CHAPTER 9

Structures

OBJECTIVES

- identify the four parts of a system.
- describe the loads and forces that act on structures.
- be able to explain the difference between a static load and a dynamic load.
- identify the main parts in the system used to build a house.

KEY TERMS

building codes
force
foundation
load
plans
smart materials
specifications
structural member
structure
superstructure

Imagine that a new house is being built across the street from you. The house is nearly finished. You and a friend have been eyeing a small pile of scrap materials in front of it. Finally, you get up the courage to ask the builder if you can have the lumber.

"Yes," the builder answers. He says that the scrap materials are yours. In the pile, you find four sheets of plywood, twelve 2 x 4's, a small amount of vinyl siding, and a can of nails.

You want to build something, but what could you build? A tree house? A doghouse? A shed? Each of these is a structure. This chapter will give you some ideas about how a structure is planned and built. For our example, we'll use a small house.

BUILDING IS A SYSTEM

As you read this chapter, think of the building of a house—or any structure—as a system. A *system* is an organized procedure for doing something. There are four parts to any system: inputs, processes, outputs, and feedback.

- *Inputs* are activities and items that go into a system.
- *Processes* are actions that accomplish a result.
- *Outputs* are results.
- *Feedback* is the comments on the outputs.

There are inputs, processes, outputs, and feedback at every stage of a building system. As we discuss the building of a house, try to identify each of these parts of the system.

WHAT IS A STRUCTURE?

A **structure** is something that is constructed, or built. Structures are made by joining parts to meet a certain need or perform a certain task. There are natural structures and human-made structures.

FASCINATING FACTS

A skilled igloo builder can build an igloo in 45 minutes. Afterwards, the builder holds a lantern against the igloo both inside and out. As the snow melts, the moisture that is drawn out freezes. Such an igloo is so well insulated that a person can sit inside without a coat—even when the outside temperature is -50°F.

Examples of natural structures include a spider web, a bird's nest, and a wasp nest. Fig. 9-1. Examples of human-made structures include houses, high-rise buildings, and bridges. Fig. 9-2. What

Fig. 9-1 Structures exist in nature. These natural structures provide us with design ideas. What are these natural structures designed to do? How does the design meet each structure's purpose?

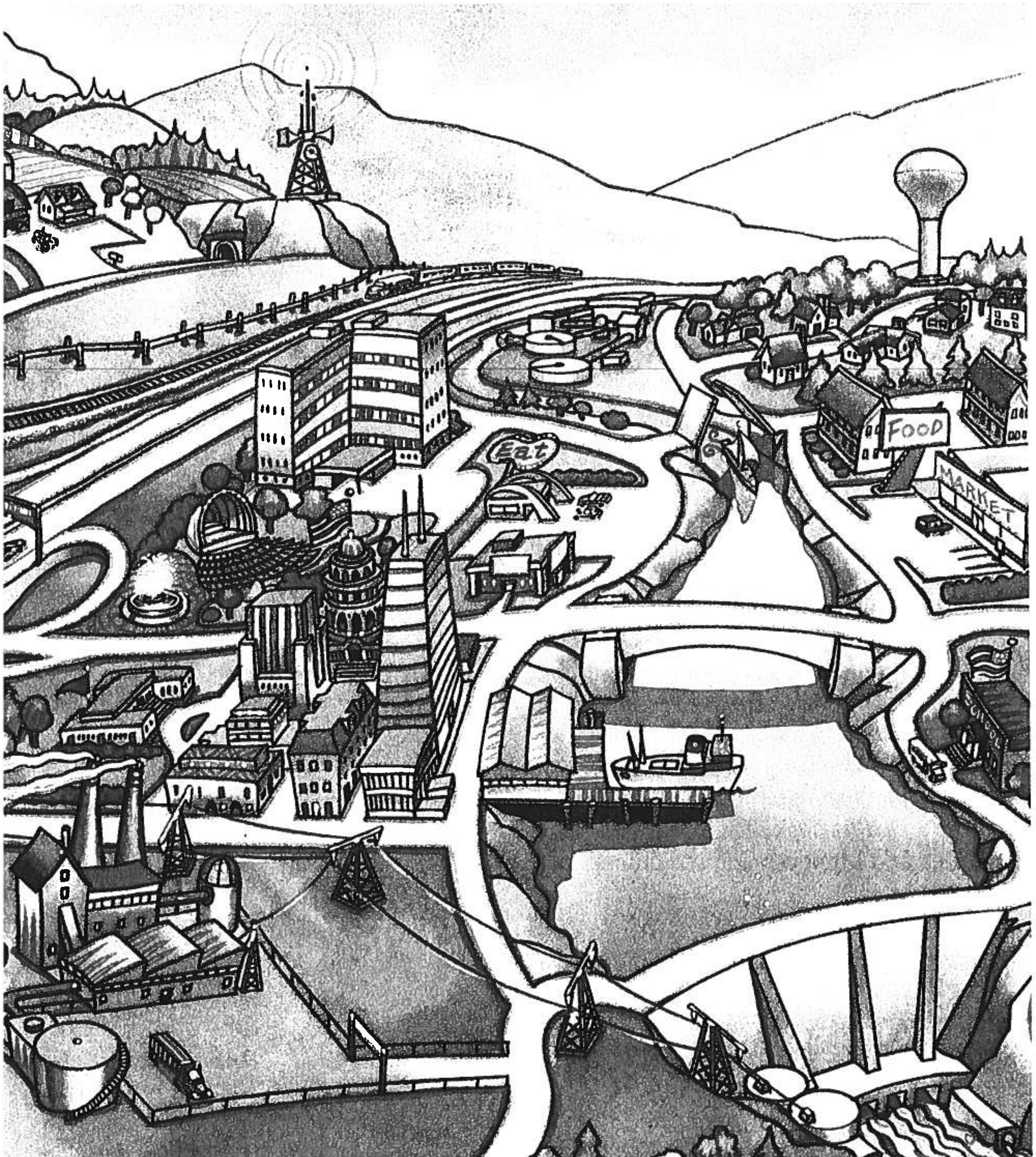


Fig. 9-2 Many human-made structures are buildings for specialized uses. We live in residential structures such as homes and apartments. Goods are manufactured in factories, which are examples of industrial buildings. Civil construction projects, such as courthouses and public libraries, meet public needs. Stores, restaurants, and office buildings are examples of commercial structures. Bridges, piers, and highway interchanges help serve our transportation needs. Dams can provide electricity. What other types of structures do you see here? What purposes do those structures serve?

similarities do you see between natural structures and human-made structures?

The design of any structure depends on its use. For example, a dam used to control the Colorado River must be rigid. A hot-air balloon must be flexible. A television-signal transmitting tower must be tall.

Figure 9-2 shows several human-made structures. Can you see that human-made structures have specific uses? For example, people *live* in houses. They *work* in factories and office buildings. This was not always the case. Hundreds of years ago, most people lived and worked in the same place. We now have buildings for specific uses because the range of human activities has expanded.

Think about why the buildings in the neighborhood of your school were built. When they were built, what human needs were they meant to satisfy? Do they still satisfy those needs?

FORCES ON STRUCTURES

A **force** is a push or a pull that transfers energy to an object. Forces on a structure can be external or internal. *External forces* are those that one body (substance) exerts on another. They are applied forces, or forces acting *upon* a structure. *Internal forces* are those that one *part* of a body exerts on an adjacent or adjoining *part* of the same body. They are forces acting *within* a structural material.

The internal forces that act within structural materials include tension, compression, shear, and torsion. A material that is being pulled is in *tension*. A material that is being pushed is in *compression*. A material that is being pushed in opposite directions along *adjacent planes* (bordering surfaces) is being subjected to *shear*. A material that is being twisted is being subjected to *torsion*. Fig. 9-3.

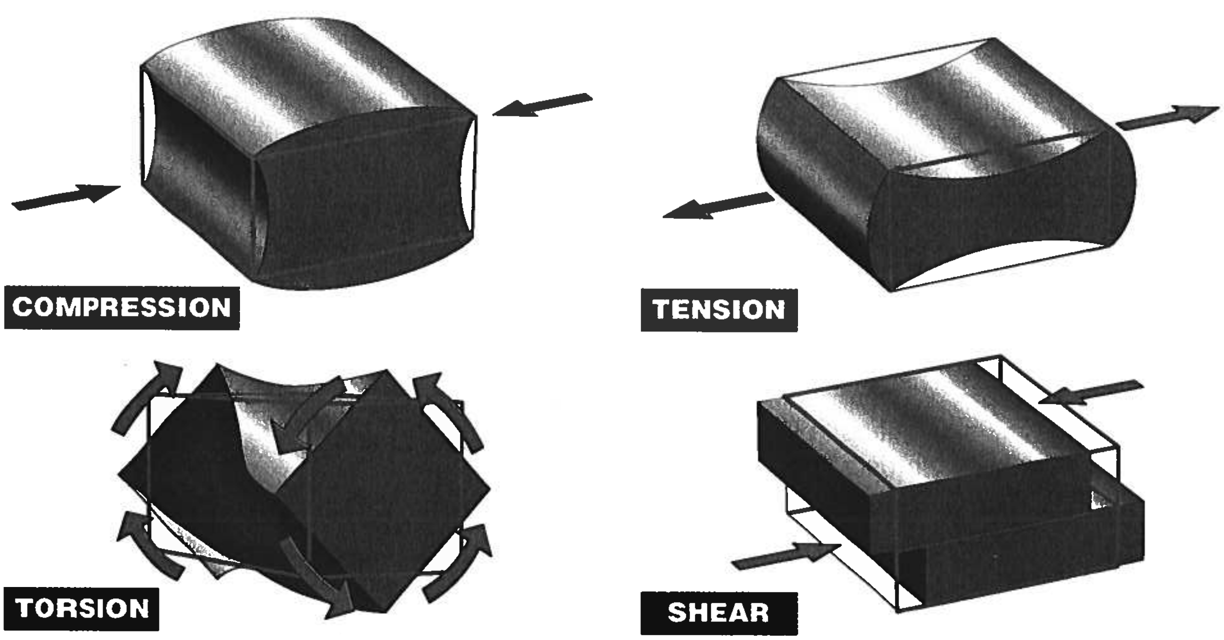


Fig. 9-3 **The four types of internal forces: (A) compression is the force that tends to shorten an object or even crush it, (B) tension is the force that tends to stretch an object or even pull it apart, (C) torsion is the force that tends to twist an object along its axis, (D) shear is the force that tends to push adjacent parts of a material in opposite directions.**

A **load** is an external force on an object. A load on a structure can be a weight of some sort. It can also be force caused by wind pressure or water pressure. Structures must be built to withstand loads. There are two types of loads: static and dynamic.

A *static load,* also called a *dead load,* changes slowly or not at all. The materials used to build a structure are part of this kind of load. For example, the bricks in a building are part of its static load. The twigs in a bird's nest are part of its static load. Can you think of other examples?

Dynamic loads, or *live loads,* move or change. A car crossing a bridge and oil flowing through a pipeline are examples of dynamic loads. Wind blowing on a building and waves pounding on a seashell are also examples of dynamic loads. Fig. 9-4.

Linking to COMMUNICATION

Word Meanings. The same words can be used in different subjects to mean different things. Review the meaning of *static* and *dynamic* as they refer to loads in technology. Ask your language arts teacher to help you understand *static* and *dynamic* as they refer to characters in stories.

Are there any similarities in the meanings of these words when talking about loads and when talking about characters? Give examples of static and dynamic loads. Explain your choice of examples. Also, give examples of static and dynamic characters. Explain your choice of examples.

STRUCTURAL MATERIALS

The materials used to build a structure are subjected to various loads and forces. The materials will help determine the structure's strength, cost, and appearance. Commonly used structural materials include steel, wood, brick, concrete, aluminum, and plastic.

It is important to choose the right material for each part of a structure. You must also choose the way the material will be used. Before choosing the materials for a structure, you should learn how they will react to loads and forces. Testing is a good way to gather this data.

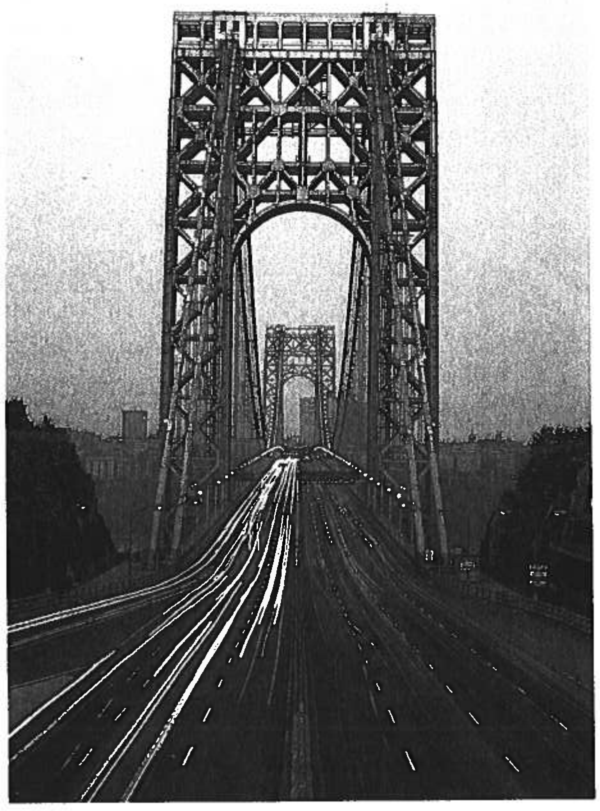


Fig. 9-4 **Both static and dynamic loads must be considered when designing a structure. Can you identify the static and dynamic loads on this suspension bridge?**

STRUCTURAL MEMBERS

A **structural member** is a building material connected to another structural member to make up the frame of a structure. Wooden studs, joists, and rafters, discussed later in this chapter, are structural members typically used to frame houses. Steel beams and columns are structural members typically used to frame towers, bridges, and large buildings.

Horizontal structural members, or supports, are known as *beams*. The top and bottom surfaces of a beam are subjected to the greatest internal forces. Fig. 9-5. Beams can be strengthened by giving them shapes such as those in Fig. 9-6. What other shapes would add strength?

Vertical structural supports are known as *columns*. Columns must have high compression strength to support the weight of a structure.

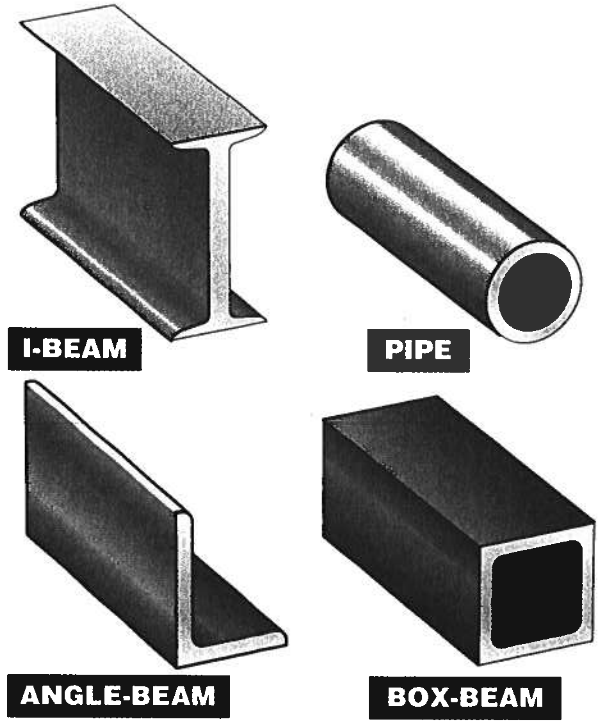


Fig. 9-6 These structural members are used in the framework of many different kinds of structures.

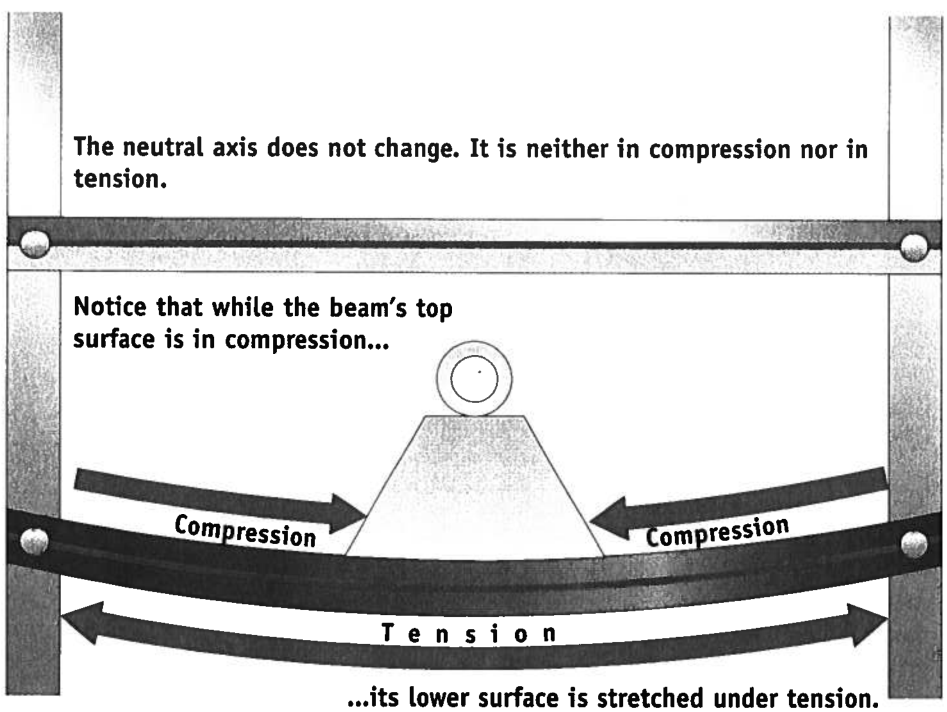


Fig. 9-5 This greatly exaggerated illustration shows what happens when you place a weight on a beam.

A CLOSER LOOK

Bridges

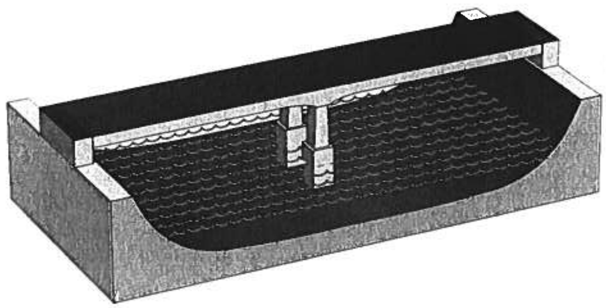
A bridge extends a roadway across a land obstacle or over water. On land, bridges are used to cross gullies and ravines, as well as highways and rail lines. Bridges also are used to cross streams, rivers, and bays.

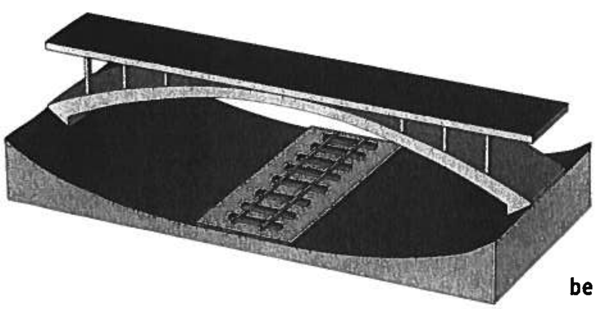
The design of a bridge depends on the obstacle being crossed and the load the bridge will carry. For example, a simple rope suspension bridge might be used to allow people to cross a mountain ravine. However, a suspension bridge such as the Golden Gate Bridge is needed to carry traffic across San Francisco Bay. The obstacle being crossed will determine the length of the bridge.

The seven basic bridge designs are shown here. Of these designs, the beam bridge is most commonly used.

BEAM BRIDGE

This bridge is built from steel or concrete beams, or girders. The beams provide horizontal supports on which the concrete roadway rests.



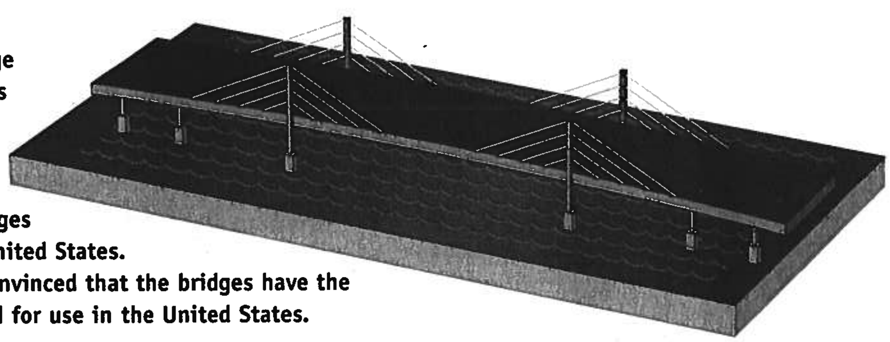


ARCH BRIDGE

The load on the roadway of this bridge is carried by the arch. The arch is supported at each end by a support called an abutment. Here the roadway is shown above the arch. However, the roadway can also be below the arch.

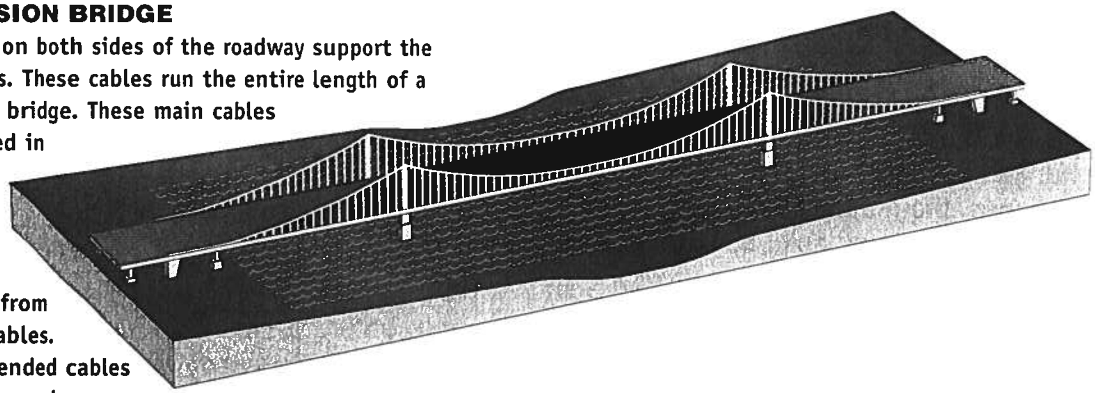
CABLE-STAYED BRIDGE

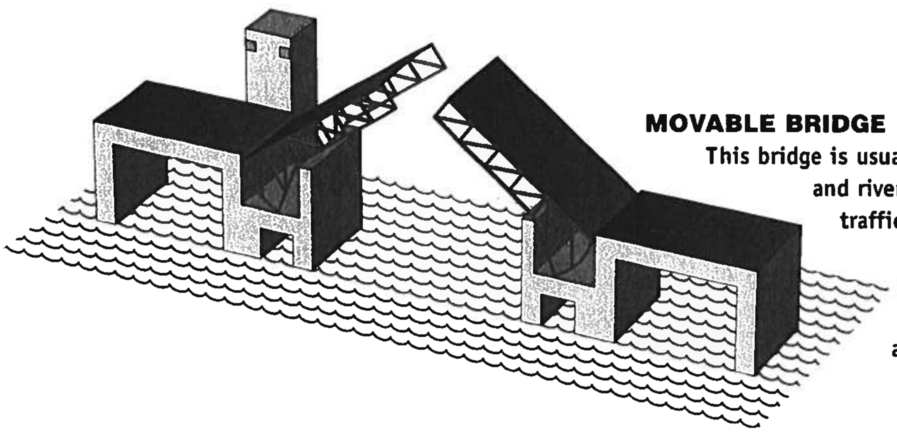
Cable-stayed bridge. This bridge supports the roadway by cables that run from towers to the roadway. In this way it is similar to a suspension bridge. Most cable-stayed bridges have been built outside the United States. American engineers are not convinced that the bridges have the strength and durability needed for use in the United States.



SUSPENSION BRIDGE

Tall towers on both sides of the roadway support the main cables. These cables run the entire length of a suspension bridge. These main cables are anchored in concrete at each end. Smaller cables are suspended from the main cables. These suspended cables support the roadway.



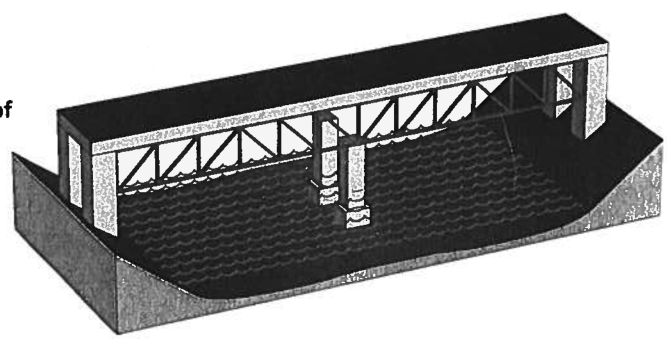


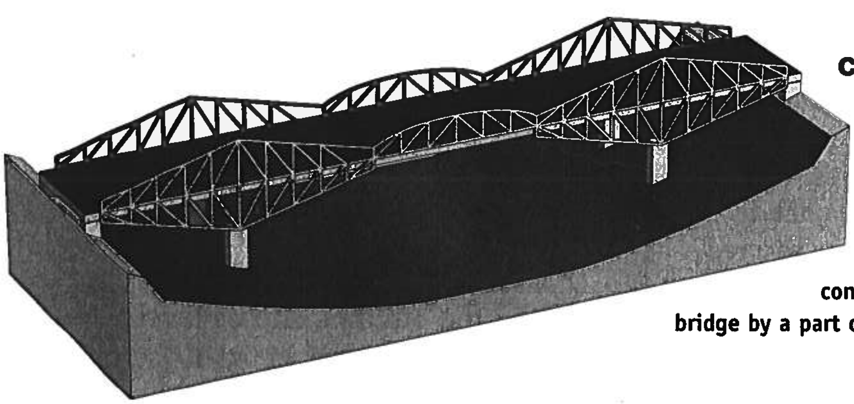
MOVABLE BRIDGE

This bridge is usually used to span canals and rivers that carry heavy boat traffic. Also called a lift bridge, this bridge has a section of roadway that can be raised to allow large ships to pass.

TRUSS BRIDGE

This bridge uses trusses to carry the load of the roadway. A truss is a framework formed from triangles. The truss may be placed above or below the roadway. A truss bridge is strong and economical to build. A truss may be used in other bridge designs to add strength.





CANTILEVER BRIDGE

A cantilever is a beam that extends from each end of the bridge. A cantilever does not reach all the way across the bridge. Cantilevers are connected in the middle of the bridge by a part called the suspended span.

Linking to SCIENCE

Elastic Limit. When subjected to a large enough load or force, a material changes shape. If the load or force continues, the material will reach its *elastic limit.* A weak point appears, and the material suddenly breaks.

You can investigate this process using a wire coat hanger. (Wear eye protection for this procedure.) Hold the hanger by the "shoulder curves." Bend the straight bottom wire slightly, so that when you stop applying pressure the wire returns to its former shape.

Take the wire to its elastic limit by straightening, then bending, then straightening it again. Repeat until little force is required to bend and straighten. The wire has reached its elastic limit. It will soon break. ▲

STRUCTURAL SHAPES

The triangle is a strong, stable shape. It is used in many structures. Triangles are used in the construction of towers and in domes. Triangles are also used in trusses. A *truss* is a triangular framework that can carry loads. Perhaps you have seen a roof truss or a truss bridge.

FASCINATING FACTS

A yurt is similar to a portable dome-shaped tent. Yurts have a dome-shaped frame made of tree branches. The frame is covered in felt. It is designed to withstand strong winds. It is secured with ropes made of animal hair. The yurt is the traditional home of the Mongolian nomad.

The *arch* is another common structural shape. An arch transfers the load it carries to the earth below. The Romans used masonry to build arch bridges. Today we use concrete and steel.

BUILDING A RESIDENTIAL STRUCTURE

A house is a residential structure. As mentioned, a system is used to construct a residential structure. You may remember that a system requires inputs, processes, outputs, and feedback. Try to identify these as we present a short outline of house construction.

Site Selection

Choosing the right location for a structure is important. A family with three children might want to build their home where there are other families with children. A retired couple might want a small home near stores and public transportation. A person planning a summer cottage might want to build it in the country on a lake or hilltop. The site will help determine the plans.

Plan Preparation

Before a structure can be designed, its desired features must be identified. An *architect* (ARC-uh-tect) is a person trained in building design. An architect designing a new home will ask questions such as:

- Who will live in the house?
- How big should the house be?
- How big will the lot be?
- Will the building site be level?
- Which rooms will be used the most?

How many bedrooms will be needed?
When must the house be completed?
How much money can be spent?

Based on the information gathered (input), the architect can make up a set of plans. Plans are also called working drawings or blueprints. **Plans** are drawings that show the builder how to construct the structure. The finished plans (output) may change as the architect receives comments (feedback) from customers. He or she may then act on their comments to produce a new set of plans (output). Can you see that a process is being used? The process involves input, output, and feedback. A similar process occurs at each stage of building construction.

Small sections of the drawings required for most residential projects are also given. These include:

- A *site plan*. This shows the location of the building(s) on the lot. It also shows sidewalks, driveways, utilities, and streets. A site plan is also called a *plot plan*.
- *Floor plans*. These show the arrangements of rooms as viewed from above. A separate drawing will be made for each floor level. Fig. 9-7.

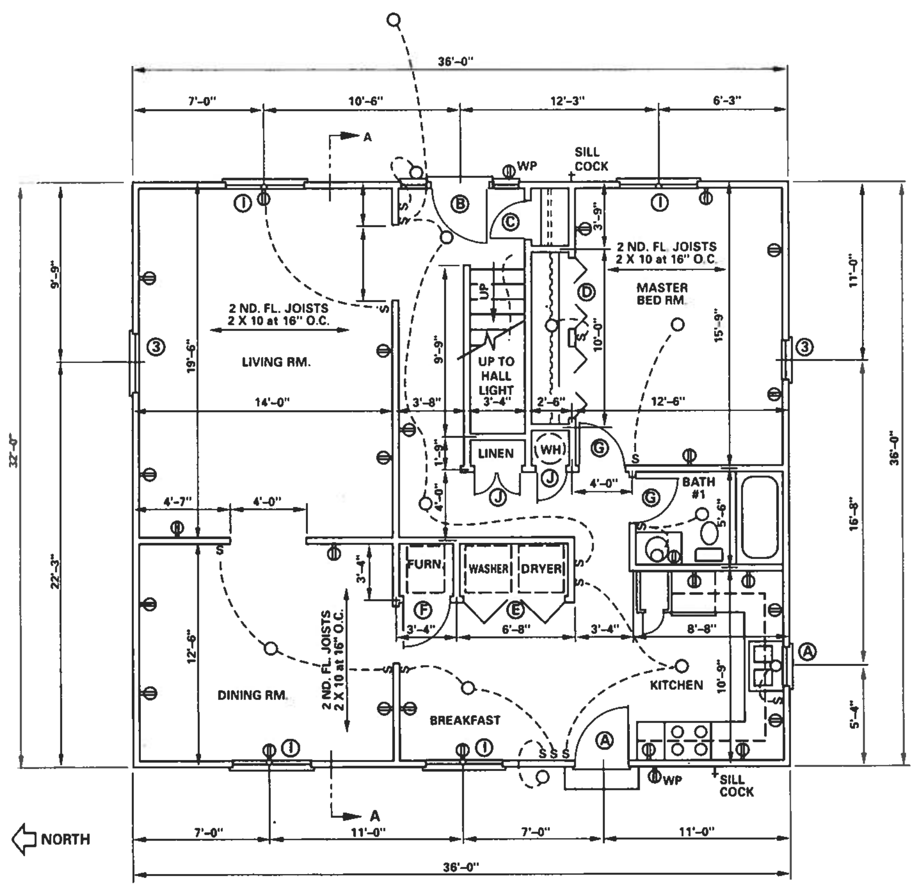


Fig. 9-7 The floor plan of a house.

- *Elevations*. These show the outside of the structure. A separate drawing (or elevation) will be made for each side of the structure. Fig. 9-8.
- *Detail drawings*. These show items that must be shown more clearly than they appear on the floor plan or elevations. Fig. 9-9.
- *Section drawings*. These show cross-sections of the inside of a structure. Fig. 9-10.
- *System drawings*. These show plumbing, electrical, and heating and ventilating systems.

A set of specifications must also be prepared. **Specifications** are written details about materials and other project-related concerns.

Fig. 9-8 **An elevation drawing.**

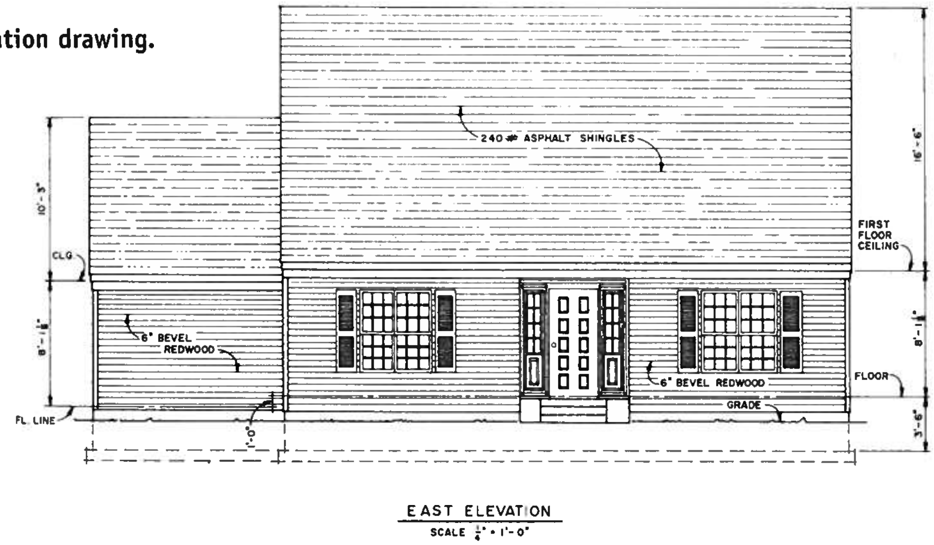
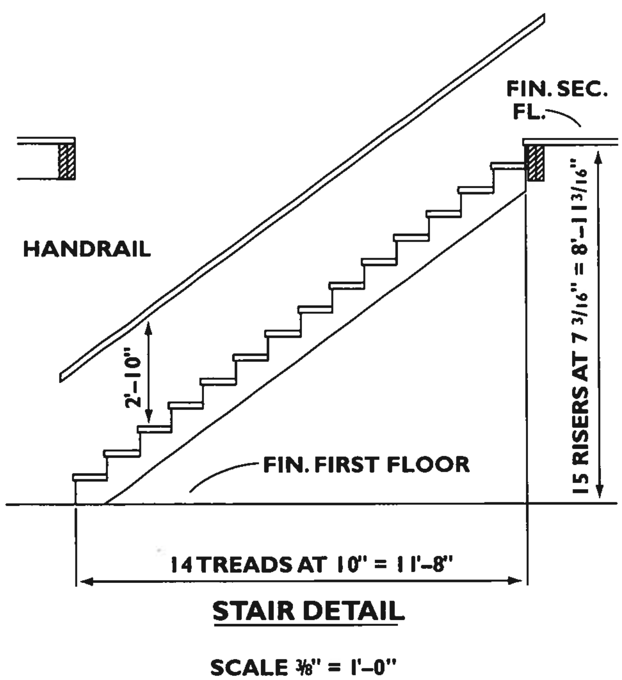


Fig. 9-9 **A detail drawing.**



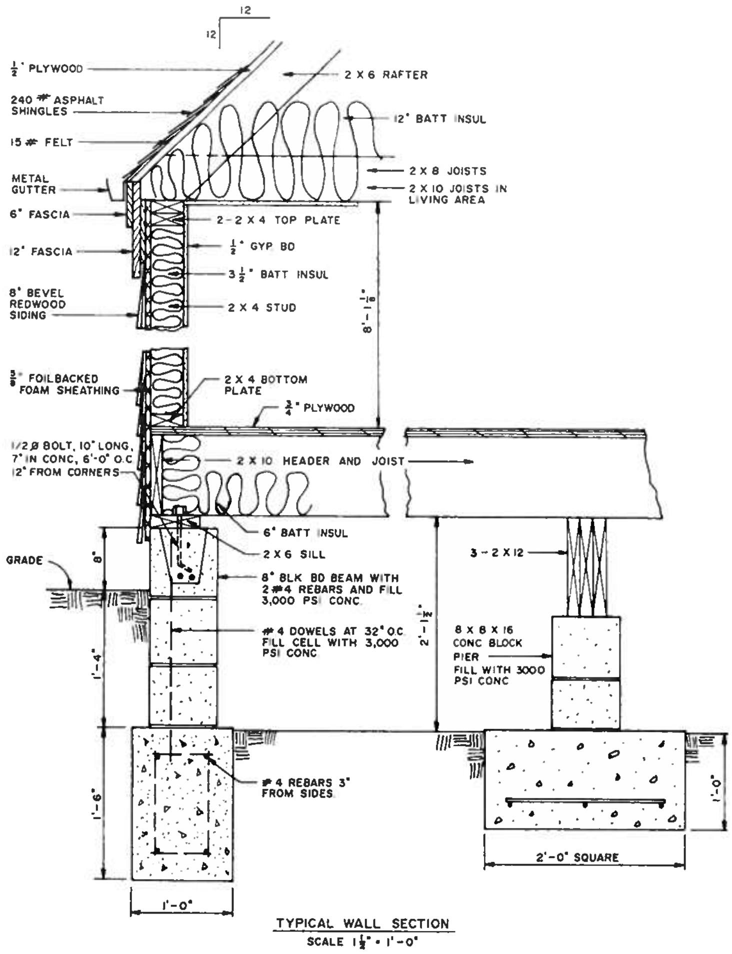
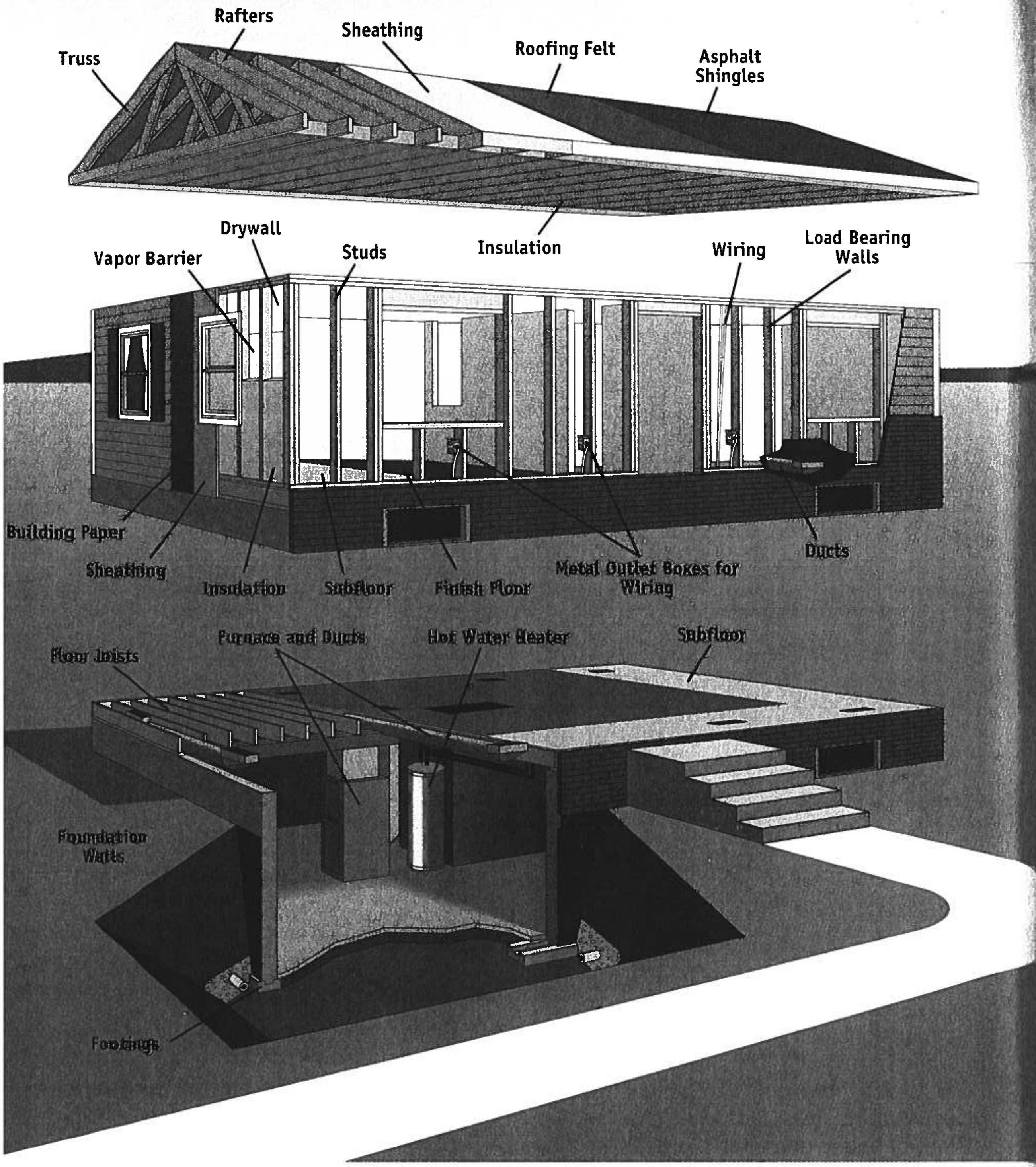


Fig. 9-10 A section drawing.

> ## *Linking to MATHEMATICS*
>
> ***Drawing to Scale.*** A floor plan obviously cannot be drawn to actual size, so it is drawn to scale. Various scale dimensions can be used, but a popular scale is 1/8" = 1'. That means that a line 1/8" long represents 1' of actual house. If you draw a line 2 3/4" long, how many feet of house does this represent?
>
> ▲

Site Preparation

Actual construction of a structure begins with *site preparation*. The site is surveyed to establish property lines. Next, trees and debris that might interfere with construction are removed. Then, the position of the house is laid out. Refer to Fig. 9-11. It shows the basic parts of a foundation and superstructure.



▸ **Fig. 9-11** **The basic processes for building are the same for most types of structures. Note the arts of this building.**

Building the Foundation

The **foundation** of a building is the part of the structure in contact with the ground. The foundation is also known as the *substructure*. The two main parts of the foundation are the *foundation walls* and the *footings*. The foundation walls are built on top of the footings. The foundation walls support the **superstructure**, which is that part of a structure above the foundation.

Some houses are built on a poured slab of concrete. Such houses do not have basements.

Fascinating Facts

Cement could be the material of the future. It may be possible to turn cement mixtures into lighter, stronger materials. The cement will be transformed by a carbon dioxide bath. The carbon dioxide will penetrate the cement, dissolving the water molecules. In minutes, this makes the cement as hard as concrete that has been aged for years.

Building the Superstructure

The frame of the superstructure provides its basic support. Most single-family homes have a wood frame. Important structural members include studs, joists, and rafters. *Studs* are upright members that help form the walls. *Joists* are horizontal members that help form the floors and ceilings. *Rafters* help form the roof.

Framing, or building the frame of the structure, typically begins with the floor. Floor joists are usually covered with plywood to create floors. The plywood is then covered with a finished floor.

Exterior (outside) walls enclose a structure to protect it from the weather. Walls that support a structure are called *load-bearing walls*. Walls that divide a building into rooms, but that are not load bearing, are called *partitions*.

There are two ways to frame the roof and ceiling of a house. Some homes use ceiling joists and rafters. Others have trusses, which serve as ceiling joists and rafters.

The roof and exterior walls are covered with sheathing. *Sheathing* is a layer of material placed between the framing and the finished exterior of a structure.

To enclose a structure, the roof, doors, windows, and siding are added. *Utility systems* are then added in two stages. Utility systems supply the services that allow someone to live comfortably in a building. Utility systems include electrical, plumbing, and climate-control systems. Pipes and wiring are installed just after the building is enclosed. This is called *rough work*. After the walls are covered, the remaining utilities are installed.

Finishing the Structure

Insulation helps keep a heated house warm in the winter. It keeps an air-conditioned house cool in the summer. After the rough work is complete, insulation is installed.

After being insulated, the ceilings and interior walls are covered. *Drywall* is the most common material used to cover ceilings and walls. Ceilings are covered first. To complete the drywall job, joint compound is applied to the nail holes and seams. Tape is pressed into the joint compound and additional joint compound is applied. After this has dried, two additional coats of joint compound are applied and lightly sanded.

Explore

Design and Build a Testing Station

Collect Materials and Equipment
4" x 6" index cards
masking tape
set of standard weights
ruler
string

State the Problem

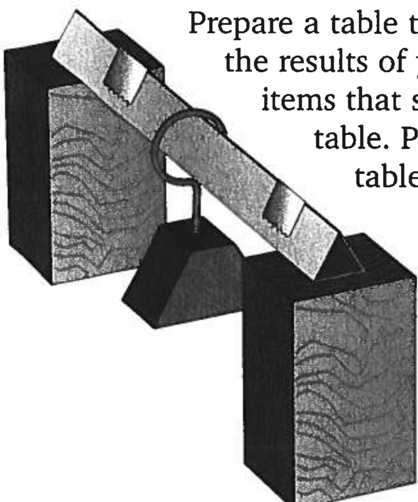
Determine how the strength of a material can be affected by changing its shape.

Develop Alternative Solutions

Refer to the beam- and column-testing setups shown here. Prepare a table that will allow you to record the results of your tests. Decide on the items that should be represented in the table. Prepare some designs for the table.

Select the Best Solution

Select the table that you think will provide the best test record.



BEAM TESTING

COLUMN TESTING

Molding is then added around the doors, windows, and floors. Cabinets are installed. The interior is painted. Finished flooring, such as carpeting or tile, is installed. Exterior finishing, which includes painting and landscaping, is then done.

CONTROL SYSTEMS

Control systems help ensure that a structure of acceptable quality has been completed on time at the expected cost. The systems used to control the quality of residential construction include zoning

Implement the Solution

1. Prepare the table in which you will record test results.
2. Make each of the shapes shown using a single index card for each shape. Hold each beam together with small pieces of masking tape. Use no more than 2 linear inches of tape per beam.
3. Find the force required to buckle the beam by testing, as shown.
4. Record the test results in the table.
5. Create smaller beams of the same shape and length.
6. Test the beams for strength as before.
7. Again record the results in the table.
8. Conduct similar tests to determine the strength of columns in these same shapes.
9. Record your results in a different table.

Evaluate the Solution

1. Which shapes were strongest during the first beam test?
2. Did reducing the size of the beams affect strength?
3. Compare the results of the beam and column tests. Which shape(s) performed well in both tests?

laws, building codes, building permits, and building inspections. The systems used to control the building costs include written contracts and agreements between the builder and the client.

Zoning Laws

Most communities have *zoning laws*. These regulate the kinds of structures that can be built in each part of the community. Zoning laws also usually specify minimum property size. They also specify how close a structure can be to the property line.

Building Codes and Building Permits

State and local governments enact **building codes.** These specify the methods and materials that can be used for each aspect of construction. Before construction can begin, most communities require a *building permit* that approves the structure for construction.

FASCINATING FACTS

Adobe bricks are often made of clay, straw, and water. These materials are kneaded together and pressed into a mold. After being baked in the sun for a few weeks, they are often finished with a coat of moist adobe or lime. Adobe is a good building material in dry climates. It is fireproof and an excellent insulator.

Building Inspections

In many communities, a building inspector will visit the site periodically. The inspector will make sure that proper construction methods are being used. The inspector usually checks footings, framing, and electrical and plumbing systems.

Before an owner accepts a building from the builder, the owner makes a final inspection. Needed corrections are written on a *punch list*. When all the corrections on the punch list have been made, the structure is considered finished.

IMPACTS

Structures benefit people in many ways. Houses and apartments provide shelter. New roads and airports improve our transportation system.

Construction creates employment opportunities for many people. Architects and drafters design new structures. Decorators suggest ways to improve existing buildings. New stores and office buildings create jobs for construction workers, as well as permanent jobs. Today, construction workers are the largest group of skilled workers in the United States.

Construction can also have negative impacts. The noise and debris created during the construction of a structure can be annoying. A new shopping mall may create traffic problems. Accidents and injuries occur during construction activities. These can be kept to a minimum by observing safe work habits.

THE FUTURE

Advances in technology will continue to change the way structures are designed, built, and used. Computer-aided drafting (CAD) systems make it possible to design structures more quickly and at less cost. The use of manufactured components such as roof trusses and floor joists improves quality. It also reduces construction time. Factory-made houses will continue to improve in quality and increase in popularity. Fig. 9-12.

In just a few years, we can expect to see more smart buildings and even some smart materials. *Smart buildings* are buildings in which computers control lighting, heating, air-conditioning, and security systems. Appliances will be controlled so that they operate when utility rates are lowest. **Smart materials** are materials that have built-in sensors to warn of unsafe conditions. For example, after an earthquake, the materials in a bridge would change color to show that the structure had become unsafe.

Fig. 9-12 Factory-made houses are assembled from manufactured components.

Apply What You've Learned

Design and Build a Small Structure

Collect Materials and Equipment
thin strips of wood glue

State the Problem

A structure must be able to support the weight of its building materials. A structure must also be strong enough to support furniture, people, vehicles or other weight depending on the use of the structure. A structure must be strong enough to resist forces such as wind, snow load, and vibration.

Design a small structure capable of supporting as much weight as possible. The structure must meet the following specifications:

- The structure cannot exceed the weight limit set by your instructor (e.g., 500 grams).
- The structure should be no larger than the size specified by your instructor (e.g., must fit within a 6-inch cube).
- The structure should have a flat surface on top and bottom to allow for easy testing.

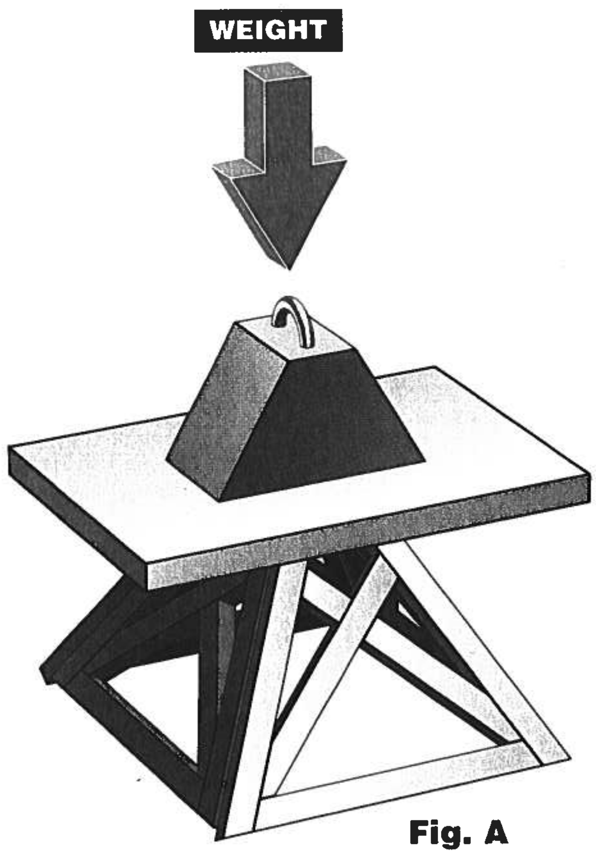


Fig. A

Develop Alternative Solutions

Design and draw a small structure that could be made from the materials provided. You will probably need to prepare several design sketches. One possible design is shown in Fig. A. This design is presented only to give you a general idea of what will be needed. Don't copy this design.

Select the Best Solution

Select the design you think will be most effective.

Implement the Solution

1. Cut the wood pieces to length and assemble the structure.
2. Weigh the structure.
3. Test the structure to determine how much weight it will hold. Your instructor will assist you.
4. Compute the weight-to-strength ratio. The more weight a structure can hold (per unit of weight of the structure), the stronger and more efficient its design.

Evaluate the Solution

1. Is the structure within the specified weight limit?
2. Did the structure have a weight-to-strength ratio as good as or better than the average of the other structures built by the class?
3. Was it possible to determine exactly where the structure failed as the load was applied? (Filming the test with a video camera and playing the film back frame by frame, will provide the answer.)

CAREERS IN Structures

CONSTRUCTION ELECTRICIAN

Commercial construction company needs trained electrician to install electrical systems in office buildings. Must ensure that work conforms to state and local building codes. Contact American Construction at (312) 466-0902 for additional information.

INTERIOR DESIGNER AND DECORATOR

Growing downtown firm with wide ranging interiors practice seeks interior designer with project experience and solid computer-assisted design background. Artistic talents and attention to detail required. Knowledge of colors and textures important. Send resume to: Box BAO13, The Design Firm, 1905 North Superior Avenue, Cleveland, OH 44114

CARPENTER

Full-time needed immediately. Commercial construction company offers year-round work. Drywall finishing a must. Experienced only need apply. Benefits. Call (312) 656-9353 for details. Office open on Sunday.

CIVIL ENGINEERING TECHNICIAN

Engineering firm has entry-level position for a technician with a strong working knowledge of CAD. Associate's Degree with emphasis in civil, highway, or environmental plan preparations required. Submit resume to: MRS Consultants, Inc., 6500 Bush Blvd., Topeka, KS 45987

SURVEY TECHNICIAN

Entry-level position for technician to work on surveying crew. Dependable individual with strong work ethic needed. Experience helpful but not required. No phone calls accepted. Send resume to: Hoffman-Metz, Inc., P.O. Box 343, Richmond, VA 42286.

ARCHITECTS

Immediate opening for registered architect to manage medium-sized retail and commercial project from initial planning through construction phase. Bachélor's degree required with computer-assisted drafting (CAD) knowledge preferred. Send resume or call: Stephen Karls, Cedar Architectural, Inc., 1567 Merriman Road, Atlanta, GA 30030, (404) 836-9972.

Linking to the WORKPLACE

There was a time when job ads in the newspaper were divided into "Help Wanted—Male" and "Help Wanted—Female." Federal laws now require that people be hired based on their qualifications, not their gender. There are still jobs held mostly by women or by men, but that is changing. Some women climb telephone poles and some men are secretaries. Are the careers you are considering held mostly by men, women, or both?

Chapter 9 Review

SUMMARY

- A system is an organized procedure for doing something. There are four parts to any system: inputs, processes, outputs, and feedback.
- A structure is something that is constructed, or built.
- A load is an external force on an object.
- The internal forces that act on structures include tension, compression, shear, and torsion.
- Beams, columns, studs, joists, and rafters are structural members.
- Building a structure involves building a foundation, or substructure, erecting the superstructure, and finishing work.
- Control systems control the quality of residential construction.

CHECK YOUR FACTS

1. What are the four parts of a system?
2. Give three examples of natural structures.
3. Explain the difference between a static load and a dynamic load.
4. Describe the loads and forces that act on structures.
5. What internal force would be present in a twisted beam?
6. What major force must the foundation of a home withstand?
7. How are beams and columns used in a structure?
8. What information does an architect need before designing a home?
9. Explain the difference between the foundation and the superstructure.
10. Identify the main parts in the system used to build a house.

CRITICAL THINKING

1. Imagine that you are going to build a structure. Discuss the type of materials that you would use for your structure. Explain why you selected them.
2. Name and sketch four different kinds of bridges.
3. How do inspections help ensure the quality of a structure?
4. Explain how a new structure can have both positive and negative impacts on a community.

SECTION 4

Power Technologies

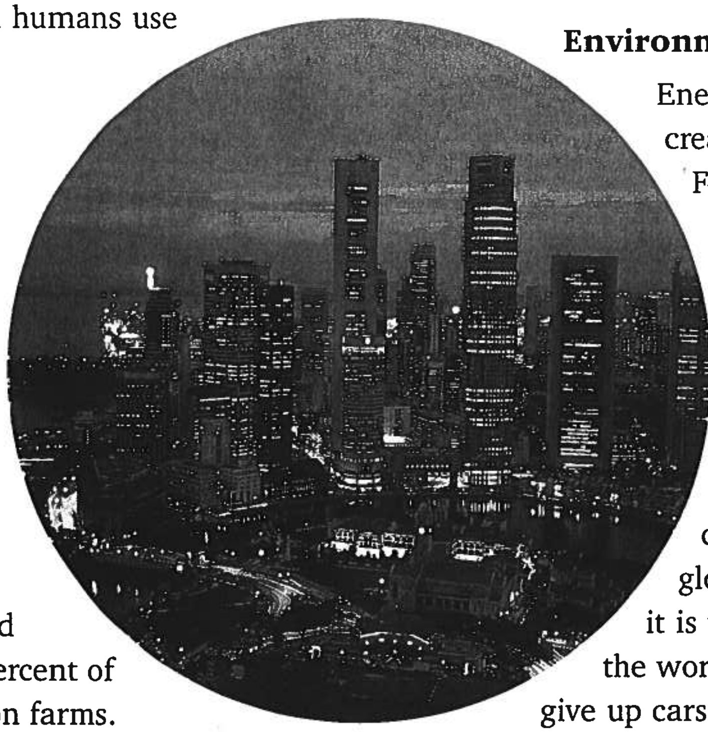
What do a rocket, a lawn mower, and a dentist's drill have in common? They are all examples of power technology. They convert and transmit energy to do work.

The chapters in Section 4 describe power technologies. You will learn how airplanes, rockets, and other forms of transportation are able to move. You will learn also about fluid power systems, such as those in the dentist's drill. As you learn about power technologies, think about the many ways they apply to our world.

Technology and Society

A Powerful Technology

Power technology began more than 300,000 years ago, when humans learned to use fire. They converted the energy in wood or other fuel into heat and light. Today every aspect of life is affected by the ways in which humans use energy.



Social Impacts

Power technology affects where we work and live. Tractors and other machines make farming more efficient. Fewer people are needed to grow food. In the United States, only 2.5 percent of the people work on farms. Most people who do work on farms don't live there.

Think of ways city life depends on power technology. What would happen, for example, if there were no electrical power?

Economic Impacts

Power technology has a huge economic impact. For example, the world's factories produce about 50 million motor vehicles (such as cars and trucks) each year. Think of the many jobs in designing, making, selling, and repairing vehicles. The people who earn money at these jobs spend it on housing, clothing, and other items, creating jobs in those industries.

Environmental Impacts

Energy use always creates some waste. For example, car engines create waste heat, as well as air pollution. These waste products pose a health hazard and may contribute to global warming. Yet it is unrealistic to think the world's people will give up cars. What might be some other solutions?

Linking to the COMMUNITY

Find out how electricity is generated in your community. What energy sources are used? How much electricity is generated? Who are the major users? Report your findings to the class.

Energy and Power

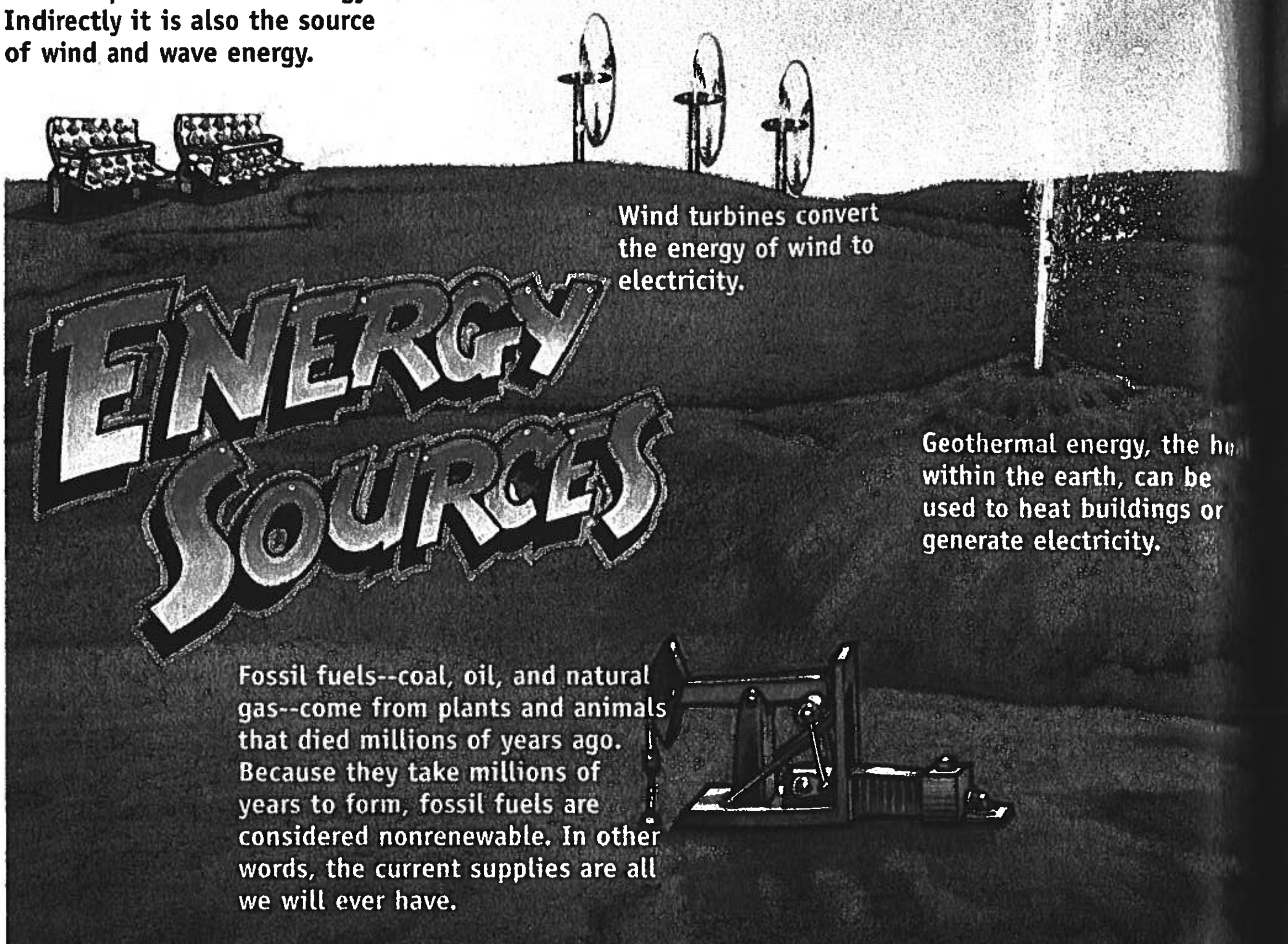
What Is Energy?

Energy is the ability to do work. Work, in this sense, isn't just what you do to make money. It's any transfer of energy through motion. In a car, energy from gasoline or diesel fuel is transferred through the engine and to the wheels. The car moves; work has been done.

There are several forms of energy. Heat, light, sound, chemical, nuclear, mechanical, and electrical energy are all used by technology. Energy can be converted from one form to another, but it cannot be destroyed under ordinary conditions.

Wherever work is being done, energy is being converted. In the example of the car, chemical energy in the gasoline or diesel fuel is converted to heat energy in the engine, which in turn is converted to mechanical energy to make the car move.

It's important to remember that work involves both force and motion. In a car's engine, for example, the pressure (the



The sun provides solar energy. Indirectly it is also the source of wind and wave energy.

Wind turbines convert the energy of wind to electricity.

Geothermal energy, the h within the earth, can be used to heat buildings or generate electricity.

Fossil fuels--coal, oil, and natural gas--come from plants and animals that died millions of years ago. Because they take millions of years to form, fossil fuels are considered nonrenewable. In other words, the current supplies are all we will ever have.

force) of a burning air-fuel mixture causes a piston to move. If the piston did not move, the energy would simply heat the engine parts. No work would be done.

What is Power?

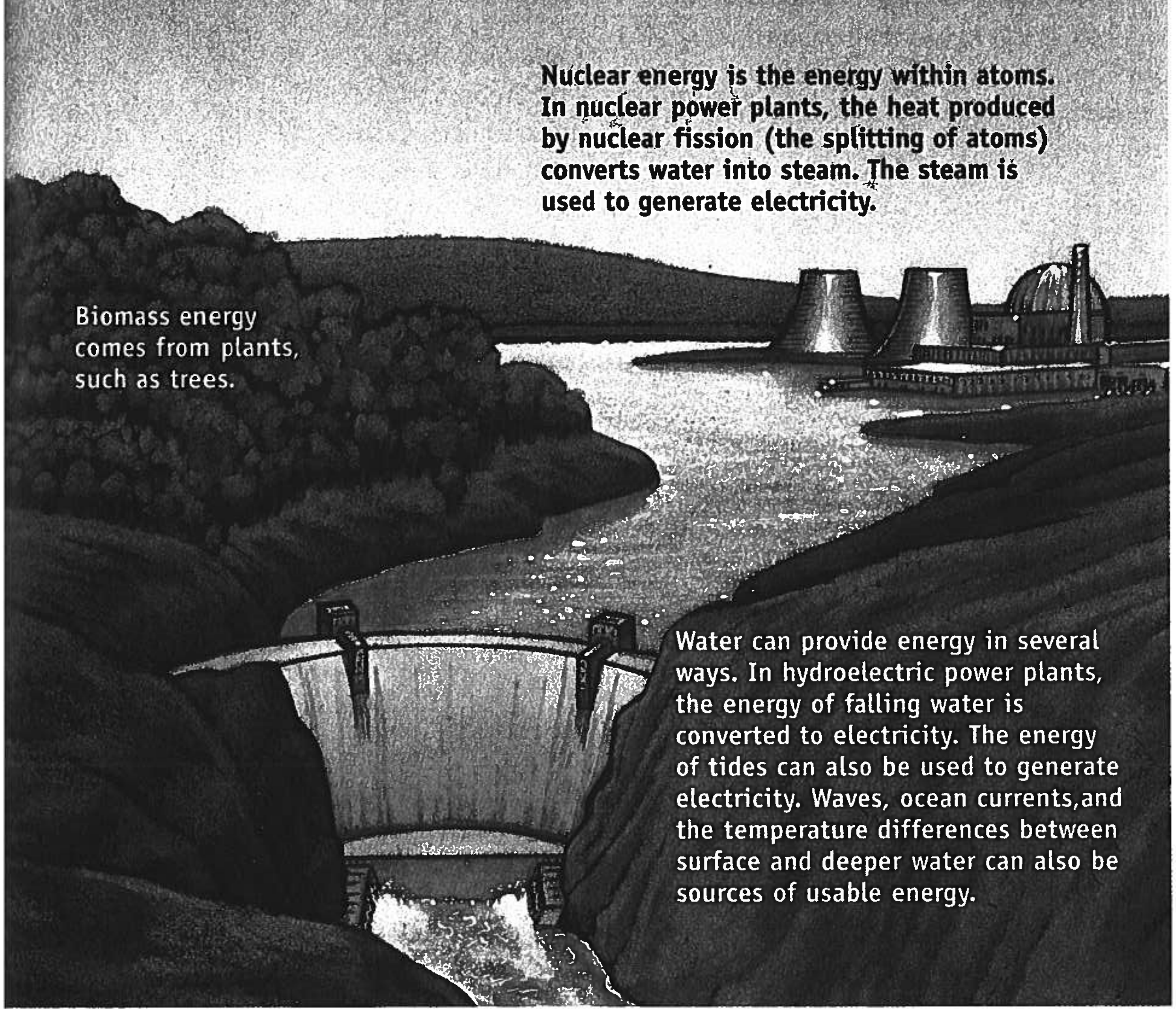
Power is the rate of work. This can be stated as a mathematical formula:

$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

From this formula, you can see there are two ways to increase power. You can increase the amount of work or decrease the amount of time.

Power Systems

Power technologies involve systems for moving and controlling power. Power systems can be mechanical, electrical, or fluid. All include a source (input); transmission and control (process); and output (use). In chapters 10-12, you will learn about power systems used for transportation and for tools and equipment.



Nuclear energy is the energy within atoms. In nuclear power plants, the heat produced by nuclear fission (the splitting of atoms) converts water into steam. The steam is used to generate electricity.

Biomass energy comes from plants, such as trees.

Water can provide energy in several ways. In hydroelectric power plants, the energy of falling water is converted to electricity. The energy of tides can also be used to generate electricity. Waves, ocean currents,and the temperature differences between surface and deeper water can also be sources of usable energy.