Keep It Up (1 Hour)

Addresses ITEEA
Level of Difficulty: 2
Grade Range: 3-5

Siemens SCIENCE Day
LEARNING BY DOING

OVERVIEW

In this activity, students will design a bridge or a building and observe how it performs in a simulated earthquake. Then they will revise their designs to make them stronger and perform the simulation again.

Topic: engineering design and earthquakes

r eal-w orld Science Topics

- An exploration of engineering design
- An exploration of the effects of earthquakes on structures

Objective

Students will gain an understanding of how earthquakes can affect structures like bridges and buildings. They will also apply the principles of engineering design to construct, test, and modify structures in response to simulated earthquakes.

Materials Needed for Teacher Demonstration

- image of damage from earthquakes
- spring

Materials Needed for Student Teams

- wooden blocks
- tape
- Popsicle sticks
- glue
- string
- freestanding table (or, alternatively, a large piece of cardboard)
- straws
- other suitable model-building material

Standards for Technological Literacy

8. Students will develop an understanding of the attributes of design. C. The design process is a purposeful method of planning practical solutions to problems.

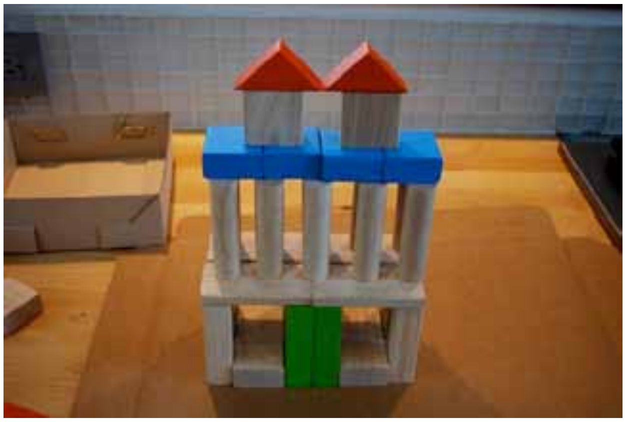
Siemens SCIENCE Day LEARNING BY DOING

1. **warm-up activity:** Introduce the activity by showing the class an image of damage caused by an earthquake. Ask the class what caused the damage they see in the image. Record responses on the board and have students vote on the event that they believe caused the damage. Prompt various students to explain why they believe the damage was caused by a particular event. For example, if they believe an earthquake caused the damage, they should point out reasons why the damage was caused by an earthquake and not something else, such as a tornado. Lead students to conclude that an earthquake caused the damage and have students make a list of the different types of damage that can be caused by earthquakes. Prompt students by asking them what happens to roads, bridges, or buildings during an earthquake.

   If your class has not previously studied earthquakes, briefly discuss the different types of earthquake waves, as described in the Background Information section of this activity. To help demonstrate these concepts, you can use a large spring. To demonstrate P waves, hold the spring horizontal and push inward on one end. Students should observe a pulse that travels horizontally from one end to the other. To demonstrate S waves, hold the spring horizontal and move one end up and down quickly. Students should observe a vertical pulse that travels horizontally along the spring from one end to the other. Explain that these pulses move through Earth's crust just like the pulses on the spring.

2. Divide students into small teams and provide each student with the materials for the lesson, as shown below. Note that if you do not have freestanding tables, students will need a large piece of cardboard to help simulate earthquake conditions.

3. Instruct students to work with their team to design a structure using only the wooden blocks. Suggest a bridge or a two (or three) level building as an appropriate structure. Allow groups time to brainstorm, sketch, and build a structure. Once groups have finished, you may opt to have each group quickly share their design with the rest of the class. A sample building is shown below.



4. Next, ask students to make a prediction about what will happen to their structures in the event of an earthquake. Most students should predict that their buildings or bridges will collapse. Instruct them to write their predictions in the space provided on the Student Handout.

5. Instruct students to simulate a moderate earthquake. They should do this by gently shaking the table or the piece of cardboard on which the structure is standing. You may want to model the appropriate amount of shaking; in this way, all groups can attempt to simulate roughly the same magnitude earthquake. Tell students to carefully observe how their structure collapses: Does it topple inward? Does the bottom give out? Have students record their observations on the Student Handout.

6. Now, instruct students to modify their designs to make their structure stronger. This time, allow students to use all of their materials. Encourage them to discuss within their team and to search for innovative ways to make their structures stronger. A modified building with tape, glue, and braces, is shown in the image below.

Your students' designs should all vary as there is no right answer to this problem. Allow for creative innovation, including securing the structure to the substrate. Have students quickly share their revised designs with the class before proceeding. Prompt students to explain the reasons for their modifications.

7. Again, instruct students to simulate an earthquake. Emphasize that they should try to use the same amount of force as the first earthquake in order to simulate the same conditions. Tell students to carefully observe what happens during the second earthquake. This time, it's possible to have a range of results: Some structures may remain standing while others collapse. Some might suffer a minor amount of damage while others are completely ruined.

8. w rap-up a ctivity: Once all groups have simulated two earthquakes, allow groups to share their results with the class. Allow each group to share the highlights of their design, discussing what worked and what didn't work. Then bring the class back together as a large group and ask students several questions to get them thinking about the implications of this activity. Sample questions include:

- Why were some designs successful while others were not?
- How does the strength of the earthquake affect the design?
- What are some ways to increase strength in a building?
- Why is it important for engineers and architects to design with earthquakes in mind?
- Do you think we'll ever be able to completely prevent the damage caused by earthquakes? How might we be able to get to that point?

Keep It Up extension a ctivities

1. Challenge students to brainstorm other variables they could introduce into this activity. For example, different groups could build their structures on varying substrates. One group might build their structure on top of sand, another on clay, another on loosely packed soil. Repeat the investigation and have groups compare their results.
2. Have students conduct research on earthquakes in your area. In their research, students should also learn about ways to minimize the damage caused by earthquakes, including site selection and building techniques. Have students share what they have learned with their classmates. If resources are available, have students share their research using a slide-show presentation on a computer.

w hat are the different types of earthquake waves?

There are two primary types of earthquake waves: *body waves* and *surface waves*. *Surface waves* are the most destructive type of wave because they travel across Earth's surface. Surface waves travel similar to ripples moving across a body of water.

There are two main types of body waves: *P waves* and *S waves*. *P waves* are fast-moving waves that push and pull at the earth in a lateral motion. These pushes and pulls are known as compressions and dilations. P waves can travel through any kind of material. *S waves* arrive after P waves and move the earth at right angles to the direction of travel (if the wave is traveling horizontally, the S wave will cause the earth to move up and down). S waves cannot travel through liquid. Body waves are often experienced as minor bumps before the more destructive surface waves strike.

How can earthquakes damage structures?

Not all earthquakes are damaging. Some occur deep within Earth's crust and are not felt at the surface. Others occur at Earth's surface, but they are so weak that they do not cause substantial damage. Other earthquakes can occur in areas of sparse population, greatly reducing the damage. For an earthquake to be damaging, it must be of a large enough magnitude to cause structures to fail. The 2010 earthquake in Haiti caused great damage because it rippled through densely populated land on which many poorly constructed buildings and roads were built. Your students should know that many different factors can contribute to the harmful effects of earthquakes.

How can engineering design help prevent or minimize earthquake damage?

There are several ways proper design and engineering can minimize earthquake damage. An important step begins with correct site selection. Some soils are prone to liquefaction, which is when the particles of the soil temporarily lose their strength and act more like a liquid during an earthquake. Engineers know to either avoid these soils or to drive supports into the bedrock so that structures can have solid foundations.

Engineers can also consider various aspects of the building design. One technique is to use diagonal bracing. Diagonal supports resist lateral compression waves and help the building stay in place. Shear walls are also used to resist lateral compression, and help the structure stay intact as one piece. Engineering can also help structures survive surface waves. This is done through tie downs, which secure a building to its foundation. Tie downs also secure each level of the structure to each other, like frosting binds layers of a cake together. None of these techniques guarantees safety during a forceful earthquake, but they can help minimize the damage.

Key vocabulary

earthquake: shaking of the ground as a result of movement within Earth's crust; can also be caused by volcanic activity

seismic wave: an elastic wave that travels through the earth as a result of an earthquake

1. Draw a picture of your design.

[Images will vary]

2. Make a prediction about what will happen to your first structure (built with only wooden blocks) in a simulated earthquake.

[Sample answer: I think my structure will fall down. There's no glue or tape to hold it together, so it won't take much for it to collapse.]

3. What did you observe about the way your structure collapsed in the first earthquake?

[Sample answer: The wooden pieces slid back and forth for about a second before they collapsed. Most of the pieces seemed to collapse inward.]

4. How did your team modify your structure after the first simulate earthquake?

[Sample answer: My team kept the design of the structure the same, but we added a lot of support. We glued pieces to each other, taped others, and used Popsicle sticks to act as braces. We then glued the entire building onto our piece of cardboard.

5. Make another prediction about how your structure will fare after another earthquake.

[Sample answer: I think the building will still move a bit, but I don't think any of it will fall down.]

6. Create a sketch of your structure in the space below and label the parts of your structure that you believe will help support it in an earthquake.

[Images will vary but will include a drawing of the structure, plus labels for supportive structures, such as braces, tape, and glue. Labels will also vary but should indicate changes to the structure as a result of what they learned from the first simulated earthquake.]

7. Why is engineering for earthquakes important in real life?

[Sample answer: I believe engineering for earthquakes in important because it can prevent buildings from collapsing. This can save many lives and keep people safer in the event of an earthquake.]

Keep iT up STuDeNT HaNDOuT

Name:

Date:

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3. What did you observe about the way your structure collapsed in the first earthquake?

4. How did your team modify your structure after the first simulated earthquake?

5. Make another prediction about how your structure will fare after another earthquake.

6. Create a sketch of your new structure in the space below and label the parts of your structure that you believe will help support it in an earthquake.

7. Why is engineering for earthquakes important in real life?