Cell Phone Towers

Lesson Overview
In this civil engineering activity students will design and make cell phone towers out of sheets of paper, and test their design by simulating wind and earthquakes; the ultimate goal is to make sure the satellite (paper clip) stays attached the whole time. How does the shape and design of a tower affect its resistance to challenges? Students should be able to understand the importance of a well-planned structure.

Lesson Focus
Students will learn different components that allow cell phone towers to sustain satellites through different environmental factors, including wind and earthquakes. They will use their understanding of shapes and structure to design, build, test, and redesign their own towers by following the steps of the engineering design process.

Lesson Objective(s)
By the end of this lesson, students will...
1. Use math and science to understand engineering concepts and to build skills.
2. Design and construct a model cell phone tower that will sustain a satellite while undergoing common environmental factors in California, and by only using the given materials (constraints).
3. Consider neatness, craftsmanship, and creativity when planning and redesigning the model.

Lesson Timing

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>5 minutes</td>
<td>Icebreaker + Introduction</td>
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<tr>
<td>10 minutes</td>
<td>Engineering Design Process + Introduce Challenge + Brainstorm/Design</td>
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<tr>
<td>8 minutes</td>
<td>Build</td>
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<tr>
<td>17 minutes</td>
<td>Test + Evaluate + Video + Redesign</td>
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<tr>
<td>10 minutes</td>
<td>Discussion + Wrap-Up</td>
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Materials
Each student/group will need:
- 7 sheets of paper
- 1 to draw/plan
- 4 to build your first prototype
- 1 to fan your tower for testing
- 1 to add any changes during redesigning stage
| 1 Paper clip  | 2.   |
| Tape          |   2. |
| Scissors      | Practice lesson |

**Teacher Prep**
1. Materials ready before lesson
2. Practice lesson

**Related Resources**
- Top Builder: Paper Structures | Design Squad: [https://youtu.be/T13NRKzCqHk](https://youtu.be/T13NRKzCqHk)
Lesson Plan

Introduction

1. Introduce and explain the concept of civil engineering. Make sure you mention why it is important for everyday life and the role of civil engineers in our society.
2. Ask students what they know about cell phone towers and their function. Let them know that these towers will be the focus of the activity.
3. Review the Engineering Design Process, including its steps and stressing the importance of making sure to follow each step for a successful project.

Brainstorming

1. Include background information about the problem they are trying to solve by designing such towers and make sure they understand the objective of this activity.
   a. The main job of a cell tower is to hold up antennas that transmit and receive radio-frequency signals from cell phones. To make sure antennas are high enough to cover a specific area, cell towers are built 50 to 200 feet tall. Towers can be standalone structures but sometimes they are attached to buildings, bridges, billboards or even church bell towers. Towers must be strong enough to not fall over during high winds or earthquakes.
   b. The problem: Imagine you are a civil engineer working for a phone company. You are assigned to create a tower that supports a satellite (a paper clip) that will cover a new town in California. Your tower must survive wind and earthquakes so it is essential so it can stay standing in this region.
2. Make sure to explain the purpose of each of the given materials. They must follow the following:
   i. 7 sheets of paper: 1 to draw/plan, 4 to build your first prototype, 1 to fan your tower for testing, and 1 to add any changes during redesigning stage
ii. A paper clip will be used to simulate the satellite of the tower.

3. Give students 5 minutes to sketch their ideas on one sheet of paper as detailed as possible.
   a. Make sure to emphasize the importance of a detailed sketch. Tell them to think about how they
      will cut their sheets of paper, what shapes they will make, how they will secure it to the table.
   b. Also tell them to include it in their plan! Not building yet only on paper! Encourage them to use
      the whole planning time!

Build

1. Give students about 8 minutes to start building their prototype.
   a. Make sure they are only using 4 sheets of paper.
2. Ask students to share their prototypes and provide reasoning behind their decisions.
   a. Ask students if they changed anything from the first sketch and why.

Test + Evaluate + Video + Redesign

1. Students will have about 5 minutes to test whether their designs resist “wind” and “earthquakes.”
   a. For wind, they will use one sheet of paper to fan in the direction of their design.
   b. For earthquakes, they can gently shake the desk or wiggle the bottom of your tower.
2. Try doing each test (the wind test and earthquake test) at least 3 times.
3. If they have time, have students write down their observations and what they think would be an
   efficient adjustment.
   a. They can record your results on the back of your “design” paper.
4. Ask students what shapes/structures they used to stabilize their tower and how they used your
   materials.
5. Show a short video clip on Paper Structures: Design Squad (link in Related Resources).
   a. After the video, discuss what they learned and what it means for their tower.

Discussion + Wrap-Up

1. Allow for at least 5 minutes to review what was covered during the session.
a. Have students write down in the chat one thing you learned today.
b. What are some steps of the engineering design process?
c. What did you learn about building a tower?
d. Call out any students to share their responses out loud or to expand on their comments in the chat.

2. To wrap up your session, remind students that there are many different career opportunities within the field of engineering. Civil engineers build towers and other structures.
   a. Mention an important figure in civil engineering whose background and work may inspire students to consider civil engineering as a career.
   b. Ask students how they feel about civil engineering after activity; you may use the chat so everyone can respond to the questions.
Lesson Background for Teachers

Real World STEM Connection

Duff A. Abrams (1880, Illinois, – 1965, New York)
- American researcher in the field of composition and properties of concrete.
- He developed the basic methods for testing concrete characteristics still in use today.
- A professor with the Lewis Institute, he studied the component materials of concrete in the early 20th century.
- Some of the results of his research was:
  - The definition of the concept of fineness modulus.
  - The definition of the water-cement ratio.
  - A test method for the workability of a concrete mix by using what is called ‘Abrams cone’.

Key Concepts and Vocabulary

➢ Civil Engineering: A professional engineering discipline that deals with the design, construction, and maintenance of the physical and naturally built environment, including public works such as roads, bridges, canals, dams, airports, sewage systems, pipelines, structural components of buildings, and railways.

➢ Structural analysis: The determination of the effects of loads on physical structures and their components. Structures subject to this type of analysis include all that must withstand loads, such as buildings, bridges, aircraft and ships.

➢ Urban planning: Also known as regional planning, town planning, city planning, or rural planning, is a technical and political process that is focused on the development and design of land use and the built environment, including air, water, and the infrastructure passing into and out of urban areas, such as transportation, communications, and distribution networks and their accessibility.