The Petronas Towers.

Summary

Student groups are challenged to design and construct model towers out of newspaper. They are given limited supplies including newspaper, tape and scissors, paralleling the real-world limitations faced by engineers, such as economic restrictions as to how much material can be used in a structure. Students aim to build their towers for height and stability, as well as the strength to withstand a simulated lateral "wind" load.

Engineering Connection

Engineering analysis or partial design

Students act as civil engineers as they design and build newspaper towers. They must pay particular attention to designing the tower to withstand the forces of high winds, a problem that students may not have considered in the construction of tall buildings.

Contents

Grade Level: 7 (6-8)

Group Size: 3

Time Required: 50 minutes

Activity Dependency :Skyscrapers: Engineering Up!

Expendable Cost Per Group : US$ 1.00

Keywords: civil engineering, structure, tower, skyscraper, design

Related Curriculum :

subject areas	Geometry
	Science and Technology
curricular units	Building towards the Future
lessons	Skyscrapers: Engineering Up!

Educational Standards

- International Technology and Engineering Educators Association: Technology
- Next Generation Science Standards: Science
- North Carolina: Math
- North Carolina: Science

Learning Objectives (Return to Contents)

After this activity, students should be able to:

- Identify which designs can and cannot withstand the self-weight of the newspaper tower as well as a lateral wind load.
- Explain how their towers worked to withstand the lateral wind load using terms learned in other lessons within this curricular unit if applicable or general engineering terms.

Materials List

- newspaper
- office tape
- scissors
- meter stick

Introduction/Motivation (Return to Contents)

Today, your engineering design challenge is to design and construct a model tower using only newspaper and tape and scissors. Your team will be given limited supplies and a time limit. The tower must be as tall as you can make it, but also stable enough to stand up to a wind load since it will be built in a hurricane-prone region.

Your task mirrors the challenges that engineers are given in the real world—with objectives, requirements and constraints such as budgets, material limitations and deadlines. An engineering team that can design a structure to meet the objectives with the fewest materials (hence, less cost), is favored over other companies that cannot utilize the given materials as effectively.

When you are brainstorming about your design approach in your teams, think about the real skyscrapers you have seen as inspiration, including the tallest buildings and towers in your home town. What are their shapes? What are their foundations like?

(Move on to provide students with details provided in the Procedure section so that they understand how much material they may use and how much time they have.)

Vocabulary/Definitions (Return to Contents)

buckling:	When a column fails by bending at some point in the height of the column, usually towards the midpoint caused by a vertical force.
lateral force:	A force that impacts a structure horizontally (that is, wind and earthquakes).

deflection : The amount a structure bends or moves from its "at rest" position.

civil engineering : The field of engineering pertaining to non-moving structures such as roads, sewers, towers, buildings and bridges.

bundled tube : The design principle that the Sears Tower is built on. The building is basically a collected bunch of tubes, with all the supporting columns of each "tube" located on the perimeter of the tube. This structure is very good at resisting wind loads.

tube-style support: Implemented on building such as the World Trade Center, Sears Tower, and many newer structures. The majority of the supporting columns are mover to the perimeter of the tower instead of spread throughout. This allows open expanses of floor space on every floor.

Procedure

Background

Several solutions to this design challenge are more obvious that others, although students can definitely surprise you with unexpected designs that work quite well.

- Rolling several small tubes to attach to the bottom or a central tube of newspaper is a good design. The cylinder acts to allow the tower to have the wind go around the building. The more narrow and slender the tower is at height the better it is able to withstand the "wind" because less surface exists for the wind to act upon.
- Another solution is a tripod type design. While the majority of the newspaper is used to build up, toward the bottom, three tightly wound newspaper rolls extend down from the tower to the table at an angle. This gives the tower more resistance against toppling in the wind load.
- Another solution involves having a very wide base for the tower to sit on, like a foundation.

With the Students

- Divide the class into groups of three students each.
- Distribute scissors around the classroom for students to share. Give each group 12 inches (30 cm) of tape and three full sheets of newspaper.
- Give teams 20 minutes to test different designs.
- After 20 minutes, students are allowed to return all their materials to the teacher in exchange for another 12 inches (30 cm) of tape and three more sheets of newspaper.
- Give students an additional 25 minutes of construction time.
- TESTING: Measure and record the height of the final tower. Then step away from the tower so it is at arm's length and blow out a full breath to simulate a hurricane. A successful tower will not topple over. Make sure the tower is not secured to a table, the floor or any other piece of furniture or wall.

Safety Issues

Watch that students are careful with the scissors.

Troubleshooting Tips

If students are struggling, consider allowing more time or providing more materials.

If students are struggling for design ideas, suggest they think about tall buildings they may have seen in cities or in their own towns that have cylindrical shapes or large foundations or triangular trusses for support. If necessary, suggest more specifics, such as the idea of rolling the paper for strength and/or using a triangular or wider base.

Assessment (Return to Contents)

Concluding Analysis: Have students explain how their towers work to resist the "wind" load, using

engineering terms learned from earlier in the lesson, or from other lessons within the curricular unit if applicable.
Results Debriefing: Have students discuss as a class what designs did and did not work and why that was so. Examples of successful design approaches included: triangular base, wide base, small tower surface area, tubes, etc. Examples of unsuccessful design approaches include: large flat surfaces for tower sides, small bases, etc.

Activity Extensions (Return to Contents)

Have students try building newspaper towers for height only or to support an object. Have them then compare the differences in design between towers designed to hold vertical vs. lateral loads, and between towers that are not designed to hold any weight but their own.

Activity Scaling

- For younger kids, allow more time and materials, and suggest some design ideas.
- For high school students, allow less time and fewer materials, or have them use only one sheet of letter-sized paper but more time.

References (Return to Contents)

Building Big. PBS. Accessed June 25, 2004. http://www.pbs.org/wgbh/buildingbig/

Contributors

Kelly Devereaux and Benjamin Burnham

Copyright

Supporting Program (Return to Contents)

Techtronics Program, Pratt School of Engineering, Duke University Last Modified: September 5, 2014