Chapter 17  Constructing Structures

Learning Objectives

After studying this chapter, you will be able to do the following:

1. Recall the two types of construction.
2. Summarize the characteristics of the major types of constructed buildings.
3. Give examples of types of buildings other than residential, commercial, and industrial.
4. Recall the steps involved in constructing a structure.
5. Recall the types of foundations.
6. Summarize the characteristics of the frameworks used in buildings.
7. Explain how buildings are enclosed.
8. Summarize the types of utility systems used in buildings.
9. Summarize the characteristics of materials used in finishing buildings.
10. Summarize the characteristics of heavy engineering structures.

Key Terms

arch bridge  beam bridge  buttress dam  cantilever bridge  ceiling  ceiling joist  commercial building  drywall  fascia board  floor joist  forced-air heating system  gravity dam  header  heat pump  hot water heating  industrial building  landscape  manufactured home  pile foundation  potable water  rafter  reinforced concrete  residential building  sheathing  sill  slab foundation  soffit  sole plate  spread foundation  stud  subfloor  suspension bridge  top plate  truss  truss bridge  wastewater

Human beings have three basic needs: food, clothing, and shelter. Each of these needs can be satisfied using technology. Agriculture and related biotechnologies help us grow, harvest, and process food. Manufacturing helps us to produce natural and synthetic fibers. These fibers become the inputs to clothing and fabric manufacture. Materials and manufactured goods can be fabricated into dwellings and buildings using construction technology. Construction uses technological actions to erect a structure on the site where the structure will be used.

Construction technology builds two types of structures. These are buildings and heavy engineering structures. See Figure 17-1. Buildings are enclosures to protect people, materials, and equipment from the elements. They also provide security for people and their belongings. Heavy engineering structures help our economy function effectively.

Buildings

Buildings are grouped into three types: residential, commercial, and industrial. See Figure 17-2. These groupings are based on how the buildings are used. Other types of buildings, however, exist. These special buildings follow the same construction steps as the other buildings. This section describes each of the main types, provides an overview of the other types, and discusses the general steps involved in constructing buildings.

Types of Buildings

The types of buildings differ because people have different uses for structures.
The multiple-unit dwellings include apartments, town houses, and condominiums. A residential building can be either owner occupied or rented from the owner. The owner of a dwelling is responsible for the dwelling’s upkeep. In some types of dwellings, such as condominiums, the costs of upkeep are shared between the owners. Each owner belongs to and pays fees to an association. This group elects officers who manage the maintenance of common areas such as entryways, garages, parking areas, and lawns. The association is also responsible for exterior repairs and insurance on the building. The individual owners maintain their own living quarters and insure their personal belongings against fire and theft.

**Commercial Buildings**

Commercial buildings are used for business purposes. These buildings can be publicly or privately owned. Commercial buildings range in size from small to very large. Retail stores, offices, and warehouses are commercial buildings.

**Industrial Buildings**

Industrial buildings house machines that make products. These buildings are used to protect machinery, materials, and workers from the weather. The building supports the machines and supplies the utility needs of the manufacturing process. Many industrial buildings are specially built for one manufacturing process.

**Other Types of Buildings**

You see commercial, industrial, and residential buildings all around you. If you look around your town or city, however, you probably see other types of buildings. See Figure 17-3. These might include the following:

- **Monuments.** These structures pay tribute to the accomplishments or sacrifices of people or groups.
- **Cultural buildings.** These buildings house theaters, galleries, libraries, performance halls, and museums. They host musical, dramatic, and dance performances; literary activities; and art exhibits.
- **Government buildings.** These buildings house government functions. Examples include city halls, post offices, police stations, firehouses, state capitols, courthouses, and government office buildings.
- **Transportation terminals.** These buildings are used to aid in the loading and unloading of passengers and cargo from transportation vehicles. Examples are airports, train and bus stations, freight terminals, and seaports.
- **Sports arenas and exhibition centers.** These facilities are used for sporting events, concerts, trade shows, and conventions.
- **Agricultural buildings.** These structures include barns and storage buildings used to house livestock, shelter machinery, and protect farm products (grain and hay, for example). As noted earlier, these special buildings are built using the same construction steps used for a single-family home.

One special type of building is the manufactured home. As you remember, manufactured homes are built using the same construction steps used for a single-family home. As veterans returned from World War II, housing demand grew as the veterans sought affordable places to live. William Levitt saw the increased housing demand as a golden opportunity. In 1946, he created the first major planned community, Levittown in Long Island. For $7,000, a person could buy one of Levittown’s 17,500 two-bedroom homes.

Many Americans live in what are called suburbs. Suburbs are not new phenomena. They have existed in one form or another throughout history. In ancient times, many cities were surrounded by walls. The villages outside of the city walls were smaller and often considered lower in the social hierarchy. Now, suburbs are often considered the opposite of that: upscale places for upper- and middle-income families. This “suburb” may have appeared over twenty-six hundred years ago in Babylon. The word comes from the Latin suburbium, which Roman Emperor Cicero used in the first century B.C. to describe luxurious estates outside Rome.

We live in buildings, buy products in buildings, work in buildings, and worship in buildings, to name a few activities we do in buildings. To help understand the types of buildings people design, build, and use, we will explore three major types of buildings and then briefly review some more unique structures.

**Residential Buildings**

Residential buildings are buildings in which people live. These buildings can be single-family or multiple-unit dwellings.
Building codes. These codes are regulations controlling the design and construction of a structure to provide for human safety and welfare.

Best (professional) practices. These practices are the accepted methods or processes the profession considers to be the most appropriate ways to complete an activity or build a structure.

Within the constraints the design provides, most construction projects follow the same basic steps. See Figure 17-5. These steps include the following:
1. Preparing the site.
2. Setting foundations.
3. Building the framework.
4. Enclosing the structure.
5. Installing utilities.
6. Finishing the exterior and interior.
7. Completing the site.

Each type of structure needs to have specific actions taken during each step.

The two halves of the structure are transported to the site, where a foundation is already in place. Each half is lifted from its transporter and placed on the foundation. The two halves are finally bolted together. The final trim that connects the halves is installed. The utilities are hooked up, and the home is ready for the homeowner.

Similar techniques are used to produce temporary classrooms, construction offices, and modular units that can be assembled into motels or nursing homes.

Constructing Buildings

Constructed structures start with architectural and engineering plans that are a result of the designing process discussed earlier. The owner’s needs and budget constrain these plans. Also, three other factors constrain the plans. These are the following:

Zoning laws. These laws are government regulations restricting how a piece of land can be used.

Building codes. These codes are regulations controlling the design and construction of a structure to provide for human safety and welfare.

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This helps complete the structure on time. We will look at the steps used to construct a small single-family home. Later in the chapter, other construction activities are discussed.

A common type of building is a single-family home. This building is designed to meet a number of needs of the owners. These needs include protection from the weather, security, and personal comfort. See Figure 17-6. To meet these needs, a home must be properly designed and constructed. The construction process starts with locating, buying, and preparing a site.

Figure 17-4. The steps in building a manufactured home.

Figure 17-5. Most construction projects follow the same basic steps.

Figure 17-6. Some of the needs a home must meet for its owner.
Preparing the Site

The location for a home needs to be carefully selected. This location should meet the needs of the people who will live there. For example, a family with children might think about the schools serving the area. The parents consider the distance to work and shopping, recreation, and cultural facilities. The condition of other homes in the neighborhood, building codes, and covenants are other factors to consider.

Once the site is chosen, it is purchased from the owner. This might require work with a real estate agent and obtaining a bank loan or other financing. The financing probably includes the money to erect the home. This is important because most banks do not loan money to build on mortgaged land.

Next, the site is cleared to make room for the structure. The location of the new building is marked out. The area is then cleared of obstacles. When it is possible, the building should be located to save existing trees and other plant life. The site might require grading to level the site. See Figure 17-7. Grading prepares areas for sidewalks and landscaping and helps water to drain from the site. These preparations are needed for the next step, setting foundations.

Figure 17-7. Before a building can be built, the site must be cleared and graded.

Setting Foundations

The foundation is the most important part of any building project. This part serves as the feet of the building. Try to stand on just your heels. You will be unstable and wobble. Likewise, a building without a proper foundation settles unevenly into the ground. Such a building leans, becomes unstable, and might collapse. The Leaning Tower of Pisa in Italy is an example of a building that has a poor foundation. Over time, the tower has settled and is leaning several feet to one side.

A complete foundation has two parts: the footing and the foundation wall. See Figure 17-8. The footing spreads the load over the bearing surface. The bearing surface is the ground on which the foundation and building will rest. This can be rock, sand, gravel, or a marsh. Each type of soil offers unique challenges for the construction project.

Figure 17-8. The foundation wall and footing spread the building’s weight onto the bearing surface. The concrete foundation shown in the photo has been insulated to reduce heat loss.
Pile foundations. These types of foundations are used on wet, marshy, or sandy soils. Piles are driven into the ground until they encounter solid soil or rock. For example, a bridge must be able to support its own weight and the weight of vehicles crossing it.

Each type of foundation is built in a unique way. Let us consider a spread foundation. The site is surveyed to locate where the foundation will be placed. See Figure 17-10. The site is then excavated in preparation for the footings and the walls. If the building is to have no crawl space under the first floor, excavation does not go as deep. Buildings with basements require deeper excavations. Footing forms are set up next. Forms are a lumber frame to hold the wet concrete until the concrete cures (hardens). They give the footings or slabs height and shape. Concrete is poured and leveled off. When the concrete is cured, the forms are removed. Walls of poured concrete or concrete block are built atop footings. Slabs are ready for aboveground superstructures. Figure 17-11 shows an excavation for a pool. Wooden foundations use no concrete for either footings or walls.

Building the Framework

The framework becomes the base for the next part of the building, the framework. Erecting the framework gives the building its size and shape. The framework includes the floors, interior and exterior walls, ceilings, and roof. Also, the locations of doors and windows are set up at this time.
Walls

The wall frames are placed on top of the floor. These frames support both exterior and interior walls. Wall framing is often made of 2 × 4 or 2 × 6 construction-grade lumber. See Figure 17-14. A framed wall has a strip at the bottom called the sole plate. Nailed to the sole plate are uprights called studs. The length of the studs is set by how high the ceilings will be. At the top of the wall, the studs are nailed to double ribs of 2 × 4s called a top plate or wall plate. Door and window openings require headers above them. Headers carry the weight from the roof and ceiling across the door and window openings. Shorter studs called trimmer studs hold up the headers.

Ceilings and roofs

The walls support the ceiling and roof. See Figure 17-15. The ceiling is the inside surface at the top of a room. The roof is the top of the structure that protects the house from the weather. Ceiling joists support the ceiling. These joists rest on the outside walls and some interior walls. Interior walls that help support the weight of the ceiling and roof are called load-bearing walls or bearing walls. The roof forms the top of the building. There are many types of roofs, including gable, flat, hip, gambrel, and shed.

Figure 17-13. The floors in single-family homes are either concrete slabs or lumber.

Figure 17-14. Many of the parts of a wood-framed wall.

Figure 17-15. How the roof meets the wall frame.

Figure 17-16. Some popular types of roofs used on homes.
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Academic Connections: Communication

Word Origins

Probably most people would be happy to have their names become part of everyday language as a result of their inventions. John McAdam, a Scottish engineer who experimented with road construction, might be doubly pleased. His work with roads has resulted in two words in common use today.

As described in this chapter, John McAdam developed the crushed-stone road. This new type of road had three layers of crushed rock compacted into a solid mass. The road was also made slightly convex. McAdam’s design improved roads tremendously because now the traffic load was spread, and rainwater ran off the surface. We are now more familiar with this type of roadway through the use of the term macadam.

The other word is even more familiar and is also related to roads. In an effort to improve roads even more, people used tar to bind the crushed rock together. This process was given the name tarmacadam or, as we now call it when we use it on runways, tarmac. Modern roads are still built using John McAdam’s principles. Can you find another common word we use today that is based on someone’s name and invention?

walls. Most foam sheets have a reflective backing to improve the insulation value of the sheet. Most homes constructed today have a layer of plastic over the sheathing to prevent air from leaking in.

Normally, the roof is put in place before the utilities are installed. See Figure 17-18. The actual roof surface has two parts. Plywood or wafer-board sheathing is applied over the rafters. Builder’s felt is often applied over the roof sheathing. Wood or fiberglass shingles, clay tiles, or metal roofings are then installed over the sheathing and felt. Flat and shed roofs often use a built-up roof. A built-up roof starts with laying down sheets of insulation. Roofing felt is laid down, followed by a coat of tar, which is covered with gravel.

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Installing Utilities

On many structures, the overhang of the roof is also finished. A fascia board is used to finish the ends of the rafters and the overhang. The soffit is installed to enclose the underside of the overhang. Softifs can be made of aluminum, vinyl, or plywood. They must have ventilation holes or vents to prevent moisture and heat buildup in the attic.

Once the sheathing and roof are installed, the openings for doors and windows are cut out. The doors and windows are then set in place. Now the house is secure and weather tight.

Electrical systems

The electrical system delivers electrical power to the different rooms of the home. The power is brought into the house through wires to a meter and distribution panel. This panel splits the power into 110-volt and 220-volt circuits. Each circuit has a circuit breaker to protect against current overloads.

Appliances such as clothes dryers, electric ranges, water heaters, and air conditioners require 220-volt power. Circuits for smaller appliances, lighting, and wall outlets use 110 volts. Outlets might have power fed to them at all times. Switches can also control outlets. Figure 17-19 shows a 110-volt circuit with wall (duplex) outlets and a ceiling light. The outlets always have power. The circuit to the light has a switch, however.
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Most 110-volt circuits are limited to 15 or 20 amps. Therefore, a number of different circuits are required to supply various parts of the home. A kitchen might be fed from one or two circuits because of how many appliances are used there. One circuit might feed two bedrooms because there are few appliances in these rooms.

Plumbing systems

The plumbing system has two separate parts. One part supplies potable water. See Figure 17-20. Potable water is safe for drinking. The other part of the system carries away wastewater. Plumbing fixtures and systems are designed to prevent mixing of potable water and wastewater and to stop sewer gas from leaking into the dwelling.

The potable-water system starts with a city water supply or a well for the house. The water enters the house through a shut-off valve and might pass through a water conditioner to remove impurities, such as iron and calcium. The waterline is split into two branches. One line feeds the water heater. The other line feeds the cold-water system. Separate hot and cold waterlines feed fixtures in the kitchen, bathrooms, and utility room. Toilets, however, receive only cold water. Most waterlines have shut-off valves before they reach the fixture. For example, the waterlines under a sink should have a shut-off valve. The valve allows repair work to be made without stopping the water flow to the rest of the house.

The second part of the plumbing system is the wastewater system. This system carries used water away from sinks, showers, tubs, toilets, and washing machines. The wastewater is routed to a city sewer line or to a septic system.

Climate-control systems

In many homes, the climate-control system is used to heat the building in winter and cool it in summer. This can be done with a single unit or with separate heating and cooling units. Heating systems can directly or indirectly heat the home. In a direct heating system, the fuel is used in the room to be heated. Direct heating might use a stove or a fireplace that burns wood or coal.

Other direct heating methods use electrical power. These systems use resistance heaters installed in the walls or along the baseboards. Also, ceiling radiant wires or panels might supply the heat.

Indirect systems heat a conduction medium, such as air or water. This medium carries the heat from a furnace to the rooms. The heat is then given off to the air in the room. See Figure 17-21. The energy sources for these systems are electricity, coal, oil, wood, natural gas, or propane.

Furnaces that heat air as a conduction medium are called forced-air heating systems. Forced-air furnaces draw air from the room. This air is heated as it moves through the furnace. A fan delivers the heated air through ducts to various rooms. Forced-air systems use pumps or fans to move a
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Finishing the Exterior and Interior

The final exterior finishing step is installing siding and trim. Siding is the finish covering used on a wood building. Wood shingles and boards, plywood, hardboard, brick, stone, aluminum, vinyl, steel, and stucco can be used as siding. Look back at Figure 17-17. You see bricks being installed over plywood sheathing. Trim is the strips of wood covering the joints between window and door frames and the siding.

The interior walls are the next walls to be finished. Insulation is placed between the studs and around the windows and doors of all exterior walls and reduces heat loss on cold days and heat gain on hot days. The most common type of insulation is fiberglass blankets or batts. A vapor barrier of polyethylene film is attached to the studs over the insulation. This barrier prevents moisture from building up in the insulation.

Once insulation and utilities are in place, the interior walls are ready for the finishing touches. Interior wood trim is installed around the doors and windows. Kitchen, bathroom, and utility cabinets are normally installed during the construction of the building. Installing them after a building is finished takes considerable work to feed the wires through attics, under floors, and inside walls. Many houses are now being built with sound systems that allow music to be played throughout the home.

The inside and outside of the house are now ready for the finishing touches. Interior wood trim is installed around the doors and windows. Kitchen, bathroom, and utility cabinets are set in place. Floor coverings, such as ceramic tile, wood flooring, carpet, or linoleum, are installed over the subflooring. Baseboards are installed around the perimeters of all the rooms. The exterior siding and wood trim are painted. Interior trim is painted or stained. The walls are painted or covered with wallpaper or wood paneling. Lighting fixtures, switch and outlet covers, towel racks, and other accessories are installed. The floors and windows are cleaned. Now the home is finished and ready to be occupied.

Completing the Site

Completing the building is the major part of the project. Other work remains to be done, however. The site must be finished. Earth is moved to fill in areas around the foundation. Sidewalks and driveways are installed.

The yard area needs to be landscaped. Landscaping is trees, shrubs, and grass that are planted to help prevent erosion and improve the appearance of the site. These trees, shrubs, and grass can divide the lot into areas for recreation and gardening. Landscaping can be used to screen areas for privacy, direct foot traffic, and shield the home from wind, sunlight, and storms.

Look at Figure 17-22. The top view shows dirt being moved onto the site for landscaping activities. The bottom view shows a finished landscaped area. Notice how the trees and lawn improve the appearance. Also, a grassy mound is used to guide people onto the sidewalk.

Heavy Engineering Structures

Construction activities do not always produce buildings. They can be used to...
produce structures that are sometimes called civil structures, or heavy engineering structures. These structures include highways, rail lines, canals, pipelines, power-transmission and communication towers, hydroelectric and flood-control dams, and airports. They provide the paths for the movement of water, people, goods, information, and electric power. These projects can be grouped in various ways. For this discussion, we group them into transportation, communication, and production structures.

Transportation Structures

Transportation systems depend on constructed structures such as railroad lines, highways and streets, waterways, and airport runways. Other constructed works help vehicles cross uneven terrain and rivers. These structures include bridges and tunnels. Pipelines are land-transportation structures used to move liquids or gases over long distances. Let us look at some examples of these constructed works. We discuss roadways and bridges.

Roadways

Roads are almost as old as civilization. People first used trails and paths to travel. Later, they developed more extensive road systems. The Romans built the first engineered roads more than 2000 years ago. Their influence remained until the 1700s, when modern road building started. Today’s roads have their roots in the work of the Scottish engineer John McAdam. He developed a crushed-stone road built of three layers of crushed rock, laid in a 10″ (25 cm)–thick ribbon. Later, this roadbed was covered with an asphalt-gravel mix that is very common today. A more recent development is the concrete roadway.

Road building is a step-by-step process. See Figure 17-23. The graded dirt is compacted, and a layer of coarse gravel is laid. This is followed with finer gravel that is leveled and compacted. Next, the concrete or asphalt top layer is applied. Concrete roads are laid in one layer. Asphalt is generally applied in two layers: a coarse undercoat and a finer topcoat. Finally, the shoulders, or edges, of the road are prepared. The shoulders can be gravel or asphalt.

Bridges

Another constructed structure vital for transportation is the bridge. Bridges provide a path for vehicles to move over obstacles. These obstacles include marshy areas, ravines, other roads, and bodies of water. Bridges can carry a number of transportation systems. These systems include highways, railroads, canals, pipelines, and footpaths.

Generally, there are fixed and movable bridges. A fixed bridge does not move. Once the bridge is set in place, it stays there. Movable bridges can change their positions to accommodate traffic below them. This type of bridge is used to span ship channels and rivers. The bridge is drawn up or swung out of the way so ships can pass.

Bridges have two parts. See Figure 17-24. The substructure spreads the load of the bridge to the soil. The abutments and the piers are parts of the substructure. The superstructure carries the loads of the deck to the substructure. The deck is the part used for the movement of vehicles and people across the bridge.

Figure 17-22. This site was finished by grading the lot and planting landscaping.

Figure 17-23. Road building is a step-by-step process.
The kind of superstructure a bridge has indicates the type of bridge it is. The types of bridges are beam, truss, arch, cantilever, and suspension. See Figure 17-25.

**Beam bridges**

Beam bridges use concrete or steel beams to support the deck. This type of bridge is widely used when one road crosses another one. Beam bridges are very common on the interstate highway system.

**Truss bridges**

Truss bridges use small parts arranged in triangles to support the deck. These bridges can carry heavier loads over longer spans than beam bridges can. Many railroad bridges are truss bridges.

**Arch bridges**

Arch bridges use curved members to support the deck. The arch can be above or below the deck. Arch bridges are used for longer spans. One of the longest arch bridges spans more than 1650′ (502 m).

**Cantilever bridges**

Cantilever bridges use trusses extending out in both directions from the support beams, similar to arms. The ends of the arms can intersect with the road leading up to the bridge or hook up to another truss unit to form a longer span. The arms transmit the load to the center.

**Suspension bridges**

Suspension bridges use cables to carry the loads. A large cable is suspended from towers. From the large cable, smaller cables drop down to support the deck. Suspension bridges can span distances as great as 4000′ (1220 m) and longer.

**Communication Structures**

Most telecommunication technology relies on constructed towers to support antennas. These towers are usually placed on a concrete foundation. A steel tower is built on top of the foundation. Once the tower is complete, the signal wiring can be installed. Similar techniques are used to construct towers for power-transmission lines. See Figure 17-26.

**Think Green**

**Green Architecture**

You may not think about this, but buildings consume a lot of resources. Buildings consume a great deal of electricity, water, and raw materials. They also output a large amount of waste and carbon dioxide. Through the practice of green architecture, the resources and waste are greatly reduced. Green architecture is a means of being more environmentally responsible with buildings from design to construction and landscaping. Buildings are designed to be more efficient with their use of resources, starting with the building materials.

Green architecture may use recycled materials in construction. This type of architecture also uses more energy-efficient resources and renewable energy sources. It is responsible in planning for landscaping, in order to consume less water. And while green architecture benefits the environment in general, even the air and water quality within the building may improve.
Production Structures

Some structures used for production activities are not buildings. For example, petroleum refineries are mixes of machinery and pipelines. Irrigation systems are constructed to bring water to farms in dry areas. Evaporation basins are built to recover salt and other minerals from seawater.

Another important production structure is the dam. Dams are used for controlling floods, supplying water, making recreational lakes, or generating electricity.

Several types of dams exist. One type is called a gravity dam. This dam’s lakeside is vertical, whereas the other side slopes outward. The sheer weight of the concrete the dam is made from holds the water back. The dam on the left in Figure 17-27 is a gravity dam.

Two more types of dams are the rock dam and the earth dam. The earth dam is also shown in Figure 17-27. A rock dam looks similar to two gravity dams placed back-to-back. Both sides slope outward. Rock and earth dams must be covered with a waterproof material to prevent seepage. Clay is often used for this covering.

A buttress dam uses its structure to hold back the water. This type of dam is not solid. A buttress dam uses walls of concrete to support a concrete slab or arches against the water.

Tall dams holding back large quantities of water are called arched dams. The arched shape increases the strength of the dam. This shape also spreads the pressure onto the walls of the canyon where the dam is built.

Test Your Knowledge

Write your answers on a separate piece of paper. Please do not write in this book.

1. List two kinds of constructed works.
2. A condominium is a residential structure that the people living in it generally own. True or false?
3. Give two examples of a government building.
4. A home built in a factory is called a(n) ______.
5. You should use spread foundations on wet or sandy soils. True or false?
6. The two types of floors in single-family homes are concrete slab or ______.
7. What is a fascia board used for?
8. The two types of water systems that are part of a plumbing system are called ______
9. The most common type of insulation is ______.
Matching questions: For Questions 10 through 22, match each description on the left with the correct construction step on the right. (Note: Answers can be used more than once.)

10. ______ Sheathing the walls.  
11. ______ Putting up drywall.  
12. ______ Grading.  
13. ______ Putting in footings.  
14. ______ Landscaping.  
15. ______ Putting in a heat pump.  
16. ______ Installing a subfloor.  
17. ______ Installing the roof.  
18. ______ Driving in piles.  
19. ______ Marking the building site.  
20. ______ Placing floor joists.  
21. ______ Adding baseboards.  
22. ______ Installing a sidewalk.  

23. What does the term grade mean, as used in this chapter?  
24. Most railway bridges are beam bridges. True or false?  
25. With cantilever bridges, the ends of the arms do not carry any of the load. True or false?  
26. Tall dams holding back large quantities of water are called ______.

STEM Applications

1. Use a chart similar to the one below to list and describe a few of the constructed structures you see as you travel from your home to school.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Type of Construction</th>
<th>Description–Use</th>
</tr>
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<tbody>
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</tbody>
</table>

2. Select one structure you saw in completing the previous assignment. Make a drawing or model of the structure. Label the major parts.

3. Develop a preventive maintenance schedule for your home. List the items or portions of the structure that need maintenance and the type of maintenance each needs.
This activity develops the skills used in TSA’s Structural Engineering event.

**Structural Engineering**

**Activity Overview**

In this activity, you will create a balsa-wood bridge and determine its failure weight (the load at which the bridge breaks).

**Materials**

- Grid paper.
- 20' of 1/8” × 1/8” balsa wood.
- A 3” × 5” note card.
- Glue.

**Background Information**

- **General.** There are several types of bridges: beam, truss, cantilever, suspension, and cable stayed. The length of the span and available materials generally determine the type of bridge used in a particular situation. For this activity, a truss design is considered the most efficient.

- **Truss bridges.** The truss bridge design is based on the assumption that the structural members carry loads along their axes in compression or tension. The members along the bottom of the bridge carry a tensile load. Those along the top of the truss carry a compressive load. The members connecting the top and bottom chords (members) can be in tension or compression.

- **Gussets.** Gussets are plates connected to members at joints to add strength. They are normally used in steel construction. The structural steel members are welded or bolted to the gusset. When designing your bridge, include a gusset at each joint, if possible.

- **Wood properties.** Due to its molecular structure, wood can normally carry a larger load in tension than it can in compression. Also, a shorter member can carry a greater compressive load than a longer member.

**Guidelines**

- You must create a scale sketch of the bridge before building.
- Two pieces of balsa wood can be glued together along lengthwise surfaces. No more than two pieces of balsa can be glued together. You cannot use an excessive amount of glue.
- Gussets cut from the 3” × 5” card can be no larger than the diameter of a U.S.-quarter coin. A gusset cannot touch another gusset. This plate cannot be sandwiched between two pieces of balsa wood.
- The bridge design must take into account the loading device. Your teacher will provide specific guidelines for bridge length, bridge width, and the required details for attachment of a loading device.
- Your bridge will be weighed before being loaded.

**Evaluation Criteria**

Your project will be evaluated using the following criteria:

- Accuracy of sketch, compared to completed bridge.
- Conformance to guidelines.
- Efficiency (failure weight ÷ bridge weight).