Soil Types and Building Stability on a Shaker Table
2025 NHERI Summer Institute Lesson Plan
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Subject:
Stem Science 6th grade

Associated Unit:
Earth Systems

Grade level:
6th grade

Time required:
2x 45-minute classes

Summary:

- Identify three common soil types: sand, clay, and silt.
- Understand how soil type affects building stability during shaking (simulated earthquake).
- Develop observational and analytical skills by testing model buildings on different soils using a shaker table.

Engineering Connection
NGSS MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future events.

Engineering Design:

Test and improve a solution to a problem.

Engineering Category:
Developing and Using Models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies,

and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineering systems. Measurements and observations are used to revise models and designs.

Keywords:

- Soil Types
- Sand
- Clay
- Silt
- Soil Properties
- Grain Size
- Moisture Content
- Soil Compaction
- Liquefaction
- Building Integrity
- Shaker Table
- Earthquake Simulation
- Foundation
- Structural Stability
- Observation
- Hypothesis
- Experiment
- Data Collection
- Measurement
- Natural Hazards
- Engineering Design
- Soil Drainage
- Soil Texture
- Soil Density
- Earthquake Safety
- Soil Erosion

Educational Standards:

Texas SEP 2

Learning Objectives:

- Identify three common soil types: sand, clay, and silt.
- Understand how soil type affects building stability during shaking (simulated earthquake).

- Develop observational and analytical skills by testing model buildings on different soils using a shaker table.

Lesson Background

- The Role of Soil in Building Stability

  When an earthquake strikes, the shaking of the ground can have vastly different effects depending on the type of soil beneath a structure. This is because soils vary in how they transmit seismic waves, absorb energy, and retain moisture—all of which influence whether buildings stay standing or collapse.

- Common Soil Types:
  1. Sand
     - Made of small, loose particles.
     - Drains well but doesn't stick together well.
     - When shaken, especially if water is present, sand can behave like a liquid—a phenomenon called liquefaction.
     - Buildings on sandy soil may sink or tilt during earthquakes.

  2. Clay
     - Very fine particles that hold water tightly.
     - Can be very stable when dry, but when saturated with water, it becomes slippery and weak.
     - During shaking, clay can also liquefy and lose strength, especially in deep layers.
     - Buildings on clay may shift or slide.

  3. Gravel
     - Larger, coarse particles that compact well and allow water to drain quickly.
     - Generally considered more stable during earthquakes.
     - Gravel resists liquefaction and provides a solid foundation for buildings.

- Shake Tables in Engineering

  Engineers use shake tables to model earthquake forces and test how buildings respond to them. These devices simulate ground movement so that engineers can experiment with:

  - Building shapes and materials
  - Soil conditions

- Reinforcement techniques

Shake table tests help us design safer buildings in earthquake-prone areas.

- Why This Matters in the Real World

  Major earthquake damage often occurs not just because of poor building materials, but because of the ground beneath buildings. For example:

  - In the 1989 Loma Prieta Earthquake (San Francisco), soft, sandy soil amplified the shaking and caused major structural failures.
  - In contrast, buildings on bedrock or well-compacted gravel fared much better.

  Civil engineers and city planners must carefully study soil conditions before construction to determine what kind of foundation and support buildings need.

Introduction

When an earthquake strikes, the shaking of the ground can have vastly different effects depending on the type of soil beneath a structure. This is because soils vary in how they transmit seismic waves, absorb energy, and retain moisture—all of which influence whether buildings stay standing or collapse.

Vocabulary/Definitions:

- Earthquake
- Shake table
- Soil composition
- Liquefaction
- Stability
- Engineering design process

Associated Activities

Day 1 Activities:

1. Engage (10 mins):

- Show a short video of buildings during an earthquake.
- Ask: *"Why do some buildings fall while others survive?"*
- Introduce the idea that the type of ground beneath a building matters.

2. Explore (25 mins):

- Students rotate through soil stations to examine texture and discuss characteristics (drainage, compactness).
- Introduce the challenge:
  Design and build a structure that can survive an earthquake on all three soil types.

3. Explain (10 mins):

- Teacher introduces basic soil science:
  - Sand = drains well, loose
  - Clay = retains water, can liquefy
  - Gravel = coarse and strong
- Show how the shake table simulates earthquake motion.

Day 2 Activities:

1. Build & Test (30 mins):

- Each group builds one mini structure.
- Place the same structure on each soil type (in the containers on the shake table).
- Shake for 10 seconds at a consistent rhythm/intensity.
- Observe and record:
  - How much the building tilted or fell?
  - How did the soil behave?

- Repeat 3 times for each soil type.

2. Analyze (10 mins):

- Students compare results and discuss:
    - Which soil type caused the most damage?
    - Why?
    - How could buildings be designed differently for poor soil?

3. Reflect & Conclude (5 mins):

- Groups share findings with the class.
- Discuss real-world applications in civil engineering and urban planning.

Materials needed per group:

For Each Group:

- Shake table (homemade or purchased)
- 3 clear plastic containers or trays
- Soil samples:
    - Sand
    - Clay (or modeling clay/mud mixture)
    - Gravel or small pebbles
- Water spray bottle (to slightly moisten soil if needed)
- Mini building materials:
    - Toothpicks, marshmallows OR
    - LEGO bricks OR
    - Mini wooden blocks
- Rulers
- Stopwatch
- Lab worksheet for observations
- Goggles (safety first!)

Assessment:

Students will be assessed on:

- Participation and collaboration during activities
- Completion of the lab worksheet with observations and analysis
- A short-written response:
  "If you were an engineer building in an earthquake-prone area, which soil would you avoid and why?"