STEM Connections

Earthquake-Resistant Structures

Below are ideas for connecting earthquake-resistant structures to STEM concepts and principles. For more ideas and detailed STEM lessons, consult the *Earthquake Towers Teacher's Guide*.

ACTIVITY OVERVIEW

Students design and build balsa towers to be resistant to earthquakes. Towers are constructed from balsa wood and precut floor plates that simulate the floors within a tower structure and can be used to add loading to one or more floors of the towers via large washers.

SCIENCE

Developing and Using Models

Have students brainstorm ideas for minimizing earthquake damage in a four-story tower. These ideas are mental models, providing a framework for development of conceptual (real-world) models that can provide both qualitative and quantitative data for students to analyze.

Students should sketch three or four of what they consider to be their best ideas and then choose one to construct.

The student towers can be tested on a shake table, such as the Pitsco EQ^S (earthquake simulator), or on the Pitsco myQuake, which uses data acquisition through National Instruments' myDAQ module.

Students should record both visual observations and any empirical data if using the myQuake. Students can vary the shake frequency and observe the frequency at which the building reaches its resonant frequency – its most destructive shaking point.

Students can rotate the towers 90 degrees to determine if the towers' strength is directional – usually dependent upon the diagonal bracing and construction techniques. Students can also load the floors of the towers with washers, documenting observations with various loading strategies.

ENGINEERING

Iterative Design Process

Iterative design is a process that engineers follow to modify or improve a product. The process is typically in the form of a design loop – a step-by-step procedure usually involving the following:

- Formulate the idea.
- Determine specifications (a Design Brief).
- Research the topic.
- Brainstorm possible solutions.
- Formulate a solution to implement.
- Prototype or model the solution.
- Test and analyze the solution.
- Redesign or improve the solution.
- Continue back through the loop until the design is complete.

Each loop through the process is an iteration.

Students begin with a simple design of a four-floor balsa tower with little or no diagonal bracing. They test the tower using the Pitsco myQuake and National Instruments' myDAQ to provide data to analyze the structure's response to the shaking.

Iterations of the design will involve the addition of bracing, and students will document both qualitative and quantitative data for each iteration.

TECHNOLOGY

Data Acquisition

Have students brainstorm ideas for minimizing earthquake damage in a four-story tower. These ideas are mental models, providing a framework for development of conceptual (real-world) models that can provide both qualitative and quantitative data for students to analyze.

Students should sketch three or four of what they consider to be their best ideas and then choose one to construct.

The student towers are tested on the myQuake shake table that uses data acquisition through National Instruments' myDAQ module. The acceleration sensors that come with the myQuake can be placed on various floors of the towers, usually one sensor is placed at the bottom of the towers to provide baseline frequency and acceleration data.

Students should record both visual observations and empirical data from using the myQuake. Students can vary the shake frequency and observe the frequency at which the building reaches its resonant frequency – its most destructive shaking point.

Students can rotate the towers 90 degrees to determine if their towers' strength is directional. Students can also load the floors of the towers with washers, documenting observations and data with various loading strategies.

MATH

Represent and Model with Vector Quantities

Vector quantities can sometimes be a difficult concept for students to visualize or connect with a real-world application. However, in nearly every common structure, force vectors are hard at work.

In the context of earthquake-resistant structures, students can physically model a tower design (specifically focusing on the diagonal bracing within the tower) and obtain empirical data by using the Pitsco myQuake shake table in conjunction with the myDAQ data acquisition module from National Instruments.

Students can work in teams to build towers that have diagonal bracing. Each team can build with bracing at a different angle than other teams, or they can build a series of towers with bracing at different angles.

The brace provides a visual of the force vector at work in the diagonal brace – and can be broken into its x, y component vectors to determine the relative amount of force being transferred through the brace in the x and y directions.

By comparing forces measured by the myDAQ sensors on towers with differing brace angles, students can see the difference in transmission of those forces through the braces and determine the physical effect from the change in bracing angle.

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