DYNAMIC SKYSCRAPERS

AT A GLANCE Students design, build and test model skyscrapers as they learn about forces that affect real skyscrapers.

OBJECTIVES:

Students will:

- Learn that engineers must consider dynamic loads like wind, earthquakes and other forces when designing skyscrapers.
- Learn how different design elements play into the structural integrity of a building.
- Use critical thinking skills to evaluate structural design.

KEY VOCABULARY

Skyscraper, Engineer, Dynamic Loads, Force, Structural Design, Blueprint

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices:

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Obtaining, evaluating and communicating information

CROSSCUTTING CONCEPTS

- Patterns
- Cause and effect
- Scale, proportion and quantity
- Structure and function

DISCIPLINARY CORE IDEAS

- ETS1: Engineering design
- ETS 2: Links among engineering, technology, science and society

PACE YOURSELF:

- 60 minutes

ADVANCE PREPARATION

1. Designate a table in front of the class where students can test their building's ability to withstand strong wind. Place two hair dryers or fans on the table.
2. Designate a second table in front of the class where each group can test their building's ability to withstand an earthquake.
3. Construct a skyscraper that is 61 cm tall or tape two or more paper clips together to use in the demonstration.

MATERIALS

Per class:

- Pictures of skyscrapers
- Four or more meter sticks
- Two tables
- Two hair dryers or fans
- Building supplies such as:
  - balsa wood
  - wood glue straws
  - popsicle sticks
  - newspaper
  - tape
  - Q-tips
  - rubber cement
  - paper clips
  - toothpicks
  - card stock
  - pipe cleaners
  - paper or plastic
  - cups
  - playing cards

WHAT YOU NEED TO KNOW

When designing buildings, engineers must consider dynamic loads which are loads that can change quickly over time. Wind and earthquakes are two examples of dynamic loads.

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As wind hits the side of a building, it puts pressure on the windward side of the building and creates suction on the opposite side. Therefore, if a building and its windows are not designed correctly, a strong gust of wind could push the building's windows in on one side and blow them out on the other. Buildings must be flexible enough to absorb this force, but if a building is too flexible, people on the top floors may get sick from feeling the building sway back and forth.

The effect of an earthquake on a building is similar to the effect of strong wind. However, wind usually blows in smooth gusts while earthquakes act in a quick jerk, making them more dangerous. This is because a sudden applied force is greater than a force applied slowly. With an earthquake, a sudden change in force can cause structures to collapse, so buildings in earthquake areas must be constructed differently in order to avoid collapsing.

WARM UP

1. Show students pictures of skyscrapers or tall buildings like the Willis Tower or John Hancock Center. Ask students, "What do engineers need to think about when designing and constructing tall buildings? What challenges will their skyscrapers have to withstand?" (Answers will vary but should include forces such as wind, earthquakes, rain, snow; loads such as people, furniture.)
2. Discuss dynamic loads with students (refer to the What You Need to Know section).

ACTIVITY

1. Tell students they will be working in engineering teams to design and construct a 61 cm tall skyscraper that must be able to withstand two different dynamic loads: strong winds and earthquakes.
2. Demonstrate what students will do with their model skyscrapers at the two testing stations. At the "wind" table, place your skyscraper in the center of the table, point one hair dryer or fan at it and turn it on. If your skyscraper is strong enough to withstand the wind from one hair dryer, try two hair dryers. At the "earthquake" table, place your skyscraper in the center of the table. Students will stand around the table and gently shake the table to simulate an earthquake.
3. Divide students into groups of two to four.
4. Give students five minutes to brainstorm what their building will look like and to draw a blueprint.
5. Pass out building supplies.
6. Give students 30 minutes to build their 61 cm tall skyscraper.
7. After 30 minutes, allow groups to test their buildings one at a time in front of the whole class.

CHECK FOR UNDERSTANDING

Have students answer the following questions in their teams or as a whole group.

- In your own words, how would you describe a dynamic load? What are two examples of dynamic loads?
- Did your skyscraper pass or fail the wind and earthquake tests? If it failed, what would you do differently? If it was successful, why?
- Would you want to become an engineer? Why or why not?

WHAT'S HAPPENING

In the real world, wind speeds increase with height so wind blows faster at the top of a skyscraper than at the bottom. A heavier base will make for a sturdier, more balanced building. Buildings that have more weight at the bottom of the structure than the top will withstand both the wind and the earthquake tests better.

DIFFERENTIATED INSTRUCTION

- Depending on the level of the students they can have varying building challenges. For example, challenge students to create shorter or taller buildings, or buildings that can withstand other natural disasters such as earthquakes.

EXTENSIONS

- Have students draw a picture of their skyscraper and write an advertisement persuading people to live or work in their building. When they are finished, have each group present their advertisement.
  - How much would rent be?
  - What amenities would their skyscraper have?
  - Where would it be located?
  - What would they name it?