

**4th Grade adaptation of
Grade Six: Earthquakes and Volcanoes
Lesson 6.11: Earthquake Building/Shaking Contest**

Lesson Concept Damage from an earthquake is dependent on local geology, the magnitude of the earthquake and building construction.

Link The previous lessons established a variety of scales used to measure intensity or location of earthquakes. Lesson 6.11 explores how damage to structures is dependent on magnitude, geology and the building construction. Building construction is one variable that can be controlled by personal action. 6.12 establishes actions one can take to prepare “kits” of supplies for an earthquake.

NGSS

Science and Engineering Practices

4-ESS3-2: Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.

3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Practices

#4 Analyzing and Interpreting Data

- Analyzing data in 3–5 builds on K–2 experiences and progresses to introducing quantitative approaches to collecting data and conducting multiple trials of qualitative observations. When possible and feasible, digital tools should be used.

- Analyze and interpret data to make sense of phenomena using logical reasoning. (4-ESS2-2)

Disciplinary Core Ideas:

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)

ETS1.B: Developing Possible Solutions

- Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)

ETS1.C: Optimizing the Design Solution

- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. (3-5-ETS1-3)

Cross Cutting Concept

#4 System and System Models: Viewing the building structure as a system.

Time 200 minutes (4 days see lesson for suggested break points)

Materials

Whole class

Computer lab – class set of computers or computer screen projected for the whole class.

Three different sized washers

Shake board/table (directions to make shake table are included in Purdue's Earthquake Shaking—Building Contest...download

(<http://web.ics.purdue.edu/~braile/edumod/building/building.htm>)

Videos:

- V1 (Resonance 1 - spag) - http://www.iris.edu/hq/files/programs/education_and_outreach/seismographs_in_schools/docs/14A.Resonance1_Spaghetti.mov
- V2 (Resonance 2 – Manilla) http://www.iris.edu/hq/files/programs/education_and_outreach/seismographs_in_schools/docs/14B.Resonance2_ManillaPaper.mov

- V3 (Resonance 3 – dowel)
http://www.iris.edu/hq/files/programs/education_and_outreach/aotm/videos/Resonance_3_BOSSmodel.mov
- V4 (Building Strength Demo)
http://www.iris.edu/hq/files/programs/education_and_outreach/seismographs_in_schools/docs/13_Building_Strength_Demo_Butler.mov

Per Group (groups of 4)

Set of earthquake damaged photo cards without word labels

Per Group (groups of 2)

3 – 8 x 8 cm paper squares (floors & roof)

8 – 2 x 10 cm paper strips (uprights)

8 – 1½ x 15 cm paper strips (reinforcing)

1 – 20 x 8 cm piece (cut and use as you wish)

100 cm length of scotch tape (plan accordingly...this is all they get!)

scissors and 20 cm ruler

Individual

Make copies of the following worksheets:

- **Pre Lab Worksheet**
- **Earthquake Building – Shaking**
- **Building Testing Recording Sheet**
- **Earthquake – Resistant Structures – After Testing**
- **Earthquake-Resistant Structure- Revised Design**

3 pieces of spaghetti per student (have students break them into three different sizes: short, medium, and tall)

6 raisins each

Advance

Preparation

1. Download Purdue's Earthquake Shaking—Building Contest...

<http://web.ics.purdue.edu/~braile/edumod/building/building.htm>)

2. Construct shake table
3. Download video list above
4. Print and cut out the earthquake photo cards without word labels (1 set per group of 4 students)
5. Cut paper lengths for building structures out of tag board, cardstock or similar weight of paper.
6. Gather spaghetti and raisins
7. View all videos
8. Download the earthquake structure powerpoint from <http://web.ics.purdue.edu/~braile/edumod/building/building.htm> or locate your own photos from the internet or newspaper pictures of damage to buildings for the powerpoint in step 12.

Procedure:

Engage

(Day 1 - 30 minutes) Damage from an earthquake is dependent on local geology, the magnitude of the earthquake, and building construction.

1. Ask students to think, pair, share why they think some buildings collapse in earthquakes and other buildings stay standing or have little damage. Share ideas.
2. Explain to students that they will be working with a partner to design and build their own earthquake resistant structures, but before they do, they will learn about the components for building an earthquake resistant structure.
3. Show students V1 (Resonance 1 - spaghetti) "Modeling Resonance and Building" video
4. Distribute 3 pieces of spaghetti and 6 raisins to each student. Ask students create their own model, break 3 pieces spaghetti into 3 sizes (small, medium and tall) and top each piece with 2 raisins, replicating the model in the video.
5. Instruct students to hold the pieces of spaghetti in one hand and hit them hard towards the bottom. Explain that this is an example of a local earthquake and point out how all the pieces shake.
6. Ask students to shake their model as follows:
 - a. Shake at a low frequency and ask students what did they notice? Which piece of spaghetti shook the most? (the tallest piece of spaghetti)

- b. Shake at a medium frequency and ask students what did they notice? Which piece of spaghetti shook the most? (the middle piece of spaghetti)
 - c. Shake at a high frequency and ask students what did they notice? Which piece of spaghetti shook the most? (the smallest piece of spaghetti)
 - d. Show students V2 (Resonance 2 - Manilla) and V3 (Resonance 3 – dowel)
7. Ask students to think-pair-share how the spaghetti model compares to the manilla folder model and the dowel model.
 8. Ask students: How could these models help you predict what would happen to buildings of different sizes during an earthquake?
 9. Ask students to discuss: What could help us prevent the destruction of buildings during an earthquake? Chart ideas

Explore ***(Day 1 - 20 minutes) Damage from an earthquake is dependent on local geology, the magnitude of the earthquake, and building construction.***

10. Show students V4 (Building Strength Demo). ***If you have the building models made, have the students use the materials to support each floor. Then show the video and have students adjust their supports for each floor to resemble the video model.***
11. Have students fill in the top half of the *Pre-Lab Sheet*.
12. Show students “Earthquake Building Structure” powerpoint and/or real life examples in “Earthquake Damage” powerpoint. To emphasize the practice of Analyzing and Interpretating Data, have students sort the powerpoint photo cards (without structure labels) into groups and explain to their table mates what happened and why prior to viewing the powerpoint. As the powerpoint is viewed (with structure labels), make corrections to card groups.
13. Ask students to work with a partner to sketch a design for their earthquake resistant building. Include ideas you have learned from the powerpoint and videos.

Extend ***(Day 2 - 50 minutes) Damage from an earthquake is dependent on local geology, the magnitude of the earthquake, and building construction.***

14. Distribute *Earthquake Building – Shaking worksheet* and review the materials and the building criteria.
 - a. Building Criteria:
 - At least 20 cm high
 - at least 2 stories high
 - no central post or uprights (leave center of each floor open for weights)
 - materials are limited
 - building must be completed the 2nd day, and tested the 3rd day
15. Ask students to review their structure design from the previous day.
16. Distribute paper materials, tape, scissors, and ruler to each group of students. Ask students to build their structures based on the criteria for the competition.
17. Have students draw their structure on the top of *Earthquake – Resistant Structures – After Testing* worksheet.

Evaluate **(Day 3 - 50 minutes) Damage from an earthquake is dependent on local geology, the magnitude of the earthquake, and building construction.**

18. Ask students to select an order in which team structures will be tested for resistance. List the order on a chart.

Teacher Notes:

- If students did not follow criteria, they are disqualified and structure will not be shaken.
- Depending on size of shake table, more than one building can be tested at a time.
- Be consistent with washer placement and shake time for each group.
- If the building breaks, students are disqualified!

19. Have selected students/teams bring up their structures and tape or clamp the bases to the shake table.
20. Tape or paperclip the smallest washers to each roof/floor of the structure and shake for approximately 10-20 seconds.

21. On *Building Testing Recording Sheet*, ask students to record the results after each shake, being sure to evaluate the type of supports used on each floor and whether the structure remained strong.
22. Repeat steps 20-22 for each group of students/team.
23. Once all structures have been tested, have students use their recorded data to answer questions at the bottom of *Earthquake – Resistant Structures – After Testing* and *Earthquake Building – Shaking* lab sheets.

Extend ***(Day 4 - 50 minutes) Damage from an earthquake is dependent on local geology, the magnitude of the earthquake, and building construction.***

24. Distribute *Earthquake-Resistant Structure - Revised Design* worksheet. Using structure designs discussed the previous day, have students re-design a new structure. Working with a partner, students can sketch a revised design of an earthquake resistant building. including ideas learned from the previous day's testing.
26. As a post-assessment, instruct students to answer the questions at the bottom of the handout using the word bank provided.