do so) while waiting for services to be restored. If a home is unusable after an earthquake, this can create problems for the people living there, and also for the community if too many people cannot shelter in place in their own homes.

Risk: Regional Vulnerability

Lifelines

The immediate response to an earthquake is dependent on the various lifelines, such as water supplies to support firefighting equipment, telecommunications lines that allow first responders to communicate, power lines, and fuel delivery systems. Interruption of these basic lifelines can slow response times in the immediate aftermath, and also create problems for economic recovery in the longer term.

Building stock

Certain types of buildings are more vulnerable to earthquake damage, such as unreinforced masonry buildings (historic brick buildings are often made of unreinforced masonry). If a region contains many of these such buildings, that creates more risk for the inhabitants and the community.

Economy

If a region is heavily reliant on an industry that is vulnerable to damage, a large earthquake could create negative effects on the regional economy. For instance, damage to a critical shipping port could devastate a region that depends on the port for its livelihood.

Comparison to Other Hazards

Other natural hazards that threaten human life and property are more predictable, or at least give more warning. For instance, hurricanes take days or weeks to form and only occur at certain times of the year, giving ample time for communities in the potential path to prepare and evacuate. Earthquakes, on the other hand, can strike at any time, with little to no warning. The best time to prepare is now.

Mitigation: General Outline

Identify Risk

- Assess -Do an assessment, or have a professional, such as a structural engineer or contractor, do an assessment, of the building to determine the potential problems.

Make a Plan

- Mitigation plan -Plan what measures you can take to address the risks you have identified.
- Earthquake Plan -Create a plan for during and after the earthquake.

Take action

- Mitigate -Address, or have a professional address, the issues or prepare to deal with the consequences.
- Post-earthquake evaluation -Evaluate, or have a professional evaluate, the building and its contents.
- Repair -If necessary, repair damaged elements. Rebuild stronger, so you won't have to rebuild again!

Identify Risk

Where do you live?

The first thing to do when assessing your risk is determining the hazard in your area. If you live in a seismically active area, you should take steps to mitigate any vulnerabilities in your building. (Links to mitigation tools are provided at the end of this session.) If you don't think you live in a seismically active area, you should check anyway. Some faults in the US have been "silent" for hundreds of years, but could still produce a very large earthquake. The best examples of this are the New Madrid Seismic Zone in Missouri and the fault underneath Charleston, South Carolina, both of which can produce M7.0 or larger quakes.

You can check the seismicity of your area on the USGS website.

When was your structure built? What type of structure is it?

Older buildings tend to need more help than newer ones, both because construction techniques have improved and also because older buildings have more wear and may have already experienced previous earthquakes.

Figuring out what kind of building you have can also go a long way to assessing your risk. A single-story, wood-framed house is far less vulnerable than a multi-level building with parking on the ground level underneath the building. This website can help you identify problematic elements: http://quake.abag.ca.gov/housing.

Insurance

In some states, earthquake insurance is available to help manage your risk. The Insurance Institute for Business and Home Safety provides good tips on reducing risk. Where available, earthquake insurance should be considered as one means to mitigate risk for home and business. Most home, renters, and business insurance policies do **NOT** cover losses from earthquakes without a specific earthquake rider.

Mitigation: Make a Plan

Commercial retrofit

Retrofitting a commercial building usually involves hiring a structural engineer to assess your building, provide recommendations, and if necessary, design a scheme to strengthen your building. A retrofit can range from a simple process that can be performed while business operations continue to more invasive solutions that will require the business shut down or move off-site temporarily.

QuakeSmart is a FEMA NEHRP initiative to help businesses in at-risk communities implement actions for both structural and nonstructural earthquake-risk mitigation.

Residential retrofit

The common kinds of damage to single-family residential buildings include the house sliding off its foundation and the chimney falling down. Fortunately, there are well-documented ways to fix this and other common problems in houses. There are several resources for home retrofits, such as FEMA's Earthquake Safety Guide for Homeowners and FEMA's Homebuilders' Guide to Earthquake-Resistant Design.

Beyond preventing widespread damage to the house, there are simple measures, such as bracing water tanks and providing flexible hosing for gas and water lines, that can provide a great deal of benefit for a relatively small cost.

Securing non-structural items

Much of the earthquake loss is the result of non-structural damage: breakage of contents, damage to windows, collateral damage caused by broken pipes and gaslines, etc. Many of these items are very simple to secure.

FEMA's "Earthquake Home Hazard Hunt" is a tool to help identify items that can cause damage in an earthquake if not properly secured. The poster provides information on how to brace or attach these items.

Homeowner Plan

Homeowners can take several basic steps that will dramatically reduce their earthquake risk. These steps include strapping water heaters and bracing bookshelves.

Contractor Plan

Under certain conditions, significant reduction in earthquake vulnerability can be achieved without an engineering investigation. For small, simple structures, one way to have vulnerabilities addressed is to hire a contractor to perform strengthening procedures, such as bolting the house to its foundation. This is done without any analysis of the structure, but is based on known problems in similar kinds of buildings.

Engineering Investigation

Structural engineers are trained to understand how earthquake forces affect buildings. An engineer can investigate your building and recommend a course of action. There could be several outcomes to such an investigation: the engineer could advise that no action is necessary, the engineer could recommend simple strengthening be done by a contractor, or the engineer could advise you that your structure is unsafe and requires substantial retrofit.

Always Remember When an Earthquake Strikes

Drop, cover, and hold on!

Get underneath something sturdy as quickly as possible and hold on for the duration of the shaking. If there is nothing to get underneath, get near an interior wall, away from glass, and cover your head with your arms. Remain in a safe place until you are sure the shaking has stopped. Don't run outside!

When the shaking stops...

Evacuate to a safe place, away from structures and objects that could fall on you. Injury from falling objects near the building perimeter is a much greater risk than collapse of the building in most cases in the US.

- Look for overhead hazards, such as dangling equipment, ceilings, etc.
- Look for hazards on the ground, such as broken glass.
- Check for gas leaks, or shut off gas service at the line feeding your house.