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Push and Pull

Structural Engineering

What You Need to Know

Structural engineering is the branch of engineering concerned with the design and construction of all types of structures such as bridges, buildings, dams, tunnels, power plants, offshore drilling platforms, and space satellites. Structural engineers research the forces that will affect the structure, then develop a design that allows it to withstand these forces.

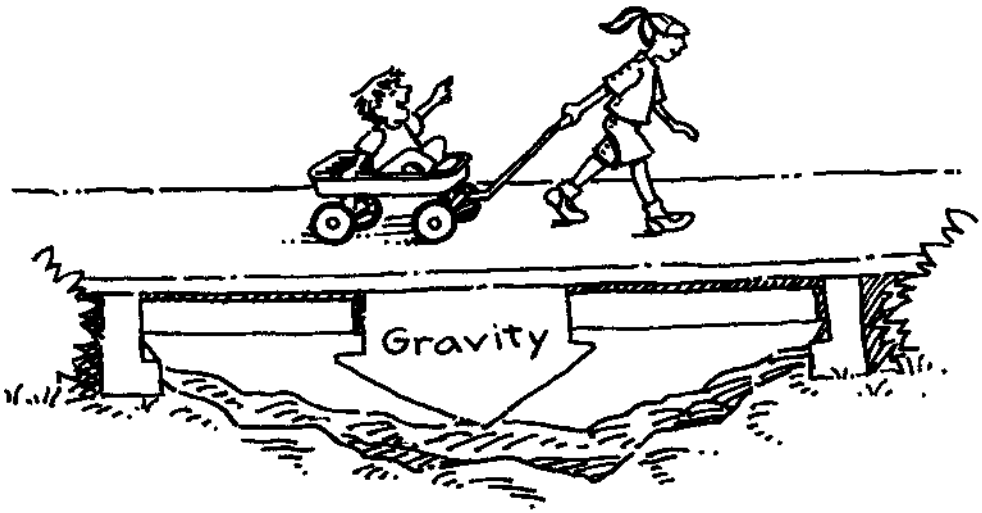
A **force** is a push or a pull on an object. The two basic forces on a structure are **lateral forces** (forces directed at the side of a structure) and **vertical forces** (forces directed up or down on a structure). Lateral forces on a structure might include **wind** (moving air).

The main vertical force on a structure is **gravity** (force pulling an object downward, which is toward the center of Earth). **Weight** is the measure of the force of gravity on an object. The weight of an object depends on **mass**, which is the amount of substance in the object. The greater the mass, the greater the weight; thus, the greater the force of gravity.

Engineers refer to the gravity force acting on a structure as the sum of its dead and live forces. **Dead forces** are the weight of the permanent parts making up the structure. In a building, dead forces include the weight of the walls, floors, and roof. **Live forces** are the weight of temporary objects in

or on a structure. In a building, live forces include the weight of people, furniture, and snow on the roof. In the figure, live forces include the weight of the wagon, the child, and the boy; dead forces include all the parts making up the bridge. The total gravity force acting on the bridge is shown by the arrow directed downward.

Since shapes of materials affect their strength, structural engineers must consider what shapes to use in designing structures that will stand up to both lateral and vertical forces.



Exercises

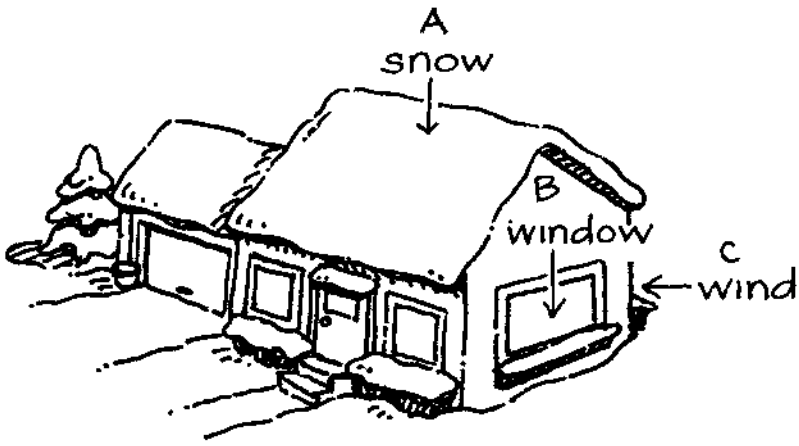
1. In a building, which choice represents a live force?

a. floors

b. windows

c. desk

2. Which force in the figure, A, B, or C, is the lateral force?



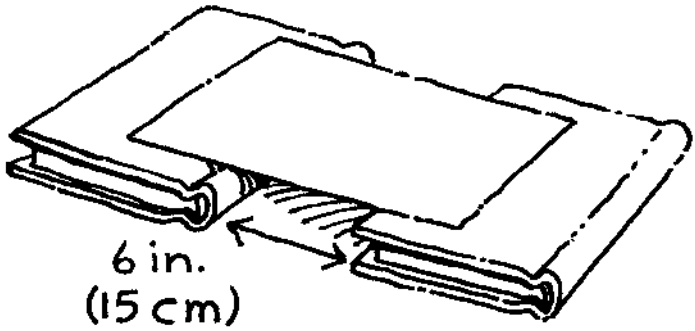
Activity: SHAPELY

Purpose To determine how the shape of a material can make it stronger.

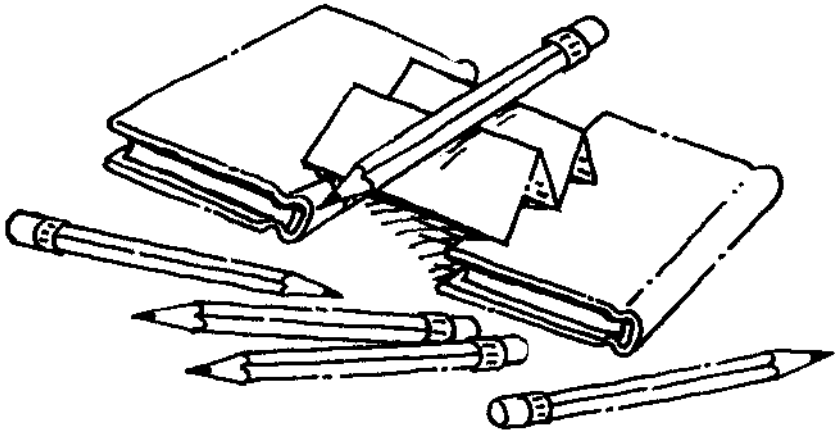
Materials 2 books of equal thickness
ruler
1 sheet of copy paper
15 or more pencils

Procedure

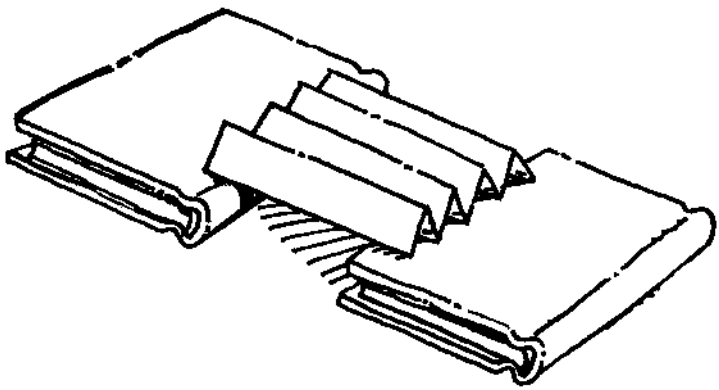
1. Lay the books on a table so that they are 6 inches (15 cm) apart.



2. Use the sheet of paper to make a bridge between the two books. Make sure that an equal amount of the paper lies on each book.
3. Test the strength of the paper bridge by gently placing one pencil at a time in the center of the paper (between the books) until the paper falls.
4. Remove the paper from the books and fold it in half by placing the short ends together. Fold the paper again in the same direction.
5. Unfold the paper, then bend it accordion style to form an M shape.
6. Use the folded paper to form a bridge between the books as shown. Again, make sure that an equal amount of the paper is on each book.



7. Test the strength of the paper bridge by gently placing one pencil at a time across the top of the folded paper. If the pencil(s) tends to roll, use your finger to stop it. Count the pencils that the paper will support before falling.
8. Remove the M-shaped bridge and press its sides together. Then fold the paper in half, placing the long sides together.
9. Unfold the paper and bend it accordion style as before. The paper now has a double-M shape.
10. Place the paper bridge across the books.



11. Repeat step 7 with the double-M bridge.

Results The unfolded paper will not support even one pencil. Depending on the weight of the pencils, the M-shaped bridge may hold 4 to 6 pencils. The double-M bridge will hold more than twice as many pencils as the single-M bridge.

Why? A flat piece of paper is not very strong, but when it is folded in an accordion shape, it becomes stronger and can support more weight. This is because all of the object's weight pushes down on one part of the flat paper. But on the folded

paper, the object's weight is spread out and smaller forces push down on different parts of the paper. The more folds, the more spread out the weight. For example, **corrugated** cardboard, which has a layer of grooves and ridges, is much stronger than flat cardboard.

Solutions to Exercises

1. ***Think!***

- Floors are part of a structure, so they are permanent forces (dead forces).
- Windows are part of a structure, so they are permanent forces (dead forces).
- A desk is not part of a structure, since it can be removed easily, so it is a temporary force—that is, a live force.

Choice C is a live force.

2. ***Think!***

- A lateral force pushes or pulls on the side of a structure.
- Force A shows snow on the roof. Snow adds weight to the house, so it is a gravitational force.
- Force B shows a window in the house. Windows add weight to the house, so force B is a gravitational force.
- Force C shows wind hitting against the side of the house.

Force C represents a lateral force.