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The Support Challenge

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By far, I have used this classroom challenge the most, always with fun results. My student participants generally ranged from 8th through 12th grades. Often, girl teams did better than boy teams. I have also given this challenge to teachers during in-service workshops I have conducted.

What you will need:

- Copy machine paper
- Scissors
- Tape
- Ruler
- Pencil
- Heavy history (or other) textbooks

Getting Started

This team activity is best served with four to five members per team. Make sure to divide your students into equally balanced teams with both head and hand learners on each team so they can learn from each other.

It's a simple design challenge I give . . .

> "Each team may do whatever they want to a single sheet of paper, just so long as it supports their history book one inch off the table."

After I issue my challenge, I also add quite casually . . .

> "I wonder how good these teams are, as my best team from another school holds the record of having 40 very heavy history books supported by a single sheet of paper."

Taking Paper Columns Even Further

What you will need:

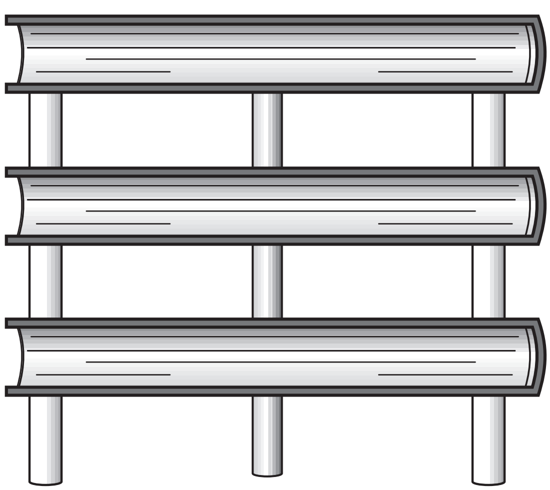
- Copy machine paper
- Scissors
- Ruler
- Pencil
- Tape
- Heavy history (or other) textbooks

Let's squeeze out another lesson from those little columns of paper.

Make a bunch of one-inch paper columns as we did in the previous exercise, maybe 20 or 30. Then, on the floor, stand six columns in the same pattern as the previous exercise (one for each corner of the book and two in the middle) and lay only one big history book atop the little columns.

Then, on top of the supported history book, place another pattern of six columns and put another history book atop that. Repeat this for a total of four or five alternating layers of columns and books.

This looks just like a high-rise office building without its glass and steel shell, but there is a very important difference. Gently push or tap this column-book structure you have built – push it at the first supported book. Notice how the whole structure wiggles and wobbles, maybe dangerously, so that some of the paper supports let go and the whole thing comes down.



This is basically a very wobbly structure. Floors and pillars are not tied together.

What's wrong?

Our little structure lacks rigidity. Imagine such a fragile structure in an earthquake where the ground rattles and shifts, accelerating in maybe one or two directions. The whole thing would be a messy pile of building debris in very short order. Obviously, this is not the way we build large structures. Again, what is wrong?

To introduce rigidity into structures, we tie all the columns and floor supports together into a giant grid of steel, making the structure stiff in three dimensions. We do not place new support columns for the next floor directly on top of the floor below. The columns penetrate the floors and are tied together into a system of vertical

Thinking Like Engineers

In the last chapter, we talked about the need to make buildings somewhat rigid by tying their walls and floors together into a tight framework or skeleton. You can see this in an everyday paper object we find in most homes. It's a milk carton, with waxed paperboard strong enough to allow us to carry milk around. This stiff paper structure can be used for a variety of classroom demonstrations.

What you will need:

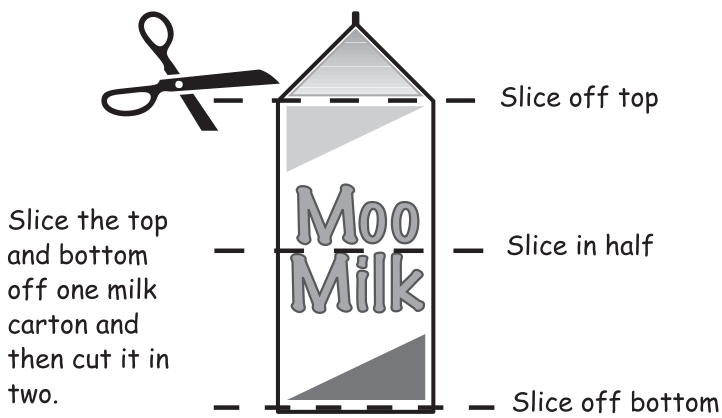
- 8 paper milk cartons. (More will be needed if you wish to conduct team activities.)
- Scissors or utility knife
- Ruler
- Books
- Piece of plywood about 3' x 3'

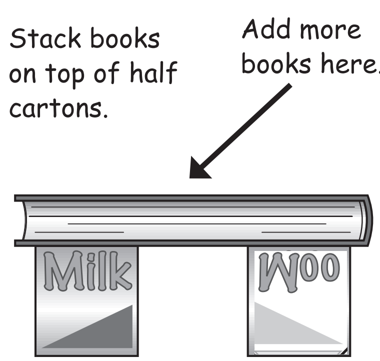
First Experiment

Take a used milk carton, clean it thoroughly with fresh water, and cut off the top and bottom. Then, cut the cylinder into two exact halves.

Place each half, open ends facing up and down, on a table and place a book across both milk carton sections to form a base.

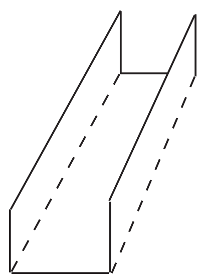
Repeat the Support Challenge (Activity 1), this time noting how much more weight can be supported on the milk cartons than on the paper cylinders. A milk carton is very strong when placed on edge. It might even be able to support a student standing on a board across the two milk carton sections – be careful here.





Taking Data on a Paper Bridge

Make a chart. Add five pennies at a time and then measure the amount of deflection. Then add five pennies more each time and always record the deflection. Do this until 25 pennies are placed on the bridge deck and you have five corresponding measures of the deflection. You can easily stack all 25 pennies in one pile in the center of the paper deck.



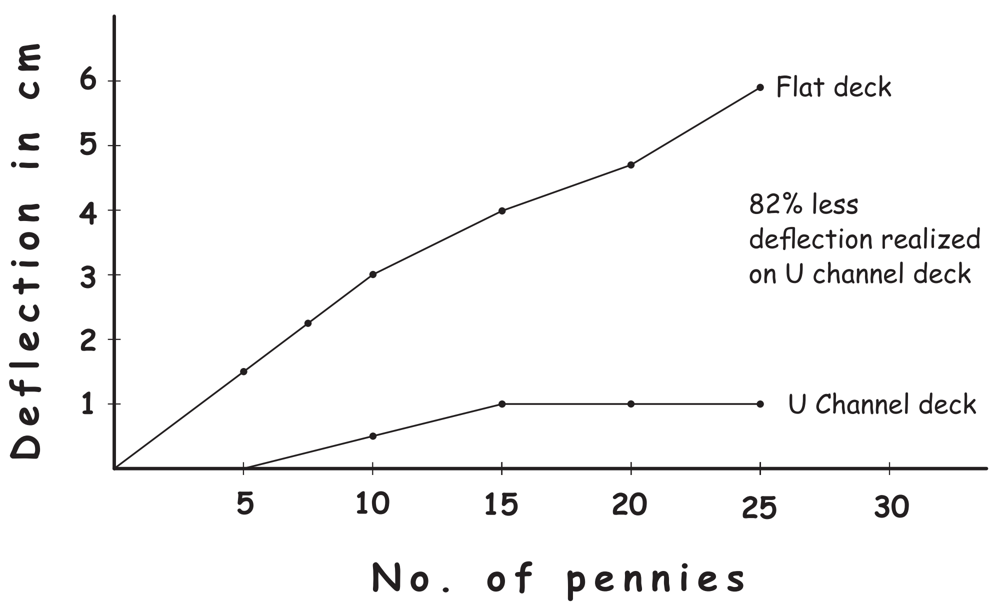
U channel

Now repeat this engineering experiment, but this time take the bridge deck and fold it into a U channel as was done in the previous activity. Place the modified paper deck back in place between the supports (U shape pointing up) and repeat the five-pennies-at-a-time procedure for loading the deck. Once again, record the corresponding deflections associated with each new load of five pennies.

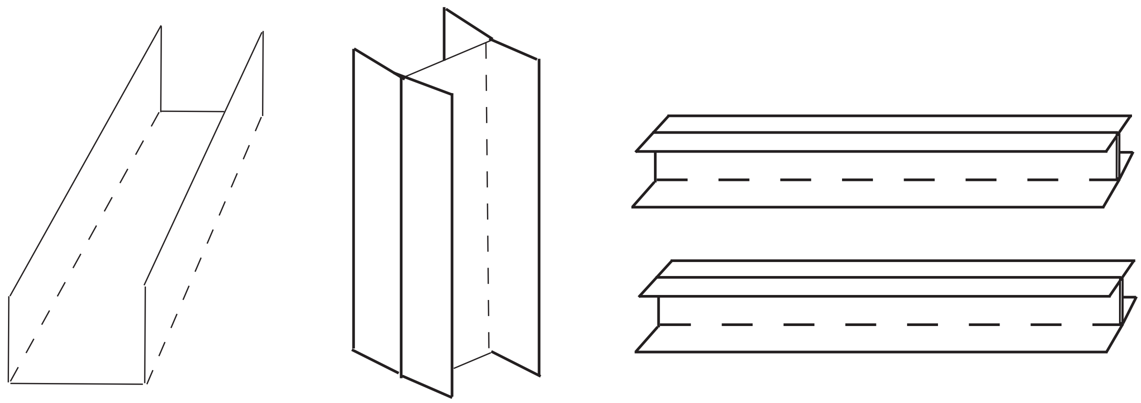
The tables above show the data I recorded when I did this experiment for the flat and folded decks. The graph below shows what it looked like when I took data for the two bridges and represented it in visual form.

Bridge with Flat Deck	
No. of Pennies	Deflection in cm
0	0
5	1.5
10	3.0
15	4.0
20	4.5
25	5.5

Bridge with U Channel Deck	
No. of Pennies	Deflection in cm
0	0
5	0
10	0.5
15	1.0
20	1.0
25	1.0

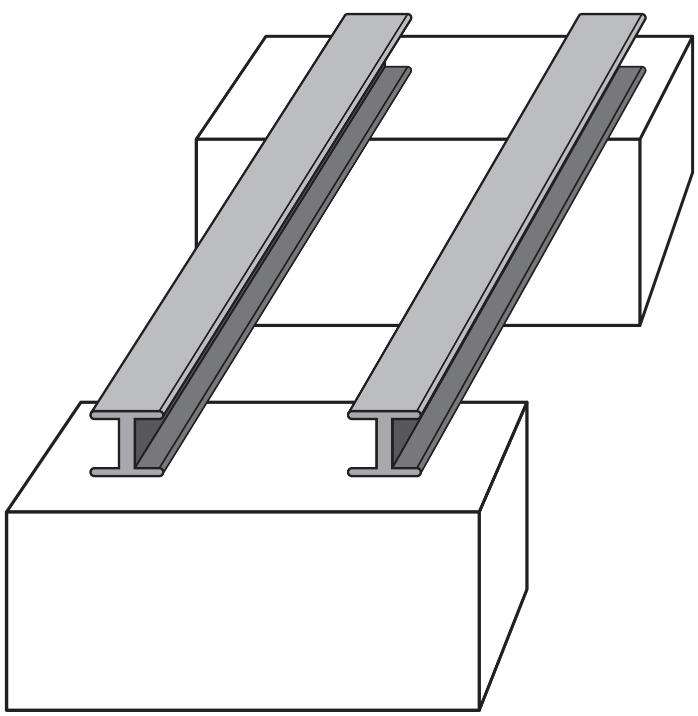


Making an I Beam



Make your own I beam! First, make two paperboard U channels (left), and then glue or tape them together back to back to make an I beam (middle). To support the bridge deck, you will need to make two I beams and position them vertically across the bridge supports as shown below.

Bridging the Gap with I Beams



Position two I beams lengthwise across the span (above), then place the bridge deck on top of the beams.

More Class Exercises

1. How are steel I beams made? Is regular steel used in their manufacture or are steel alloys used? Who invented the I beam, and when did it come into common use?
2. How are I beams catalogued – by size, load-carrying capability, or size of central section? How do structural engineers know which size to use?
3. Where have I beams been used? What are their common applications? What are some unusual applications? How are I beams attached to each other?
4. Can aluminum I beams be substituted for steel? How about plastic or other materials?
5. Does weather cause rusting on I beams, thereby weakening their strength? How about cracks? What kinds of mechanical action can cause cracks in steel I beams?
6. Does fire weaken the strength of an I beam? How are I beams protected from fire and excessive heat?
7. During earthquakes, buildings are subjected to tremendous twisting, or shear movements. When building large structures in earthquake-prone areas, structural engineers do something special with bracing the walls of the building. What is it they do?
8. What are the basic types of bridges? Can your class name some famous examples of each type? What key design differences must structural engineers deal with when building such bridges?
9. How are the giant cables in suspension bridges constructed? How are they anchored at the ends of the bridge?