



The Associated General Contractors of America

# **CONSTRUCTION PLANNING AND SCHEDULING**

**SECOND EDITION**

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construction project using a bar (Gantt) chart is covered in Chapter 4. Planning and scheduling a construction project using Activity-On-Node (AON) and Activity-On-Arrow (AOA) networks is covered in Chapters 5, 6, and 7.

## 2.2 Learning Objectives

The learning objectives of this chapter are:

- ▶ Understand what a schedule activity is and know its characteristics.
- ▶ Know the five activity categories and be able to categorize project activities into these categories.
- ▶ Be able to identify the activities that make up a construction project.
- ▶ Understand the importance of identifying activities that are of the right scale for the planning process, accurately describing the activity and the work that it comprises and the need to be able to assign the performance of that activity to ensure timely completion.
- ▶ Be able to develop a work breakdown structure for a construction project and understand its importance in planning and scheduling the project and serving as a framework for monitoring and controlling the project during construction.

## 2.3 Activity Defined

Any construction project is a unique, one-of-a-kind undertaking aimed at achieving specific time, cost, and quality goals and objectives. Each project is made up of a number of individual activities that must be accomplished in order to achieve these goals and objectives. The first step in the construction planning and scheduling process is to identify the activities that must be completed in order to complete the entire project.

An activity is a discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction project. Activities have the following five characteristics:

- ▶ Activities consume time
- ▶ Activities usually consume resources
- ▶ Activities have a definable start and finish
- ▶ Activities are assignable
- ▶ Activities are measurable

### 2.3.1 Activities Consume Time

The primary objective of the construction planning and scheduling process is to determine what work items need to be accomplished and when. To be classified as an activity, a project work item must consume time. The purpose of identifying project activities is to develop a plan for completing the project that sequences and schedules each individual activity. If a work item does not consume time, then there is no need for it to be identified, sequenced, and scheduled as part of the construction planning and scheduling process.

Schedule elements that do not consume time are normally referred to as milestones. Milestones represent a special type of schedule element that mark points in time that correspond to specific project events. The definition and use of

milestones in construction planning and scheduling is covered in Chapter 4 for bar charts and Chapter 5 for network schedules.

### **2.3.2 Activities Usually Consume Resources**

Activities usually consume resources, although it is not necessary that a work item consume resources in order to be classified as an activity. There are many construction activities that require time but do not require the active use of labor, material, equipment, or subcontractors. These activities must be identified and included in the construction planning and scheduling process. Without these activities, the construction plan may be incomplete, and the effectiveness of the construction schedule as a viable management tool reduced.

Cure time for concrete is an example of a construction activity that requires time but no resources. The minimum concrete cure time required before performing follow-up activities such as stripping forms or setting columns needs to be considered in the planning and scheduling process. Cure time in this case might affect the start or production rate of follow-up activities.

### **2.3.3 Activities Have a Definable Start and Finish**

Activities represent specific work items that must be accomplished in order to complete the project. Therefore, each activity will have a readily definable start and end point. The start of an activity will occur when work begins on it and the end point will occur when the scope of work defined by the activity is completed. A construction activity's start and end point are normally definable in terms of specific work that is to be accomplished at the project site. For example, excavation of footings starts with the first bucket of embankment excavated and ends when the footing trench is completed, allowing follow-up activities such as forming and reinforcing footings to begin.

### **2.3.4 Activities Are Assignable**

The responsibility for completing an activity is assignable because activities represent discrete work items that must be accomplished in order to complete the overall project. Assignability is a very important activity characteristic because it allows the construction project to be divided into manageable pieces and assigned to those most capable of performing the work. This characteristic is also very important during the construction process for monitoring and controlling the work.

Assignability expands the scope of the planning and scheduling process from determining what and when activities need to be accomplished to identifying who will be responsible for completing them. For example, the responsibility for excavating the building footings may be assigned to the excavation subcontractor. Similarly, the responsibility for fabricating and supplying reinforcing steel for the footings may be assigned to a reinforcing steel supplier.

### **2.3.5 Activities Are Measurable**

Activities are measurable in terms of progress because activities represent individual work items with unique scopes of work. Work in process can be measured in terms of actual physical work in place or time elapsed. In the case of footing excavation, activity progress would be measured in terms of the actual amount of footing trench excavated versus the total amount of footing excavation defined by the activity. Similarly, progress on a concrete-curing activity would be measured by the amount of time elapsed versus the required cure time defined by the activity.

## 2.4 Activity Categories

Activities for planning and scheduling a construction project can be categorized as follows:

- ▶ Administration
- ▶ Mobilization/demobilization
- ▶ Procurement
- ▶ Construction
- ▶ Start-up and testing

### 2.4.1 Administration

Administrative activities are as important as construction activities and should be included in the construction planning and scheduling process. Administrative activities can include the following:

- ▶ Request and receipt of notice to proceed
- ▶ Application and receipt of permits and licenses
- ▶ Request and receipt of technical information
- ▶ Request and approval of contract changes and modifications
- ▶ Request and approval of means and methods
- ▶ Review and acceptance of all or part of the work
- ▶ Corrective work for substantial and final completion

Administrative activities can also include closeout activities such as the following:

- ▶ Final accounting of quantities and/or costs
- ▶ Inspection and certification of equipment and systems by outside entities
- ▶ Submission of operation and maintenance manuals
- ▶ Submission of warranties and guarantees

### 2.4.2 Mobilization/Demobilization

Mobilization activities are those necessary to physically prepare to begin construction at the site, and normally include the establishment of on-site facilities and services necessary to carry out specific work and tasks. Mobilization activities usually occur at the beginning of a project, but can occur at any time during a project when specific on-site facilities are required. Examples of mobilization activities include the following:

- ▶ Set up field office and storage facilities
- ▶ Construct temporary access roads, laydown areas, and perimeter fences
- ▶ Procure the necessary utilities for construction
- ▶ Procure, train, and certify specialized labor
- ▶ Procure, set up, test, and certify construction equipment
- ▶ Perform site surveys and testing

Demobilization activities are the opposite of mobilization activities, and include the removal of on-site services and equipment when they are no longer needed. Demobilization activities normally occur at the end of the project when work is complete and temporary offices, storage facilities, and utilities are no longer needed. However, like mobilization activities, demobilization activities can occur at any time during the project when on-site services and equipment are no longer required and can be removed. For example, once the building's elevators are operational, manlifts on the outside of a building under construction could be removed so that the building exterior can be completed.

### 2.4.3 Procurement

Procurement of the necessary materials and equipment for incorporation into the construction project is a very important part of the construction process. The ability to erect, install, or construct any part of a construction project is dependent on the availability of the materials and equipment necessary to perform the work. In addition, the contractor's ability to meet planned production rates is dependent on the fabricator's or supplier's ability to supply the contractor with sufficient materials and equipment on time at the required rate.

Procurement activities include all activities necessary to obtain the required equipment and materials for construction. Included in the procurement process are all of the steps necessary to get materials and equipment on site and ready for erection, installation, or construction, and may include the following:

- ▶ Identifying the necessary type and quantity of materials and equipment where not specifically specified and detailed in the construction documents
- ▶ Preparing shop drawings, catalog cuts, samples, and technical information for submission to the owner and/or designer.
- ▶ Designing and/or laying out customized materials, equipment, and systems by the supplier, fabricator, or specialty subcontractor (an example of this would be the design and layout of a fire suppression system by the fire sprinkler subcontractor).
- ▶ Submitting shop drawings, catalog cuts, samples, technical data, and design/layout information to the owner and/or designer for review and approval.
- ▶ Constructing sample or mock-up installations for review and testing (examples are masonry mock-ups that allow the architect to review the aesthetic suitability of a certain type of brick prior to fabrication and the testing of piles that allows the engineer to review the performance of the specified foundation prior to foundation construction).
- ▶ Testing of materials, equipment, and systems to ensure that performance meets the design requirements. (This may not be necessary, as only certified test data may need to be submitted to the owner and/or designer for review and approval. On the other hand, testing may need to be carried out on an ongoing basis during manufacture or fabrication and test data submitted to the owner and/or designer on an ongoing basis or full-scale testing may be required that necessitates agreement on test procedures, identification of a suitable testing facility and equipment, fabrication and shipping of sample materials and equipment to the testing facility, carrying out the required tests, and submission of test results.)
- ▶ Scheduling the review and the approval of materials, equipment, and systems by the owner and/or designer. This review and approval process can also include others such as the owner's specialty consultants, lenders, and insurance carriers. Reasonable time should be factored into the project schedule for the owner's review and approval.
- ▶ Procuring the raw materials necessary for the manufacture and fabrication of finished materials, equipment, and systems. (Normally, this is the responsibility of the manufacturer or fabricator; however, there are cases when the procurement of raw materials is separated from the manufacturing or fabrication process. An example of this is the purchase of a specific type of stone from a specific quarry to be shipped to a stonecutter for cutting and finishing before being transported to the project site for erection by a specialty subcontractor.)

- ▶ Manufacturing and fabricating the required materials, equipment, and systems.
- ▶ Arranging shipping and deliveries to the project site.
- ▶ Preparing materials and equipment at the site for incorporation into the work. (In the case of large quantities of bulk materials, time may be required for the unloading, inspection, inventorying, and cleaning of the materials. In the case of bulk materials and equipment, procurement does not stop with the initial material delivery. The delivery of bulk materials and equipment is usually an ongoing process due to the supplier's production capabilities, site logistics, and economics. Therefore, the ability of material and equipment deliveries to support planned production rates at the project site is a very important aspect of the construction planning and scheduling process.)

Failure to balance material and equipment deliveries with planned production rates can result in problems. Faster than anticipated delivery can result in excess materials and equipment at the site, causing shortages in storage space, loss of efficiency in material and equipment handling, and increased carrying charges. On the other hand, slow delivery can result in idle labor and equipment, which may result in the contractor falling behind schedule and losing money.

Construction projects require the assembly of many different types of materials and equipment at the construction site. This means that the right equipment and materials must be available at the site at the right time and in the right quantities for the contractor to successfully complete the project. The identification of procurement activities is a very important part of the construction planning process.

#### 2.4.4 Construction

Construction involves the erection, installation, or construction of any part of the project, and is carried out at the construction site by the contractor's own forces or subcontractors. (The manufacturing or fabrication of materials and equipment take place off-site and is part of the procurement process.)

Examples of construction activities include:

- ▶ Clear and excavate the project site
- ▶ Build foundations, including footing
- ▶ Form, reinforce, and place the floor slab
- ▶ Lay up masonry walls
- ▶ Erect steel columns and roof joists
- ▶ Install roof system
- ▶ Apply interior finishes

#### 2.4.5 Start-Up and Testing

Start-up and testing activities are required after the installation of a system. In commercial, industrial, and institutional construction, these activities are normally associated with mechanical and electrical systems. Examples of start-up and testing activities in commercial building construction include the following:

- ▶ Testing and checkout of major equipment such as chillers, cooling towers, communications equipment, and uninterruptible power supplies
- ▶ Testing and balancing of the Heating, Ventilating, and Air-Conditioning (HVAC) systems
- ▶ Flushing and cleaning of the domestic water system
- ▶ Testing life safety and security systems, which include detection and annunciation devices, smoke evacuation, stairwell pressurization, transfer to

an emergency power source, and elevator capture (these tests normally have to be coordinated and scheduled with specialty subcontractors, local inspection authorities, and manufacturer representatives)

## 2.5 Activity Identification

A construction project must be fully understood in order to effectively plan and schedule the work. A complete review and analysis of the construction documents must be made to identify what has to be done, when it has to be done, how it should be done, and who needs to do it. When identifying project activities, all of the contract documents need to be considered and not just the plans and specifications.

The following documents should also be reviewed to identify other project activities, requirements, and constraints that need to be included in the construction planning and scheduling process:

- ▶ Agreement between the owner and contractor
- ▶ General, supplemental, and special conditions to the owner-contractor agreement
- ▶ Bill of quantities for unit price contracts
- ▶ Addenda to the owner-contractor agreement
- ▶ Owner-furnished labor, materials, and equipment
- ▶ Any milestone dates or schedule information included as part of the owner-contractor agreement

The identification of activities for planning and scheduling a construction project requires that the project be analyzed and broken down into discrete work items. How the project is broken down varies from contractor to contractor and from project to project; however, the identification of activities usually entails dividing the project work up based on one or more of the following criteria:

- ▶ **What work has to be done?** In other words, what are the work items that need to be accomplished in order to complete the project? For a commercial building, one category of work would probably be the installation of HVAC ductwork.
- ▶ **Where will the work be accomplished?** For example, the installation of HVAC ductwork may be scheduled as a separate activity for each floor of a multi-story building. HVAC ductwork installation could also be further broken down for different areas on each floor.
- ▶ **Who will be responsible for performing the work?** The crew, subcontractor, or supplier responsible for performing the work may determine the activity breakdown. For example, the HVAC ductwork installation could be broken down into two activities: the sheet metal subcontractor may be responsible for fabricating and installing the ductwork, while the insulation subcontractor may be responsible for insulating the ductwork once it is in place.
- ▶ **When will the work be performed?** In the case of the HVAC ductwork, the large trunk ducts may be installed early in the project, while the branch ducts may be installed later after other interior finish work is completed. As a result, the installation of trunk and branch ducts for each floor may need to be divided into two separate activities.
- ▶ **How will the work be accomplished?** The means and methods of performing a particular type of work may determine the activity breakdown. For example,

the installation of ductwork in a part of the building atrium requiring lifting equipment and scaffolding may be scheduled as a separate activity from other ductwork installed by conventional means in the same area.

## 2.6 Activity Detail

Activity detail means how large or small the activities should be in a schedule. The goal of breaking down and analyzing a project is to divide the project work into the appropriate level of detail for effective planning and management. There is no definitive answer as to how large or small a schedule's activities should be in terms of duration or cost. The level of activity detail depends on the following:

- ▶ **What is the purpose of the schedule and who is going to use it?** A different level of schedule detail is normally required by the owner to monitor construction progress than is required by the superintendent to plan and control day-to-day construction activities.
- ▶ **How complex is the part of the project being scheduled?** Different parts of the same project may require different levels of detail. For example, site earthwork may require little activity breakdown, whereas interior finishes may require a great deal of activity breakdown to assist in coordinating concurrent work by different subcontractors.
- ▶ **What is the contractor's management philosophy?** Different contractors have different philosophies regarding project management. Some contractors provide very detailed schedules that site personnel are expected to adhere to; others use a summary schedule to provide a framework for site personnel to plan and accomplish day-to-day work.
- ▶ **What is known about the project when the schedule is prepared?** At the beginning, there may not be enough information to schedule the entire project in detail. Work to be accomplished later in the project may be initially scheduled as summary activities with little detail. As the project progresses and additional information is obtained, these summary activities can be broken down into greater detail for planning and managing the project. Fast-track construction, in which final design and construction are carried out concurrently, is an example of this.
- ▶ **Who is responsible for carrying out the work?** As noted previously, how the responsibility for completing the work is divided between crews, trades, subcontractors, and suppliers may determine the level of activity breakdown.
- ▶ **Will more or less detail affect the usefulness or accuracy of the schedule?** If additional detail is not required and will not be used in planning and managing the project, then it should not be included in the schedule. On the other hand, sufficient detail needs to be included in the schedule to provide a viable tool for monitoring and controlling construction.

Activities identified in breaking down a project must encompass all of the work that needs to be accomplished in order to achieve the project's goals and objectives. Activities may include a number of tasks, or each activity may represent one specific part of the project. For example, there could be one activity for forming, reinforcing, and placing a building's footings, or this one activity could be broken down into three separate activities: forming, reinforcing, and placing footings.



On a large project, forming, reinforcing and placing footings could be further divided by location. Other related work may also need to be broken out when it is performed by another trade or subcontractor. In the footing example, additional footing work such as the bonding and grounding of reinforcing steel by the electrical contractor may also need to be included as a separate activity.

## 2.7 Activity Description

The descriptions assigned to activities in a schedule are very important if the schedule is to be used as an effective communication tool. Activity descriptions must be concise and unambiguous, and must communicate in shorthand the scope and location of the portion of the project work that the activity encompasses. An activity description must mean the same thing to everyone using the schedule to plan and manage the project. This means that the owner, contractor, and designer, as well as subcontractors and suppliers, must be able to read and understand the schedule.

Activity descriptions must be consistent in format. A lot of information must be communicated in a short activity description. Abbreviations are often used in activity descriptions due to limited space on bar charts and network diagrams and reports. Where used, abbreviations should be consistent throughout the schedule, and standard industry abbreviations should be used wherever possible. Appendix B provides a list of common abbreviations used in construction project schedules.

## 2.8 Activity Responsibility

It is not enough to identify activities and how they fit into the overall structure of the project. The management team must also assign responsibility for completing each activity to make sure that nothing is overlooked. The responsibility for completing each activity should be documented so that there is no confusion as to who is responsible for completing the work.

## 2.9 Work Breakdown Structure

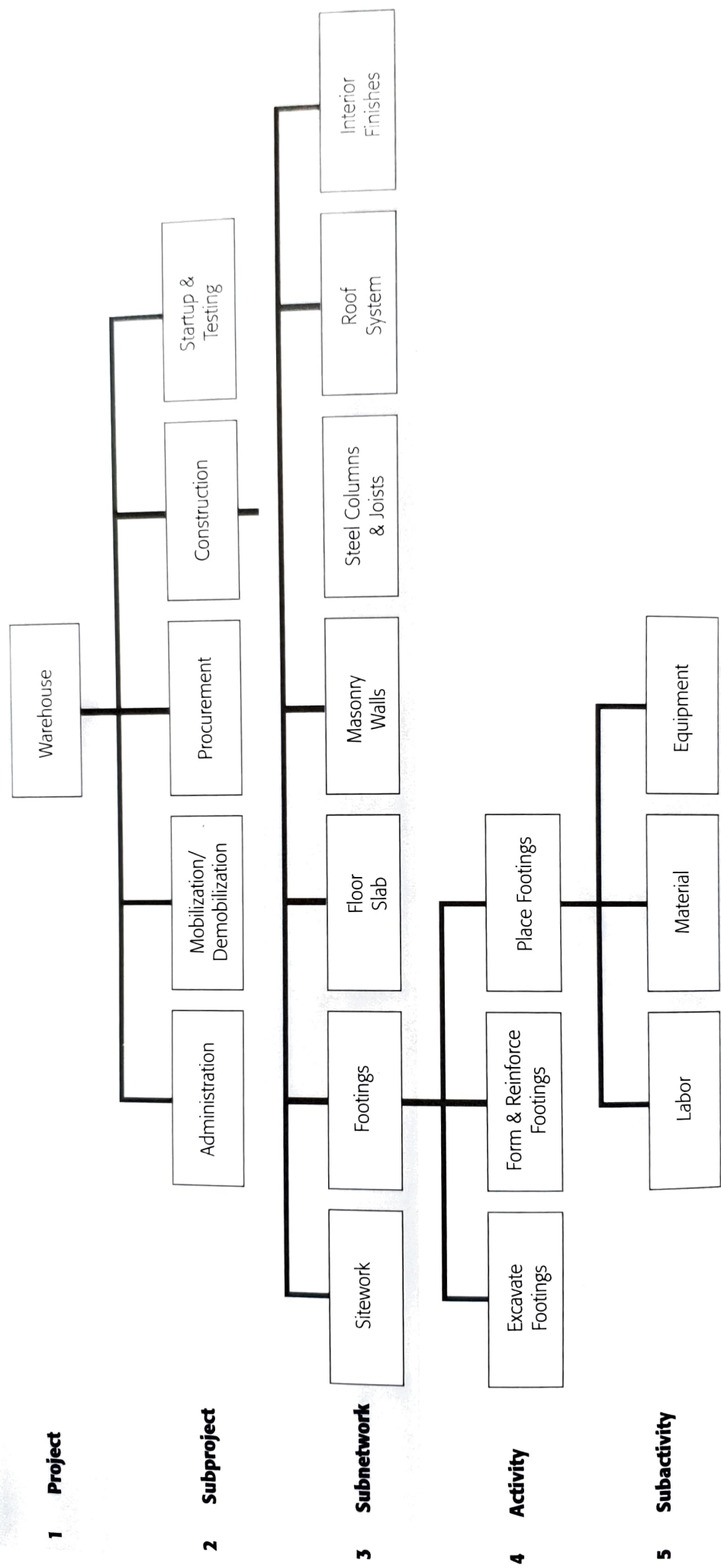
A Work Breakdown Structure (WBS) provides a framework for organizing and ordering the activities that make up a project. A WBS breaks a project down into successively greater detail by level, and organizes the project work but does not address the sequencing and scheduling of the project activities. A WBS is a planning tool and not a scheduling method.

As can be seen from Figure 2-1, an example of a five-level WBS for a simple warehouse construction project, a WBS is similar in appearance to an organizational chart. The activities are arranged in a hierarchy, starting with the overall project itself and dividing the project downward by level in increasing detail. In the five-level WBS shown in Figure 2-1, the warehouse project is divided into the following five levels:

<b>WBS LEVEL</b>	<b>SCHEDULE DETAIL</b>
Level 1	Project
Level 2	Subproject
Level 3	Subnetwork
Level 4	Activity
Level 5	Subactivity

**Work Breakdown Structure**

**Level** | **Level Description**



**Figure 2-1**  
**Example Work Breakdown Structure**

**Level 1/Project** is the starting point for developing a WBS. Level 1 includes all work that must be completed in order to complete the project. The scope of work for Level 1 would be defined by the owner-contractor agreement.

**Level 2/Subproject** breaks the project down into the next level of detail. The Level 2 breakdown divides the project into definable subprojects such as each building on a multi-building site. Level 2 might also divide the project into stages such as design, construction, and start-up for a large project. In Figure 2-1, Level 2 breaks the project down into the activity categories discussed in this chapter.

**Level 3/Subnetwork** is a subgrouping of activities that deal with a discrete part of the project. An example of a subnetwork might be building foundations, which would include a number of different activities related to foundation construction and could include such things as underground electrical and plumbing services and excavation and concrete work. Level 3 in Figure 2-1 breaks down warehouse construction into its major components, which includes the construction of footings.

**Level 4/Activity** is the lowest level of the WBS that is addressed in the project schedule. As discussed throughout this chapter, activities represent the smallest increment of work that will be monitored and controlled during construction using the project schedule. Activities identified during the project breakdown and analysis and included in the activity level of the WBS are the basis for the project schedule.

**Level 5/Subactivity** further breaks down the project using the WBS. Subactivity breakdown is usually used for cost accumulation and control during construction. In the warehouse WBS illustrated in Figure 2-1, the place footings activity is broken down into labor, materials, and equipment. The subactivity level can be used as the basis for resource planning and scheduling, as will be discussed in Chapter 19.

## 2.10 Summary and Key Points

Identifying activities is the foundation on which the construction planning and scheduling process is built. If the set of activities identified for planning and scheduling a construction project is not complete or includes poorly defined activities whose scope of work or responsibility for performance cannot be identified by those using the construction schedule, then the value of the planning process is greatly reduced and may result in problems during construction.

To ensure that the set of activities used to plan and schedule a construction project is complete, the project scheduler should include administrative, mobilization and demobilization, procurement, and start-up and testing activities in addition to construction activities. All of these categories of activities consume time and are important to the completion of any construction project. When identifying project activities, the project scheduler should consider the purpose of the schedule and level of detail needed to achieve that purpose, and accurately describe the activity so that anyone familiar with the project will understand the activity scope and be able to assign responsibility for performing the activity.

The WBS provides an effective framework that can be used to not only plan the project but also to monitor and control the project during construction. The WBS can also be used to organize schedule activities and tie the project budget and resources to the project plan. Effective construction planning and scheduling is not just about time. Time and resources are interdependent in a construction project, as will be discussed in Chapters 19 through 23. Both time and resources must be managed to have a successful project, defined as one that is completed on time

and within budget, and meets the owner's needs and expectations as defined by the contract documents.

## 2.11 Review Questions

1. What are the five characteristics of an activity and why is each important when defining activities during the construction planning and scheduling process?
2. Describe why each of the five characteristics of an activity is important when monitoring and controlling the project during construction.
3. Identify the five categories of activities that make up a construction schedule and give an example of each.
4. When identifying activities for planning and scheduling a construction process, why is it important to consider the purpose of the schedule that is being developed? Should there be a difference between the scopes of individual activities identified for a proposal to an owner for a future project versus a schedule that will be used for monitoring and controlling construction?
5. Why is it so important that the activity scope be well-defined and accurately depicted in the activity description?
6. What does it mean that all activities should be assignable? How does assignability relate to the contracts that the general contractor has with the owner and its subcontractors and suppliers?
7. What is a WBS? Give an example of a four-level WBS for a construction project.
8. How can a WBS be used to tie the project schedule and budget together? Will relating project schedule and budget together through the WBS provide a more effective means for monitoring and controlling a construction project? If yes, why? If no, why not?