Earthquake
IN THE CLASSROOM

Experiment

Classroom resources provided by Cairns Regional Council

Students learn how engineers construct buildings to withstand damage from earthquakes by building their own structures with toothpicks and marshmallows. Students test how earthquake-proof their buildings are by testing them on an earthquake simulated in a pan of jelly.

Introduction:

Read out loud to students before starting the experiment

Earthquakes can cause much loss of life and millions of dollars worth of damage to cities. Surface waves and body waves from earthquakes can cause walls to crack, foundations to move and even entire buildings to crumble.

Engineers continually strive to make buildings stronger to resist the forces of earthquakes.

Engineers face the challenge of designing more robust buildings to withstand earthquakes.

Earthquake-proof buildings are intended to bend and sway with the motion of earthquakes, instead of cracking and breaking under the pressure.

Have you ever looked at a really tall building, such as a skyscraper?

What does it look like?

Does it appear fragile and unstable?

It might, but it is most probably quite sturdy and can withstand wind, rain and other natural elements and phenomena.

Earthquake-proof buildings typically have cross bracing that forms triangles in its design geometry (like a bridge).

Such buildings also typically have a large “footprint,” or base, and a tapered shape, decreasing in size as the building gets taller (or simply, smaller at the top).

Short buildings are more earthquake proof than tall ones. Why do you think that is?

Have you ever climbed up a tree or been on top of a playground jungle gym in the wind?

Do you sway more when you are up high than when on the ground?

All buildings shake at the same frequency as the shaking of the Earth, but the movement is magnified as the building gets taller.

Sometimes, as can be the case during earthquakes, buildings sway too much, crack and crumble and fall.

Experiment:

Allow 50 minutes for the activity

Materials:

Each student needs:

- 30 toothpicks
- 30 miniature marshmallows
- Earthquake Journal

For the class to share:

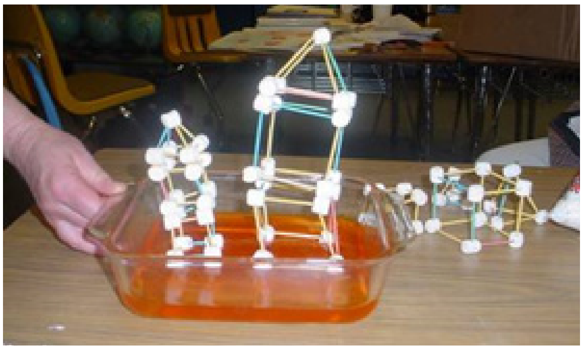
- eight 20-cm square disposable baking dishes, or one 20 x 30-cm disposable roasting or baking pan
- 8 boxes jelly crystals (plus a stove, water and pan to make the jelly in advance)

Preparation:

Prepare the jelly the night before the activity so that it is fully set when students begin the activity.

Pour the jelly into eight 20-cm square pans to be shared by four students, or in one large pan for the entire class to share.

Make one marshmallow-toothpick structure as a display example for students.



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With the students:

1. Hand out student journals. Have students fill in the top left section of the journal with vocabulary terms. Direct students to record their activity observations as they work.
2. Tell students that today they are acting as if they are engineers. They will make models of buildings and conduct an experiment to test how well their structures stand up under the stress of an earthquake. Explain to them that this is similar to what some civil engineers do as their jobs.
3. Show students the display model of a structure.
4. Illustrate how to make cubes and triangles using toothpicks and marshmallows.
5. Show students how to break a toothpick approximately in half. Explain that cubes and triangles are like building blocks that may be stacked to make towers. The towers can have small or large "footprints" (or bases).
6. Distribute 30 toothpicks and 30 marshmallows to each student. Explain that Earth has limited resources, so therefore engineers also have limited resources when building structures.

   For this engineering challenge, students are limited to using only the materials they have been given to make structures.

   They may make large or small cubes or triangles by using full-size or broken toothpicks. They may use cross bracing to reinforce their structures.

   Note: for higher grade levels, give students more rules for their buildings.

   You can use one or more of the following rules or create your own.

   Buildings must be:

   - at least two toothpick levels high,
   - contain at least one triangle,
   - contain at least one square,
   - or buildings must contain one triangle and square.
7. Place the structures on the pans of jelly.

   If aluminium pans are used, tap the pans on the bottom to simulate compression or primary waves. If glass baking dishes are used, shake them back and forth in a shearing motion to simulate S or secondary waves.

   After students have tested their structures, have them redesign and rebuild them and finally test them again.

   What can they do to make it stronger? Did it topple? Should they make the base bigger? Make the structure taller or shorter? Let students design and rebuild as many times as the class period allows.
8. Have students draw and label the shapes in their designs (cube, triangle, etc).
9. Have students pretend that they are engineers who work for a civil engineering company designing buildings for Cairns.
10. Instruct them to make a flyer to convince their company to let them design a better building or structure.

Safety issues:

Inform students that in a science lab or during science experiments, nothing should ever be put into their mouths. The marshmallows and jelly are not for eating! Instead, set some aside for a treat after the activity.

Troubleshooting tips:

The activity works best with fresh (soft) marshmallows. As the marshmallows sit and dry out, they and the structures become stable and rigid.

Do not leave the Jelly uncovered too long, as it dries out and becomes less fluid, which affects the activity results.

Assessment

Pre-activity assessment

Journal: Use the attached Earthquake Journal page or have students make their own by doing the following:

1. Put a title on the page: Measuring Earthquakes.
2. Divide the page into four quadrants labelled:
   - Vocabulary
   - What I've Learned
   - What I Observed
   - Questions I Have.
3. Have students enter the new vocabulary words for the lesson (such as: tectonic plates, Ring of Fire, focus, epicentre, surface waves, body waves, P waves, S waves, aftershocks, seismograph, Richter scale, Mercalli scale) in the vocabulary section.

Activity embedded assessment

Journal: Have students record their own observations in the section titled, "What I've observed."

Measurement: Have students measure the length, width, and height of their structures and calculate the volume using the equation V=L x W x H.

Post-activity assessment

Journal: Have students fill in the final sections of the journal labelled, "What I've Learned," and "Questions I Have." Solicit questions from the students and let other students answer.

Re-Engineering: After students have tested their structures, they should redesign and rebuild them, then test again. What can they do to make it stronger? Did it topple? Should they make a bigger base? Make it taller or shorter? Let students design and rebuild as often as time allows.

Drawing the Geometry: Have students make drawings and label the shapes in their designs (cube, pyramid, triangle, etc.).

Make a Pitch! Have students pretend to be engineers and make flyers to convince a LOCAL

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company to let them design a better building or structure.

News Broadcast: Have student teams write news broadcasts about an earthquake that has hit Cairns. Have the broadcast begin with something exciting to catch the listener's attention. Then tell the facts of the event. Have the teams share their news broadcasts with the class.

Activity extensions

Have students examine the school for earthquake engineering. Does the school building encompass some of the principles of earthquake proofing?

Observe buildings in the community or city. What do students observe about the structure of the buildings?

Can you obtain fault maps of the area by searching the Internet? Try Geoscience Australia and your regional council website. Is this area in a zone at risk for earthquakes? How far is it from an area with a volcanic history? Does the local architecture plan for this? How would you find out?

Curriculum links

11-12	Earth and Environmental Science	ACSES098: Science Understanding; Science hazards	Earth hazards result from the course and impacts of earth interactions of Earth systems and can threaten life, health, property or the environment; their occurrence may not be prevented but their effect can be mitigated
11-12	Earth and Environmental Science	ACSES099: Science Understanding; The cause and impacts of Earth hazards	Plate tectonic processes generate earthquakes, volcanic eruptions and tsunamis; the occurrence of these events affects other Earth processes and interactions (eg ash clouds influence global weather)
11-12	Earth and Environmental Science	ACSES100: Science Understanding; The causes and impacts of Earth hazards	Monitoring and analysis of data, including earthquake location and frequency data and ground motion monitoring, allows the mapping of potentially hazardous zones, and contributes to the future prediction of the location and probability of repeat occurrences of hazardous Earth events, including volcanic eruptions, earthquakes and tsunamis
11-12	Earth and Environmental Science	ACSES101: Science Understanding; The cause and impacts of Earth hazards	Major weather systems generate cyclones, flood events and droughts; the occurrence of these events affects other Earth processes and interactions (eg habitat destruction, ecosystem regeneration)
11-12	Earth and Environmental Sciencet	ACSES102: Science Understanding; The cause and impacts of Earth hazards	Human activities, including land clearing, can contribute to the hazards frequency, magnitude and intensity of some natural hazards (eg drought flood, wildfires & landslides) at local and regional scales
11-12	Earth and Environmental Science	ACSES103: Science Understanding; The cause and impacts of Earth hazards	The impact of natural hazards on organisms, including humans, and ecosystems depends on the location, magnitude and intensity of the hazard and the configuration of Earth materials influencing the hazard (eg biomass and substrate)
11-12	Geography	CHGEE013: Geographic Knowledge and Understanding; Overview of natural and ecological hazards	The concept of risk as applied to natural and ecological hazards
11	Geography; Natural Hazards & Ecological Hazards	ACHGE012: Geographical Knowledge and Understanding; Overview of natural and ecological hazards	An overview of the nature of natural hazards (atmospheric, hydrological, and geomorphic) and ecological hazards
11	Geography; Natural Hazards & Ecological Hazards	ACHGE013: Geographical Knowledge and Understanding; Overview of natural and ecological hazards	The concept of risk as applied to natural and ecological hazards
11	Geography; Natural Hazards & Ecological Hazards	ACHGE022: Geographical Knowledge and Understanding; Overview of natural and ecological hazards	The nature and causes of the selected hazard and how the activities of people can intensify its impacts
11	Geography; Natural Hazards & Ecological Hazards	ACHGE024: Geographical Knowledge and Understanding; Overview of natural and ecological hazards	The diffusion and resulting spatial distribution of the hazard, and how an understanding of biophysical and human processes can be used to explain its spread

11	Geography; Natural Hazards & Ecological Hazards	ACHGE025: Geographical Knowledge and Understanding; Depth and study of an ecological hazard	The physical and human factors that explain why some places are more vulnerable than others
12	Earth and Environmental Science	ACSES094: Science as a Human Endeavour; The cause and impact of earth hazards	People can use scientific knowledge to inform the monitoring, assessment and evaluation of risk
12	Earth and Environmental Science	ACSES097: Science as a Human Endeavour; The cause and impact of earth hazards	Scientific knowledge can be used to develop and evaluate projected economic, social and environmental impacts and to design action for sustainability
12	Earth and Environmental Science	ACSES098: Science Understanding; The cause and impact of Earth Hazards	Earth hazards result from the interactions of Earth systems and can threaten life, health, property, or the environment; their occurrence may not be prevented but their effect can be mitigated
12	Earth and Environmental Science	ACSES099: Science Understanding; The cause and impact of Earth Hazards	Plate tectonic processes generate earthquakes, volcanic eruptions and tsunamis; the occurrence of these events affects other Earth processes and interactions (for example, ash clouds influence global weather)
12	Earth and Environmental Science	ACSES103: Science Understanding; The cause and impact of Earth Hazards	The impact of natural hazards on organisms, including humans, and ecosystems depends on the location, magnitude

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