Structural Failure

An umbrella bends out of shape in a wind gust (Figure 1). A suitcase handle breaks. A bridge collapses. A drinking glass cracks (Figure 2). These are examples of structures that have failed. Structural failure occurs when a structure, or part of a structure, loses the ability to support a load. Once the structure loses its load-carrying ability, it cracks, deforms, or even collapses completely. There are many reasons why a structure can fail.

Bad Design

Approximately 40% to 60% of all structural failures are due to bad design. Bad designs can be caused by design errors such as failure to account for load, specifying incorrect materials, or not considering important factors and stresses.

On January 28, 1986, just 73 s after takeoff, the space shuttle Challenger exploded (Figure 3). All seven crew members were killed. The explosion was caused by a gas leak when an O-ring failed. An O-ring is a circular piece of plastic or rubber that stops water or gases from escaping. An O-ring is usually in a connection between two pipes (Figure 4). In the case of the Challenger, the weather in Florida was unusually cold. The cold O-ring failed and caused the gas leak that led to the explosion.
Faulty Construction

Faulty construction is the second most common cause of structural failure. Construction errors can result from the use of poor quality materials, poor installation from either sloppiness or lack of expertise, or a combination of these. For example, homeowners are aware of how easily shingles are blown off a roof in windy conditions. This is a bigger problem if the shingles were poorly installed by not securing them correctly with the right type of nail (Figures 6 and 7). Using the wrong nail for the job can mean the difference between a roof that lasts for 20 years and one that fails on the first windy day.

Figure 6  A roofing nail is rustproof and has a large head and a notched shank to hold down the shingles in windy conditions.

Figure 7  A finishing nail has a smooth shank and smaller head that is less visible on wood trim around doorways or cabinets. What would happen if a worker used finishing nails for roof shingles?

TRY THIS: Observe the Effect of Temperature

SKILLS MENU: observing, communicating, analyzing

Different materials change at different temperatures. Materials can become more brittle at some temperatures and more flexible at other temperatures. In this activity, you will observe the effect of temperature on elastic bands.

Equipment and Materials: 2 bulldog paper clips; 2 identical elastic bands; 2 small bowls or glasses; 250 mL warm water; 250 mL ice water

1. Fold each elastic band in half and clamp it with a bulldog clip.
2. Place one elastic band and clip in the cup of ice water. Place the other elastic band and clip in the cup of warm water (Figure 5).
3. After 5 min, remove the elastic bands and bulldog clips from the water.
4. Remove the clips from the elastic bands. Examine the elastic bands. Using a graphic organizer of your choice, compare the size, shape, and texture of the two elastic bands.

A. What did you observe about the elastic bands? Write a brief report of your observations.
B. In small groups, discuss how the results of this activity may relate to the O-ring failure in the space shuttle Challenger disaster.
Faulty construction can have tragic consequences. The Sampoong Department Store (Figure 8) in Seoul, South Korea, collapsed on June 29, 1995. The collapse killed 501 people. An investigation of the disaster showed that the construction materials were inadequate, and that the installation and building methods were poor. The government allowed the structure to pass inspections that it should have failed. The chairman of the building was charged with negligence for his disregard for public safety. Several government officials were also charged with accepting bribes to conceal the building’s flaws.

Extraordinary Loads

Extreme conditions can also result in structural failure. Often these failures are not the result of poor design, but the result of unexpected events that create extraordinary loads on structures.

In January 1998, North America experienced a massive ice storm. For days, parts of Ontario, Québec, Nova Scotia, New York, and Maine were drenched with freezing rain. The rain coated everything with a 120 mm–thick layer of ice. About 130 transmission towers were crushed under the weight of the ice (Figure 9). More than 4 million people in Québec, Ontario, and New Brunswick had no electricity. Some people had no electricity for more than a month. At least 25 people died, many of them from the cold.
Foundation Failure

Failure of a structure's base, or foundation, is less common than bad design and faulty construction. However, it can also lead to significant structural problems. Foundation failure can be caused by poor soil conditions, poor installation, a foundation that is not large enough for the load of the structure, or earthquakes.

A well-known example of foundation failure is the Leaning Tower of Pisa in Italy (Figure 10). The tower was built in 1178 on sandy, unstable soil with an inadequate foundation. The soil shifted and the tower began to lean almost right after construction began. Over the centuries, the tower leaned more and more. Modern construction methods have finally slowed down the movement of the tower and returned it to the angle at which it was leaning in 1870.

Foundation failure is more common in smaller buildings. Cracks in the walls of a house or misaligned doors are often the result of a house's foundation shifting due to poor soil conditions. However, any structure can shift as a result of a poor foundation.

Figure 10  The Leaning Tower of Pisa

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**CHECK YOUR LEARNING**

1. (a) List four possible causes of structural failure. 
   (b) Identify a structural failure that occurred on account of each of the four causes. 
   (c) Suggest one way in which each of the structural failures in (b) could have been prevented.

2. A 12-year-old student sits on a child’s tricycle and one of the rear wheels breaks off.
   (a) What was the most likely cause of the structural failure? 
   (b) How could this failure have been prevented?