

Hazard Literacy Center

Hazard Literacy Education Program

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How Do Buildings Withstand Earthquakes? Building an Earthquake-Resistant Tower



1. Program Overview

This hands-on science program centers on the question, “How do buildings withstand earthquakes?” Students design and construct tower structures using spaghetti and marshmallows, then test their stability through load and vibration experiments. By varying structural shapes, connection methods, load distribution, and center of mass, they analyze which designs are more stable and identify the causes of structural failure. Through the iterative process of designing, testing, analyzing, and improving their structures, students develop an understanding of force transmission, equilibrium, vibration, and structural stability while exploring the importance of earthquake-resistant design. The program also fosters scientific inquiry, engineering design, problem-solving, and collaborative thinking.

Grade Level	Grades4-6	Instructional Methods	Lecture, Discussion, Experiment
Learning Environment	Classroom	Duration	110 minutes (55 minutes × 2 class periods)
Required Materials	spaghetti and marshmallows		

2. Learning Objectives (Hazards Literacy Framework)

① Learn about the distribution of earthquake-prone regions and understand why earthquakes occur frequently in Japan.

② Construct rectangular and truss structures, compare their structural stability, and explore why one structure is stronger than the other.

③ Design and build a strong, earthquake-resistant tower and learn how structural design can help reduce earthquake damage.

Learning Objectives	Knowledge & Understanding		Reasoning & Skills					Values & Attitudes			Psychology & Emotion			Behavioral & Practical Enagement		
	A1	A2	B1	B2	B3	B4	B5	C1	C2	C3	D1	D2	D3	E1	E2	E3
Objective ①	O		O	O												
Objective ②			O	O					O							
Objective ③	O													O		

3. Key Concpets

· Earthquake

· Plate Boundary

· Earthquake-Resistant Design or Seismic Design

· Truss Structure

4. Program Sequence

Learning Activities	
Introduction	·Briefly explain the causes of earthquakes and compare earthquake cases in Japan and Korea to introduce the problem context. ·Share students' ideas on "How can buildings withstand earthquakes?" ·Demonstrate how a rectangular structure deforms into a parallelogram when force is applied to help students recognize structural vulnerability. ·Introduce the need for earthquake-resistant design.
Inquiry 1	·Freely construct tower structures using spaghetti and marshmallows. ·Conduct a load test focusing on rectangular structures to examine their structural characteristics. ·Use a shaking table to observe and record how the structures respond to vibration.
Inquiry 2	·Apply force to a triangular structure and observe its resistance to deformation to compare structural stability. ·Introduce the concept and basic structure of a truss. ·Reinforce existing structures by adding diagonal braces (spaghetti) to create truss structures. ·Add weights to the top or sides of the structures to simulate increased loads. ·Retest the structures using the shaking table, compare the results before and after reinforcement, and present group findings.
Conclusion	·Briefly introduce examples of seismic design applied to real buildings. ·Share and summarize students' ideas for designing safer buildings.

5. Theoretical Background and Activity Design for Disaster Education

Earthquakes are major natural disasters caused by the movement and interaction of tectonic plates and occur particularly frequently along plate boundaries. Although Korea has traditionally been regarded as a region with relatively low seismic activity, the 2016 Gyeongju earthquake and 2017 Pohang earthquake have raised awareness that the country is not entirely safe from earthquakes. The extent of earthquake damage is determined not only by earthquake magnitude but also by various factors, including the structural characteristics of buildings, ground conditions, and urban density. Even earthquakes of similar magnitude can cause very different levels of damage depending on how buildings are designed. Therefore, earthquakes need to be understood as disasters involving both natural processes and human structural responses.

Building collapse occurs when ground vibrations generated by an earthquake are transmitted to structures. Buildings are subjected to repeated shaking, and the vibrations may be amplified or reduced depending on structural shape, materials, and load distribution. For example, rectangular structures can deform relatively easily when external forces are applied, making them less stable, whereas triangular structures are more resistant to deformation and can distribute forces more effectively. In addition, as a structure becomes taller, movement at the upper levels may increase, contributing to a greater risk of structural failure. For these reasons, modern buildings use reinforcement systems such as truss structures and seismic isolation systems, which reduce the transmission of ground motion to the building, to minimize earthquake damage.

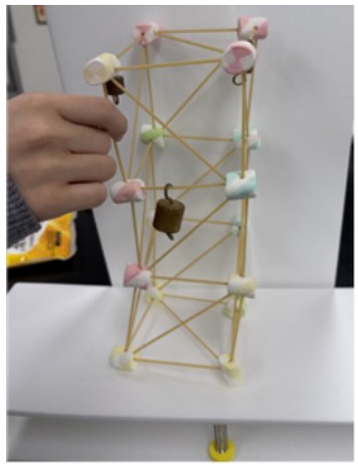

Figure1. Vibration Test of a Spagetti Tower with a Truss Sturcture

The model experiment used in this program (Figure 1) provides a simplified representation of these processes. The structure made of spaghetti and marshmallows represents the structural framework of an actual building, while the weights represent the loads acting on the building. Repeated shaking applied with a shaking table simulates an earthquake, allowing students to observe how the magnitude of movement and patterns of structural failure vary depending on the shape of the structure. In particular, the initial rectangular structure tends to deform and collapse relatively easily, whereas reinforcing it with diagonal braces to form a truss structure with triangular elements improves its structural stability. Through this activity, students learn that earthquake damage is determined not only by natural processes but also by human responses, such as structural design. By directly observing and comparing how different structures deform and collapse, students can understand earthquakes not simply as “sudden and unpredictable events,” but as phenomena in which force transmission, structural stability, and engineering design interact to influence the resulting damage.

6. Instructional Considerations

Teachers should emphasize that structural stability is determined by the interaction of multiple factors, including structural shape, load distribution, material properties, and vibration, rather than by simple explanations such as “it collapses because it shakes.” Open-ended questions such as “Why does a rectangular structure deform easily?” and “Why does diagonal bracing make it more stable?” can encourage students to explain their observations scientifically and identify ways to improve failed structures. Because spaghetti structures can break easily, teachers should provide safety instructions and carefully supervise the use of the shaking table. Finally, the activity should be connected to real-world earthquake-resistant design, emphasizing that although earthquakes cannot be prevented, their impacts can be reduced through appropriate structural design.

7. References

- Nam, M., Park, S., & Jung, E. (2018). A Study on Continuous Exposure Plan of Earthquake Safety Manuals - Focusing on Improving the Information Accessibility of Adults -. Journal of the Korean Society Design Culture, 24(3), 215-229.
- Park, J., & Son, J. (2020). A Study on the Revitalization Plans According to the Status of Operations in Leading Preliminary Gifted Education Schools. Journal of Gifted/Talented Education, 30(2), 113-137.

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Theme	Earthquake and building structure
What Will We Learn?	①Learn about the distribution of earthquake-prone regions and understand why earthquakes occur frequently in Japan. ②Construct rectangular and truss structures, compare their structural stability, and explore why one structure is stronger than the other. ③Design and build a strong, earthquake-resistant tower and learn how structural design can help reduce earthquake damage.

1 Let's Think

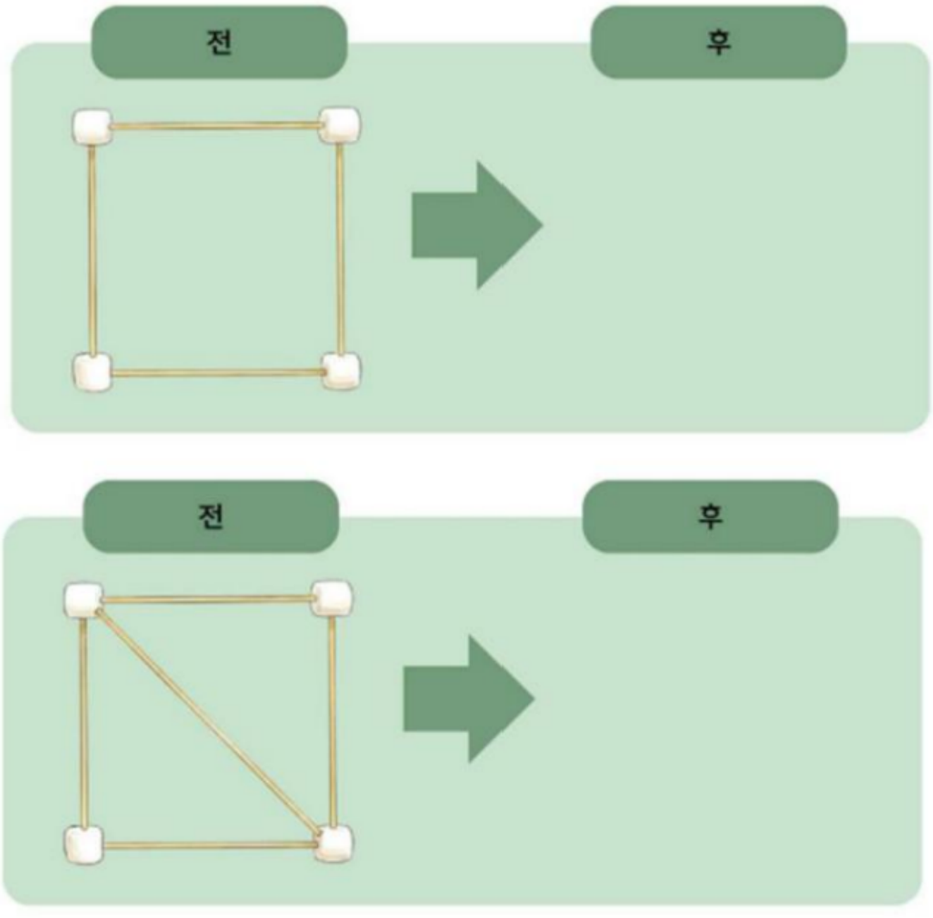
Earthquakes occur less frequently in Korea than in Japan. Why do you think this is?



The Earth's surface is made up of several [ ]. Earthquakes occur when energy builds up and is suddenly released at [ ], where these plates collide with or push against each other, causing the ground to shake.

2 Think in advance

- What shape will a rectangular structure become when force is applied to its diagonal corners?



3 Activity 1

Building a Tower with Rectangular Structures

- Materials: Spaghetti, marshmallows
- Mission: Using only the materials provided, work with your group to build a tower made of rectangular structures within 20 minutes. The base and all sides of the tower must be rectangular, and the tower must be able to stand on its own without being held.

- Place all the towers on the shaking table and apply the same vibration. Observe which tower remains standing the longest.

- How did your tower's movement change as the shaking continued? Draw your group's tower and circle the parts that shook the most.

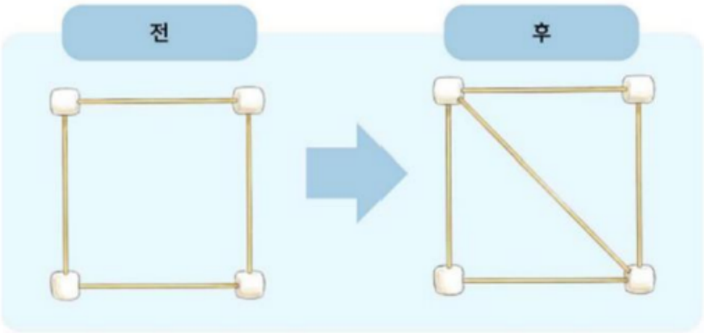
- Draw your group's tower and circle the parts that shook the most.

4 Activity 2

Building a Tower with Truss Structures

- Materials: Spaghetti, marshmallows
- Mission: Each group should use only the provided materials to build a truss-structure tower within 20 minutes. The tower must be able to stand on its own without any support.

- Place the improved tower back on the shaking table and compare it with the tower from Activity 1.



- How did adding diagonal braces to the square structure of your tower change the way it shook?

- Draw your group's tower.

- The Secrets of Earthquake-Resistant Design



Bridge



Roof



Centre Pompidou

When a diagonal brace is added to a square, a [ ] is formed. This shape does not easily change even when force is applied, making it strong and stable. This type of structure, commonly used in bridges, towers, and roofs, is called a [ ] structure.

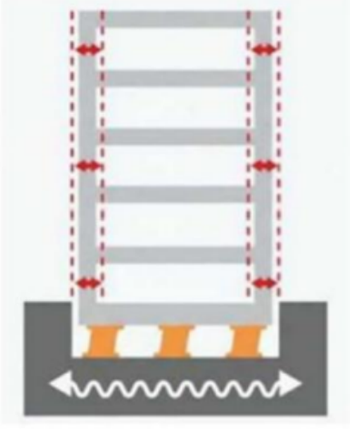
- Add weights to your group's tower. How well did the tower support the added weight?

- Compared with the other groups' towers, what was unique about your group's tower?

5 Activity 3

Exploring Base Isolation Structures

Find and circle the correct words to describe what a base isolation structure is.





It is one type of design that helps buildings withstand earthquake vibrations. Devices such as rubber pads or bearings are installed between the building and the ground to make the building shake [less / more]. This structure [reduces / increases] the transmission of earthquake vibrations.

- What is something new you learned today?