

# BRACE YOURSELF

What can keep a simple structure from collapsing during an earthquake?

**Curriculum topics**

- Structures
- Vibration/Waves
- Earthquakes
- Engineering/Design

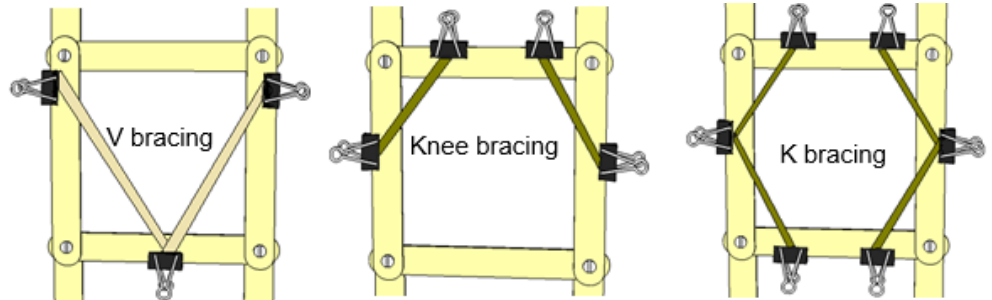
**Subjects**

- Science
- Engineering

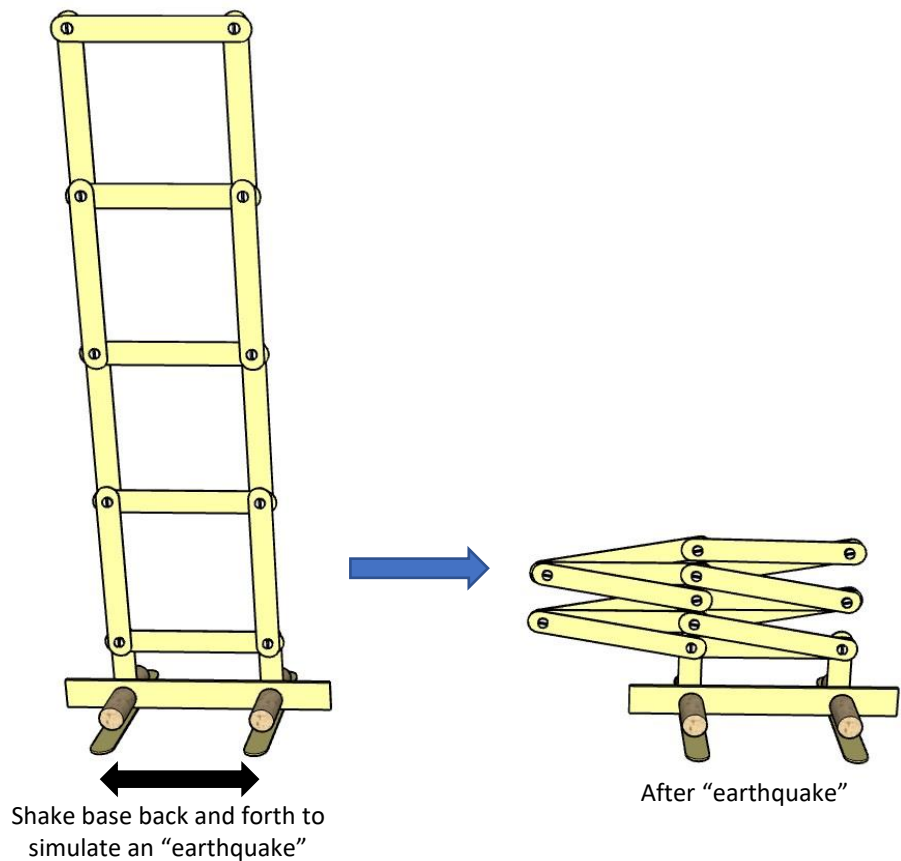
**Grade range:** 6 – 8

**Serves:** Each kit can be used by 1-4 students at a time, individually or in small group collaboration depending on the intended outcomes.

**Who we are:** Resource Area for Teaching (RAFT) helps transform the learning experience by inspiring joy through hands-on learning



How will an earthquake, simulated by shaking, affect a “building” made of linked squares? How can the square “stories” be cross-braced to prevent the “walls” from collapsing? What dangers are there in building above a garage? Learn the answers to these questions and more by working with this kit!



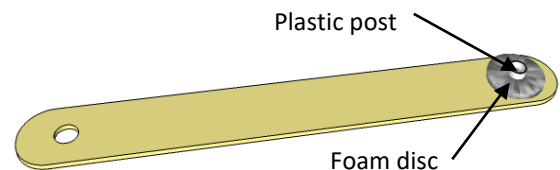
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<http://bit.ly/RAFTkitsurvey>

# Materials

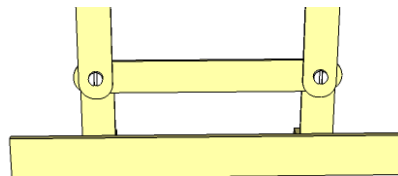
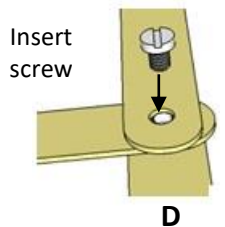
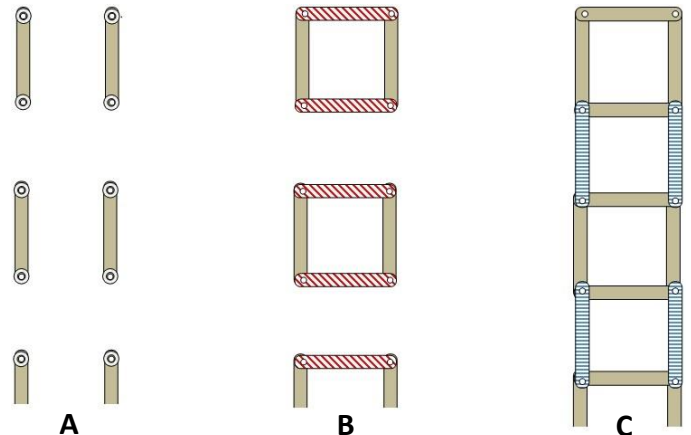
Materials in the kit may vary but generally, this kit contains the following:

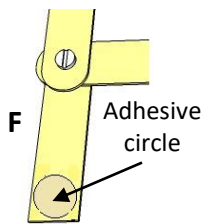
- Foam discs w/ center hole,  $\frac{3}{4}$ " x  $\frac{1}{4}$ " (10)
- Jumbo craft sticks with  $\frac{1}{4}$ " holes on ends, spaced 5" apart (13)
- Jumbo craft sticks, no holes (2)
- Jumbo craft stick halves with  $\frac{1}{4}$ " holes (4)
- Adhesive circles, double sided,  $\frac{3}{4}$ " (6)
- Paint stick, 9" long (1)
- Corks (4) or 1" wooden cubes (4)
- Post & screw, plastic,  $\frac{1}{4}$ " tall (10 pairs)
- Binder clips, small (12)
- Bracing materials: folder strips, regular craft sticks, coffee stir sticks

## Build It



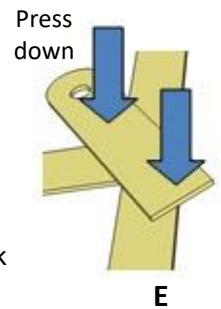
- 1** Creating the Framework: Enlarge the center hole of a foam disc by sliding it onto a pencil. Repeat for the remaining foam discs.
- 2** Sandwich a jumbo craft stick (with holes) between a plastic post (not the screw part) and a foam disc (see above). Repeat for 3 more jumbo craft sticks and 2 half craft sticks.
- 3** Arrange the jumbo craft sticks and half craft sticks on a flat surface as shown in (A) below.
- 4** Lay 5 jumbo craft sticks (with holes) horizontally as shown in (B) below. Position the holes in the crafts sticks over the plastic posts.
- 5** Lay 4 jumbo craft sticks (with holes) vertically, connecting the 3 sections as shown in (C) below. Position the holes in the craft sticks over the plastic posts.
- 6** For each of the 10 post-craft stick junctions, in turn:
  - 1) Insert a plastic screw partway into the hole in the plastic post (D).
  - 2) Place the middle of a half craft stick over the screw head.
  - 3) Press down on the half craft stick to force the screw into the post (E).
- 7** Peel the backing from an adhesive circle, place near the cut edge of the craft stick with adhesive side facing downward and press firmly (F). Repeat for the other half craft stick.
- 8** Peel the remaining backing from both adhesive circles. Align and center the bottom edge of the paint stick with the bottom edges of the half craft sticks as shown in (G). Press firmly.





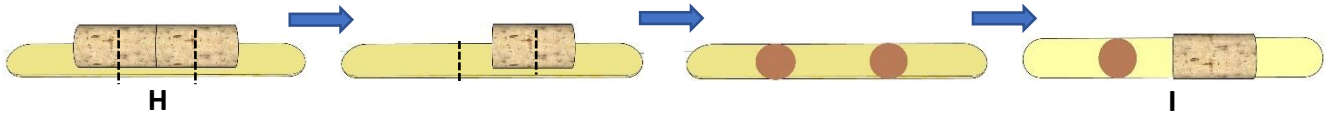
**G**

Paint stick



**9**

**Creating the two stands:** For the first stand, center two corks horizontally on a jumbo craft stick (no holes). Use a pencil to mark the middle of each cork on the jumbo craft stick (**H**). Remove the corks and set them aside. **Note:** Wooden cubes (1") can be used in place of corks.

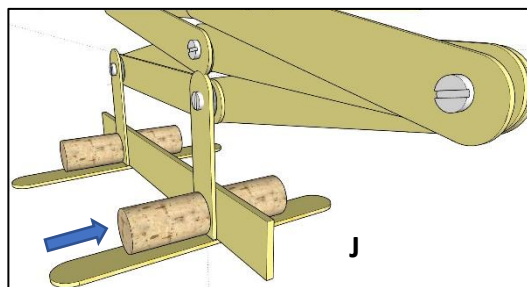
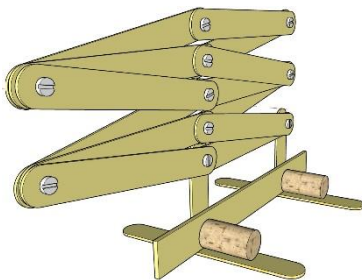


**10**

Peel the backing from 2 adhesive circles and adhere the circles to the jumbo craft stick on the pencil marks. Peel the remaining backing from one of these circles and attach a cork to it horizontally (**I**).

**11**

Collapse the framework accordion-style and press the framework's paint stick next to the cork on the jumbo craft stick. Peel off the adhesive circle backing on the craft stick. Adhere the other cork to the adhesive circle so it presses firmly against the framework paint stick (**J**). Repeat for the second stand.



**Note:**

If you have rubber bands, they can be wrapped twice around the corks and craft stick for a more secure hold.

## To Do and Notice

**1**

Set the framework in its stands and pull on the top to create a 4 story "building". The posts and screws should be just tight enough so the building will stay standing when released. If the building does not stay upright use the remaining 2 half-craft sticks as screwdrivers to tighten the joints.

**2**

Give the paint stick a gentle back and forth motion, along the long dimension to simulate the shaking due to an earthquake. Increase the shaking speed until the building collapses. If the building does not collapse, unscrew joints until it will reliably collapse with enough shaking

**3**

Use folder strips and binder clips to model flexible bracing. Use different methods for each story of the building while leaving the top story unchanged to use as a control. Shake the paint stick until the top story collapses and observe the other stories. Repeat until the top story collapses at least once to the left and once to the right, to check how effective the bracing is for both directions.

**4**

Replace the folder strips with narrow craft sticks to model rigid bracing and repeat the step above. Continue exploring the common bracing systems of "K", Knee, "V", and inverted "V" (see page 1).

**5**

If you have the shake table kit, use it to test the framework with the various bracing methods above. Make a note the most effective bracing pattern and materials.

**6**

Share your learning with RAFT! Submit photos/video via email at [education@raft.net](mailto:education@raft.net) or social media ([Facebook](#), [Twitter](#), [Instagram](#)).

## Core Content Skills:

### Science & Engineering (NGSS)

Natural Hazards, Patterns, Analyzing and Interpreting Data, Planning and Conducting Investigations, Stability & Change, Developing and Using Models, Developing Possible Solutions, Optimizing the Design Solution

### CCSS Mathematics

Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems.

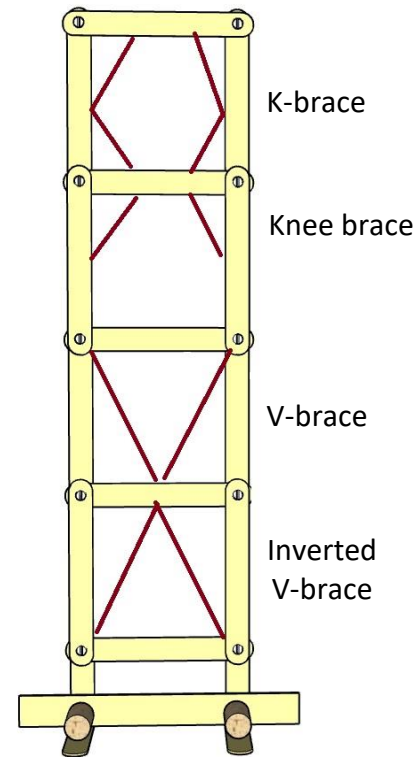
### Social Emotional Learning

- Self-awareness
- Self-management
- Responsible decision-making

# The Content Behind the Activity

Structures are formed by joining rigid (stiff) beams (such as toothpicks, straws, and craft sticks) into an assembled frame. A square can be made by joining 4 beams together at the ends. Pushing on the sides of a square can easily cause the square to deform as the force is focused on the joints – usually the weakest parts. With a triangular shape a pushing force causes the joints to be pushed together so the force is resisted mainly by the stiffness of the sides of the triangle.

How can rectangular shaped living spaces, with walls having large rectangular window openings, be kept from collapsing? One way is to include angled beams in such a way as to form smaller triangular shapes. These angled **braces** are added to square outlines to resist the potentially collapsing forces due to the wind, a high roof load, or earthquakes. There are different bracing methods that structural engineers often use: **knee bracing**, **V-bracing**, **inverted V-bracing**, and **K-bracing** (see images on page 1). These methods are often used in combination depending on the level of structural integrity to be achieved and other factors such as structure height, composition of the ground underneath the structure, and seismic activity in the area.



## Reuse

This kit uses 100% reusable materials designed for other uses. To continue making a positive impact in reducing waste, reuse these materials in other projects. Additionally, any unused materials can be collected and delivered back to RAFT.

## Feedback

Please comment on this kit by taking this short survey: <http://bit.ly/RAFTkitsurvey>. Let us know of any material concerns such as missing, broken, or poorly fitting parts as well as improvements or other suggestions.

Visit <https://raft.net> to view related activities!

Foam Faults  
Shake Table (unmotorized)  
Motorized Shake Table  
Talents of Triangles  
Your Room in an Earthquake

## Resources

- Additional at-home bracing exploration - <https://bit.ly/3H8WDka>
- Extensive info on earthquake effects and bracing - <https://bit.ly/3D69m4L>