CHAPTER 1

An Overview of the Building Delivery Process (How Buildings Come into Being)

CHAPTER OUTLINE

Building construction is a complex, significant, and rewarding process. It begins with an idea and culminates in a structure that may serve its occupants for several decades, even centuries. Like the manufacturing of products, building construction requires an ordered and planned assembly of materials. It is, however, far more complicated than product manufacturing. Buildings are assembled outdoors by a large number of diverse constructors and artisans on all types of sites and are subject to all kinds of weather.

Additionally, even a modest-sized building must satisfy many performance criteria and legal constraints, requires an immense variety of materials, and involves a large network of design and production firms. Building construction is further complicated by the fact that no two buildings are identical; each one must be custom-built to serve a unique function and respond to its specific context and the preferences of its owner, user, and occupant.

Because of a building's uniqueness, we invoke first principles in each building project. Although it may seem that we are "reinventing the wheel," we are in fact refining and improving the building delivery process. In so doing, we bring to the task the collective wisdom of the architects, engineers, and contractors who have done so before us. Although there are movements that promote the development of standardized, mass-produced buildings, these seldom meet the distinct needs of each user.

Regardless of the uniqueness of each building project, the flow of activities, events, and processes necessary for a project's realization is virtually the same in all buildings. This chapter presents an overview of the activities, events, and processes that bring about a building—from the inception of an idea or a concept in the owner's mind to the completed *design* by the architects and engineers and, finally, to the actual *construction* of the building by the contractor.

Design and construction are two independent but related and generally sequential functions in the realization of a building. The former function deals with the creation of the *documents,* and the latter function involves interpreting and transforming these documents into reality—a building or a complex of buildings.

The chapter begins with a discussion of the various personnel involved in a project and the relational framework among them. Subsequently, a description of the two major elements of design documentation—construction drawings and specifications—is provided. Finally, the chapter examines some of the methods used for bringing a building into being, referred to as the *project delivery methods*. From the owner's perspective, these methods are called *project acquisition methods*.

The purpose of this chapter, as its title suggests, is to provide an overall, yet distilled, view of the construction process and its relationship with design. Although several contractual and legal issues are discussed, they should be treated as introductory. A reader requiring additional information on these topics should refer to texts specially devoted to them.

1.1 PROJECT DELIVERY PHASES

The process by which a building project is delivered to its owner may be divided into the following five phases, referred to as the *project delivery phases*. Although there is usually some overlap between adjacent phases, they generally follow this order:

- Predesign phase
- Design phase
- Preconstruction phase
- Construction phase
- Postconstruction phase

1.2 PREDESIGN PHASE

During the *predesign phase* (also called the *planning phase*), the project is defined in terms of its function, purpose, scope, size, and economics. This is the most crucial of the five phases, and is almost always managed by the owner and the owner's team. The success or failure of the project may depend on how well this phase is defined, detailed, and managed. Obviously, the clearer the project's definition, the easier it is to proceed to the subsequent phases. Some of the important predesign tasks are:

- *Building program definition*
- *Economic feasibility assessment,* including the project's overall budget and financing
- *Site assessment and selection,* including verifying the site's appropriateness and determining its designated land use (Chapter 2)
- *Governmental constraints assessment,* for example, building code and zoning constraints (Chapter 2) and other legal aspects of the project
- *Sustainability rating*—whether the owner would like the project to achieve the U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) certification at some level (see Chapter 10)
- *Design team selection*

Building (Project) Program

This includes defining the activities, functions, and spaces required in the building, along with their approximate sizes and their relationships with each other. For a house or another small project, the program is usually simple and can be developed by the owner without external assistance. For a large project, however, where the owner may be an institution (such as a corporation, school board, hospital, religious organization, or governmental entity), developing the program may be a complex exercise. This may be due to the size and complexity of the project or the need to involve several individuals—a corporation's board of directors, for example—in decision making. These constituencies may have different views of the project, making it difficult to create a consensus.

Program development may also be complicated by situations in which the owner has a fuzzy idea of the project and is unable to define it clearly. By contrast, experienced owners tend to have a clear understanding of the project and generally provide a detailed, unambiguous program to the architect.

It is not unusual for the owner to involve the architect and a few other consultants of the design team in preparing the program. In this instance, the design team may be hired during the predesign phase. When the economic considerations of the project are paramount, the owner may also consult a construction cost analyst.

Whatever the situation, preparing the program is the first step in the project delivery process. It should be spelled out in writing and in sufficient detail to guide the design, reduce the liability risk for the architect, and avoid its misinterpretation. If a revision is made during the progress of the project, the owner's written approval is necessary.

NOTE

Building (Project) Program

The American Institute of Architects (AIA) Document B141, *Standard Form of Agreement Between Owner and Architect*, defines the building program as "the owner's objectives, schedule, constraints and criteria including space requirements and relationships, special equipment, flexibility, expandability, systems, and site requirements."

1.3 DESIGN PHASE

The *design phase* begins after the selection of the architect. Because the architect (usually a firm) may have limited capabilities for handling the broad range of building-design activities, several different, more specialized consultants are usually required, depending on the size and scope of the project.

In most projects, the design team consists of the architect, civil and structural consultants, and mechanical, electrical, plumbing, and fire-protection (MEPF) consultants. In complex projects, the design team may also include an acoustical consultant, roofing and waterproofing consultant, cost consultant, building code consultant, signage consultant, interior designer, landscape architect, and so on.

Some design firms have an entire design team (architects and specialized consultants) on staff, in which case the owner will contract with a single firm. Generally, however, the design team comprises several different design firms. In such cases, the owner typically contracts the architect, who in turn contracts the remaining design team members, Figure 1.1.

Thus, the architect functions as the prime design professional and, to a limited degree, as the owner's representative. The architect is liable to the owner for his or her own work and that of the consultants. For that reason, most architects ensure that their consultants carry adequate liability insurance.

In some projects, the owner may contract some consultants directly, particularly a civil consultant (for a survey of the site, site grading, slope stabilization, and site drainage), a geotechnical consultant (for investigation of the soil properties), and a landscape architect (for landscape and site design), Figure 1.2. These consultants may be engaged before or at the same time as the architect.

Even when a consultant is contracted directly by the owner, the architect retains some liability for the consultant's work. This liability occurs because the architect, being the prime design professional, coordinates the entire design effort, and the consultants' work is influenced a great deal by the architectural decisions. Therefore, the working relationship

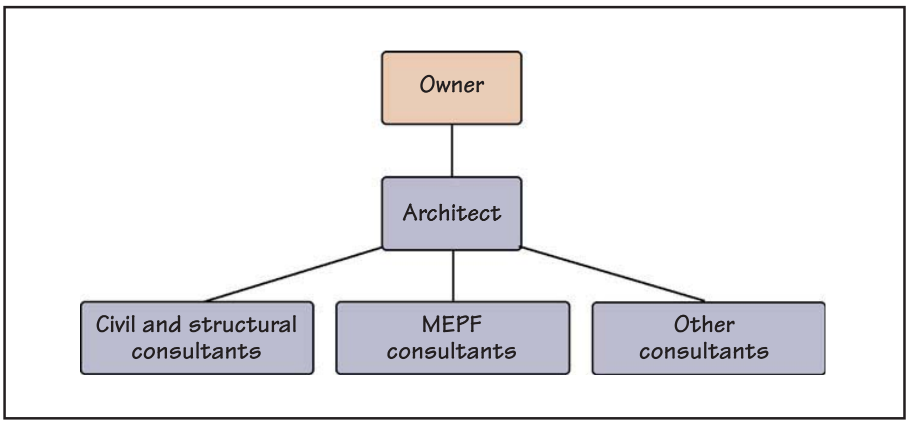


FIGURE 1.1 Members of a typical design team, and their interrelationships with each other and the owner in a traditional contractual setup. A line in this illustration indicates a contractual relationship between parties. ("MEPF consultants" is an acronym for mechanical, electrical, plumbing and fire consultants.)

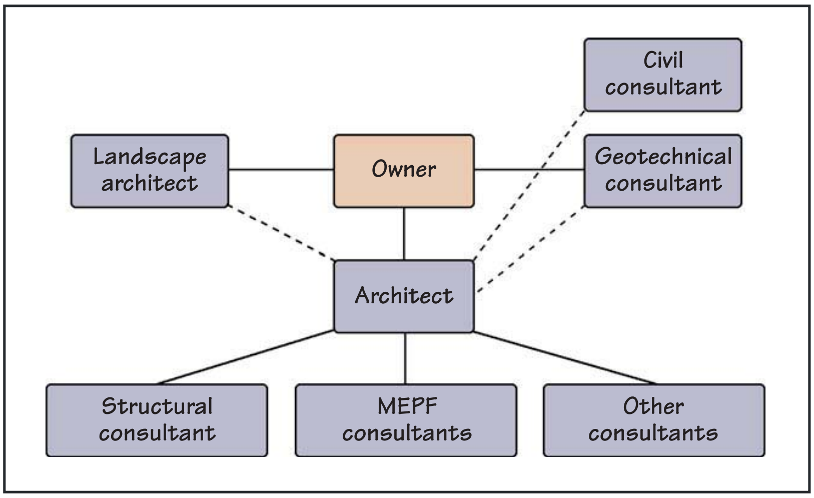


FIGURE 1.2 Members of a typical design team, and their interrelationships with each other and the owner in a project where some consultants are contracted directly by the owner. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link, not a contract.

between the architect and an owner-contracted consultant remains essentially the same as if the consultant were chosen by the architect.

In some cases, an engineer or another professional may coordinate the design process. This generally occurs when a building is a minor component of a large-scale project. For example, in a highly technical project such as a power plant, an electrical engineer may be the prime design professional.

In most building projects, the design phase consists of three stages:

- Schematic design stage
- Design development stage
- Construction documents stage

SCHEMATIC DESIGN (SD) STAGE—EMPHASIS ON DESIGN

The *schematic design* gives graphic shape to the project program. It is an overall design concept that illustrates the key ideas of the design solution. The major player in this stage is the architect, who develops the design scheme (or several design options) with only limited help from the consultants. Because most projects have strict budgetary limitations, a rough estimate of the project's probable cost is generally produced at this stage.

The schematic design usually goes through several revisions, because the first design scheme prepared by the architect will rarely be approved by the owner. The architect communicates the design proposal(s) to the owner through various types of drawings—plans, elevations, sections, freehand sketches, and three-dimensional graphics (isometrics, axonometrics, and perspectives). For some projects, a three-dimensional scale model of the entire building or the complex of buildings, showing the context (neighboring buildings) within which the project is sited, may be needed.

With significant developments in electronic media technology, especially building information modeling (BIM), computer-generated imagery has become common in architecture and related engineering disciplines. Computer-generated walk-through and flyover simulations are becoming increasingly popular ways of communicating the architect's design intent to the owner and the related organizations at the SD stage.

It is important to note that the schematic design drawings, images, models, and simulations, regardless of how well they are produced, are not adequate to construct the building. Their objective is merely to communicate the design scheme to the owner (and to consultants, who may or may not be on board at this stage), not to the contractor.

DESIGN DEVELOPMENT (DD) STAGE—EMPHASIS ON DECISION MAKING

Once the schematic design is approved by the owner, the process of designing the building in greater detail begins. During this stage, the schematic design is developed further—hence the term *design development* (DD) stage.

While the emphasis in the SD stage is on the creative, conceptual, and innovative aspects of design, the DD stage focuses on developing practical and pragmatic solutions for the exterior envelope, structure, fenestration, interior systems, MEPF systems, and so forth. This development involves strategic consultations with all members of the design team.

Therefore, the most critical feature of the DD stage is decision making, which may range from broad design aspects to details. At this stage, the vast majority of decisions about products, materials, and equipment are made. Efficient execution of the construction documents depends directly on how well the DD is managed. A more detailed version of the specifications and probable cost of the project is also prepared at this stage.

Construction Documents (CD) Stage—Emphasis on Documentation

The purpose of the *construction documents* (CD) stage is to prepare all documents required by the contractor to construct the building. During this stage, the consultants and architect collaborate intensively to work out the "nuts and bolts" of the building and develop the required documentation, referred to as *construction documents*. All of the consultants advise the architect, but they also collaborate with each other (generally through the architect) so that the work of one consultant agrees with that of the others.

The construction documents consist of the following:

- Construction drawings
- Specifications

Construction Drawings

During the CD stage, the architect and consultants prepare their own sets of drawings, referred to as *construction drawings*. Thus, a project has architectural construction drawings, civil and structural construction drawings, MEPF construction drawings, landscape construction drawings, and so on.

Construction drawings are dimensioned drawings (usually computer generated) that fully delineate the building. They consist of floor plans, elevations, sections, schedules, and various large-scale details. The details depict a small portion of the building that cannot be adequately described on smaller-scale plans, elevations, or sections.

Construction drawings are the drawings that the construction team uses to build the building. Therefore, they must indicate the geometry, layout, dimensions, types of materials, details of assembling the components, colors and textures, and so on. Construction drawings are generally two-dimensional drawings, but three-dimensional isometrics are sometimes used for complex details. Construction drawings are also used by the contractor to prepare a detailed cost estimate of the project at the time of bidding.

Construction drawings are not a sequence of assembly instructions, such as for a bicycle. Instead, they indicate what every component is and where it will be located when the building is completed. In other words, the design team decides the "what" and "where" of the building. The "how" and "when" of the building are entirely in the contractor's domain.

Specifications

Buildings cannot be constructed from drawings alone, because there is a great deal of information that cannot be included in the drawings. For instance, the drawings will give the locations of columns, their dimensions, and the material used (such as reinforced concrete), but the quality of materials, their properties (the strength of concrete, for example), and the test methods required to confirm compliance cannot be furnished on the drawings. This information is included in the document called *specifications*.

Specifications are written technical descriptions of the design intent, whereas the drawings provide the graphic description. The two components of the construction documents—the specifications and the construction drawings—complement each other and generally deal with different aspects of the project. Because they are complementary, they are supposed to be used in conjunction with each other. There is no order of precedence between the construction drawings and the specifications. Thus, if an item is described in only one place—either the specification or the drawings—it is part of the project, as if described in the other.

For instance, if the construction drawings do not show the door hardware (hinges, locks, handles, and other components) but the hardware is described in the specifications, the owner will get the doors with the stated hardware. If the drawings had precedence over the specifications, the owner would receive doors without hinges and handles.

NOTE

Working Drawings and Construction Drawings

The term *working drawings* was used until the end of the twentieth century for what are now commonly referred to as *construction drawings*.

EXPAND YOUR KNOWLEDGE

Relationship Between Construction Drawings and Specifications

Construction Drawings	Specifications
Design intent represented graphically	Design intent represented with words
Product/material may be shown many times	Product/material described only once
Product/material shown generically	Product/material identified specifically, sometimes proprietary to a manufacturer
Quantity indicated	Quality indicated
Location of elements established	Installation requirements of elements established
Size, shape, and relationship of building elements provided	Description, properties, characteristics, and finishes of building elements provided

Generally, there is little overlap between the drawings and the specifications. More importantly, there should be no conflict between them. If a conflict between the two documents is identified, the contractor must bring it to the attention of the architect promptly. In fact, construction contracts generally require that before starting any portion of the project, the contractor must carefully study and compare the drawings and the specifications and report inconsistencies to the architect.

If the conflict between the specifications and the construction drawings goes unnoticed initially but later results in a dispute, the courts have in most cases resolved it in favor of the specifications—implying that the specifications, not the drawings, govern the project. However, if the owner or the design team wishes to reverse the order, it may be so stated in the owner-contractor agreement.

THE CONSTRUCTION DOCUMENT SET

Just as the construction drawings are prepared separately by the architect and each consultant for their respective portions of the work, so are the specifications. The specifications from various design team members are assembled by the architect in a single document called the *project manual.* Because the specifications consist of printed (typed) pages (not graphic images), a project manual is a bound document—like a book.

The major component of a project manual is the specifications. However, the project manual also contains other items, as explained later in this chapter.

The set of construction drawings (from various design team members) and the project manual together constitute what is known as the *construction document set,* Figure 1.3. The construction document set is the document that the owner and architect use to invite bids from prospective contractors.

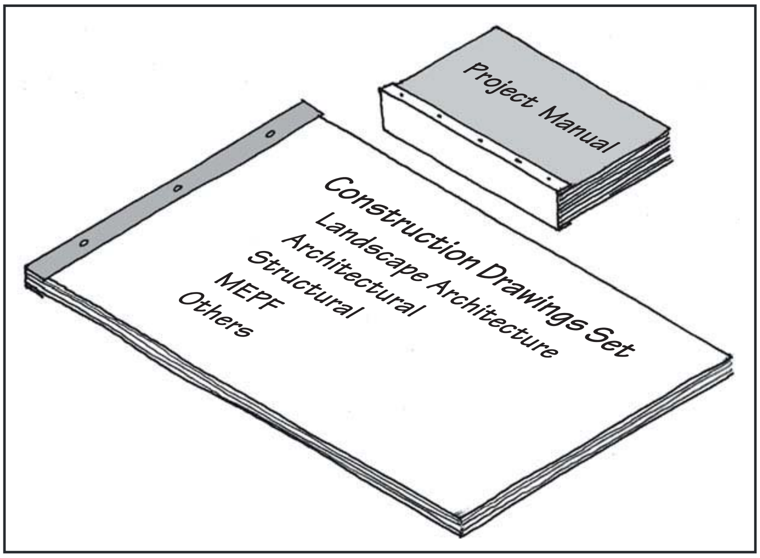


FIGURE 1.3 A construction document set consists of a set of architectural and consultants' construction drawings plus the project manual. The project manual is bound in a book format.

Owner's Role

The owner's role in the design phase of the project may not appear as active as in the predesign phase, but it is important all the same. In fact, a conscientious owner will be fully involved throughout the entire project delivery process—from the predesign phase through the project closeout phase.

PRACTICE QUIZ

Each question has only one correct answer. Select the choice that best answers the question.

1. The realization of a typical building project, as described in this text, may be divided into
   a. two phases.
   b. three phases.
   c. four phases.
   d. five phases.
   e. six phases.

2. Establishing the project's economic feasibility and its overall budget is part of the design phase of the project.
   a. True
   b. False

3. The term MEPF stands for
   a. mechanical, electrical, piping, and foundations.
   b. mechanical, electrical, plumbing, and foundations.
   c. mechanical, electrical, plumbing, and fire.
   d. mechanical, electrical, piping, and fire.

4. The program for a building project is usually provided by the
   a. owner.
   b. general contractor.
   c. building official of the city.
   d. architect.
   e. any one of these, depending on the type of building.

5. In a typical building project, the coordination of the building's design is done by the
   a. owner.
   b. general contractor.
   c. building official of the city.
   d. architect.
   e. any one of these, depending on the type of building.

6. The construction drawings of a building project are prepared during the
   a. SD stage of the project.
   b. DD stage of the project.
   c. CD stage of the project.
   d. preconstruction phase of the project.
   e. construction phase of the project.

7. The construction drawings of a building project are drawings that the architect uses to explain the design to the owner.
   a. True
   b. False

8. The construction drawings of a building project are generally in the form of
   a. freehand sketches.
   b. two-dimensional plans, elevations, sections, and details.
   c. three-dimensional drawings.
   d. photographs of three-dimensional scale model(s).
   e. all of the above.

9. The construction drawings for a building project generally consist of
   a. architectural drawings.
   b. structural drawings.
   c. MEPF drawings.
   d. all of the above.
   e. (a) and (b) only.

10. The most extensive part of a project manual is
    a. construction drawings.
    b. construction schedule.
    c. owner's program.
    d. owner-architect agreement.
    e. none of the above.

1.4 CSI MASTERFORMAT AND SPECIFICATIONS

The specification document for even a modest-sized project can run into hundreds of pages. It is used not only by the contractor and the subcontractors, but also by the owner, the material suppliers—in fact, the entire construction team. With so many different people using it, it is necessary that the specifications be organized in a standard format so that each user can go to the section of particular interest without having to wade through the entire document.

The standard organizational format for specifications, referred to as *MasterFormat*, has been developed by the Construction Specifications Institute (CSI) and is the format most commonly used in the United States and Canada. MasterFormat consists of 50 divisions, which are identified using six-digit numbers.

The first two digits of the numbering system (referred to as *Level 1* digits) identify the division number. The 50 division numbers are 00, 01, 02, 03, . . . , 48, and 49. A division identifies the broadest collection of related products and assemblies, such as Division 03—Concrete.

The next two digits of the numbering system (*Level 2* digits) refer to various sections within the division, and the last two digits (*Level 3* digits) refer to the subsections within a section. In other words, Level 2 and Level 3 digits classify products and assemblies into progressively closer affiliations. Thus, Level 1 digits in MasterFormat may be compared to chapter numbers in a book, Level 2 digits to section numbers of a chapter, and Level 3 digits to subsection numbers of a section.

A complete list of MasterFormat titles is voluminous. Figure 1.4 gives the division titles and the additional details of one of the divisions, Division 04—Masonry, as an illustration of the numbering system. Note that apart from the classification in divisions, MasterFormat is divided into two groups: the *Procurement and Contracting Group* (Division 00) and the *Specifications Group* (Divisions 01 to 49).

Because MasterFormat deals with all types of construction (new facilities, renovations, facility maintenance, services, urban infrastructural construction, equipment, and so forth), the Specification Group has been divided into four subgroups, as shown in Figure 1.4.

50 Divisions of the MasterFormat

PROCUREMENT AND CONTRACTING GROUP

Div. 00 Procurement and Contracting Requirements

SPECIFICATIONS GROUP

Div. 01 General Requirements

FACILITIES CONSTRUCTION SUBGROUP

Div. 02 Existing Conditions
Div. 03 Concrete
Div. 04 Masonry
Div. 05 Metals
Div. 06 Wood, Plastics, and Composites
Div. 07 Thermal and Moisture Protection
Div. 08 Openings
Div. 09 Finishes
Div. 10 Specialties
Div. 11 Equipment
Div. 12 Furnishings
Div. 13 Special Construction
Div. 14 Conveying Equipment
Div. 15 Reserved for future expansion
Div. 16 Reserved for future expansion
Div. 17 Reserved for future expansion
Div. 18 Reserved for future expansion
Div. 19 Reserved for future expansion

Level 1 digits (otherwise known as the Division number)
Level 2 digits
Level 3 digits

04 00 00 MASONRY
04 01 00 Maintenance of Masonry
04 05 00 Common Work Results for Masonry
04 06 00 Schedules for Masonry
04 10 00 Reserved for future expansion
04 20 00 Unit Masonry
04 30 00 Reserved for future expansion
04 40 00 Stone Assemblies
04 50 00 Refractory Masonry
04 60 00 Corrosion-Resistant Masonry
04 70 00 Manufactured Masonry
04 80 00 Reserved for future expansion
04 90 00 Reserved for future expansion

FACILITIES SERVICES SUBGROUP

Div. 20 Reserved for future expansion
Div. 21 Fire Suppression
Div. 22 Plumbing
Div. 23 Heating, Ventilating, and Air Conditioning
Div. 24 Reserved for future expansion
Div. 25 Integrated Automation
Div. 26 Electrical
Div. 27 Communications
Div. 28 Electronic Safety and Security
Div. 29 Reserved for future expansion

SITE AND INFRASTRUCTURE SUBGROUP

Div. 30 Reserved for future expansion
Div. 31 Earthwork
Div. 32 Exterior Improvements
Div. 33 Utilities
Div. 34 Transportation
Div. 35 Waterway and Marine
Div. 36 Reserved for future expansion
Div. 37 Reserved for future expansion
Div. 38 Reserved for future expansion
Div. 39 Reserved for future expansion

PROCESS EQUIPMENT SUBGROUP

Div. 40 Process Integration
Div. 41 Material Processing and Handling Equipment
Div. 42 Process Heating, Cooling, and Drying Equipment
Div. 43 Process Gas and Liquid Handling, Purification, and Storage Equipment
Div. 44 Pollution Control Equipment
Div. 45 Industry-Specific Manufacturing Equipment
Div. 46 Reserved for future expansion
Div. 47 Reserved for future expansion
Div. 48 Electrical Power Generation
Div. 49 Reserved for future expansion

FIGURE 1.4 MasterFormat divisions. The Masonry division has been further elaborated as an illustration.

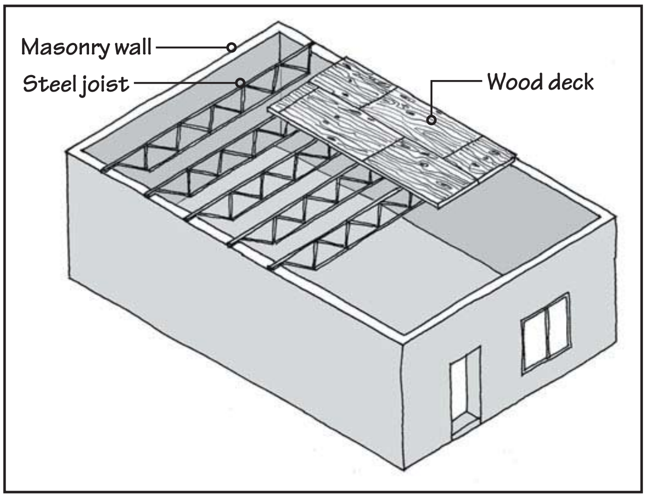


FIGURE 1.5 A simple load-bearing masonry wall building with steel roof trusses and wood roof deck used as an aid to recalling the sequence of the first few (architecturally important) divisions of the MasterFormat.

Recollecting the MasterFormat Division Sequence

Architectural design typically involves Divisions 2 to 14 of the Facilities Construction Subgroup. Although the basis for sequencing the Divisions in this subgroup is far more complicated, the first few divisions (those that are used in virtually all buildings) may be deduced by visualizing the sequence of postearthwork operations required in constructing the simple building shown in Figure 1.5. The building consists of load-bearing masonry walls, steel roof joists, and wood roof deck.

The first operation is the foundations for the walls. Because foundations are typically made of concrete, *Concrete* is Division 03. After the foundations have been completed, masonry work for the walls can begin. Thus, *Masonry* is Division 04. After the walls are completed, steel roof joists can be placed. Thus, Division 05 is *Metals*. The installation of the wood roof deck follows that of the steel joists. Hence, *Wood, Plastics, and Composites* is Division 06.

After the roof deck is erected, it must be insulated and protected against weather. Therefore, *Thermal and Moisture Protection* is Division 07. Roofing and waterproofing (of basements) are part of this division, as are wall insulation and joint sealants. The next step is to protect the rest of the envelope; hence, Division 08 is *Openings*. All doors and windows are part of this division, regardless of whether they are made of steel, aluminum, or wood.

With the envelope protected, finish operations, such as those involving the interior drywall, flooring, and ceiling, can begin. Thus, Division 09 is *Finishes*. Division 10 is *Specialties*, which consists of several items that cannot be included in the previous divisions, such as toilet partitions, lockers, storage shelving, and movable partitions.

Obviously, the building must now receive all the necessary office, kitchen, laboratory, or other equipment. Thus, Division 11 is *Equipment*. Division 12 is *Furnishings*, followed by *Special Construction* (Division 13) and *Conveying Equipment* (Division 14).

Before any construction operation can begin, there must be references to items that apply to all divisions, such as payment procedures, product-substitution procedures, contract-modification procedures, contractor's temporary facilities, and regulatory requirements imposed by the city or any other authority having jurisdiction. This is Division 01, *General Requirements*. Division 00 (*Procurement and Contracting Requirements*) refers to the requirements for the procurement of bids from prospective contractors.

Construction-Related Information

Familiarity with MasterFormat is required to prepare the project manual and write the specifications for the project. It is also helpful in filing and storing construction information in an office. Material manufacturers also use MasterFormat division numbers in catalogs and publications provided to design and construction professionals.

MasterFormat is also helpful when seeking information about a construction material or system, as any serious student of construction (architect, engineer, or builder) must frequently do.

NOTE

Difference Between Specialties (Division 10) and Special Construction (Division 13)

Specialties (Division 10) includes prefabricated items such as marker boards, chalkboards, tackboards, lockers, shelves, grilles and screens, louvers and vents, flagpoles, manufactured fireplaces, and demountable partitions.

Special Construction (Division 13) includes items that are generally site fabricated but are not covered in other divisions, such as air-supported fabric structures, swimming pools, ice rinks, aquariums, planetariums, geodesic structures, and sound and vibration control.

NOTE

Important Items Included in Division 00 (Procurement and Contracting Requirements)

- Advertisements for bids
- Invitation to bid
- Instruction to bidders
- Prebid meetings
- Land survey information
- Geotechnical information
- Bid forms
- Owner-contractor agreement forms
- Bond forms
- Certificate of substantial completion form
- Certificate of completion form
- Conditions of the contract

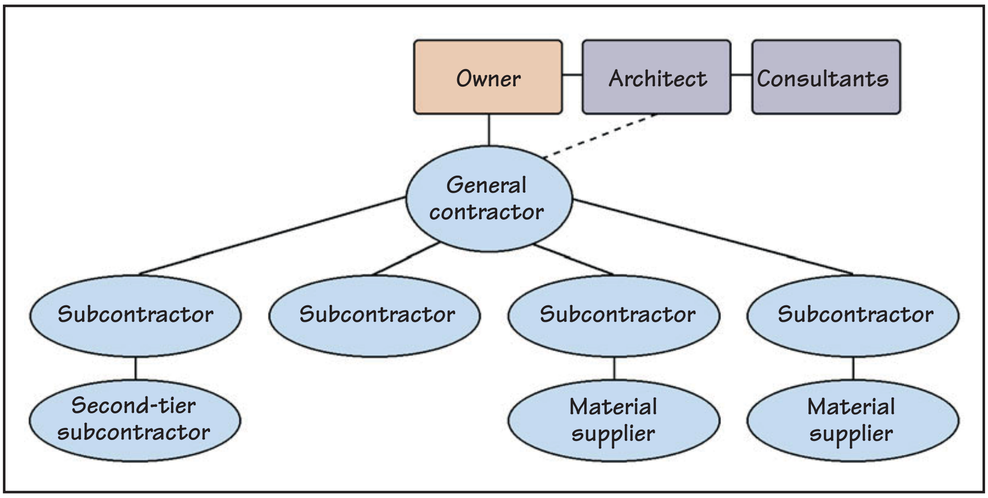


FIGURE 1.6 Members of the construction team and their interrelationships with each other and the owner. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link, not a contract. The relationships shown here are not absolute and may change with the nature of the project.

1.5 PRECONSTRUCTION AND BID NEGOTIATION PHASE

The preconstruction phase generally begins after the construction drawings and specifications have been completed and culminates in the selection of the construction team. The construction of even a small building involves so many specialized skills and trades that the work cannot normally be undertaken by a single construction firm. Instead, the work is generally done by a team consisting of the *general contractor* and a number of specialty *subcontractors.*

Thus, a project may have roofing; window and curtain wall; plumbing; and heating, ventilation, and air-conditioning (HVAC) subcontractors, among others, in addition to the general contractor. The general contractor's own work may be limited to certain components of the building (such as the structural components—load-bearing walls, reinforced concrete beams and columns, roof and floor slabs, etc.), with all the remaining work subcontracted.

In contemporary projects, however, the trend is toward the general contractors not performing any actual construction work but subcontracting the work entirely to various subcontractors. Because the subcontractors are contracted by the general contractor, only the general contractor is responsible and liable to the owner.

In some cases, a subcontractor will, in turn, subcontract a portion of his or her work to another subcontractor, referred to as a *second-tier subcontractor,* Figure 1.6. In that case, the general contractor deals only with the subcontractor, not the second-tier subcontractor.

Whether the general contractor performs part of the construction work or subcontracts the entire work, the key function of the general contractor is the overall management of construction. This includes coordinating the work of all subcontractors, ensuring that the work done by them is completed in accordance with the contract documents, and ensuring the safety of all workers on the site. A general contractor with a good record of site safety not only demonstrates respect for the workers but also improves the profit margin by lowering the cost of construction insurance.

1.6 GENERAL CONTRACTOR AND PROJECT DELIVERY METHODS

Selecting the general contractor is a crucial part of a project. A number of selection methods exist. The method used in selecting the general contractor, its timing, and the contractor's obligations under the contract distinguishes one project delivery method from the other. Some of the most commonly used delivery methods are:

- Design-bid-build method
- Design-negotiate-build method

NOTE

Important Items Included in Division 01 (General Requirements)

- Summary of work
- Price and payment procedures
- Product substitution procedures
- Contract modification procedures
- Project management and coordination
- Construction schedule and documentation
- Contractor's responsibility
- Regulatory requirements (codes, laws, permits, etc.)
- Temporary facilities
- Product storage and handling
- Owner-supplied products
- Execution and closeout requirements

NOTE

Relationship Between the Architect and the General Contractor

A notable feature of design and construction contracts is that they are all two-party contracts, that is, an owner-architect contract, an architect-consultant contract, an owner-general contractor contract, and so on. There is no direct contractual relationship between the owner and the subcontractor. Also, there is no contractual relationship between the architect and the general contractor (see Figure 1.6). In the overall interest of the project, however, and as per the terms of the owner-contractor agreement, the owner generally communicates with the general contractor through the architect.

- Construction manager as agent method
- Construction manager at risk method
- Design-build method
- Integrated project delivery method

The design-bid-build method is the oldest and most familiar method of project delivery. This method is covered first. Because the essential features of construction and postconstruction phases are almost identical in all delivery methods, a discussion of what is included in these two phases is presented next. Subsequently, other methods are discussed in terms of how they differ from the design-bid-build method. The table "Project Delivery Methods at a Glance" provides a synopsis of these methods at the end of this chapter.

1.7 DESIGN-BID-BUILD PROJECT DELIVERY METHOD

In the design-bid-build method, the general contractor is selected through competition. The owner obtains multiple bids for the project from which the general contractor, who provides the "best value for money," is selected. Within this overall approach, several versions are available to suit the requirements of the project and the particular needs of the owner. Collectively, these delivery versions are referred to as the *design-bid-build* (DBB) method because in this version, the design, bid, and construction phases of a project are sequential, and one phase does not begin until the previous phase has been completed, Figure 1.7. Following are three commonly used versions of the DBB method of delivery:

- DBB method—competitive sealed bidding (open bidding)
- DBB method—competitive sealed proposal
- DBB method—invitational bidding (closed bidding)

DBB Method—Competitive Sealed Bidding

On several publicly funded projects, the award of a construction contract to the general contractor is based on *competitive sealed bidding*, also called *open bidding*. This refers to the process by which qualified contractors are invited to bid on the project. The invitation is generally issued through advertisements in newspapers, trade publications, and other public media.

The advertisement for bids includes a description of the project, its location, where to obtain the bidding documents, the price of the bidding documents, the bid opening date and location, and other important information. The purpose of the advertisement is to notify and thereby attract a sufficient number of contractors to compete for the construction contract.

The general contractor's bid for the project is based on the information provided in the *bidding documents*. The bidding documents are essentially the construction document set

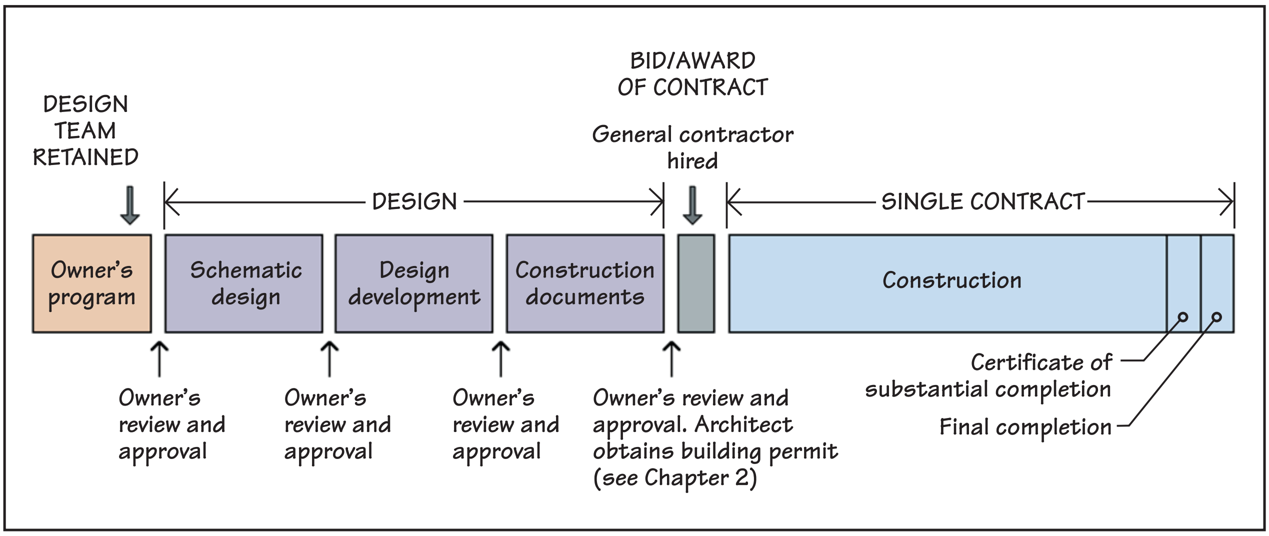


FIGURE 1.7 Sequence of operations in the design-bid-build (DBB) method of project delivery. Note that the owner's approval is required before proceeding from one phase or stage to the next.

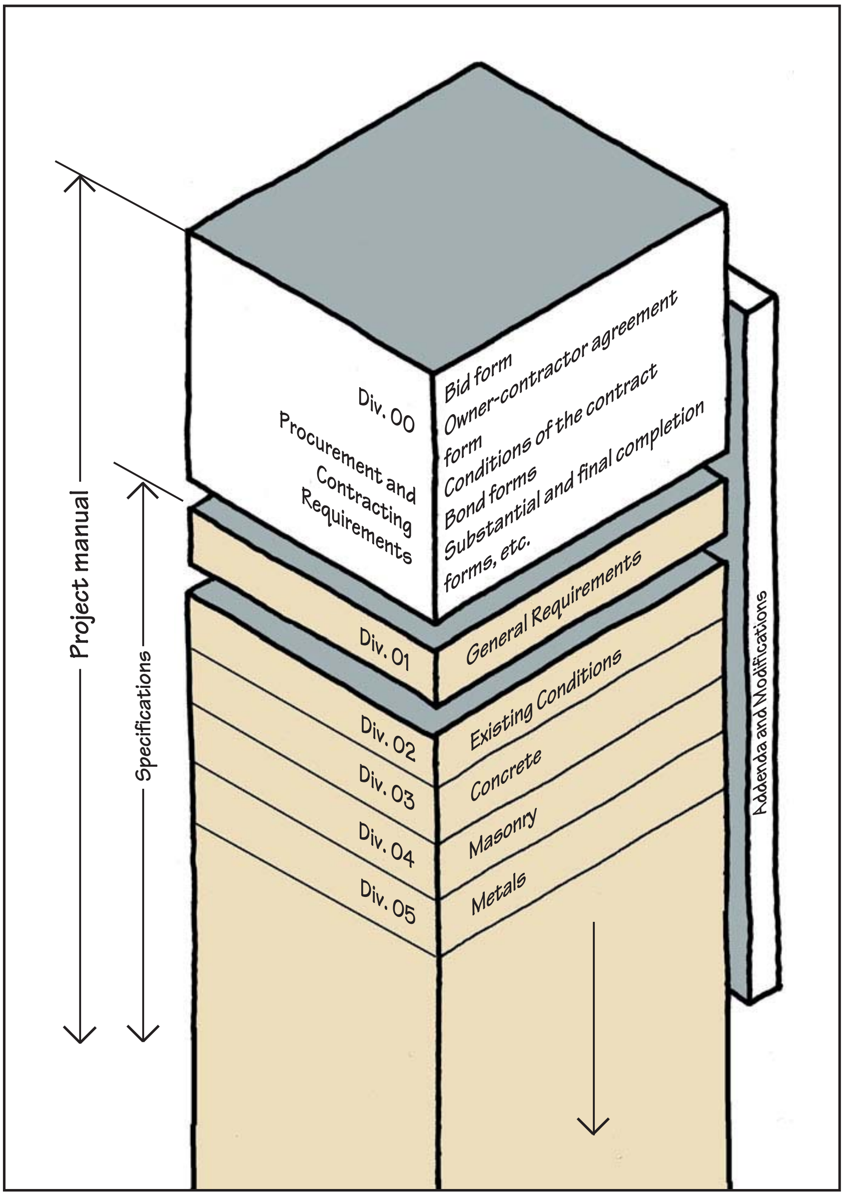


FIGURE 1.8 The project manual in the bidding document set includes specifications and Division 00. After the general contractor has been selected, the project manual (in the contract document set) generally excludes Division 00.

with such additional items as the instructions to bidders, requirements with respect to the financial and technical status of bidders (see the information on surety bonds in the box "Expand Your Knowledge"), and the contract agreement form that the successful bidder will sign when the contract is awarded. Because these additional items are text items, they are bound together as a project manual, Figure 1.8.

In the competitive sealed bidding method, the bidding documents are generally given only to contractors who are capable, by virtue of their experience, resources, and financial standing, to bid for the project. Therefore, the architect (as the owner's representative) may prescreen the bidders with respect to their reputation and ability to undertake the project.

An exception to prescreening for the release of bidding documents involves projects funded by the federal, state, or local government, for which almost anyone can access the bidding documents. However, even in this kind of project, the number of contractors who can actually submit the bids is practically limited. This limitation is generally the result of the financial security required from the bidders, known as a *bid bond*. The bidder must obtain a bid bond from a surety company in the amount specified in the bidding documents. This bond is issued based on the contractor's experience, ability to perform the work, and financial resources required to fulfill the contractual obligations.

Surety Bonds

The purpose of a surety bond is to ensure that if the contractor fails to fulfill contractual obligations, there will be a financially sound party—referred to as the *surety* (also called the *guarantor* or *bonding company*)—available to take over those unfulfilled obligations. The bond is, therefore, a form of insurance that the contractor buys from a surety, generally a corporation.

There are three types of surety bonds in most building projects (A few others may be required in some special projects):

- Bid bond
- Performance bond
- Payment bond

Bid Bond

The purpose of the *bid bond* (also called the *bid security bond*) is to exclude frivolous bidders. It ensures that, if selected by the owner, the bidder will be able to enter into a contract with the owner based on the bidding requirements, and that the bidder will be able to obtain performance and payment bonds from an acceptable surety.

A bid bond is required at the time the bidder submits the bid for the project. If the bidder refuses to enter into an agreement or is unable to provide the required performance and payment bonds, the surety is obliged to pay the penalty (bid security amount), usually 5% of the bid amount, to the owner.

Performance Bond

The *performance bond* is required by the owner before entering into an agreement with the successful bidder. The performance bond ensures that if, after the award of the contract, the contractor is unable to perform the work as required by the bidding documents, the surety will provide sufficient funds for the completion of the project.

A performance bond protects the owner against default by the contractor or by those for whose work the contractor is responsible, such as the subcontractors. For that reason, the general contractor will generally require a performance bond from major subcontractors.

Payment Bond

A *payment bond* (also referred to as a *labor and materials bond*) ensures that those providing labor, services, and materials for the project—such as the subcontractors and material suppliers—will be paid by the contractor. In the absence of the payment bond, the owner may be held liable to those subcontractors and material suppliers whose services and materials have been invested in the project. This liability exists even if the owner has paid the general contractor for the work of these subcontractors and material suppliers.

Pros and Cons of Bonds

The bonds are generally mandated for a publicly funded project. In a private project, the owner may waive the bonds, particularly the bid bond. This saves the owner some money because although the cost of a bond (the premium) is paid by the contractor, it is in reality paid by the owner since the contractor adds the cost of the bond to the bid amount.

Despite their cost, most owners consider the bonds (particularly the performance and payment bonds) a good value because they eliminate the financial risks of construction. The bid bond is unnecessary in an invitational bidding method where the owner knows the contractor's financial standing and the ability to perform. However, where uncertainty exists, a bid bond provides excellent prequalification screening of the contractor. Responsible contractors generally maintain a close and continuous relationship with their bonding company, so the bonding company's knowledge of a contractor's capabilities far exceeds that of most owners or architects (as an owner's representative).

Whether or not the release of the bidding documents is restricted, the procedure stated earlier ensures that all the bidders are similarly qualified with respect to financial ability, experience, and technical expertise. Because all bidders receive the same information and are of the same standing, the competition is fair; therefore, the contract is generally awarded to the lowest qualified bidder.

DBB Method—Competitive Sealed Proposal

This method is very similar to competitive sealed bidding and is commonly used for publicly funded projects. The difference between competitive sealed bidding and competitive sealed proposal methods is that the owner's selection of the general contractor is not based on price alone but also on such other criteria as the contractor's past experience, safety record, proposed personnel, project schedule, and so on. To ensure fairness, the advertisement and bidding documents must provide the details of the selection criteria, with relative weightings assigned to each criterion.

DBB Method—Invitational Bidding

Invitational bidding, also called *closed bidding*, is another variation of the DBB method that is generally used for quasi-public and some private projects. In this method, the owner preselects general contractors who have demonstrated, based on their experience, resources, and financial standing, their qualifications to perform the work. The selected contractors are then invited to bid for the project, and the contractor with the lowest bid is then awarded the contract. The architect (as the owner's representative) may be involved in the prescreening process.

PRACTICE QUIZ

Each question has only one correct answer. Select the choice that best answers the question.

11. The MasterFormat has been developed by the
- **a.** Construction Specifications Institute.
- **b.** American Society for Testing and Materials.
- **c.** American National Standards Institute.
- **d.** American Institute of Architects.
- **e.** Associated General Contractors of America.

12. The MasterFormat consists of
- **a.** 20 divisions.
- **b.** 30 divisions.
- **c.** 40 divisions.
- **d.** 50 divisions.
- **e.** none of the above.

13. In the MasterFormat, Division 02 refers to
- **a.** General Requirements.
- **b.** Existing Conditions.
- **c.** Masonry.
- **d.** Metals.
- **e.** none of the above.

14. In the MasterFormat, Division 04 refers to
- **a.** General Requirements.
- **b.** Existing Conditions.
- **c.** Masonry.
- **d.** Metals.
- **e.** none of the above.

15. In the MasterFormat, windows are part of
- **a.** Division 05.
- **b.** Division 06.
- **c.** Division 07.
- **d.** Division 08.
- **e.** none of the above.

16. In the MasterFormat, roofing is part of
- **a.** Division 05.
- **b.** Division 06.
- **c.** Division 07.
- **d.** Division 08.
- **e.** none of the above.

17. In the MasterFormat, flooring is part of
- **a.** Division 05.
- **b.** Division 06.
- **c.** Division 07.
- **d.** Division 08.
- **e.** none of the above.

18. In the traditional competitive bidding method, the owner has separate contracts with the general contractor and the subcontractors.
- **a.** True
- **b.** False

19. Who is responsible for ensuring the safety of workers on the construction site of a typical building project?
- **a.** The architect
- **b.** The structural engineer
- **c.** The general contractor
- **d.** The owner
- **e.** All of the above collectively

20. In the traditional competitive bidding method for a building, there is generally
- **a.** one general contractor.
- **b.** one general contractor and one subcontractor.
- **c.** one general contractor and several subcontractors.
- **d.** several general contractors and several subcontractors.

21. A surety bond is provided by the owner to the general contractor.
- **a.** True
- **b.** False

22. The three surety bonds used in a typical construction contract are
- **a.** bid bond, contract award bond, and completion bond.
- **b.** prescreening bond, award bond, and completion bond.
- **c.** bid bond, performance bond, and completion bond.
- **d.** bid bond, performance bond, and payment bond.
- **e.** none of the above.

NOTE

Construction Documents and Contract Documents

The terms *contract documents* and *construction documents* are used interchangeably. Although both sets of documents are essentially the same, the construction documents become contract documents when they are incorporated into the contract between the owner and the contractor.

1.8 CONSTRUCTION PHASE

Once the general contractor has been selected and the contract awarded, the construction work begins, as described in the *contract documents*. The contract documents are virtually the same as the bidding documents, except that the contract documents are part of a signed legal contract between the owner and the contractor. They generally do not contain Division 00 of the MasterFormat.

In preparing the contract documents, the design team's challenge is to efficiently produce the graphics and text that effectively communicate the design intent to the construction professionals and the related product suppliers and manufacturers so that they can do the following:

- Propose accurate and competitive bids
- Prepare detailed and descriptive submittals for approval
- Construct the building with a minimum number of questions, revisions, and changes

Shop Drawings

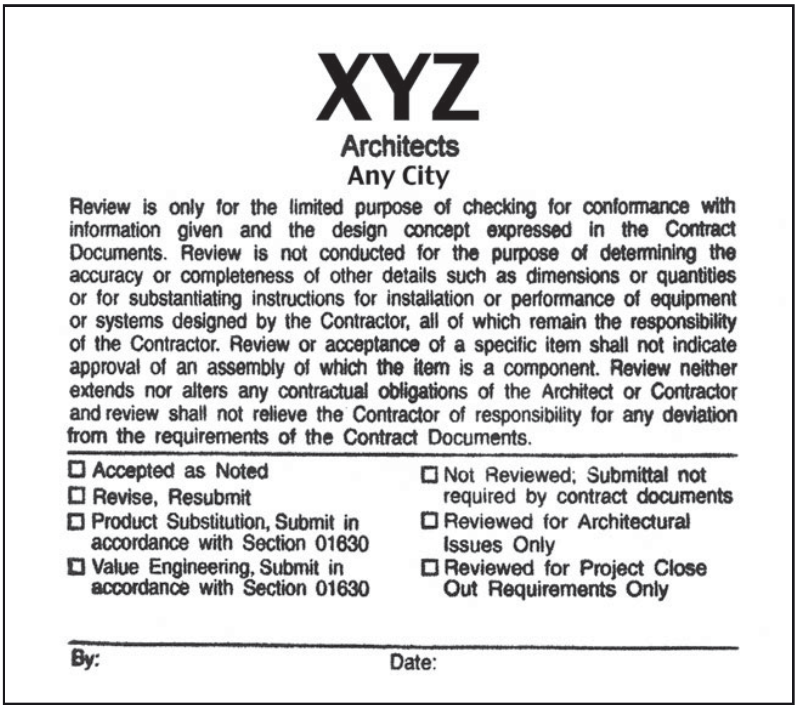
The construction drawings and the specifications should provide a fairly detailed delineation of the building. However, they do not describe it to the extent that fabricators can produce building components directly from them. Therefore, the fabricators generate their own drawings, referred to as *shop drawings*, to provide the higher level of detail necessary to fabricate and assemble the components.

Shop drawings are not generic, consisting of manufacturers' or suppliers' catalogs, but are specially prepared for the project by the manufacturer, fabricator, erector, or subcontractors. For example, an aluminum window manufacturer must produce shop drawings to show that the required windows conform with the construction drawings and the specifications. Similarly, precast concrete panels, stone cladding, structural steel frame, marble or granite flooring, air-conditioning ducts, and other components require shop drawings before they are fabricated and installed.

Before commencing fabrication, the fabricator submits the shop drawings to the general contractor. The general contractor reviews them, marks them "approved," if appropriate, and then submits them to the architect for review and approval. Subcontractors or manufacturers cannot submit shop drawings directly to the architect.

The review of all shop drawings is coordinated through the architect, even though they may actually be reviewed in detail by the appropriate consultant. Thus, the shop drawings pertaining to structural components are sent to the architect and then to the structural consultant for review and approval. The fabricator generally begins fabrication only after receiving the architect's review of the shop drawings.

The review of shop drawings by the architect is limited to checking that the work indicated therein conforms with the overall design intent shown in the contract documents. Approval of shop drawings that are later discovered to deviate from the contract documents does not absolve the general contractor of the responsibility to comply with the contract documents for quality of materials, workmanship, or the dimensions of the fabricated components, Figure 1.9.



XYZ
Architects
Any City

Review is only for the limited purpose of checking for conformance with information given and the design concept expressed in the Contract Documents. Review is not conducted for the purpose of determining the accuracy or completeness of other details such as dimensions or quantities or for substantiating instructions for installation or performance of equipment or systems designed by the Contractor, all of which remain the responsibility of the Contractor. Review or acceptance of a specific item shall not indicate approval of an assembly of which the item is a component. Review neither extends nor alters any contractual obligations of the Architect or Contractor and review shall not relieve the Contractor of responsibility for any deviation from the requirements of the Contract Documents.

☐ Accepted as Noted
☐ Revise, Resubmit
☐ Product Substitution, Submit in accordance with Section 01630
☐ Value Engineering, Submit in accordance with Section 01630
☐ Not Reviewed; Submittal not required by contract documents
☐ Reviewed for Architectural Issues Only
☐ Reviewed for Project Close Out Requirements Only

By: Date:

FIGURE 1.9 A typical stamp used by architects to indicate the result of review of shop drawings and other submittals.

Mock-Up Samples

In addition to shop drawings, full-size mock-up samples of one or more critical elements of the building may be required in some projects. This is done to establish the quality of materials and workmanship by which the completed work will be judged. For example, it is not unusual for the architect to ask for a mock-up of a typical area of the curtain wall of a high-rise building before the fabrication of the actual curtain wall is undertaken. Mock-up samples go through the same approval process as the shop drawings.

Other Submittals

In addition to shop drawings and any mock-up samples, some other submittals required from the contractor for the architect's review are:

- Product material samples
- Product data
- Certifications
- Calculations

1.9 CONSTRUCTION CONTRACT ADMINISTRATION

The general contractor will normally have an inspection process to ensure that the work of all subcontractors is progressing as indicated in the contract documents and that the work meets the standards of quality and workmanship. On smaller projects, this may be done by the *project superintendent*. On large projects, a team of quality-assurance inspectors generally assists the contractor's project superintendent. These inspectors are individuals who, by training and experience, are specialized in their own areas of construction—for example, concrete, steel, or masonry.

Additional quality control is required by the contract through the use of independent testing laboratories. For instance, structural concrete to be used on the site must be verified for strength and other properties by independent concrete testing laboratories.

Leaving quality control of materials and performance entirely in the hands of the contractor is considered inappropriate. It can render the owner vulnerable to omissions and errors in the work, and it places an additional legal burden on the contractor. Therefore, the owner usually retains the services of the project architect to provide a third-party level of scrutiny to administer the construction contract. If not, the owner will retain another independent architect, engineer, or inspector to provide construction contract administration services. The contracting community favors this third-party oversight of its work.

Architect's Observation of Construction

The architect's role during the construction phase has evolved over the years. There was a time when architects provided regular supervision of their projects during construction, but the liability exposure resulting from the supervisory role became so adverse for the architects that they have been forced to relinquish this responsibility. Instead, the operative term for the architect's role during construction is *field observation* of the work.

The observational role still allows the architects to verify that their drawings and specifications are transformed into reality just as they had conceived. It also provides a sufficient safeguard against the errors caused by the contractors' misinterpretation of contract documents in the absence of the architects' clarification and interpretation.

The shift in the architect's role to observer of construction also recognizes the important and entirely independent role that the contractor must play during construction. This recognition provides full authority to the general contractor to proceed with the work in the manner that the contractor deems appropriate. This reinforces the earlier statements that:

- The architect determines the *what* and *where*.
- The contractor determines the *how* (means and methods) and *when* (sequence) of construction.

In other words, daily supervision or superintendence of construction is the function of the contractor—the most competent person to fulfill this role. The architect provides periodic observation and evaluation of the contractor's work and notifies the owner if the work is not in compliance with the intent of the contract documents. This underscores the division between the responsibilities of the architect and the contractor during construction.

Note that by providing observation, the architect does not certify the contractor's work. Nor does the observation relieve the contractor of its responsibilities under the contract. The contractor remains fully liable for any error that has not been discovered through the architect's observation. However, the architect may be held liable for all or part of the work observed, should the architect fail to detect or provide timely notification of work not conforming with the contract documents. This omission is known as *failure to detect*.

Because many components can be covered up by other items over days or hours, the architect should visit the construction site at regular intervals, as appropriate to the progress of construction. For example, earthwork covers foundations and underground plumbing, and gypsum board covers ceiling and wall framing. Observing the work after the components are hidden defeats the purpose of observation.

On some projects, a resident project architect or engineer may be engaged by the architect, at an additional cost to the owner, to observe the work of the contractor. Under the conditions of the contract, the contractor is generally required to provide this person with an on-site office, water, electricity, a telephone, and other necessary facilities.

Inspection of Work

There are only two times during the construction of a project that the architect makes an exception to being an observer of construction. At these times, the architect inspects the work. These inspections are meant to verify the general contractor's claim that the work is (a) substantially complete and (b) has been completed and hence is ready for final payment. These inspections, explained in Section 1.10, are referred to as:

- Substantial completion inspection
- Final completion inspection

Payment Certifications

In addition to construction observation and inspection, there are several other duties the architect must discharge in administering the contract between the owner and the contractor. These are outlined in the box "Summary of Architect's Functions as Construction Contract Administrator." Certifying (validating) the contractor's periodic requests for payment against the work done and the materials stored at the construction site is perhaps the most critical of these functions.

An application for payment (typically made once a month unless stated differently in the contract) is followed by the architect's evaluation of the work and necessary documentation to verify the contractor's claim. Because the architect is not involved in day-to-day supervision, the issuance of the certificate of payment by the architect does not imply acceptance of the quality or quantity of the contractor's work. However, the architect has to be judicious and impartial to both the owner and the contractor and perform within the bounds of the contract.

Change Orders

There is hardly a construction project that does not require changes after construction has begun. The contract between the owner and the contractor recognizes this fact and includes provisions for the owner's right to order a change and the contractor's obligation to accept the *change order* in return for an equitable price adjustment. Here again, the architect performs a quasi-judicial role to arrive at a suitable agreement and price between the owner and the contractor.

1.10 POSTCONSTRUCTION (PROJECT CLOSEOUT) PHASE

Once the project is sufficiently complete, the contractor will ask the architect to conduct a *substantial completion inspection* to confirm that the work is complete in most respects. By doing so, the contractor implies that the work is complete enough for the owner to occupy the facility and start using it, even though there might be cosmetic and minor work yet to be completed.

The contractor's request for substantial completion inspection by the architect should include a list of incomplete portions of the work (to be completed), referred to as the *punch list*. The punch list, which is prepared by the contractor, is used by the architect as a checklist to review all work, not merely the incomplete portions of the work. If the architect's inspection discloses incomplete items not included in the contractor's punch list, they are added to the list by the architect.

The substantial completion inspection is also conducted by the architect's consultants, either with the architect or separately. Incomplete items discovered by them are also added to the punch list. If the additional items are excessive, the architect may ask the contractor to complete the selected items before rescheduling the substantial completion inspection.

Substantial Completion—The Most Important Project Date

Before requesting a substantial completion inspection, the contractor must submit all required guaranties and warranties from the manufacturers of equipment and materials and the specialty subcontractors and installers used in the building. For instance, the manufacturers of roofing materials, windows, curtain walls, mechanical equipment, and other materials warrant their products for specified time periods. These warranties are in addition to the standard one-year correction period between the owner and the contractor.

The warranties are to be given to the architect at the time of substantial completion for review and transmission to the owner. Because the obligatory one-year correction period between the owner and the contractor, as well as other extended-time warranties, begin from the date of substantial completion of the project, the substantial completion date is an important project closeout event. That is why the contractor is allowed a brief time interval to complete the work fully after the successful substantial completion inspection.

Before seeking a substantial completion inspection, the contractor is required to secure a *certificate of occupancy* (Chapter 2) from the authority having jurisdiction over the project—usually the city where the project is permitted and built. The certificate of occupancy confirms that all appropriate inspections and approvals, required by the authority having jurisdiction, have taken place and that the site has been cleared of the contractor's temporary facilities so that the owner can occupy the building without obligations to any authority.

After substantial completion, the contractor is no longer liable for the maintenance (cleaning and upkeep), utility costs, insurance, and security of the project. These responsibilities and liabilities are transferred to the owner.

Final Completion Inspection

After the contractor carries out all the corrective work identified during the substantial completion inspection and so informs the architect, the architect (with the assistance of the

NOTE

Summary of the Architect's Functions as Construction Contract Administrator

- Observe construction
- Inform the owner of the progress of work
- Guard the owner against defects and deficiencies
- Review and approve shop drawings, mock-up samples, and other submittals
- Prepare change orders, if required
- Review correspondence between the owner and the contractor and take action if required
- Prepare certificates of payment
- Make the substantial completion inspection
- Make the final completion inspection
- Review manufacturers' and suppliers' warranties and other project closeout documentation and forward them to the owner
- Make a judicious interpretation of the contract between the owner and the contractor when needed

consultants) carries out the final inspection of the project. If the final inspection passes, certification for final payment is issued by the architect, which entitles the contractor to receive the final payment from the owner.

Before the certification for final payment is executed by the architect and, finally, by the owner, the owner receives the record documents, keys and key schedule, equipment manuals, and other specified necessities. Additionally, the owner receives all legal documentation to indicate that the contractor will be responsible for claims made by any subcontractor, manufacturer, or other party with respect to the project.

Record Documents (As-Built Documents)

As previously stated, minor changes are often made during the construction of a project. These changes must be recorded for the benefit of the owner should the owner wish to alter or expand the building in the future. Therefore, after the building has been completed, the contractor is required to provide a set of *record drawings* (previously known as *as-built drawings*). These drawings reflect the changes that were made during the course of construction by the contractor.

In addition to record drawings, *record specifications,* as well as a set of approved shop drawings, are usually required to complete the record document package delivered to the owner.

1.11 DESIGN-NEGOTIATE-BUILD PROJECT DELIVERY METHOD

In the design-bid-build (DBB) method, discussed thus far, the architect designs the project and prepares the bidding documents. After the bidding documents have been completed, the architect assists the owner in selecting the general contractor, which is done through competitive bids (sealed bids, sealed proposals, or invitational bids).

Once construction begins, the architect visits the site to observe the work in progress, advises the owner whether the work conforms with the contract documents, and acts on the general contractor's requests for periodic payments to be made by the owner. In other words, the architect functions (in a limited sense) as the owner's representative and provides professional service from the inception to the completion of the project.

Apart from the fact that the DBB method is simple and well understood, it has several other advantages: (a) there is a single point of responsibility for construction, (b) the contractor is selected through aggressive and open competition, and (c) the project's scope and cost are fully defined before construction starts.

A major disadvantage of the DBB method is the absence of the contractor's preconstruction (design-phase) services. A delivery method that addresses this concern uses a negotiated contract and is called the *design-negotiate-build* (DNB) project delivery method.

The DNB method is used when the owner knows of one or more reputable, competent, and trusted general contractors. The owner simply negotiates with these contractors concerning the overall contract price, time required for completion, and other important details of the project. The negotiations are generally conducted with one contractor at a time, and after negotiations with all selected contractors are complete, the owner analyzes the bids and selects a general contractor.

A major advantage of the negotiated contract is that the general contractor can be on board during the design (or predesign) phase. This helps the owner ensure that the architect's design is realistically constructible. In many situations, the contractor may advise the architect of simpler, less expensive, or more sophisticated building systems to realize the architect's design intentions.

Additionally, because the contractor is the one who is most knowledgeable about construction costs, budget estimates can be obtained at various stages during the design phase. This means that *value engineering* can proceed throughout the design phase instead of being undertaken at the end of this phase or during construction, as in the DBB method of project delivery.

Because the vast majority of owners have to work within a limited budget, the negotiated contract is a popular delivery method for private projects. The services offered by the contractor during the design phase of a negotiated contract are referred to as the contractor's *preconstruction services.*

The negotiated contract is not devoid of competition, because the general contractor obtains competitive bids from numerous subcontractors and material suppliers. Because the general contractor is selected during the SD or DD stage, the bids from some or all subcontractors can be obtained earlier, which may shorten the project delivery time.

NOTE

Value Engineering

Value engineering (VE) is the science of obtaining balance among the cost, reliability, and performance of a product or project. VE is commonly used in building projects when the project's cost exceeds its budget. It relates to the substitution for a product or assembly that is part of the original design with an alternative that provides equivalent performance, reliability, and aesthetics at a lower cost.

1.12 CONSTRUCTION MANAGEMENT-RELATED PROJECT DELIVERY METHODS

In the delivery methods so far discussed (design-bid-build and design-negotiate-build), the role of the architect remains essentially the same: the architect designs the project, helps the owner select the contractor, and provides construction administration services during the construction phase as the owner's representative. In the 1970s, in response to cost overruns and time delays caused by lack of realism in the design of several projects, owners began to seek the assistance of the contracting community during the design phase of the project. This approach became more common as project complexities grew, giving birth to an entirely new profession called *construction management*.

Construction Manager as the Owner's Agent—CMAA Method

The project delivery method in which a construction manager (CM) is included is referred to as the *construction manager as agent (CMAA) method*. In this method, the owner retains a CM as the owner's agent to advise on such issues as cost, scheduling, site supervision, site safety, construction finance administration, and overall building construction.

Note that the CM is not a contractor, but a manager who plays no entrepreneurial role in the project (unlike the general contractor, who assumes financial risks in the project). In most CMAA projects, the owner hires the CM as the first step. The CM may advise the owner in the selection of the architect and other members of the design team as well as the contracting team.

The birth of the CMAA delivery method does not mean that there is no construction management in design-bid-build, or the negotiated contract method. It exists, but it is done informally and shared by the design team and the general contractor.

The introduction of a CM on the project transfers various functions of the general contractor (in a traditional method) to the CM. Thus, in the CMAA method, the general contractor becomes redundant. Therefore, there is no general contractor in this method.

In the CMAA method of project delivery, the owner awards multiple contracts to various trade and specialty contractors, whose work is coordinated by the CM. Thus, the structural framework of the building may be erected by one contractor, masonry work done by another, interior drywall work by yet another, and so on.

Each contractor is referred to as the *prime contractor,* who may have one or more subcontractors, Figure 1.10. The task of scheduling and coordinating the work of all the contractors and ensuring site safety—undertaken by the general contractor in the DBB and DNB methods—is done by the CM in the CMAA method. Additionally, the CM administers the contracts between the prime contractors and the owner. Note, however, that because the CM is only an agent (employed to administer the contract on behalf of the owner), all the financial risks and other liabilities in the project are assumed by the owner.

Thus, the owner, by assuming part of the role of the general contractor, eliminates the general contractor's markup on the work of the subcontractors. The owner may also receive a reduction in the fee charged by the architect for contract administration. Although these savings are partially offset by the fee that the owner pays to the CM, there can still be substantial savings in large but technically simple projects.

The CMAA project delivery method is particularly attractive to owners who are knowledgeable about the construction process and can participate fully in all of its aspects, from bidding and bid evaluation to the closeout phase.

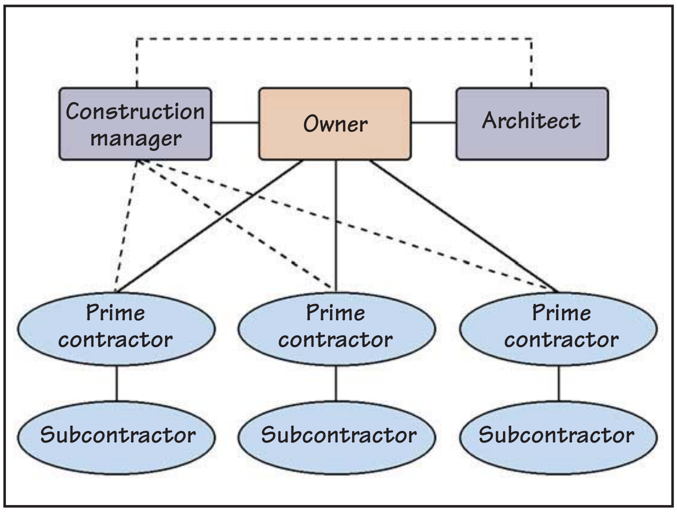


FIGURE 1.10 Contractual relationships between various parties in the CMAA method of project delivery. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link, not a contract.

Construction Manager at Risk (CMAR) Method

A disadvantage of the CMAA method lies in the liability risk that the owner assumes, which in the design-bid-build method is held by the general contractor. This means that there is not the same incentive for the CM to optimize efficiency as when the CM carries financial risks.

Additionally, in the CMAA method, there is no single point of responsibility among the various prime contractors. Each prime

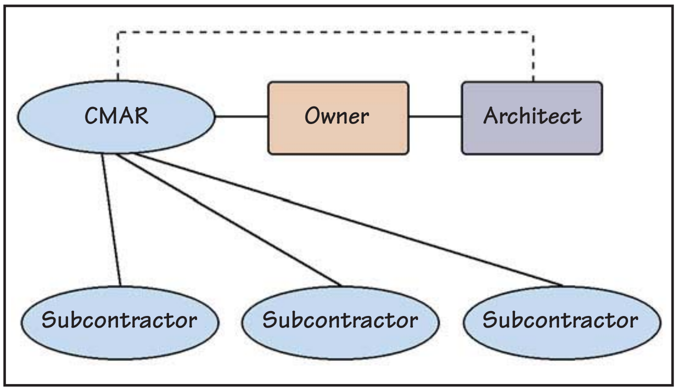


FIGURE 1.11 Contractual relationships between various parties in the CMAR method of project delivery. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link, not a contract.

contractor has a direct contract with the owner. Consequently, the CM has little leverage to ensure timely performance. The owner must therefore exercise care in selecting the CM because the cost, timeliness, and quality of the ultimate product are heavily dependent on the expertise of the CM.

In response to the preceding concerns, the CMAA method has evolved into what is known as the *construction manager at risk* (CMAR) method. In this method, the roles of the CM and general contractor are performed by one entity, but the compensation for these roles is paid separately by the owner.

In the CMAR method, the owner contracts with a CMAR company (a) to provide construction management services during the design phase of the project for a professional fee and (b) to work as the general contractor of the project. Thus, the CMAR company works with the architect during the design phase to develop construction documents that will meet the owner's budget and schedule. In doing so, the CMAR company functions as the owner's representative. The relationships between the various parties in a CMAR project delivery method are shown in Figure 1.11.

After the drawings are completed, all the work is competitively bid by subcontractors and the bids are opened in the owner's presence. The work is normally awarded to subcontractors with the lowest bids. In working as the general contractor, the CMAR company assumes all responsibilities for subcontractors' work and site safety. The CMAR method is being increasingly used for publicly funded projects such as schools, university residence halls, and apartments buildings.

1.13 DESIGN-BUILD (DB) PROJECT DELIVERY METHOD

A project delivery method that integrates design and construction activities into a single entity is called the *design-build (DB) method*. In this method, the owner awards the contract to one firm, which designs the project and also builds it, either on a cost-plus-profit basis or a lump-sum basis. In many ways, this method resurrects the historic *master-builder method*, in which there was no separation between the architect and the contractor. The design-build firm is usually a general contractor, which, in addition to providing construction capabilities, has a design team (of architects and engineers) within the organization or a closely allied separate organization.

The DB method has the advantage of integrating design and construction, thus fostering teamwork between the design team and the contractor throughout the project. It can provide a reduction in change orders for the owner, faster project completion, and a single source of responsibility. The major disadvantage is that the owner does not receive the protection provided by the checks and balances inherent in delivery methods with separate design and construction responsibilities. Consequently, once the contract has been awarded to a DB firm, the owner loses much of the control over the project. Therefore, for the DB method of delivery to succeed, the end result must be meticulously defined prior to the award of the contract.

The DB method has been in existence for decades in single-family residential construction. It is now being increasingly accepted in commercial construction—for both private and publicly funded projects. The establishment of the Design-Build Institute of America (DBIA) has further promoted the method.

A special version of the DB method, referred to as the *turnkey method*, consists of the DB firm arranging for the land and financing for the project in addition to designing and constructing it.

1.14 FAST-TRACK PROJECT SCHEDULING

A scheduling technique that can be used to save project delivery time with most project delivery methods is known as the *fast-track scheduling technique*. In this technique, the project is divided into multiple segments, and each segment of construction is awarded to different contractors through negotiations. The division of construction into segments is such that the segments are sequential. Thus, the first segment of the project may be site construction (site development, excavations, and foundations), the second segment may be structural framing (columns, beams, and floor and roof slabs), and the third segment may

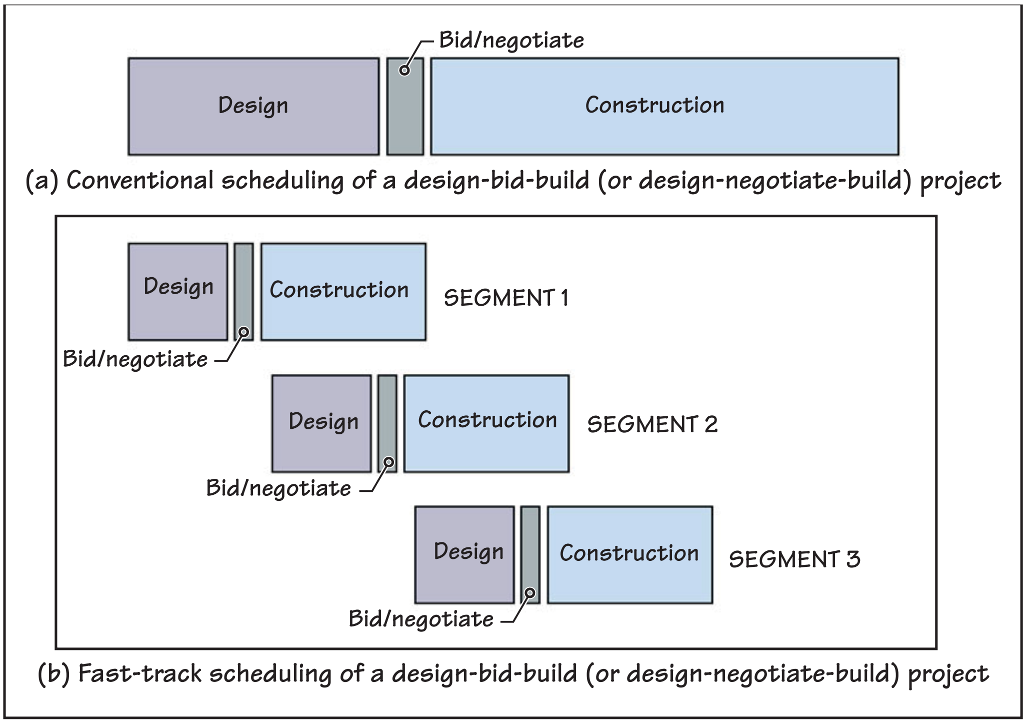


FIGURE 1.12 In fast-track scheduling, a project is segmented into parts, which overlap in time. As shown in this illustration, segmentation shortens project delivery in comparison with the design-bid-build or design-negotiate-build method. Fast-track scheduling can also be applied to other project delivery methods.

be the exterior enclosure, interior finishes, and project closeout that takes the project to completion.

Sequential segmenting of the project saves time because the earlier segments of the project can be constructed while the construction documents for the later segments are still in progress, resulting in overlapping design and construction processes, Figure 1.12.

Fast-track sequencing requires a great deal of coordination between segments. It also requires a commitment from the owner that the decisions will not be delayed and, once made, will not be changed.

1.15 THE INTEGRATED PROJECT DELIVERY (IPD) METHOD

The *integrated project delivery* (IPD) method is the ultimate in promoting harmony, collaboration, and integration among all team members who contribute to the project. While the members of the triad (owner, architect-engineer team, and contracting team) are separated into three distinct entities in the design-bid-build or CMAR method, and into two distinct entities in the design-build method, they are integrated fully into one entity in the IPD method, Figure 1.13.

In fact, the IPD method involves not simply the integration of the three major entities but of all those who contribute to the project (owner, architect, engineers, general contractor, subcontractors, fabricators, material suppliers, etc.). All participants come on board during the design phase or as soon as their expertise is needed. The entire delivery process, from inception to completion, is open across participants, with continuous sharing of knowledge.

The central underlying philosophy of IPD is across-the-board, trust-based collaboration in a zero-blame and zero-litigation environment. Differences and disputes are

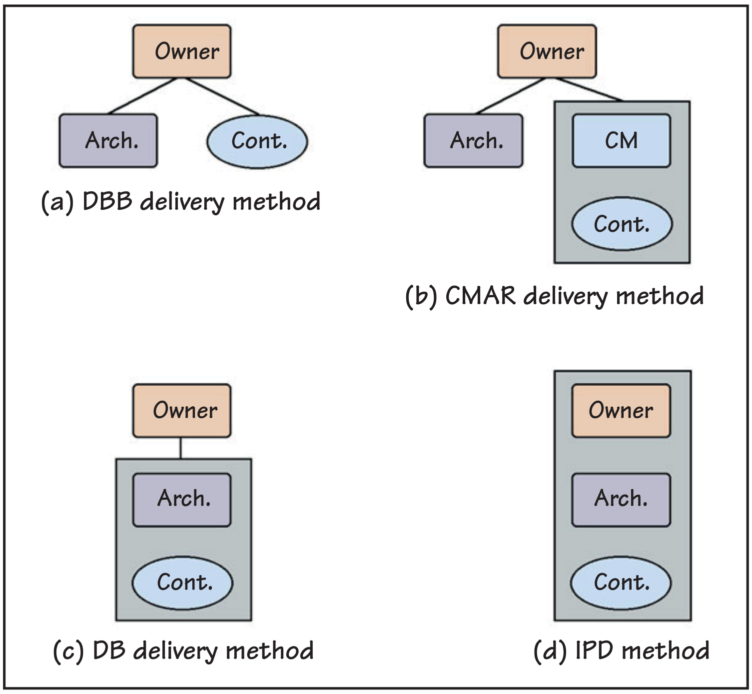


FIGURE 1.13 This illustration shows the relative integration among three major entities—owner, architect (Arch.), and contractor (Cont.)—in four major project delivery methods. Note that there is limited integration among the three entities in the DBB or CMAR method, partial integration in the DB method, and (supposedly) full integration in the IPD method. (The term *architect* implies the entire design team, which includes the architect and the architect's consultants.)

resolved without delay, as in any well-run organization under a single command authority comprising a group of individuals representing different interests and expertise in the project. Therefore, the project's management is shared, and so are the responsibilities, risks, and rewards.

NOTE

Replacement of the Term *Contractors* by *Constructors*

In view of the increasingly important and collaborative role being played by the contracting community (general contractors and subcontractors) during the design phases of a project (i.e., by providing CM service), the term *constructors* is replacing the term *contractors*. This trend has received further momentum from the development of IPD. In the American Institute of Architects (AIA) publication *Integrated Project Delivery: A Guide*, the term *constructor* is used consistently.

TECHNOLOGY FOR IPD—BUILDING INFORMATION MODELING (BIM)

IPD can be used with traditional computer-aided design (CAD) technologies for design, preparation of construction documents, and actual construction and its management, but it is best suited for use with the emerging technology known as *building information modeling* (BIM). Simply explained, BIM technology produces a virtual, three-dimensional model of the proposed building so that a complete digital version of the building is completed before its actual construction begins.

The virtual model is constructed through the participation and coordination of all members of the triad representing the owner, the architect-engineer team, and the contracting team, Figure 1.14. The model is built over a period of time in the same way that a real building is constructed. That is why the process using BIM is commonly referred to as *virtual construction*. Consequently, conflicts between various building systems or components, discovered during the construction of the building in a conventional project delivery system, are eliminated because they are detected in the virtual model through the built-in capability of BIM.

For example, because of the two-dimensional nature of conventional technology, unintended but serious errors, such as an HVAC duct passing through a floor beam or an underground utility pipe crossing a column footing, are not uncommon in conventional projects. When discovered during construction, such errors result in a blame game, request for information (RFI) from the contractor, change orders, increased project costs, and delayed project completion. In extreme cases, litigation is a possibility.

Error checking and ensuring compatibility among the works of various design and fabrication teams are revolutionizing project delivery because of BIM. Consequently, in some projects, there may be zero (or almost zero) change orders, providing substantial savings in project costs.

Because virtual model building is comprehensive, the time needed to complete the predesign and design phases is greater in IPD than in a conventional delivery method, but it is more than compensated for by the reduction in the time needed for actual construction, Figure 1.15.

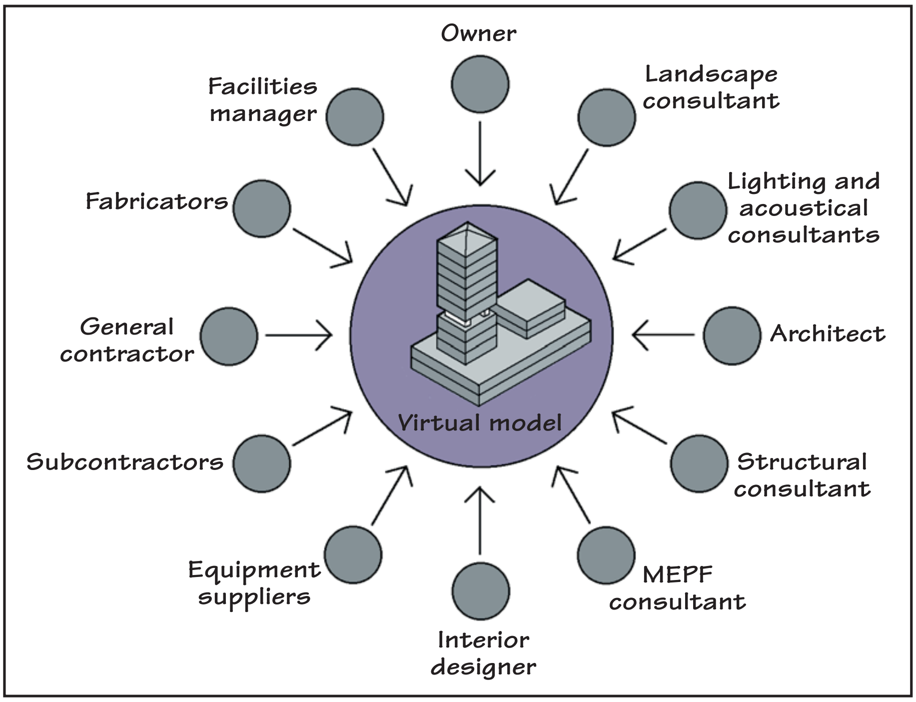


FIGURE 1.14 In an IPD method, all stakeholders in the project, such as the owner, architect, architect's consultants, general contractor, and subcontractors, contribute in constructing the virtual model.

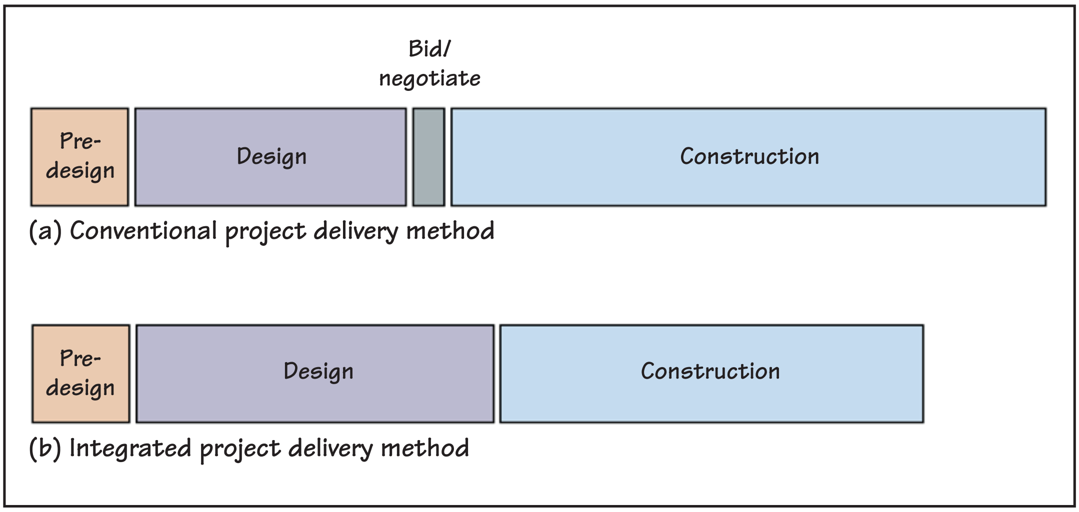


FIGURE 1.15 The overall time needed for project delivery is generally shorter using IPD than a conventional delivery method, although the time needed to complete the predesign and design phases is longer in IPD.

A virtual, three-dimensional model of the building is one important feature of BIM. The other important feature is that the model contains information about the physical and performance characteristics of various components of the model—walls, floors, roofs, openings, finishes, and so on. Therefore, the model comprises intelligent, data-rich three-dimensional objects rather than mere two-dimensional graphics (lines, rectangles, curves, etc.). Additionally, the model allows the extraction of conventional two-dimensional construction documents (plans, elevations, sections, and specifications) with the press of a button.

BIM Tools and Interoperability

Various team members (shown in Figure 1.14) who contribute to the construction of the virtual model must use different software that are specific to their specialty. Thus, an architect uses architectural design BIM software to construct the model (e.g., Autodesk's Revit Architecture), a structural engineer uses structural analysis and design software (e.g., Autodesk's Revit Structure), and so on. These software tools are referred to as *BIM tools*. In order for a BIM tool to extract, process, and insert the information into the virtual model to update or modify it, it must be capable of providing seamless two-way communication with the model and other BIM tools.

The ability to exchange information between the virtual model and BIM tools is called *interoperability*. Interoperability is not unique to BIM. It is used in all processes that require electronic information exchange between the software components contributing to the process. A broadly accepted definition of interoperability is the ability of two system components to communicate correctly and completely—with minimal cost to either component user or component vendor—where the component can be from any vendor worldwide.

All four requirements in the above definition ("correctly," "completely," "minimal cost," and "worldwide") are important. These requirements imply that software developed by a vendor as a BIM tool (say, a code analysis tool) is considered interoperable provided that it can be used correctly, completely, and easily with other BIM tools (such as BIM software for architectural design, for structural design, etc.). Through the International Association for Interoperability (IAI), standards for interface language have been developed to which various vendors developing interoperable BIM tools must adhere.

Life-Cycle Nature of BIM

The dynamic nature of the model precludes the need to require record documents, as all changes made to the project during the design or construction phases are recorded in the model in real time. For the same reason, the model also serves as a maintenance tool for building users and facilities managers, providing a tool for record keeping throughout the life of the building, concerning factors such as life-cycle cost, energy use, sustainability assessment, and so on.

Because BIM can track building performance, repairs, maintenance, and changes made to the building over its entire life, the owner's knowledge of and participation in virtual construction are critical. The same applies to architects and engineers, who will need to be more knowledgeable about building construction—how building assemblies go together—because they will be fully involved in the building's construction, albeit in the virtual environment.

It is unclear whether IPD delivery process or the BIM technology was developed first. However, it is clear that each will work as the driving force for the other. An additional factor that will power their development is sustainability (life-cycle assessment), which is no longer optional. Increasingly, local, state, and federal governments, as well as large corporations across the globe, are mandating sustainability-rated buildings. Therefore, the IPD process (because it reduces waste in labor and materials) and BIM technology (because it tracks life-cycle inputs to the building) will be increasingly required for building design and construction.

It should be noted that BIM is not limited to IPD but can be used with any project delivery method.

PRACTICE QUIZ

Each question has only one correct answer. Select the choice that best answers the question.

23. A contract document set consists of
- **a.** construction drawings and specifications.
- **b.** construction drawings and a project manual.
- **c.** specifications and a project manual.
- **d.** specifications and bidding documents.

24. The shop drawings are prepared by the
- **a.** architect.
- **b.** structural engineer.
- **c.** mechanical engineer.
- **d.** general contractor.
- **e.** none of the above.

25. Shop drawings are generally reviewed by the
- **a.** architect.
- **b.** concerned engineering consultant.
- **c.** general contractor.
- **d.** all of the above.

26. In the traditional project delivery (design-bid-build) method for a building, the day-to-day supervision of the construction is generally the responsibility of the
- **a.** architect.
- **b.** structural engineer.
- **c.** general contractor.
- **d.** all of the above.

27. In the traditional project delivery (design-bid-build) method, who is typically responsible for obtaining the certificate of occupancy from the local jurisdiction?
- **a.** The architect
- **b.** The structural engineer
- **c.** The general contractor
- **d.** The owner

28. The certificate of occupancy predates substantial completion inspection of the project.
- **a.** True
- **b.** False

29. The final completion inspection of the project is generally conducted by the
- **a.** architect.
- **b.** structural engineer.
- **c.** general contractor.
- **d.** architect with the help of his or her consultants.
- **e.** local jurisdiction.

30. A record document set is generally prepared by the
- **a.** architect.
- **b.** general contractor.
- **c.** structural engineer.
- **d.** architect with the help of consultants.

31. When does the owner receive manufacturers' warranties from the general contractor?
- **a.** At the substantial completion inspection
- **b.** At the final completion inspection
- **c.** Within one year of final completion

32. In the CMAA method of project delivery, there is normally no general contractor.
- **a.** True
- **b.** False

33. In the CMAR method of project delivery, the CM
- **a.** advises the owner with respect to construction costs during the design phase.
- **b.** manages the project's construction during the construction phase.
- **c.** works as the general contractor for the project.
- **d.** all of the above.
- **e.** only (a) and (b).

34. The project delivery method in which only one firm is contracted for both design and construction of the building is called the
- **a.** design-bid-build method.
- **b.** design-build method.
- **c.** CM method.
- **d.** CMAR method.
- **e.** IPD method.

35. The project delivery method that ensures the least amount of litigation among parties contributing to the project is the
- **a.** design-bid-build method.
- **b.** design-build method.
- **c.** CM method.
- **d.** CMAR method.
- **e.** IPD method.

36. BIM is the most recently developed project delivery method.
- **a.** True
- **b.** False

PROJECT DELIVERY METHODS AT A GLANCE

Project Delivery Method	Description
Design-Bid-Build (DBB) Delivery (Competitive Sealed Bids)	The oldest and most familiar project delivery method. Construction work is awarded to the general contractor (GC) with the lowest bid through open aggressive bidding. There is no design-phase assistance from the GC, and hence a lack of coordination between the design and construction processes. The price is unknown until the bidding process is complete. Commonly used for public projects.
Design-Bid-Build (DBB) Delivery (Competitive Sealed Proposals)	Same as the DBB (competitive sealed bid) method, except that the owner's selection of the GC is based not only on cost but also on several other criteria such as the project schedule, safety record, and qualifications of the GC's personnel. Commonly used for public projects.

(*continued*)

Project Delivery Method	Description
Design-Bid-Build (DBB) Delivery (Invitational Bidding)	Same as the above two methods except that the competition is not open, but limited to those GCs who are preselected by the owner and invited to bid. The GC with the lowest bid is generally awarded the contract. Commonly used for private or quasi-private projects.
Design-Negotiate-Build (DNB) Delivery	Same as the DBB (invitational bidding) method, except that the competition among GCs is limited to those who are preselected by the owner. Negotiations are conducted early during the design phase with one GC at a time. The GC who provides the best value for money is awarded the contract, and then provides design-phase assistance. Commonly used for private or quasi-private projects.
Construction Manager as Agent (CMAA) Delivery	The owner hires a construction manager (CM) as his or her agent (instead of the architect), who provides design-phase assistance to the architect and also performs several functions of the GC, such as construction scheduling, coordination, and site safety. There is no GC in this method, and the work is awarded to several subcontractors (called *prime contractors*) under contracts with the owner. The CM is paid a fee and carries no financial risk or legal responsibility for the prime contactors' work. Commonly used for projects when the owner is familiar with contract administration.
Construction Manager at Risk (CMAR) Delivery	In this method, which has largely replaced the CMAA method, the CM performs two sequential roles. In the first role, the CM works as the owner's representative and provides design-phase assistance to the architect. For this role, the CM is paid a fee. In the second role, the CM functions as the GC after the completion of the design phase, and is compensated under a conventional owner-contractor agreement with all attendant risk and liability, hence, the CM is called the *CMAR*. The CMAR obtains competitive bids from subcontractors, as in a DBB method. Used for both private and public projects.
Design-Build (DB) Delivery	In all previous methods, there is a lack of collaborative relationship between the design and construction teams—a lack that is addressed in this method because both design and construction work are awarded to one firm, called a *design-build* firm. The method generally saves time and cost to the owner, but to be successful, the owner's program must be precisely defined at the beginning of the project. Used for both private and public projects.
Integrated Project Delivery (IPD)	This method, which is still evolving, differs substantially from all other methods. It requires complete collaboration between the owner, architect, and GC in a zero-blame and zero-litigation environment. For successful integrated delivery, a virtual model of the project is constructed (using building information modeling, BIM) during the design phase with collaboration from all parties—owner, architect, consultants, general contractor, subcontractors, fabricators, material suppliers, etc.

REVIEW QUESTIONS

1. List the major phases into which the work on a traditional (design-bid-build) building project may be divided.
2. Using a diagram, show the contractual relationships among the owner, the general contractor, subcontractors, and the architect in a traditional (design-bid-build) building project.
3. List the important items contained in a project manual.
4. Explain the differences between competitive bidding and invitational bidding.
5. From memory, list the first 10 divisions of the MasterFormat.
6. Explain what is included in record documents.
7. Explain the differences between the CMAA and CMAR project delivery methods.
8. Provide the spelled-out versions of the following acronyms: (a) CMAA, (b) CMAR, (c) BIM, and (d) IPD.
9. What does interoperability imply in BIM tools? Explain.
10. What is the relationship between BIM and IPD? Explain.