

**Collapse: Failure by Design: Teacher’s Guide**

**Grade Level:** 6-8  
**Curriculum Focus:** Technology  
**Lesson Duration:** One to two class periods

**Program Description**
When builders use innovative materials or implement creative design, sometimes the result is disastrous. Explore the flaws of four structures that failed the test of integrity and collapsed.

**Onscreen Questions**
Before watching the video
- What are the different elements and conditions that you would have to consider if you were designing a building?
- As you watch the program, notice how designers are influenced by weather conditions, building materials, and budgets. What other factors determine a structure’s design?

After watching the video
- After the 1967 silver bridge collapse, the U. S. government initiated a national inspection program for bridges.
- If you were the mayor of a city, what steps would you take to insure the safety of citizens if a bridge in your city collapsed? Explain your reasoning.

**Lesson Plan**

**Student Objectives**
- Examine the structural flaws that caused three bridges to collapse.
- Determine what factors need to be considered in building a stable structure.
- Compare and contrast the pros and cons of various bridge-building materials.

**Materials**
- Computers with Internet access (optional but very helpful)
- Paper
- Pens and pencils
Procedures

1. Begin a discussion by showing the class two photographs of the Tacoma Narrows Bridge in Washington in the process of collapsing. You can find these images at these Web sites:
   - PHOTO 1: http://www.pbs.org/wgbh/buildingbig/wonder/structure/narrows1_bridge.html
   - PHOTO 2: http://www.pbs.org/wgbh/buildingbig/wonder/structure/narrows2_bridge.html

2. Ask students to brainstorm about what they think caused the bridge to wobble, then fall apart. (You may ask them if weather conditions may have contributed to the collapse.) Write their suggestions on newsprint. After discussing the ideas, explain that the force from high winds (more than 40 miles an hour) caused the collapse.

3. Discuss with the class two other bridges that have collapsed.
   - **Silver Bridge, Point Pleasant, West Virginia, 1967.** When this bridge collapsed, 37 vehicles fell into the water. The worst bridge disaster in the history of the United States was caused by a broken I-bar, a small metal beam that connects the bridge’s parts. Engineers discovered that one I-bar had a tiny crack at the time of construction; over time wear and tear broke it apart. When one side of the bridge fell, the other side couldn’t handle the weight, and it collapsed, too.
   - **Melbourne Bridge, Melbourne, Australia, 1968.** Engineers and architects made a simple mathematical error when constructing the bridge, which resulted in instability in the bridge’s steel girder box. When some of the steel expanded from heat, the bridge fell 120 feet to the ground.

4. Using the information about bridge collapses, ask students what variables must be considered when building a bridge. These include environmental factors such as wind and temperature, building materials, and shapes used to support the structure. Also discuss the natural forces that structures must contend: compression—the weight of a building pressing down on the lower columns—and tension, the natural stretching that takes place. These factors must be taken into consideration, also, when designing a bridge.

5. Divide the class into groups of three or four students. Tell each group to design a plan, or blueprint, for a local bridge that could cross a river or to join two sections of land. The goal for each group is to propose the strongest, safest bridge possible with the least expensive materials. As students work, have them answer the questions below and record their findings on a sheet of paper.

   1. What natural forces might affect your bridge? How can you compensate for them?
   2. Which materials are most suitable for your bridge? Why? (Keep in mind wear and tear on the bridge, temperature, wind speed, and expense when making your decision.)
   3. Which shapes are you using to support weight on your bridge? Why?
To conduct the necessary research, have students visit the Web sites listed below.

- Forces Lab: squeezing, stretching, bending, sliding
  [http://www.pbs.org/wgbh/buildingbig/lab/forces.html](http://www.pbs.org/wgbh/buildingbig/lab/forces.html)
- Materials Lab: wood, plastic, aluminum, brick, concrete, reinforced concrete, cast iron, steel
- Shapes Lab: rectangles, arches, and triangles
  [http://www.pbs.org/wgbh/buildingbig/lab/shapes.html](http://www.pbs.org/wgbh/buildingbig/lab/shapes.html)

6. Have the groups write down their recommendations and draw their blueprints. Suggest that each student make a copy of the group’s recommendations. Then have the groups present their designs to the class. Give other students a chance to comment on the strengths and weaknesses of each design.

7. Assign the following for homework. Students will research one of the structures honored by the architectural community in 1999. They will record important facts about the structure and find out how it is reinforced to protect against destructive forces. After students complete the assignment, have them share their findings with the class.

   In 1999 the architectural community recognized structures it considered the finest architectural achievements of the 20th century. These structures were chosen because each had a strong benefit for humanity, measurable economic impact, were innovative in using new technology, and added value to its community.

   Use library books or the Internet to learn more about one of these structures. (A good source is the site at [http://192.215.32.157/conexpo/news20.asp](http://192.215.32.157/conexpo/news20.asp).) As you research, record important facts, including location, size, date built, materials, and design features. Then find out how these structures are reinforced to protect against high winds, floods, and earthquakes, and other destructive forces.

1. Channel Tunnel (links England and France)
2. Golden Gate Bridge
3. Dwight D. Eisenhower system of Interstate and Defense Highways
4. Empire State Building
5. Hoover Dam
6. Panama Canal
7. Sydney Opera House
8. Aswan High Dam
9. Hong Kong Airport
Assessment

Use the following three-point rubric to evaluate students’ work during this lesson.

- **3 points:** Students worked well together in their groups, developed an exemplary plan for their bridge, drew an accurate blueprint that was labeled clearly and accurately, and made an interesting presentation to the class.

- **2 points:** Students worked somewhat well together in their groups, developed a reasonable plan for their bridge, drew a somewhat accurate blueprint that was labeled clearly and accurately, and were prepared for their presentation to the class.

- **1 point:** Students had some difficulties working together in their groups, developed a partial plan for their plan, drew a partial blueprint for their bridge, and made a brief presentation to the class.

Vocabulary

**box-girder bridge**
*Definition:* A type of bridge made of steel or concrete that is constructed from supporting beams that look like a long box
*Context:* Box-girder bridges, such as the Melbourne Bridge in Australia, are popular because they are light, strong, and economical.

**I-beam**
*Definition:* A steel joist or girder with short flanges and a cross section formed like the letter “I”
*Context:* An I-beam on the Silver Bridge in West Virginia broke in 1967, causing the bridge to collapse.

**torsion**
*Definition:* A force that causes a structure to twist and fall apart
*Context:* In 1940, strong winds and torsion caused the Tacoma Narrows Bridge to twist violently and collapse.

**unstable**
*Definition:* Characteristic of a structure that collapses or deforms under a realistic load
*Context:* The bridge was unstable and it collapsed during the earthquake.

Academic Standards

**National Academy of Sciences**
The National Science Education Standards provide guidelines for teaching science as well as a coherent vision of what it means to be scientifically literate for students in grades K-12. To view the standards, visit [http://books.nap.edu](http://books.nap.edu).
This lesson plan addresses the following science standards:

- Physical Science: Motions and forces
- Science and Technology: Abilities of technological design, Understandings about science and technology

**Mid-continent Research for Education and Learning (McREL)**

McREL’s Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit link: [http://www.mcrel.org/compendium/browse.asp](http://www.mcrel.org/compendium/browse.asp)

This lesson plan addresses the following national standards:

- Science — Physical Sciences: Understands forces and motion
- Language Arts — Reading: Uses reading skills and strategies to understand and interpret a variety of informational texts
- Technology — Understands the nature of technological design

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**Support Materials**

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- [http://school.discovery.com/teachingtools/teachingtools.html](http://school.discovery.com/teachingtools/teachingtools.html)