PART 1

PRINCIPLES OF CONSTRUCTION

CHAPTER 1  An Overview of the Building Delivery Process—How Buildings Come into Being
CHAPTER 2  Governmental Constraints on Construction
CHAPTER 3  Loads on Buildings
CHAPTER 4  Load Resistance—The Structural Properties of Materials
CHAPTER 5  Thermal Properties of Materials
CHAPTER 6  Air Leakage and Water Vapor Control
CHAPTER 7  Fire-Related Properties
CHAPTER 8  Acoustical Properties of Materials
CHAPTER 9  Principles of Joints and Sealants (Expansion and Contraction Control)
CHAPTER 10 Principles of Sustainable Construction
CHAPTER 1

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

CHAPTER OUTLINE

1.1 Project Delivery Phases
1.2 PreDesign Phase
1.3 Design Phase
1.4 CSI MasterFormat and Specifications
1.5 Preconstruction (Bid Negotiation) Phase
1.6 Construction Phase
1.7 Construction Contract Administration
1.8 Postconstruction (Project Closeout) Phase
1.9 Alternative Project Delivery Methods
1.10 Construction Management (CM) Method
1.11 CM at Risk (CMAR) Method
1.12 Design-Build (DB) Method
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 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. It is further complicated by the fact that no two buildings are truly identical; each one must be custom-built to serve a unique function and respond to the uniqueness of its 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 events and processes necessary for a project’s realization is virtually the same in all buildings. This chapter presents an overview of the events and processes that bring about a building—from the inception of a mere idea or 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 documentation, 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 emerging methods of bringing a building into being and compares them with the traditional 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 detailed information on these topics should refer to sources such as those provided at the end of the chapter.

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 the order listed below:

- 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. It is the most crucial of all the five phases, as the success or failure of the project may depend on how well this phase is defined 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 as follows:

- Building program definition, including activities, functions, and spaces required in the building, along with their approximate sizes, and relationships with each other
- Economic feasibility assessment, including the project’s overall budget and financing
The progress of the project, the owner’s written approval is necessary. It should be spelled out in writing and in sufficient detail to guide design, reduce liability risk for the architect, and avoid its misinterpretation. If a revision is made during the predesign phase. When the economic considerations of the project are paramount, the owner may also consult a construction cost analyst. Depending on the size and scope of the project, the owner may require assistance from specialized consultants. For a house, or other 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, church, 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.

The 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. On the other hand, 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, the owner’s program is the first step in the project delivery process. It should be spelled out in writing and in sufficient detail to guide design, reduce 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.

### 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 also 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 level of liability for the consultant’s work. This liability occurs because the architect, being the prime design professional, coordinates the entire design effort, and the architect retains some level of liability for the consultant’s work. This liability occurs because the architect, being the prime design professional, coordinates the entire design effort, and the architect retains some level of liability for the consultant’s work.
consultants’ work is influenced a great deal by architectural decisions. Therefore, the working relationship 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 other 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 owner’s 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 proposal 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, 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.

Although 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 are also prepared at this stage. It is not uncommon in a negotiated contract (Section 1.5) for the general contractor to become involved at this stage to provide input about the cost and constructibility of the project.

**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 engineering 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.
Each consultant advises 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, 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 contractor uses to build the building. Therefore, they must indicate the geometry, layout, dimensions, type 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, however, 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, called *specifications*, is included in the document.

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.

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.

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 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 architect uses to invite bids from prospective contractors.

**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 in the entire breadth of the project delivery process—from the predesign phase through the project closeout phase.

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**EXPAND YOUR KNOWLEDGE**

**Relationship Between Construction Drawings and Specifications**

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

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**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 a 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 the 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 the 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 format 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 the above.

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

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Answers: 1-d, 2-b, 3-c, 4-a, 5-d, 6-c, 7-b, 8-b, 9-d.
1.4 CSI MASTERFORMAT AND SPECIFICATIONS

The specification document for even a modest-size project can run into hundreds of pages. It is used not only by the contractor and the subcontractors, but also by the owner, material suppliers, and the site superintendent. With so many different people using it, it is necessary that the specifications he 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 the MasterFormat, has been developed by the Construction Specification Institute (CSI) and is the format most commonly used in the United States and Canada. The 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.

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 with section numbers of a chapter, and Level 3 digits with subsection numbers of a section.

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

Because the MasterFormat deals with all types of construction (new facilities, renovation, 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.

RECOLLECTING 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 wood roof deck follows the joists. Hence, Wood, Plastics, and Composites is Division 06. Wood, plastics, and composites are grouped together because they are chemically similar hydrocarbons.
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 a part of this division, regardless of whether they are made of steel, aluminum, or wood.
With the envelope protected, finish operations, such as interior drywall, flooring, and ceiling, can begin. Thus, Division 09 is *Finishes*. Division 10 is *Specialities*, 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, called the *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 the MasterFormat is required to prepare the project manual and writing 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.

The 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.

### 1.5 PRECONSTRUCTION (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; and heating, plumbing, ventilation, and air-conditioning (HVAC) subcontractors, among others, and so on, in addition to the general contractor. The general contractor’s own work may be limited only to the structural components of the building—basements and foundations, load-bearing walls, reinforced concrete beams and columns, roof, floor slabs, and other components—with all the remaining work subcontracted.

In contemporary projects, however, the trend is toward the general contractor 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 a 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 profit margin by lowering the cost of construction insurance.

SELECTING A GENERAL CONTRACTOR

Several methods are used in selecting a general contractor to suit the peculiarities of the project and particular needs of the owner. Here are four commonly used methods:

- Competitive bidding method
- Invitational bidding method
- Negotiated contract method
- Multiple prime contract method

COMPETITIVE BIDDING

On most publicly funded projects, the award of a construction contract to the general contractor is based on competitive bidding. This refers to the process by which qualified contractors are invited to bid on the project. The invitation is generally 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, 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.

In the competitive 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 agent) may prescreen the bidders with respect to their reputation and capability 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

![Figure 1.6](image-url) 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. The relationships shown here are not absolute and may change somewhat with the nature of the project.
bidding documents. However, even in this kind of project, the number of contractors who can actually submit the bids is 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 contractual obligations.

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 experience, technical expertise, and financial status. 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 bidder.

**Invitational Bidding**

Invitational bidding is a variation of the competitive bidding method that may be followed for some private projects. This procedure allows the owner to preselect general contractors who have demonstrated, based on their experience, resources, and financial standing, their qualifications to perform the work. The architect (as the owner’s agent) may conduct the prescreening process.

**Negotiated Contract**

A method of selecting the general contractor without seeking bids is referred to as a negotiated contract. This method is used when the owner knows of one or more reputable, competent, and trusted general contractors. In this case, the owner simply negotiates with these
Surety Bonds

The purpose of a surety bond is to ensure that should the contractor fail to fulfill contractual obligations, there will be a financially sound party—refereed to as the surety (also called guarantor or bonding company)—available to take over those unfulfilled obligations. The bond is, therefore, a kind 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 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 because the contractor adds the cost of the bond to the bid amount.

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

MULTIPLE PRIME CONTRACTS—FAST-TRACK PROJECT DELIVERY

A variation of the negotiated contract, which can save project delivery time, is one in which the project is divided into multiple phases, and each phase of construction is awarded to different contractors through negotiations. The division of the project into phases is such that the phases are sequential. Thus, the first phase of the project may be site construction (site development, excavations, and foundations), the second phase may be the structural framing (columns, beams, and floor and roof slabs), the third phase may be roofing, and the subsequent phase(s) take the project to completion.

In this method of contractor selection, there is no single general contractor, the multiple contractors are each referred to as a prime contractor.
Sequential phasing of the project saves time because the earlier phases of the project can be constructed while the construction documents for the later phases are still in progress. Thus, the design and construction phases of the project overlap.

This project delivery method, referred to as fast-track project delivery, requires a great deal of coordination between phases and (several) contractors, particularly because there is no single contracting authority. It also requires a commitment from the owner that the decisions will not be delayed and, once made, will not be changed.

By contrast, the competitive (or invitational) bidding project delivery is slower because all the construction documents must be completed before the general contractor is selected. The competitive (or invitational) bidding method is also referred to as the traditional, or design-bid-build, method because each of the three phases—designing, bidding, and construction—are sequential, and one phase does not begin unless the previous phase is completed.

**Practice Quiz**

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

10. The MasterFormat has been developed by the
   d. American Institute of Architects.
   e. Associated General Contractors of America.

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

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

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

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

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

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

17. In the traditional project delivery (design-bid-build) method, the owner has separate contracts with the general contractor and the subcontractors.
    a. True
    b. False

18. Who is responsible for ensuring the safety of workers on a construction site of a typical building project?
    a. The architect
    b. The structural engineer
    c. The general contractor
    d. The owner
    e. A collective responsibility of all the above

19. In the traditional project delivery (design-bid-build) 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.

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**1.6 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 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 manufacturing industries so that they can do the following:

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

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**NOTE**

**Construction Documents and Contract Documents**

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

The approval of the shop drawings by the architect is a review to check that the work indicated therein conforms with the overall design intent shown in the contract documents. Approval of shop drawings that 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.

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

A typical stamp used by the architect on the submittals to indicate the outcome of the review is shown in Figure 1.8.

1.7 CONSTRUCTION CONTRACT ADMINISTRATION

The general contractor will normally have his or her own 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 through independent concrete testing laboratories.

Leaving quality control of materials and performance entirely in the hands of the contractor is considered inappropriate. It can leave the owner vulnerable to omissions and errors in the work and, in some instances, to unscrupulous activities. Therefore, the owner usually retains the services of the architect to provide an additional 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.

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 determine that their drawings and specifications are transformed to reality just as they had conceived. It also provides 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. Remember:

- The architect determines the what and where.
- The contractor determines the how and when.

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 dividing line 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 a part of the work observed, should the architect fail to detect or provide timely notification of work not conforming with the contract documents. This is known as failure to detect.

Because many components can be covered up by other items in days or hours, the architect should visit the construction site at regular intervals, 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 to this person a trailer office, water, electricity, a telephone, and other necessary facilities.

Inspection of Work

There are only two times during the construction of a project (Section 1.8) 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) is fully performed and hence is ready for final payment. These inspections are, therefore, referred to as follows:

- 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 entitled “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.

A request 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 be 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.

**1.8 Postconstruction (Project Closeout) Phase**

Once the project is sufficiently complete, the contractor will request 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, notwithstanding the fact that there might be cosmetic and minor items yet to be completed.

The contractor’s request for substantial completion inspection by the architect may include a list of incomplete corrective portions of the work, 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 list. If the additional items are excessive, the architect may ask the contractor to complete the selected items before rescheduling 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 warranty 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 warranty 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...
marks an important project closeout event. That is why the contractor is allowed a brief
time interval to complete fully the work after the successful substantial completion
inspection.
Before seeking a substantial completion inspection, the contractor is generally 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 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.

Certificate of Final Completion
After the contractor carries out all the corrective work identified during substantial com-
pletion inspection and so informs the architect, the architect (with the assistance of the con-
sultants) carries out the final inspection of the project. If the final inspection passes, the
certificate of final completion is issued by the architect, and the contractor is entitled to final
payment.
Before the certificate of final completion is executed by the architect and, finally, the
owner, the owner receives the record documents, keys and key schedule, equipment manu-
als, and other necessities. Additionally, the owner receives all legal documentation to indi-
cate that the contractor will be responsible for claims made by any subcontractor, manufac-
turer, or other party with respect to the project.
After the certificate of final completion, the contractor is no longer liable for the main-
tenance, utility costs, insurance, and security of the project. These responsibilities and lia-
Bilities transfer to the owner.

Record Documents
Changes of a minor nature 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 draw-
ings). 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.

1.9 Alternative Project Delivery Methods
As stated in Section 1.5, several building projects are constructed on the basis of the owner
awarding the contract to a general contractor, who, in turn, subcontracts much (or all) of
the work to subcontractors. This is the traditional, design-bid-build method of project
delivery, accomplished through competitive bidding, invitational bidding, or negotiated
contract.
In recent times, three new methods of project delivery have become popular:
• Construction management (CM) method
• CM at risk (CMAR) method
• Design-build (DB) method

1.10 Construction Management (CM) Method
In the traditional design-bid-build project delivery method, the architect designs the proj-
ec, prepares the bidding documents, and assists the owner in the selection of the general
contractor. During the construction phase, the architect visits the site to observe the work
in progress, advises the owner whether the work progress conforms with the contract docu-
ments, and takes action 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 agent and provides professional service from the inception to the completion of the project. Various phases of this method, as described previously, are represented graphically in Figure 1.9.

In the 1970s, because of the large cost overruns and time delays on many projects, owners began to require architects to include a cost-estimating professional during the early stages of the design process. Because the best expertise in cost estimating and construction scheduling resides in the contracting community, it often meant involving the contractor during the design phase.

As the contracting community acquired the ear of the owner during the design phase, it began to influence many issues that in the traditional method were entirely within the architects’ realm. The contractors’ involvement in the design phase, the increased complexity of building projects, and the owners’ push for timely and on-budget project deliveries made the contractors realize the need for professional management assistance in construction.

This gave birth to the full-time professional construction manager and to a new method of project delivery, referred to as the construction management (CM) method. In the CM method, the owner retains a construction manager as an agent to advise on such aspects as cost, scheduling, site supervision, site safety, construction finance administration, and overall building construction.

Note that the construction manager 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 CM projects, the owner hires the construction manager 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 CM delivery method does not mean that there was no construction management in the traditional, or design-bid-build method. It was there, but it was done informally and shared between the design team and the general contractor, both of whom had little formal training in the management and financial aspects of a project.

The introduction of a construction manager on the project transferred various functions of the general contractor (in a traditional method) to the construction manager. Thus, in the CM method, the general contractor became redundant, therefore, there is no general contractor in this method.

In the CM method of project delivery, the owner awards multiple contracts to various trade and specialty contractors, whose work is coordinated by the construction manager. Thus, the structural framework of the building may be erected by one contractor, masonry work done by another, interior drywall work by yet another contractor 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 traditional method—is, in the CM method, done by the construction manager on behalf of the owner. Additionally, the construction manager administers the contracts between the contractors and the owner.

Thus, the owner, by assuming a 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 some 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 construction manager, there can still be substantial savings in large but technically simple projects.
The CM project delivery method is particularly attractive to owners who are knowledgeable about the construction process and can fully participate in all its aspects from bidding and bid evaluation to the closeout phase.

1.11 CM AT RISK (CMAR) METHOD

A disadvantage of the CM method lies in the liability risk that the owner assumes, which in the traditional 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 CM method, there is no single point of responsibility among the various prime contractors. Each prime 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 construction manager because the cost, timeliness, and quality of the ultimate product are heavily dependent on the expertise of the construction manager.

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

In the CMAR method, the owner contracts a CMAR company for (a) construction management services for a professional fee and (b) building the project as the general contractor. The CMAR company then works with the architect to develop construction documents that will meet the owner’s budget and schedule. In doing so, the CMAR company functions as the owner’s agent. Relationships between various functionaries 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 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.
22. A contract document set consists of
   a. construction drawings and specifications.
   b. construction drawings and project manual.
   c. specifications and project manual.
   d. specifications and bidding documents.

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

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

23. 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 the above.

24. 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

25. The certificate of occupancy predates substantial completion inspection of the project.
   a. True
   b. False

26. 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/her consultants.
   e. local jurisdiction.

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

28. 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

29. In the CM method of project delivery, there is normally no general contractor.
   a. True
   b. False

30. In the CMAR method of project delivery, the construction manager
   a. advises the owner with respect to construction cost 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 the above.
   e. only (a) and (b).

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

1. List the major phases in which the work on a traditional (design-bid-build) building project may be divided.
2. Using a diagram, show the contractual relationships between 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 ten divisions of the MasterFormat.
6. Explain what is included in record documents.
7. Explain the differences between construction management (CM) and construction management at risk (CMAR) project delivery methods.

SELECTED WEB SITES

American Institute of Architects  (www.aiaonline.com)
Associated General Contractors of America  (www.agc.org)
Construction Management Association of America  (www.cmaanet.org)
Construction Specifications Institute  (www.csinet.org)
Design-Build Institute of America  (www.dbia.org)

FURTHER READING
