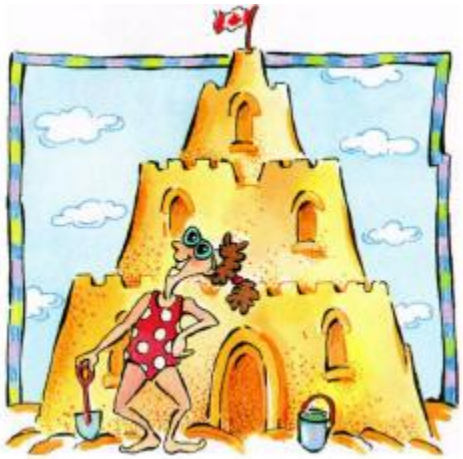
Types of Structures



Have you ever made a sand castle or created a snow sculpture? What about building an igloo or assembling a tent? Perhaps you have woven a basket or baked a cake. All of these objects are examples of structures: things that have a definite size and shape. We can classify structures as **manufactured** (made by people) or **natural** *(not* made by people).

Structures are also classified according to what they do. All manufactured structures have a purpose or **function.** To perform this main job, every part of the structure must resist forces that could change its shape or size. For example, you might build a brick wall around your backyard. The wall must be able to stand up to the force of the wind. The bricks at the bottom must support the weight of the bricks above. If a person climbs on top of the wall, the bricks must support that **load** (the weight carried or supported by a structure) as well. A third classification of structures is based on how they are built. There are three basic designs: mass, frame, and shell structures. Each design uses a particular type of construction, with its own set of advantages and problems.

Mass Structures

To build a sand castle, you start by making a big pile of sand. If you want the castle to be larger or last longer, you start with a bigger pile. Sand castles and other things built by piling materials up are called **mass structures.** Snow sculptures, dams, and brick walls are mass structures. So are natural structures like mountains and coral reefs, and foods like omelettes, cakes, and breads.

Making something from a lot of building materials has advantages. The structure is held firmly in place by its own weight. If small parts are worn away or broken, this usually makes very little difference. Mass structures like Hadrian's Wall in England have been eroding for thousands of years without being destroyed.

A Layered Look

All around you there are mass structures made of carefully arranged pieces. Have you ever noticed the pattern of bricks in a brick wall? The centre of each brick is usually placed over the ends of two bricks in the row below, as Figure 1 shows. Bricks and concrete blocks are often arranged in other ways, however. Compare the patterns used for several outside and inside walls made of bricks or blocks. Look around doors and

windows to see if the arrangement is different there. If you can, ask a bricklayer or a mason to explain when particular patterns are used.

Figure 1. The pattern in these bricks is called a "running bond." It is used for strength.

Take a close look at the dam in Figure 2 below. Try to guess the purpose of each type of material.

Mass structures are not always solid. Inside many power dams are enormous rooms that hold electric generators. Bricks and concrete building blocks are hollowed out so that wires and pipes can pass through them.

Because of their large size and weight, mass structures must be very carefully designed. Think of a wall of sandbags holding back a flooding river. There will be big problems if the wall fails! There are four main ways that this can happen.

- The wall may not be heavy enough to stay in place. The whole structure is pushed out of place by the force of the water against it.
- The wall may be so heavy that the earth beneath it is pressed down unevenly. The structure becomes unstable and tips over or falls apart.
- The wall may not be thick enough or fastened tightly together, so parts of it are pushed out of place. Then the whole structure breaks apart.
- The structure may not be anchored firmly to the ground. If there are very large forces pressing against the top, the whole structure may tip over.

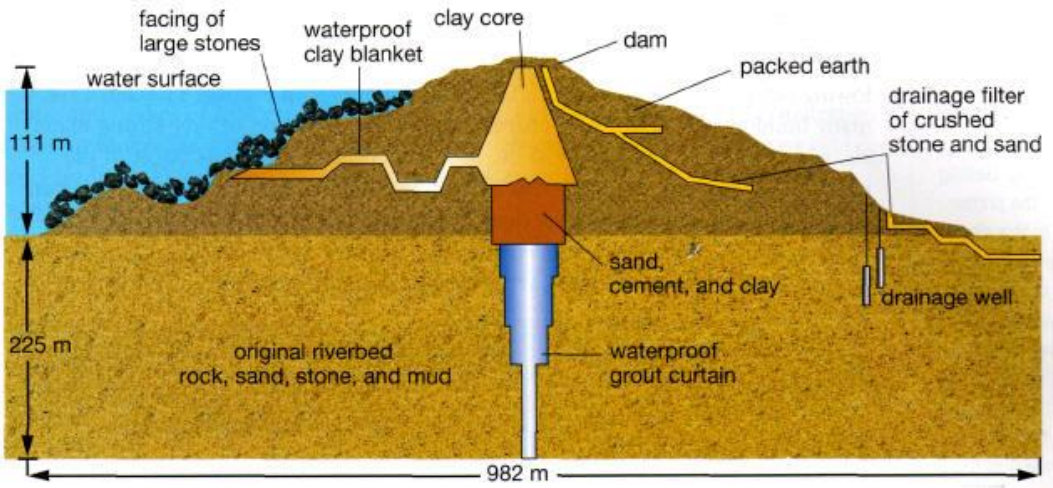


Figure 2. A dam is an example of a mass structure.

Frame Structures

Human dwellings and office buildings are not usually mass structures made by hollowing out piles of building materials. Like the houses in Figures 3 and 4, many buildings are **frame structures.** They have a skeleton of very strong materials, which supports the weight of the roof and covering materials. Most of the inside of the building is empty space. Extra partition walls can be built to separate different rooms, but they do not need to be particularly strong because the load-bearing framework supports the structure and everything in it. Can you identify the load-bearing walls and the partition walls in the diagrams of the house?

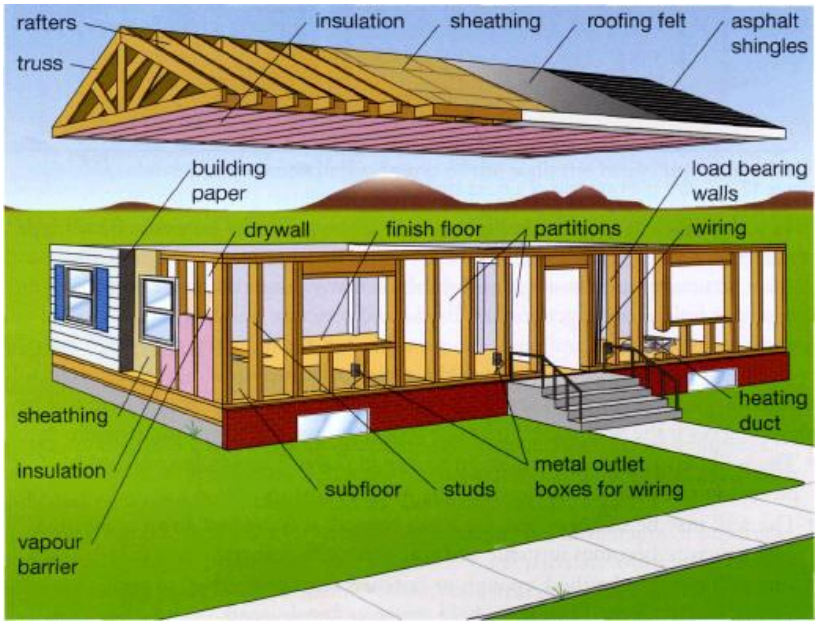


Figure 3. Load-bearing walls hold up a frame structure, while partition walls simply divide rooms.

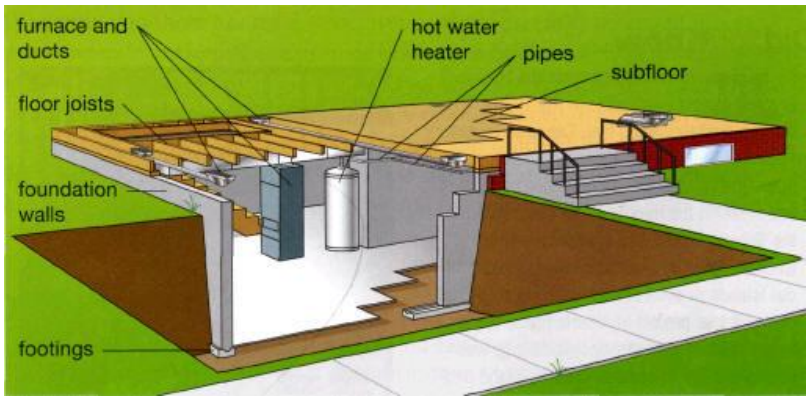


Figure 4. Which parts of the basement level of this house are load-bearing?

Frame structures are very common and are designed in many different ways. Some objects, such as ladders, snowshoes, and spider webs, consist of only a frame. More complex objects may have other parts added to the frame, such as the pedals, gears, and brakes of a bicycle. The frame may be hidden beneath covering materials (as in umbrellas, automobiles, and boats) or left exposed (as in drilling rigs and steel bridges). Whether simple or complex, hidden or exposed, all frames must overcome similar problems.

Do you remember building frame structures, like towers or bridges, in other science classes? How did you fasten the parts together? How did you make your frames strong without using too much material? How did you shape or brace them so that they would not bend or collapse?

Certain kinds of frame structures present special design challenges. Tents and other lightweight structures do not have enough mass to stay in place without some type of anchor to fasten them securely to the ground. Very tall frame structures, such as communications towers, can easily become unstable unless they are carefully braced. Large, complicated projects, such as buildings and bridges, have many parts that all have to fit together perfectly when they are finally assembled at the building site. This can happen only if every detail of the design is calculated in advance.

Shell Structures

Think igloo. Think egg. Think cardboard box. All of these objects are strong and hollow. They keep their shape and support loads even without a frame or solid mass of material inside. Egg cartons, food cans and bottles, pipes, and clay pots are other examples of **shell structures:** objects that use a thin, carefully shaped outer layer of material to provide their strength and rigidity. Flexible structures, such as parachutes, balloons, and many kinds of clothing, are a different type of shell. Even the bubbles in foams and cream puffs can be thought of as shell structures.

Shell structures have two very useful features. They are completely empty, so they make great containers. Because they have only a thin outside layer, they use very little building material.

You might think that the material in a shell structure would have to be extremely strong, but this is not always the case. The shape of a shell spreads forces through the whole structure. Each part of the structure supports only a small part of the load, and the complete structure can be amazingly strong.

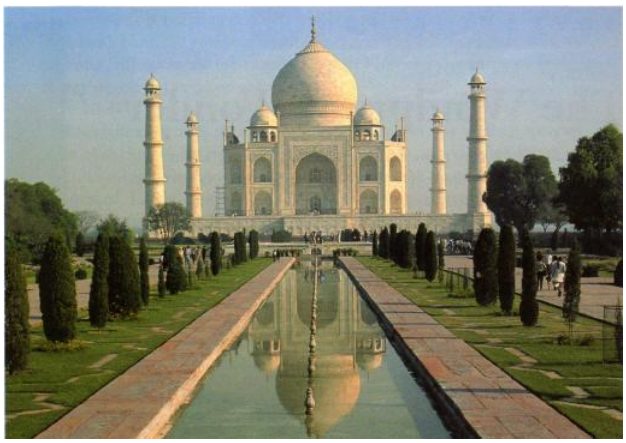


Figure 5. The dome of the Taj Mahal in Agra, India, is one of the most famous shell structures in the world.

Constructing strong shell structures can be tricky. Builders face problems like these:

- Tiny weaknesses or flaws like scratches on a glass jar can cause the whole structure to fail. Bubbles pop, balloons burst, and glass seems to explode when forces are not resisted equally by all parts of the shell.
- If a shell is formed from hot or moist materials, such as melted plastic or clay, uneven cooling or drying can cause some areas to push and pull on nearby sections. Strong forces (stresses) build up inside the shell, as in Figure 6. If any extra force, even a small one, acts on the shell, the stressed places may break unexpectedly.
- Flat materials, such as sheets of plywood, are not easily turned into the rounded shape of a shell structure. Imagine building a plywood igloo! Each piece would need to be shaped and fitted into place individually, so construction would be slow and difficult. If you were paying a builder, the cost would be higher than for a frame structure.
- Assembling flexible materials into a shell is also tricky. Garment pieces need to be pinned into position before sewing. Afterward, the fabric edges must be specially finished so that the cloth will not pull apart along the seams.

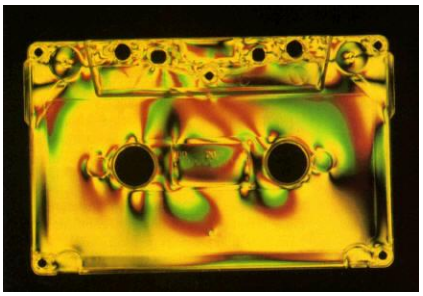


Figure 6. When polarized light (light waves of only one direction) passes through transparent materials, such as this cassette tape, the stressed areas appear as coloured fringes.