just in case arizona™

Structure Design

Did you ever notice that after an earthquake some structures have a lot of damage while others have little? There are different factors that affect how structures perform during an earthquake.

Important Design Considerations

When you design buildings, there are a number of factors you need to consider:

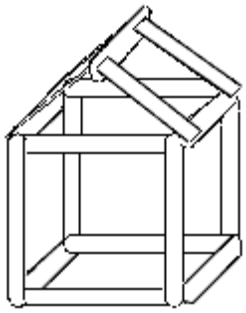
- Shape of the building: different shaped buildings behave differently. Geometric shapes such as a square or rectangle usually perform better than buildings in the shape of an L, T, U, H, +, O, or a combination of these.
- Various materials used to construct the building(s) can be used (alone or in combination): steel, concrete, wood, brick. Concrete is the most widely used construction material in the world. It is comprised of sand, gravel, and crushed stone, held together with cement. Each material behaves differently. Ductile materials perform better than brittle ones.
- Examples of ductile materials include steel and aluminum.
- Examples of brittle materials include brick, stone and unstrengthened concrete.
- Height of the building, different heights shake at different frequencies.
- Soil beneath the building.
- Regional topography.
- Magnitude and duration of the earthquake.
- Direction and frequency of shaking.
- The number of earthquakes the building has previously had and the kinds of damage suffered, if any.
- Intended function of the building (e.g. hospital, fire station, office building).
- Proximity to other buildings.

What Can You Learn by Constructing Buildings?

- The effect of the different variables on building performance during a simulated earthquake.
- Ways to strengthen the buildings
- What physical forces are at work during an earthquake.

Making Wood Frame Structures

Materials:



- popsicle sticks
- clay
- styrofoam piece
- a shake table for testing

Procedure:

- Construct one or two story frame buildings using popsicle sticks with clay for jointing.
- Let the building sit until the clay is cool and stiff.
- If desired, use the styrofoam piece to make a foundation for the building. Cut the styrofoam the same size as the external perimeter of the house with a cutout for a basement.
- Try setting the building on the styrofoam or fastening the building to the styrofoam with clips, tacks, or an adhesive.
- Test your model structure, like engineers often do, on a shake table or seismic simulation equipment to see how it performs during a simulated earthquake.

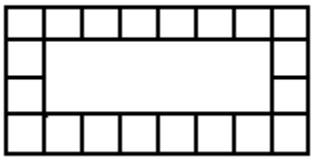
Strengthening Your Building:

Try cross or diagonal bracing to further stabilize your building. Cross-bracing means you put in vertical "X' shaped braces between the popsicle stick walls.

Try different materials for your cross braces and see which works best: popsicle sticks, kite string, straws.

Simulating Masonry (Brick, Stone or Adobe Structures)

Materials:



- sugar cubes (1 box per structure)
- peanut butter, frosting or doublesided tape
- piece of Styrofoam, cardboard and aluminum window screen scraps

Procedure:

- Construct one and two story rectangle and L-shaped buildings on Styrofoam bases, using sugar cubes for bricks, cardboard for the floor and roof, peanut butter, and frosting or double-sided tape for mortar.
- Try setting the building on the Styrofoam or somehow connecting it to the Styrofoam.
- Test your model structures on shake tables to see how they perform during a simulated earthquake.
- Which are more stable, one or two story structures? How did the right angle in the L-shaped building effect the stability of the structure?

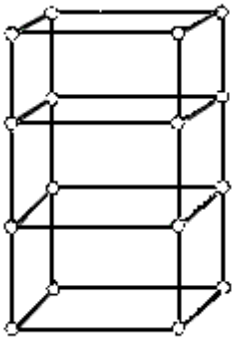
Strengthening Your Building:

Carefully cut pieces of screen smaller than the size of each of the walls. Spread a very thin layer of peanut butter or frosting on each screen and carefully attach the screen to each of the inside walls of the first story. Reinforce the corners with extra peanut butter from inside.

This is a model of a one story reinforced masonry structure. Try different sized screen fine and widely spaced. How do the buildings respond now when shaken?

Steel Frame Structures

Materials:



- Pipe cleaners
- T-pins
- Styrofoam piece
- cardboard/ paper pieces (optional)

Procedure:

- Construct a model of a modern high-rise steel framed city building using pipe cleaners.

- Bend the end of one pipe cleaner around the end of the other. Do not twist the ends together.
- Attach each model to a Styrofoam base with T-pins.
- Test it on a shake table to see how it performs during a simulated earthquake.

Adding the Walls:

A steel frame structure looks sort of like a jungle gym. However, the finished building has walls and windows. Make cardboard or paper walls and add them to your structure. How does it perform on the shake table? Try other materials for the walls and cross-bracing to strengthen the structure.

Additional Resources:

- Levy, M., & Salvadori, M. (1992). Why buildings fall down: How structures fail. NY: W. W. Norton.
- Salvadori, M. (1990). The art of construction: Projects and principles for beginning engineers and architects. Chicago: Chicago Review Press.
- Steinbrugge, K. V. (1982). Earthquakes volcanoes, and tsunamis: An anatomy of hazards. NY: Skandia America Group.

Models developed by: Gary Dargush, Kathy Donnatin, Donna Lico and Tori Zobel.

(Source: Multidisciplinary Center for Earthquake Engineering Research (MCEER), http://mceer.buffalo.edu)