

Shake Table Investigation

Natural Disasters
Mr. Ling

Name _____

Team _____

On Saturday, April 20, 2002, a magnitude 5.1 earthquake struck a remote region near Clintonville, New York in the Adirondack Park. Figure 1 shows a huge rockslide that resulted on Hogback Mt. Some of the huge boulders, such as the one in Figure 2, tumbled down the mountainside, snapping off only the tops of trees as they bounced. Extensive damage occurred to masonry chimneys, foundations and buildings in nearby towns. Damage in Ausable Forks was so extensive that numerous buildings, including the one shown in Fig. 3, had to be demolished.



Figure 1 - the rockslide on Hogback Mt. near Clintonville, NY

The severity of an earthquake disaster results from numerous factors, including the magnitude, depth and distance of the earthquake, the composition, structure and saturation of local bedrock and soils, and the design, materials and construction of manmade

structures. In this investigation, you will use a simple shake table to compare damage that might occur to structures with standard rectilinear construction, versus cross-braced and pyramidal designs.



Figure 2 - a boulder in the talus pile at the foot of Hogback Mt.

PROBLEM: In this investigation, your team will test the effects of structural design on the magnitude of damage to built structures.

MATERIALS: shake table (large base board, small foundation board, 6 large rubber bands, 4 rubber balls, square metal pan, 2 c-clamps, 4 neodymium magnets), newspaper, wooden construction sticks, mini-marshmallows, weights, metric ruler, graphing software

NOTE: no wood chips or other materials should get into the sinks. After picking up your work area, all such materials should be cleaned up.

PROCEDURE:

- A. Construct at least 2 structures** - all structures must be built to fit into the 4 neodymium magnets, must have a square-shaped base footprint / cross-section measuring 3-4 cm per side, and must be *at least* 6 times as tall as wide (at least 6 stories tall). Use marshmallows to connect the toothpicks. Please be careful not to get marshmallow on the magnets, nor lose them.
1. lay down newspaper beneath all your work!
 2. **First day:** build a rectilinear structure(s) (no cross-bracing). [cont. on other side]



Figure 3 - severe structural damage to a masonry building in Ausable Forks, NY

3. **Second Day:** build trapezoidally trussed structure(s) - similar to #1 (same size, design, materials, etc.) but using diagonal cross-bracing. If the toothpicks just poke through the marshmallows, the diagonal cross bracing should reach both diagonal corner marshmallows. Or, you can use shorter (broken) toothpicks for the rectilinear pieces and whole toothpicks for the diagonals.
4. If there is time, other structures can be built using pyramidal design or more cross-bracing.

B. Construct the shake table

1. center the square pan on the large base board
2. wrap the rubber bands around both the pan and the board (the narrow dimension)
3. place the 4 balls between the board and pan; arrange in a square pattern near center
4. straighten the bands and remove any twists
5. clamp diagonally opposite corners of the base board to a corner of the lab table - DO NOT OVERTIGHTEN - IT WILL DAMAGE THE BOARD!

C. **HYPOTHESIS:** State a testable hypothesis, describing the effect of using rectilinear (square) versus trapezoidal (cross-braced) structural designs, on the magnitude of damage likely to result.

D. Earthquake simulation

1. Using the 4 neodymium magnets, attach the rectilinear structure to the center of the pan. Please be careful not to get marshmallow on the magnets.
2. pull the metal pan diagonally back ($\sim 45^\circ$) 3cm. Wait until all motion stops.
3. note any structural damage.
4. repeat steps 1-3 as many times as possible, but now use a 4 cm distance, and repeat by increasing the distances by 1 cm each time until structural failure. Note the displacement that produced structural failure
5. If the structures prove to be very strong, try attaching the weight toward the top.
6. repeat steps 1-4 using the trapezoidal truss structure.
7. clean-up: Retain the unused marshmallows for other classes
8. dispose of the used marshmallows
9. reclaim all unbroken toothpick materials so they can be re-used.
10. return all supplies in a *clean and dry* condition.
11. clean up your entire work area.

CONCLUSION: