Title of Lesson:

Quake Safe Buildings

Essential Question:

How do movements of Earth's surface impact human and wildlife habitats?

Conceptual Statement:

Human habitats can be changed due to earthquakes resulting from plate movements.

Conceptual Learning Sequence:

This lesson is the culmination of a conceptual unit focusing on Earth's plates, the movement of those plates, and the effects of earthquakes on human environments. As the lesson unfolds, students discover how the motion of Earth and the structural design of a building can determine the ability of a building to withstand the powerful force of an earthquake.

Student Outcomes:

- Students review the natural phenomena of earthquakes and learn how the force released in an earthquake can cause structural damage to buildings.
- Students test various structural designs of buildings to determine "quake-safeness."
- Students use "Graphic Outlining" as they review the book *Earthquakes* by Seymour Simon.

Lesson Overview:

In this lesson, students read the book *Earthquakes* and use "Graphic Outlining," to graphically organize information on earthquakes and their consequences. The literature selection serves as a review as well as leading students to predict and discover new information about earthquake motion and its consequences. Students test various structural designs for a building.

English Language Learning:

English Language Development standards are referenced in the lesson where appropriate. The hand icon appears throughout the lesson when learning strategies and lesson components are identified as pathways for academic success and reflect critical developmental differences for students who are English learners.

Literature in the Science Learning Cycle:

The book *Earthquakes* is utilized in the ENGAGE stage to connect to students' prior knowledge and in the EXPLORE stage to focus the students' investigation on structural stability as it relates to surface motion.

Learning Strategy:

Students use "Graphic Outlining" with *Earthquakes* to highlight the organizational pattern of the text. This strategy helps students organize what they read, leads them to predict what may come next, and integrate the new information they encounter. (See Appendix pages 162-163.)

Literature Selection:

Title: *Earthquakes*
Author: Simon, Seymour
Publisher: William Morrow, 1991 ISBN: 0688096336
Annotation: This book, from award-winning science writer Seymour Simon, examines the mysteries surrounding earthquakes. Why do they happen? Why are they more frequent in certain areas? What can people do to protect themselves and their property? Simon combines a detailed, clear text with actual photographs to provide some surprising answers.
Genre: Nonfiction

California Science Content Standards:*

Science: Grade 6, Earth Science

Plate Tectonics and Earth's Structure

1. Plate tectonics accounts for important features of Earth's surface and major geologic events. As a basis for understanding this concept:
   - c. Students know lithospheric plates the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.
   - d. Students know that earthquakes are sudden motions along breaks in the crust called faults and that volcanoes and fissures are locations where magma reaches the surface.
   - e. Students know major geologic events, such as earthquakes, volcanic eruptions, and mountain building, result from plate motions.
   - g. Students know how to determine the epicenter of an earthquake and know that the effects of an earthquake on any region vary, depending on the size of the earthquake, the distance of the region from the epicenter, the local geology, and the type of construction in the region.

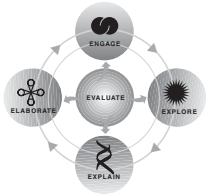
2. Topography is reshaped by the weathering of rock and soil and by the transportation and deposition of sediment. As a basis for understanding this concept:
   - d. Students know earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

7. Investigation and Experimentation

Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other three strands, students should develop their own questions and perform investigations. Students will:

a. Develop a hypothesis.
b. Select and use appropriate tools and technology (including calculators, computers, balances, spring scales, microscopes, and binoculars) to perform tests, collect data, and display data.
c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
d. Communicate the steps and results from an investigation in written reports and oral presentations.
g. Interpret events by sequence and time from natural phenomena (e.g., the relative ages of rocks and intrusions).

*Selected standards addressed within this lesson.

Lesson at  a Glance

Science Learning Cycle	Objective Science Thinking Process, Learning Strategy	Suggested Time
ENGAGE	Students read *Earthquakes* to engage them in thinking about the causes of earthquakes. They graphically outline the literature selection, making connections to their prior knowledge. Communicating, Categorizing	30 minutes
EXPLORE	Students explore the literature selection for evidence of structural damage. They connect photos in the text to a teacher demonstration and the students' own investigation of structural design to determine "quake-safeness." Observing, Comparing, Analyzing	1 hour
EXPLAIN	Students whiteboard, relate their findings, and explain their data to the class while comparing information found in *Earthquakes*. Communicating, Relating, Comparing	1 hour
EVALUATE	Students evaluate their understanding of force and structural design as they build models and test them for structural integrity. Students compare their findings to real scenarios. Teacher evaluates student understanding of student outcomes in this activity as well throughout the lesson. Communicating, Inferring, Applying	2 hours
ELABORATE	Using a variety of resources, students research building destruction caused by earthquakes and relate the building design to "quake-safeness." Communicating, Inferring, Applying	1 hour

Quake Safe Buildings

Teacher Background:

During an earthquake, seismic waves move through the ground, causing it to shake and move. The movement of the ground determines the forces acting upon and transferring to surface structures. Ground motion depends on the magnitude of the earthquake, distance from the epicenter, and local geology. A house built on sandy soil where water is close to the surface will suffer much greater damage than if it were constructed on and bolted to rock.

A building with a mass of thousands of metric tons must withstand tremendous forces that may cause it to sway with a back-and-forth motion. If the forces and the sway of the building are strong enough, the building may faulter, lose its stability and collapse. To overcome the effects of the destructive forces, engineers rely on structural design, types and strengths of building materials, and different methods of anchoring to the ground. A considerable amount of research and testing has been conducted to develop building structures that withstand these destructive forces, and protect people's lives and property.

Grouping: Whole class, groups of 4

For hands-on activities, mix the EL with the native speakers. For debriefing, include at least two EL with native speakers to form discussion groups.

Related California Content Standards

Math: Grade 6 Statistics

Data Analysis, and Probability

2.4 Identify data that represents sampling errors and explain why the sample (and the display) might be biased.

2.5 Identify claims based on statistical data and, in simple cases, evaluate the validity of the claims.

Language Arts: Grade 6

Reading Comprehension

2.3 Connect and clarify main ideas by identifying their relationships to other sources and related topics.

2.4 Clarify an understanding of texts by creating outlines, logical notes, summaries, or reports.

English Language Development Standards: Grades 6-8

Reading Comprehension:

Early Advanced - Identify and explain the main ideas and critical details of informational materials, literary texts, and text in content areas.

Advanced - Identify and explain the main ideas and critical details of informational materials, literary texts, and text in content areas.

Materials:

Per Class (Demonstration Wall)

4 Styrofoam sticks, 3 cm x 13 cm,

4 Bolts #10-32 x 1", 4 Nuts to fit the bolts, 4 Washers to fit the bolts

Per Group

Whiteboard and markers

5 Styrofoam sticks, 3 cm x 13 cm (see Advanced Preparation)

2 Styrofoam sticks, 3 cm x 18 cm (see Advanced Preparation)

6 Bolts #10-32 x 1", 6 Nuts to fit the bolts, 6 Washers to fit the bolts

25 Cubes of sugar

2 oz Cake frosting

Plastic knife

1 Toothpick

1 Spring scale (must measure up to 500 grams)

Graph paper (1 cm scale)

Masking tape

Various building materials for Investigation #2: toothpicks, white glue, cardboard, duct tape, popsicle sticks, strips of heavy paper, hot glue gun, plastic coffee stir sticks, etc.

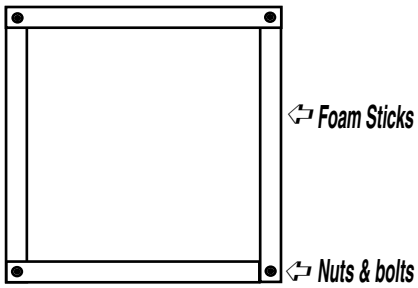
Board (cardboard, wood, etc.) to attach building from Investigation #2

Per Student

Earthquakes by Seymour Simon

Advance Preparation:

1. Purchase a large piece of 1/4" Styrofoam sheet.
2. Prepare a square demonstration wall by cutting 4 foam sticks (3 cm x 13 cm) from the large sheet.
3. Punch a hole in each end of every stick about 1.5 cm from the end.
4. Using #10-32 x 1" bolts, washers and nuts, assemble the sticks to build a wall.
5. From the large sheet, cut 5 foam sticks (3 cm x 13 cm) and 2 foam sticks (3 cm x 18 cm) for each group; punch holes in each of the sticks about 1.5 cm from the end.
6. Duplicate Student Pages 1.0, 1.1, 2.0, 2.1



Teacher Resources:

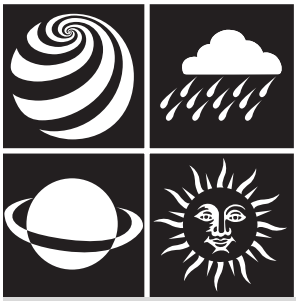
Skinner, Brian J. and Porter, Stephen C. *The Dynamic Earth, An Introduction to Physical Geology*. John Wiley & Sons, William Morrow and Company, Inc., New York, 1995.

Teacher Tips:

- Draw the "Example Graphic for Earthquakes" (see Teacher Page 1.0) on the board. In your drawing, include only the shapes and titles for students to copy. Do not copy the bulleted text in the example. Instead, use this information as a guide for what students should be gathering from the text/pictures.
- Purchase foam board at craft stores; purchase nuts, bolts and washers at hardware stores.
- Provide time for buildings constructed from glue or frosting to dry before they are tested.
- Decide with the class what it means for a building to be "stressed." Use this description as a guide to observe the amount of force needed to stress the building in Investigations 1 and 2.
- For presentations of the results from Investigation 1, consider having students do a "gallery walk:" have one student stay with the whiteboard to explain the information and have the other members of a group rotate to see/discuss each group's work.
- For the second investigation, pre-determine how large the student projects can be. Provide a variety of materials for students to use in their building.
- Construct a class testing station for Investigation 2: create an edge for the table by taping a ruler or some other board to two sides meeting at a corner of the testing table. Have students place their building against these edges and tape their building to the table. Attach the spring scale to the top corner of the building and pull to measure the applied force.

Related Student Resources:

Disaster Science. Klutz Press, 1998.
Gallant, Roy A. *Earth, The Making of a Planet.* Cavendish Children's Book, 1998.
Pope, Mary. *Earthquake In The Early Morning.* Magic Tree House, July 2001.
Walker, Jane. *Terremotos* (Earthquakes). Aglo Publishers, Spain, 1995.



VOCABULARY

applied force – a push or pull exerted on a body (building)

focus – a point within Earth at which an earthquake originates or starts

force – cause of motion or change

seismic – related to, or caused by an earthquake

seismic waves – energy that moves through the ground after the earthquake happens

waves – rhythmic disturbances that travel through space or matter. In an earthquake, the wave is the movement of the energy released from the earthquake as it moves through the Earth

The Science Learning Cycle:

Quake Safe Buildings

ENGAGE:

1. Ask students, “Have you ever been in an earthquake? If so what did the earthquake feel like to you?” Have students describe what they felt, the motion of the ground, and how long the earthquake lasted. Chart their responses.

2. Link their comments to today’s lesson which is to review some of the causes of earthquakes and to learn more about the effects of earthquakes on structures–particularly buildings.

3. Introduce “Graphic Outlining” by reconstructing the skeleton of the graphic organizer (see Teacher Tips and Teacher Page 1.0) on the board. Ask students to copy it into their notebook.

4. In groups, ask students to brainstorm what they know about earthquakes and have each student write the ideas in the middle oval of his/her graphic outline.

5. Hold up the book, *Earthquakes*. Explain that students will use the graphic outline to extract information from this literature selection and will add that information to their brainstorm. Ask students to scan the text and examine the pictures that deal with causes of earthquakes (use the first ten pages starting with the crooked train tracks ending with the text opposite the map of “Earthquakes Around The World.”). Ask students to add this information to their brainstorm in the middle oval of the graphic outline.

6. Have students share the beginning of their graphic outline with their group.

EXPLORE:

7. Ask students to compare the pictures on pages describing events in Mexico City, Armenia, San Francisco, Niigata, and Anchorage. Have students add to their graphic outline in the appropriate city-box information about the different earthquakes and the structural damage they caused.

8. Ask several students to share their graphic organizer and their understanding of the organization of the text. What new information did they gain from the text about earthquakes or the destruction caused by earthquakes?

9. Discuss with students the similarities they noticed and the damage that was caused. What differences were there? What might account for the types of damage that the students noted? Summarize, noting things like building design, type of soil, and proximity to the focus.

10. Ask students to think of a building (e.g., their house, school, favorite store). What is the structure of the building? What types of materials were used to construct the building? List the various types of structures and discuss that even though the face of a building may be brick or rock, the structure or frame of the building may be wood or steel.

11. Show the demonstration wall to the students and tell them that it represents part of the frame of a building. Ask students to predict what will happen if you quickly push on one of the top corners of the wall. Push and have students observe the results.

12. Discuss the results. Ask students what they think would help the wall to withstand the forces of an earthquake. Be sure to discuss that the strength of any building depends on what it is made of, the construction of the frame and how the building is anchored to the ground.

13. Explain that students will investigate the effect of earthquakes on different frame constructions. Group students into "Seismic Engineering Teams" with two or three students per team. For this activity, be sure to group at least two EL students on the same Seismic Engineering Team.

14. Demonstrate how to attach the spring scale to various walls and to read the applied force on the spring scale. With the class, develop a consistent description of what it means for the wall to be "stressed." Remind students to read the spring scale measurement when and if their wall matches this "stressed" description.

15. Distribute materials for the first investigation and remind students that the instructions for the investigation are on their sheet. If necessary demonstrate how to construct a wall (Student Page 1.0).

16. Provide time for students to construct and test their walls. Ask them to make a bar graph of their results recorded in their data table (Student Page 1.1).

EXPLAIN:

17. Ask groups to synthesize on whiteboards what they learned from their graphic outline, the pictures of building damage in the book, and the results of their investigation. Have groups make a short presentation of their findings (See Teaching Tips).

18. After all the groups have presented, have the class discuss the similarities and differences in their findings. What structural design(s) seemed to work best? How did the sugar cube wall differ from the foam stick frames?

EVALUATE:

19. Using what students learned from their first investigation, the Seismic Engineering Teams will plan, construct, and test the strength of a building in the second investigation (Student Page 2.0 and 2.1). Ask students to read the instructions for this investigation.

20. Discuss your specifications for the project and show students the materials that are available to them. Remind them that they must have teacher approval before constructing their building and to record their progress on Student Page 2.0 and 2.1.

21. Provide time for construction. When teams are ready, explain that they will present their design and test its stability in front of the class.

22. Invite each group to describe to the class their design and the rationale for it. With the class, develop a consistent description of what it means for a building to be "stressed" in comparing their relative structural stability. Ask the class to discuss the designs and predict how they will do on the test.

23. Set up the "testing area" (see description in Teacher Tips). Invite each group, one at a time, to come to the testing area and test their structure. Record the results on a class chart. Continue until all groups have had a chance to test their building. Have students comment on the class results. Which designs worked best? Why?

ELABORATE:

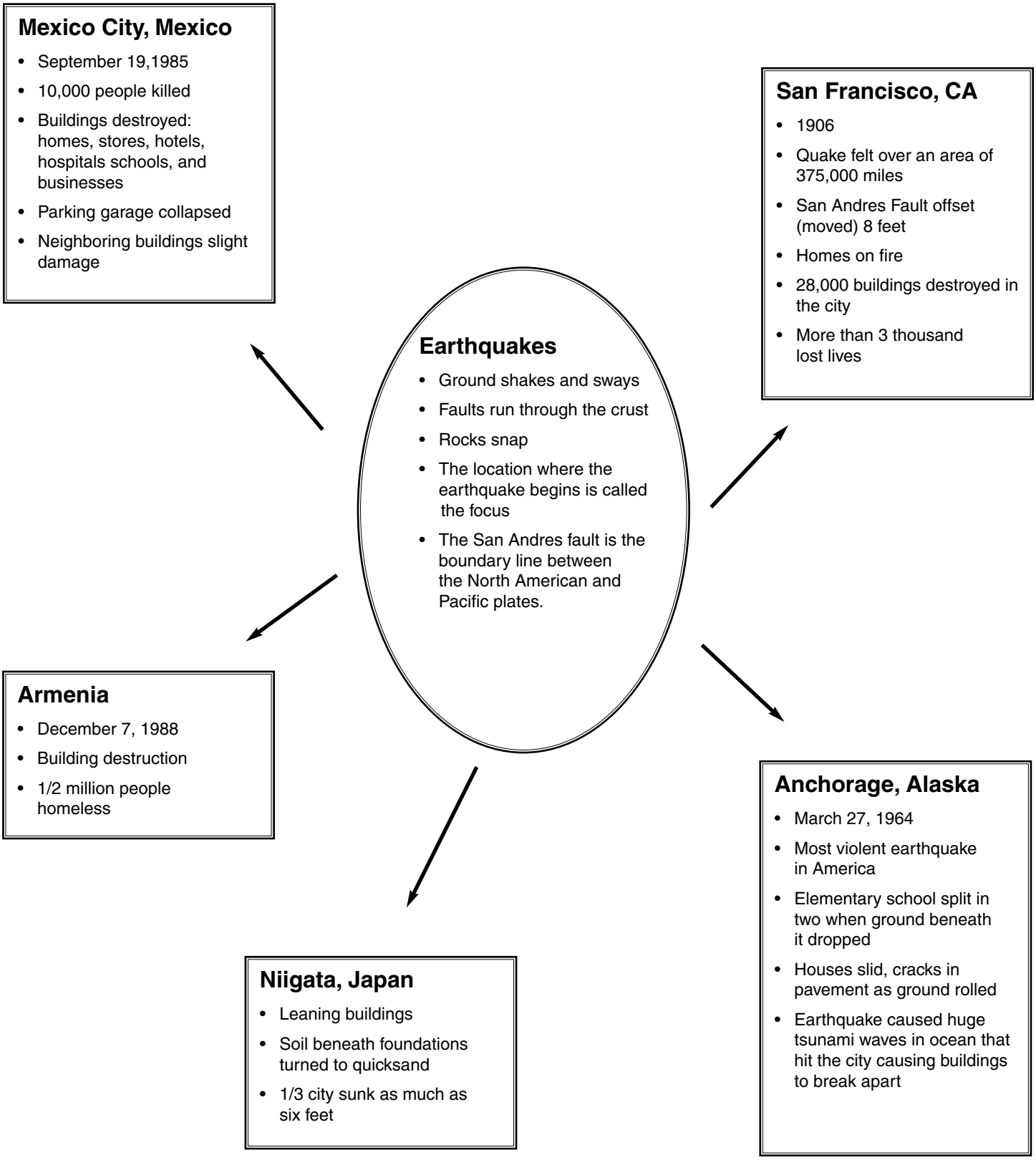
24. As a culminating activity, have students conduct research of building destruction caused by earthquakes. Provide a variety of resources (e.g., books, magazine, web sites, government documents on building requirements, interviews with local building experts).

25. Based on their research, have students compare buildings for the amount of damage, the structural framing, and the materials used to build the structures. Ask students to compare and contrast their experimental data with observed damage of the real buildings.

Teacher Reflection:

1. How does the student work provide evidence of the student's understanding of the effects of earthquakes on structures?
2. What instructional strategies used in this lesson promote student understanding? How do you know?
3. How does the literature selection support student understanding of the science concepts?
4. How would you modify the instruction to ensure understanding of student outcomes by all students?

Example Graphic for *Earthquakes* by S. Simon



Student Name: _____ Date: _____

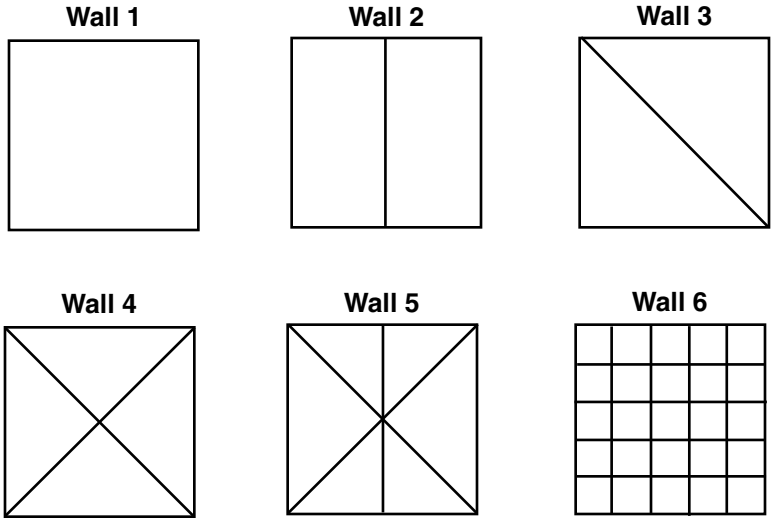
I'm Still Standing

Investigation 1: Building Structure

A major earthquake happened in your area. Many people were injured in tall buildings as a result of the building collapsing. You and your "Seismic Engineering Team" have been selected to conduct research on the construction of buildings and what structural features would help it to withstand the forces of an earthquake.

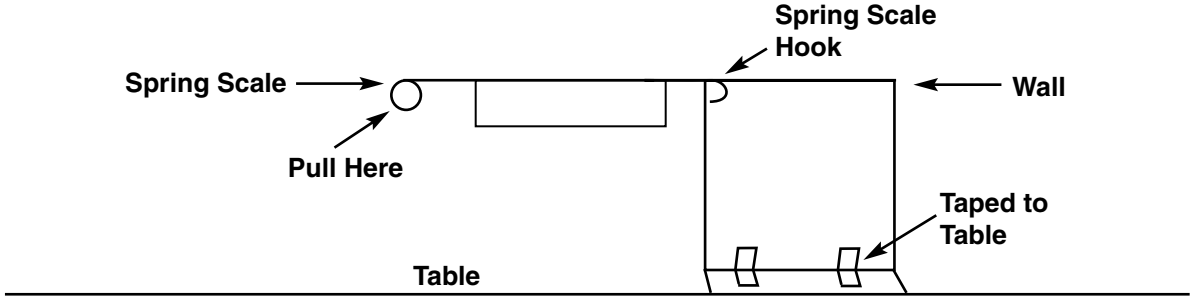
Prediction:

Which wall do you think will be able to hold up to the greatest force as it is applied to one of the top corners? In the table on the next page, record your predictions from 1 to 6 (Note: 1 being the strongest and 6 the weakest).



Construct the first wall as pictured above. Each line represents a Styrofoam stick. The diagonals are the 3 cm x 18 cm sticks; all others are 3 cm x 13 cm sticks. The walls are held together with bolts, washers, and nuts at each joint. Be sure to tighten the bolts.

Each wall will be tested using the spring scale. For your first test, tape Wall 1 tightly to the table. Hook the end of the spring scale to the upper corner of the wall. Hold the spring scale in the horizontal position and gently pull on the end the spring scale that is not attached to the wall (see diagram below).



Observations

Observe what happens as the force is applied to the wall. Record your observations on the data table. Record the applied force when the wall is stressed (as defined by the class). Continue to construct walls 2-5. Apply a force as you did for the first wall, and record all observations on the chart.

Wall 6 is constructed out of frosting and 25 sugar cubes. Spread frosting only on the surfaces you want to stick together. Once the wall is complete, push a toothpick into the frosting between the second and third column so that 1 cm of the toothpick is sticking out. Allow time for drying. Hook the spring scale onto the top of the toothpick to apply the force. Observe and record on the data table.

Wall	Prediction Rank 1-6	Applied Force	Observations
1			
2			
3			
4			
5			
6			

1. Compare your predictions with your actual test results. How close were your predictions to what happened in the investigation?

2. Construct a graph of the applied force observed to stress each wall.

3. What do you think helped the strongest wall to hold up to the greatest force?

4. How would you made the weakest wall stronger?

Student Name: _____ Date: _____

Investigation 2: Engineering Challenge

You and your "Seismic Engineering Team" are now ready to construct a building that may save lives in the event of an earthquake. Your task is to construct a structural model of a building that will withstand the forces applied to it.

Your teacher will discuss the timeline for the planning, construction, and the testing phases of the buildings. All buildings will be constructed using only the materials provided. Your building must be at least _____cm tall and no more than _____cm wide.

All buildings must be attached to the board your teacher will provide.

Phase 1 - Plan

What materials does your group plan to use in the construction of the building? List them.

Record the steps your team will use in order to construct the building. Be sure to use your knowledge of what makes a strong building.

Sketch what your building will look like from the front and from the side.

Front	Side

Explain why you think your team's building design will hold up structurally in an earthquake.

Phase 2 - Build

What materials does your group plan to use in the construction of the building? List them.

Stop! Have the building inspector (your teacher) review your building plan and sign here.

Building Inspector Signature _____

Gather all materials and begin building according to the approved plan.

Phase 3 - Test

Test your building. Record your results using sketches and words.

Explain your results in terms of building design, force applied, and damage.