11.2 Making Structures Strong: The Beam

Many structures have similar features. You may have seen many bridges that look similar. You may also have seen many buildings being constructed that use similar features—most house frames look very similar, even if the finished house looks very different. One of the features common to many structures is the beam.

A **beam** is any reasonably level structure that is designed to support a load. The frame of a typical doorway consists of a horizontal upper beam and two vertical supports (Figure 1). One of the oldest beam structures was probably a log lying across the banks of a river—a log bridge. In this case, the log is a beam that is supported by the banks of the river.

beam: a horizontal structure designed to support a load

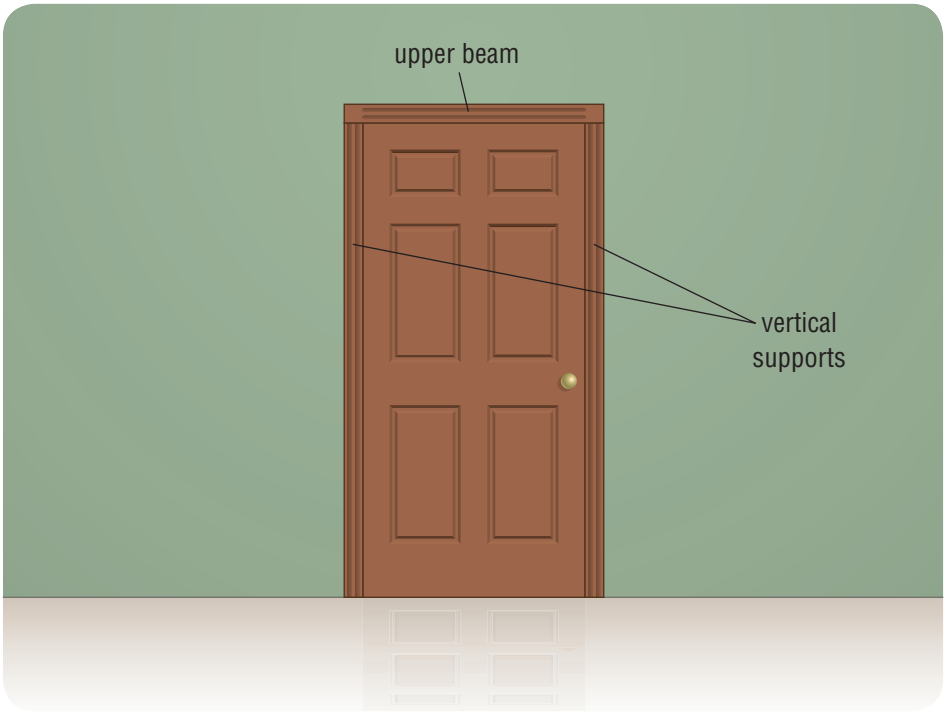

Figure 1 A typical doorframe is a beam structure.

LINKING TO LITERACY

Making Predictions

Prepare for reading by making a prediction about the information that will be explained or described on this page. Start by scanning the page for the most visible information: the title, subtitles, pictures, and margin information. Then, skim the first sentence of the first one or two paragraphs of the text.

What do these tell you about this text? What kind of information will be described or explained on this page?

Make a prediction about the text. As you read, confirm or change your prediction. Make new predictions about what will come next.

Making predictions will help to make reading informational text easier.

Strengthening the Beam

On its own, a beam may not be able to support a large load. Some beams can bend or break if the load on them is too great. Beams can be strengthened in several ways. One way is to change the material that a beam is made of. A beam made of balsa wood is not as strong as one made of steel. Beams can be made out of many different materials, such as wood, stone, concrete, or steel, depending on the load requirements of the structure. Choosing the right material is an important factor in building a strong and stable structure. Steel is stronger than wood, but steel is also heavier. An engineer needs to consider both strength and mass when selecting the material for any structure.

I-Beams

I-beam: a beam that is in the shape of the letter "I" when seen from the end

Another way to strengthen a beam is to change its form. A stronger beam shape is the **I-beam**. When you look at the end of an I-beam, it looks like the letter "I." I-beams are commonly used in the construction of buildings, including houses (Figure 2). Wooden I-beams, sometimes called I-joists, are now being used as the structural support for ceilings and floors in homes. These beams are much lighter than steel beams, but they can still support very heavy loads. They also make use of wood chips, rather than solid wood. This means that they could reduce the amount of trees needed in construction.

Corrugation

corrugation: multiple folds in a material that provide additional strength

Folding the beam also adds strength. Placing triangular ridges, grooves, or folds in a structure is called **corrugation** (Figure 3). Corrugation is common in cardboard boxes. Corrugation is applied to plastic and metal, particularly for roofing, to provide additional strength.

Figure 2 A steel I-beam is used to provide structural strength.

Figure 3 The corrugation in a steel roof provides added strength.

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Reading for Meaning

Scientific words are defined or explained on this page: I-beam, corrugation, and rebar. What do these mean? How do these explanations help you to better understand your reading?

Rebar

Concrete beams are often strengthened with steel reinforcing rods. A beam experiences compression on top and tension on the bottom. Concrete can withstand a great deal of compression, but it is very weak when it experiences tension. Steel reinforcing bars called rebar are placed in the concrete to help it resist the forces of tension. Concrete that contains rebar is known as "reinforced concrete" and is able to resist both compression and tension (Figure 4).

Figure 4 Steel reinforcing bars (rebar) serve to strengthen concrete by allowing it to resist both tension and compression.

The Cantilever

Beams are not always supported at both ends. A **cantilever** is a beam that is supported, or fixed, at only one end (Figure 5). A branch on a tree and a diving board are examples of simple cantilevers. Cantilevers are very common. Canopies over entrances to buildings and apartment balconies are also examples of cantilevers.

Cantilevers are useful in spanning great distances without the use of a central support. Cantilevers are used in areas where a central supporting structure would be unrealistic, such as over a deep gorge. Look at Figure 5. This cantilever is on the Observation Tower over the American Falls at Niagara Falls. Can you imagine trying to build a supporting structure at both ends of the cantilever at this location?

Figure 5 A cantilever is a beam that is supported at only one end.

cantilever: a beam supported at only one end

Supporting the Beam

Adding structural support also strengthens a beam (Figure 6). A tie is a structural support that is part of a framework and is designed to resist tension forces. A tie is usually set at an angle between a beam and its support base (the wall in this example). A strut is similar to a tie, but it is placed below a beam where it provides resistance to the forces of compression. A gusset is a flat, plate-like device, often triangular, that supports a beam by reinforcing the connection between the beam and its support base.

tie strut gusset

Figure 6 The tie, strut, and gusset add support to the beam.

Unit Task How will you use what you learned about the beam in the design of the playground equipment for the Unit Task?

CHECK YOUR LEARNING

1. Briefly describe four ways that a beam can be strengthened.
2. How is a cantilever different from a fully supported beam?
3. Provide two examples of cantilevers that you have seen in your neighbourhood.