8.3 Destruction from Earthquakes

The Good Friday Alaskan Earthquake in 1964 was the most violent earthquake to jar North America in the 20th century. The earthquake was felt throughout Alaska. It had a moment magnitude of 9.2 and lasted 3 to 4 minutes. The quake left 131 people dead and thousands homeless. The state’s economy was also badly damaged because the quake affected major ports and towns. Had the schools and businesses been open on this holiday, the death toll would surely have been much higher.

Seismic Vibrations
The 1964 Alaskan earthquake gave geologists new insights into the role of ground shaking as a destructive force. The damage to buildings and other structures from earthquake waves depends on several factors. These factors include the intensity and duration of the vibrations, the nature of the material on which the structure is built, and the design of the structure.

Building Design All multistory buildings in Anchorage, Alaska, were damaged by the vibrations. However, the more flexible wood-frame buildings, such as homes, were less damaged. Figure 10 offers an example of how differences in construction can affect earthquake damage. You can see that the steel-frame building on the left withstood the vibrations. However, the poorly designed building on the right was badly damaged. Engineers have learned that unreinforced stone or brick buildings are the most serious safety threats during earthquakes.

Seismic Vibrations

Reading Strategy
Preview the Key Concepts, topic headings, vocabulary, and figures in this section. List two things you expect to learn. After reading, state what you learned about each item you listed.

<table>
<thead>
<tr>
<th>What I Expect To Learn</th>
<th>What I Learned</th>
</tr>
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Figure 10 Earthquake Damage
This five-story building in Anchorage, Alaska, collapsed from the great earthquake of 1964. Very little structural damage was incurred by the steel-framed building to the left. Inferring Why do some buildings undergo little damage, while nearby buildings are nearly destroyed?

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Customize for Inclusion Students

Gifted When we consider how many earthquakes there are in one year, the number of earthquakes that cause terrible damage is actually very small. The amount of damage an earthquake causes depends on many conditions. For example, if a building is well constructed and built on solid ground, it may survive an earthquake. Most injuries and deaths during earthquakes are because of poor construction or substandard building sites. Another serious problem is not knowing how to respond to an earthquake. When people panic and rush out of buildings there is a danger of being trampled, suffocated, or injured by falling debris. Go to the Red Cross website at http://www.redcross.org/services/disaster and read about earthquake safety.

Reading Focus

Build Vocabulary

Paraphrase Ask students to write the vocabulary words on a sheet of paper. Instruct students to write a definition, in their own words, for each term as they encounter the term while going through the chapter. After writing their own definition, they should also write a complete sentence with the term.

Reading Strategy

Sample answers:

a. how seismic vibrations can cause damage

b. Damage depends on the building design, intensity and length of time of the vibrations, and the material that the building was constructed on.

c. dangers associated with earthquakes

These include tsunamis, landslides, and fire.

2 INSTRUCT

Reading Strategy

Invite a structural engineer to speak to the class about the construction of earthquake-safe buildings. Have students ask about specific regulations for building codes in your area.

Answer to . . .

Figure 10 Damage to buildings often depends on the construction and design of the building. For example, buildings made of wood often are more flexible than buildings made of concrete.

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Many students may have heard that the safest place in a house during an earthquake is in a doorway. Challenge this misconception by pointing out that modern doorways are no stronger than other sections of a house and usually have doors that could swing and injure someone. Encourage students to come up with another plan for earthquake safety. This should involve ducking under a sturdy table or desk and staying clear of objects that could tip over, such as file cabinets and bookcases.

Build Reading Literacy
Refer to p. 334D in Chapter 12, for guidelines on outlining content.

Outline
Have students read the section. Then have students use the headings as major divisions in an outline. Allow students to refer to their outlines when answering the questions in Section 8.3 Assessment.

Visual

Tsunamis

Build Science Skills

Observing
Have pairs of students investigate recent or historically significant tsunamis. (They may use library resources or conduct a Web search.) After students have had time to obtain information, have them compare their findings with another group.

Interpersonal, Verbal

Liquefaction
Where loosely consolidated sediments are saturated with water, earthquakes can cause a process known as liquefaction. Under these conditions, what had been stable soil turns into a liquid that is not able to support buildings or other structures. Buildings and bridges may settle and collapse. Underground storage tanks and sewer lines may float toward the surface.

When does liquefaction occur?

Tsunamis
Most deaths associated with the 1964 Alaskan quake were caused by seismic sea waves, or tsunamis. These destructive waves often are called tidal waves by news reporters. However, this name is incorrect because these waves are not produced by the tidal effect of the moon or sun.

Causes of Tsunamis
A tsunami triggered by an earthquake occurs where a slab of the ocean floor is displaced vertically along a fault. A tsunami also can occur when the vibration of a quake sets an underwater landslide into motion. Once formed, a tsunami resembles the ripples created when a pebble is dropped into a pond. A tsunami travels across the ocean at speeds of 500 to 950 kilometers per hour. Despite this speed, a tsunami in the open ocean can pass without notice because its height is usually less than 1 meter, and the distance between wave crests can range from 100 to 700 kilometers. However, when the wave enters shallower coastal water, the waves are slowed and the water begins to pile up to heights that sometimes are greater than 30 meters, as shown in Figure 11.

Figure 11 Movement of a Tsunami
A tsunami is generated by movement of the ocean floor. The speed of a wave moving across the ocean is related to the ocean depth. Waves moving in deep water travel more than 800 kilometers per hour. Speed gradually slows to 50 kilometers per hour at depths of 20 meters. As waves slow down in shallow water, they grow in height until they topple and hit shore with tremendous force.
**Tsunami Warning System** The destruction from a large tsunami in the Hawaiian Islands led to the creation of a tsunami warning system for coastal areas of the Pacific. Large earthquakes are reported to the Tsunami Warning Center in Honolulu from seismic stations around the Pacific. Scientists use water levels in tidal gauges to determine whether a tsunami has formed. Within an hour of the reports, a warning is issued. Although tsunamis travel very rapidly, there is sufficient time to evacuate all but the area closest to the epicenter. Fortunately, most earthquakes do not generate tsunamis. On average, only one or two destructive tsunamis are generated worldwide every year. Only about one tsunami in every 10 years causes major damage and loss of life.

**Other Dangers**

The vibrations from earthquakes cause other dangers, including landslides, ground subsidence, and fires.

**Landslides** With many earthquakes, the greatest damage to structures is from landslides and ground subsidence, or the sinking of the ground triggered by the vibrations. The violent shaking of an earthquake can cause the soil and rock on slopes to fail, resulting in landslides. Figure 12 shows some of the damage landslides can cause. Earthquake vibration can also cause large sections of the ground to collapse, liquefy, or subside. Ground subsidence can cause foundations to collapse, as shown in Figure 12. It can also rupture gas and water pipelines.

**Fire** The 1906 San Francisco earthquake reminds us of the major threat of fire. The city contained mostly large wooden structures and brick buildings. The greatest destruction was caused by fires that started when gas and electrical lines were cut. Many of the city’s water lines had also been broken by the quake, which meant that the fires couldn’t be stopped. A 1923 earthquake in Japan caused an estimated 250 fires. They devastated the city of Yokohama and destroyed more than half the homes in Tokyo. The fires spread quickly due to unusually high winds. More than 100,000 people died in the fires.

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**Facts and Figures**

The 1906 earthquake in San Francisco was one of the most devastating in the United States. The earthquake and resulting fires caused an estimated 3,000 deaths and $524 million in property loss. Damage in San Francisco alone was estimated at $20 million; outside the city, it was estimated at $4 million. The duration of the shaking in San Francisco was about 1 minute. The earthquake damaged buildings and structures in all parts of the city and county of San Francisco. On the San Andreas fault, buildings were completely destroyed or torn apart; trees fell to the ground. The surface of the ground was torn and heaved into furrow-like ridges. Roads crossing the fault line were impassable. Pipelines were broken, shutting off the water supply to the city. The fires that ignited soon after the earthquake quickly raged through the city because of the lack of water to control them.
Predicting Earthquakes

Section 8.3 (continued)

Predicting Earthquakes

Integrate Biology

Can Animals Predict Earthquakes?

There is much speculation as to the ability of animals to predict earthquakes. Documented cases have shown snakes and bees rapidly leaving their homes, excessive dog barking, and erratic behavior in domesticated and wild animals prior to major earthquakes. The US Geological Survey, however, is more skeptical. They acknowledge the abundance of cases of reported behavioral changes prior to an earthquake but there aren’t enough reproducible connections to conclusively state that animals are predicting the earthquakes. Have students research specific cases of odd animal behavior prior to earthquakes and present their findings in a newspaper article.

Verbal

ASSESS

Evaluate Understanding

Have students work in groups to develop a short public service announcement on the other dangers facing areas that have experienced an earthquake.

Reteach

Ask students to use the diagram in Figure 11 to explain how tsunamis are generated and how they move to shore.

If there were some way to measure the amount of energy stored in rocks, this might lead to the prediction of earthquakes. If scientists could observe and measure the buildup of stress within rocks, they might be able to determine the amount of stress the rocks could withstand before the energy needed to be released. This could provide an estimate of time for an earthquake.

Go Online

For: Links on predicting earthquakes
Visit: www.SciLinks.org
Web Code: cjn-3082

Go Online

Download a worksheet on predicting earthquakes for students to complete, and find additional teacher support from NSTA SciLinks.

Predicting Earthquakes

The earthquake in Northridge, California, in 1994 caused 57 deaths and about $40 billion in damage. Scientists warn that quakes of similar or greater strength will occur. But can earthquakes be predicted?

Short-Range Predictions

The goal of short-range prediction is to provide an early warning of the location and magnitude of a large earthquake. Researchers monitor possible precursors—things that precede and may warn of a future earthquake. They measure uplift, subsidence, and strain in the rocks near active faults. They measure water levels and pressures in wells. Radon gas emissions from fractures and small changes in the electromagnetic properties of rocks are also monitored. **So far, methods for short-range predictions of earthquakes have not been successful.**

Long-Range Forecasts

Long-range forecasts give the probability of a certain magnitude earthquake occurring within 30 to 100-plus years. These data are important for updating building codes, which have standards for designing earthquake-resistant structures. Long-range forecasts are based on the idea that earthquakes are repetitive or cyclical. In other words, as soon as one earthquake is over, the forces in Earth will begin to build strain in the rocks again. Eventually the rocks will slip again, causing another earthquake. Scientists study historical records of earthquakes to see if there are any patterns of recurrence. They also study seismic gaps. A seismic gap is an area along a fault where there has not been any earthquake activity for a long period of time. There has been only limited success in long-term forecasting. **Scientists don’t yet understand enough about how and where earthquakes will occur to make accurate long-term predictions.**

Section 8.3 Assessment

Reviewing Concepts

1. What destructive events can be triggered by an earthquake?
2. What physical changes have been used in the attempts to predict earthquakes?
3. What is a tsunami?
4. What is a seismic gap?

Critical Thinking

5. Making Judgments Do you think scientists are close to being able to accurately predict earthquakes? Explain your answer.

6. Drawing Conclusions Why is it incorrect to refer to tsunamis as tidal waves?

Connecting Concepts

Earthquakes

In Section 8.1, you learned about the elastic energy stored in rocks before an earthquake and the elastic rebound hypothesis. How could this information be used to try to predict earthquakes?

Section 8.3 Assessment

1. Events such as landslides, tsunamis, and fires can be triggered by earthquakes.
2. Physical changes such as uplift, subsidence, strain in rocks along faults, water levels in wells, and radon gas emissions from fractures have been measured in hopes of predicting earthquakes.
3. A tsunami is a seismic sea wave created by an underwater earthquake or a landslide under the ocean floor generated by an earthquake.
4. A seismic gap is an area along a fault that has not had any earthquake activity for a long period of time.
5. Answers will vary. Sample answer: Scientists don’t yet understand enough about how and where earthquakes occur to make accurate predictions.
6. Tidal waves are caused by the gravitational pull of the moon and sun. Tsunamis are large waves caused by earthquake movements.