Critical Load Day 3

Days 3 & 4: BUILD & TEST

Today you will design a structure and test your structure's strength to determine its critical load. You must work together on a design. The design should be based on your research of successful and failed structures of the past.

Construction Materials:

- Twelve unused playing cards
- One roll of scotch tape

Testing materials:

- Gram weights
- Base of empty 2 qt. milk Carton

◆ **Procedure**

1.
2. Use materials to devise a structure that will hold the most weight. You are to plan out your structure, and build a prototype for testing. Allow 10 minutes for planning and execution.
3. Place weights on each team's prototype increasing the weight until the structure fails. Students chart the maximum load each prototype successfully held. (The amount just prior to failure)
4. Each student group presents their vision for their design, and explains why they think their design did well or failed. Ask students how would they adjust the design if they could do it again?

Critical Load

Student Worksheet:
Measuring Critical Load - Page One

Step One:
You have been provided with four playing cards, some scotch tape, and scissors. As a team, and without altering (cutting for example) the cards, devise a structure that you think will hold up a two quart/64 oz/1.69L container without collapsing.

Question:
1. What is your team's strategy or plan for construction using just 4 cards?

Prediction:

1. Predict the "critical load" of your structure as you have designed it.

Step Two:
As a team, build your structure (prototype) for testing.

Step Three:
Your instructor will test your structure, and determine at what weight your team's structure will fail by adding measurable weights until it collapses. This is your structure's "critical load."

Questions:

1. What was your structure's "critical load?"

2. How close were you to your prediction from Step One?

Step Four:
Now use 8 cards to build your structure.

1. What was your structure's "critical load?"

2. How close were you to your prediction from Step One?

3 How did you modify your structure to increase carrying capacity? Did this modification make a positive difference? Explain.

Step Five:
Now use 12 cards to build your structure. Answer questions 1-3 again.

Critical Load

Student Worksheet:
Measuring Critical Load - Page Two

3. What aspects of your design do you think helped its ability to hold more weight?

4. What aspects of your design do you think hindered its ability to hold more weight?

5. What was the highest critical load in your classroom?

6. What was the difference in the winner's design and yours? Or…if your team had the winning structure, what do you think set your structure apart from the rest?

7. If you could do your design all over….what would you change, and why?

8. What human factors do you think a civil/structural engineer needs to take into consideration when planning an office building? (examples are the weight of people and furnishings, need for water, fresh air, escape routes)

Critical Load

Student Resource:
Civil Engineering Challenges

◆ What Civil Engineers Do

Civil engineers are problem solvers, meeting the challenges of pollution, traffic congestion, drinking water and energy needs, urban redevelopment, and community planning. This activity focuses on the work of structural engineers who face the challenge of designing structures that support their own weight and the loads they carry, and that resist wind, temperature, earthquake, and many other forces.

◆ Famous Building Failures

The John Hancock Tower in Boston, Massachusetts is said to have been "known more for its early engineering flaws than for its architectural achievement." Wind-induced swaying was so large, it was said to cause motion sickness for people on the upper-floors. This problem was solved by adding a pair of 300-ton dampers on the 58th floor. Another unrelated but serious problem was that 65 of its 10,344 floor-to-ceiling plate-glass windowpanes fell out of the building to the ground during construction -- luckily no injuries resulted to either workers or passersby! Another example is a library built at Syracuse University in the late 1970's was built without having taken into consideration the weight of the books!

◆ Famous Structures

- The Stratosphere Tower in Las Vegas, Nevada, is the tallest free-standing tower (1,149 feet) in the United States, rising taller than Paris' Eiffel Tower, and the Tokyo Tower.
- The world's tallest bridge is in France and spans the Tarn valley. It is 2460m long and is supported by seven piers ranging from 77m to 244m in height.
- The Petronas Twin Towers in Kuala Lumpur, Malaysia, are the tallest office buildings in the world. They soar 451.9 metres from street level.
- The CN Tower in Toronto, Ontario, Canada has the title of "World's Tallest Building and Free-Standing Structure." It is 1,815' 5" or 553.33m tall.
- Canada also has the world's largest shopping and entertainment complex -- the West Edmonton Mall in Edmonton, Alberta. It spans 49 hectares (121 acres) an houses over 800 stores!

◆ Efficiency Ratings and Critical Load

The efficiency rating measures the weight that will cause a structure to fail divided by the weight of the structure itself. The most efficient structures are strong and lightweight - a difficult combination to achieve. For example, roofers in areas which experience heavy snows must factor in the weight of a massive snowstorm into designing the strength of the roof. The weight at which a building or structure fails is called the "critical load."