11.4 Making Structures Strong: The Truss, Arch, and Dome

Designers sometimes want to use shapes other than beams to make structures stronger and more interesting looking. They can do this by adding triangles (trusses) or curves (arches and domes).

The Truss

truss: a network of beams arranged in triangles

A **truss** is a network of beams that form triangles. A truss can be used as a bridge or a cantilever, and for many other applications. In the following Try This activity, you will learn how trusses can be strengthened and how their mass can be reduced.

TRY THIS: Building and Testing Trusses

SKILLS MENU: performing, observing, analyzing, communicating

SKILLS HANDBOOK 4.C.1.

In this activity, you will learn how to build trusses and reduce their mass while maintaining their strength. You will test for strength, not for failure, by gently pushing on your structures. In each step, record your observations.

Equipment and Materials: 11–15 equal-sized strips of stiff cardboard or large craft sticks with a small hole drilled near each end; paper fasteners (brads); string

1. Construct a four-piece structure using cardboard and fasteners (Figure 1(a)). With the structure resting upright, determine how sturdy it is.
2. Add a fifth component to create a bridge truss made of two triangles (Figure 1(b)). Place the truss to span a small space between two textbooks. Gently test how sturdy this truss is, but *do not* break it.
3. Make a larger truss using the triangular design (Figure 1(c)).
   - **(a)** Test the sturdiness of the truss as a bridge spanning a space.
   - **(b)** Test the sturdiness of the truss when used as a cantilever (over the edge of a book).

(a) **(b)** **(c)**

Figure 1 Structures used in steps 1 to 3

4. Reduce the mass of your truss bridge by replacing beams with pieces of string (Figure 2). Start by replacing one beam, and then two beams, and so on. Draw a diagram of your final design. Gently test its strength.

Figure 2 Reduce the mass of a suspended truss

5. Turn over the truss you made in step 4. Describe what happens to its sturdiness.
6. Put the long truss back together and support it at one end only (as a cantilever). Discover how to reduce the mass of the cantilever by replacing at least one beam with string (Figure 3). Draw a diagram of the cantilever truss with the least mass.

A. What basic form provides a truss with strength?

B. How can a spanning truss be reduced in mass while maintaining strength?

Figure 3 Reduce the mass of the cantilever

Most people are familiar with the trusses used in the roofs of home construction (Figure 4). You can see examples of trusses in many places. Construction cranes, communication and hydro towers, bridges, and the International Space Station all contain trusses.

Trusses can be bent or curved and still retain their strength (Figure 5). Trusses take advantage of the strength of triangles to make structures strong. In a truss, forces are distributed between the points of the triangles that make up the truss. The triangles help the structure support more weight. Notice the complex truss structure that makes up the circle of the Ferris wheel. A beam used in this application could be too heavy. Remember that the structure needs to support its own weight as well as the weight of the passengers. Using trusses allows for different structural designs. Trusses can be used for applications that other types of supports, such as beams, cannot be used for.

Figure 4 Trusses are used in the construction of many structures.

Figure 5 Trusses provide strength to this Ferris wheel.

The Arch

An **arch** is a curved structure often used to support loads. Arches are used in spaces where supporting beams are not practical. Such spaces include doorways or windows, bridges, or places of worship. An arch's curved design transfers compression force downward (Figure 6). Like the beam and the truss, the arch is one of the basic components of structures.

arch: a curved structure used to span a space while supporting a load

Many early civilizations, such as the Romans, used the arch when building structures. Some of the arches that the Romans built over 2000 years ago are still standing. Today, arches are still used to span long distances (Figure 7).

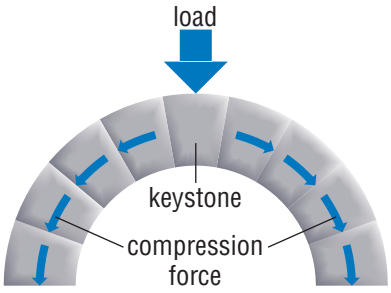

Figure 6 The arch transfers compression force downward from each stone to the next.

Figure 7 Arches can be used to make bridges stronger.

The Dome

dome: a shell structure that looks like the top half of a sphere

A **dome** is a structure that looks like the top half of a sphere or an egg. Like an arch, a dome directs compression force downward. In an arch, the compression force occurs in only one plane of application (Figure 8). However, in a dome, the compression force is directed downward in many planes at once (Figure 9). You could consider a dome to be a series of arches that have been connected at a centre point.

Figure 8 The compression force on this arch is directed downward in a single plane.

Figure 9 The compression force on this dome is directed downward in many planes at once.

Domes are popular structures because they are strong and can still enclose a large volume of space. Planetariums, churches, mosques, and many stadiums use domes in their design (Figure 10).

Figure 10 The Pantheon in Rome, Italy, is an example of a dome.

Unit Task Will you be able to use trusses, arches, or domes in your playground design for the Unit Task?

CHECK YOUR LEARNING

1. What are some advantages of using trusses?
2. List four examples of structures that use trusses.
3. Describe the similarities and differences between arches and domes.
4. Explain how compression forces are different in arches and domes.