Introduction & Overview of Design and Building Processes of Disaster Resistant Homes™

The first 2 page summary, and a comprehensive outlined-illustrated overview of, the descriptions of the home's designing-engineering & methods of Building Project Product Delivery, of the construction industry.

Details & options of a potential customized Building Program with 'Building Project Delivery Methods', and with developments of 'Plans & Specifications' and types of contracts for the principals involved in the home building project which will be customized for each project and investment.

Information provide by, EcoUSA Developers Corporation in consultation with Innovative Design Development & Construction Company, California Contractor's License 539500, for Design & Build Projects, which comprehensively explains the means and methods usually used in the design and construction process.

The 3 Principals of the Building Project are, the Project Owner, the Lead Design Consultant, or the Architect, and the General Contractor, for the Delivery of the Project.

The American Institute of Architects have available, '*Standardized Forms of Agreement between Owner and Architect*, and or between Owner and Contractor that defines the building program, which can be used for the project, or a customized investor's agreement and contract can be created for each project.

A Disaster Resistant Home™ building program is a written statement setting forth design objectives, constraints, and criteria for a home building project.

Summary of the Prime Design Consultant, who maybe an Architect, or a General Contractor in the case of a Design & Build Contract, who functions as Construction Contract Administrator and provides:

- Design and Supervise the Engineering and the creation the PLANS & SPECIFICATIONS of the Building Project
- Observe construction & inform the owner of the progress of work
- Guard the owner's interests against defects and deficiencies
- Review and approve shop drawings, mockups, and other submittals
- Prepare change orders, if required
- Review correspondence between the owner and the contractor and take action as required
- Prepare certificates of payments
- Make the substantial completion inspections
- Make the final completion inspection
- Review manufacturers' and suppliers' warranties and other project closeout documentation and forward them to the owner

The Owner, Developer, and or the Contractor, as Prime Design Professional, and or an owner can authorize an owner's representative to facilitate and coordinate the designing & building project.

An owner can be fully involved throughout the entire project design & delivery process, or remain a passive investor, as is desired by each owner and or investment partner.

A Disaster Resistant Home™ building program is a set of illustrated and written documents, setting forth design objectives, constraints, and criteria for the home building project.

A Disaster Resistant Home™ building program includes marketing research for home marketability & sales, space requirements and relationships, flexibility and expandability, special equipment and systems, and site requirements. If a comprehensive program is not available at the outset of the project, the owner may obtain the architect's or contractor's or other lead design consultant's assistance in developing each custom designed home, which must satisfy many performance criteria and legal constraints, and use specific systems, parts, components, and materials to build the Disaster Resistant Home™ with Zero Net Energy Systems and certifications.

Building construction is complicated, by the fact that no two lots and no two homes are identical; each one is custom designed and built to serve a unique preferences of its new family, the owner.

The Design and Engineering Goal is to create the Construction Plans & Specifications to Submit to the local Planning and Building Jurisdictions for 'APPROVAL' to build the new Home.

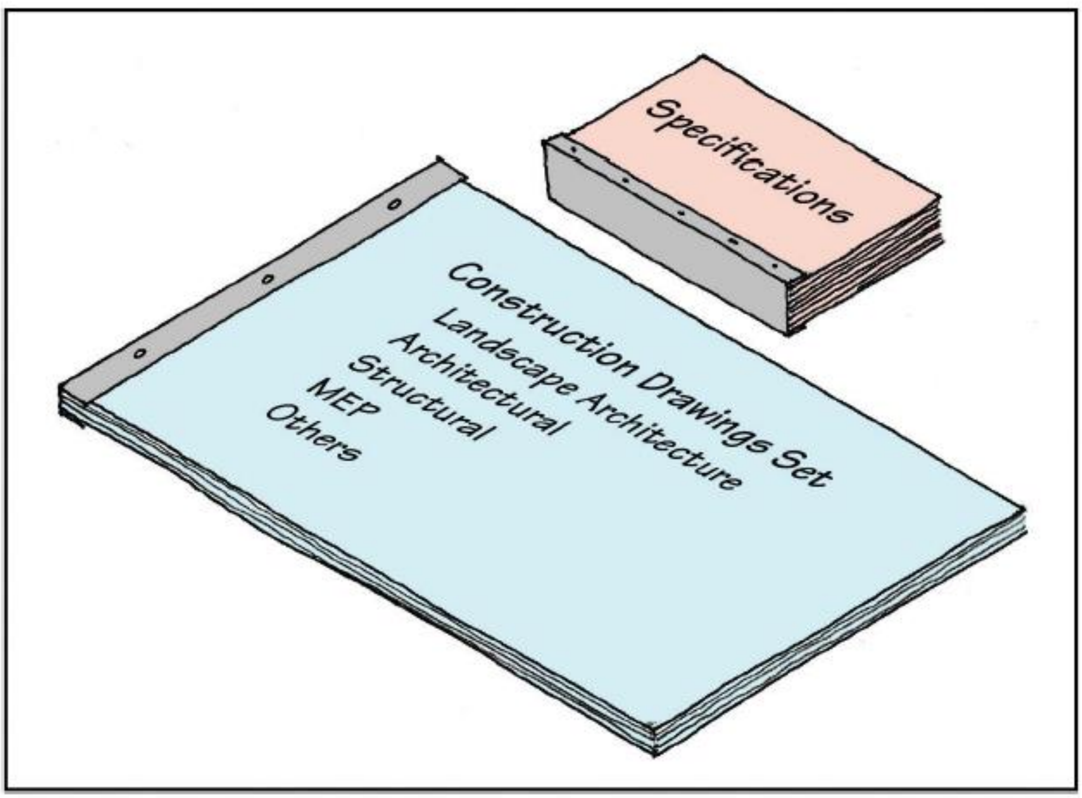


Figure 1.4 A construction document set consists of architectural and consultants' construction drawings plus the specifications prepared by the architect and the consultants. The Specifications are bound in book format along with other specified materials use to build the home.

Contents

The Generalized Design and Building Project 'The Design Phase'
The design phase begins after the selection of the architect or other Prime Design Consultant.

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, landscape architect, civil and structural consultants, and mechanical, electrical, and plumbing (MEP) 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, 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 usually functions as the prime design professional and, to a contractual 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.

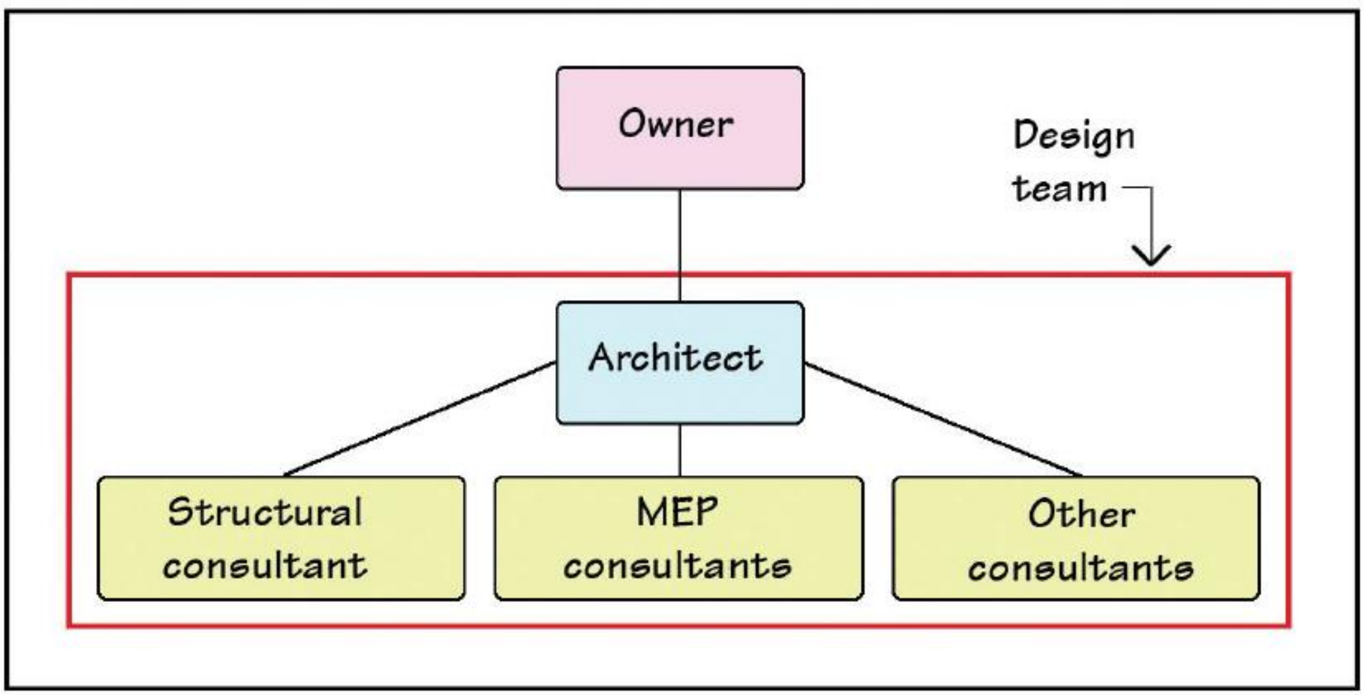


Figure 1.1 Members of a Typical Design Team, and their interrelationships with each other and the owner in a traditional contractual set up. A line in this illustration indicates a contractual relationship between parties. ("**MEP consultants**" is an acronym for mechanical, electrical and plumbing consultants)

The Architect's or Lead Consultant's Liability for work done on the Building Project.

In some projects, the owner-developer team may contract some consultants directly, particularly a civil consultant for a survey of the building site, site grading, slope stabilization, and the design of site drainage system, 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.

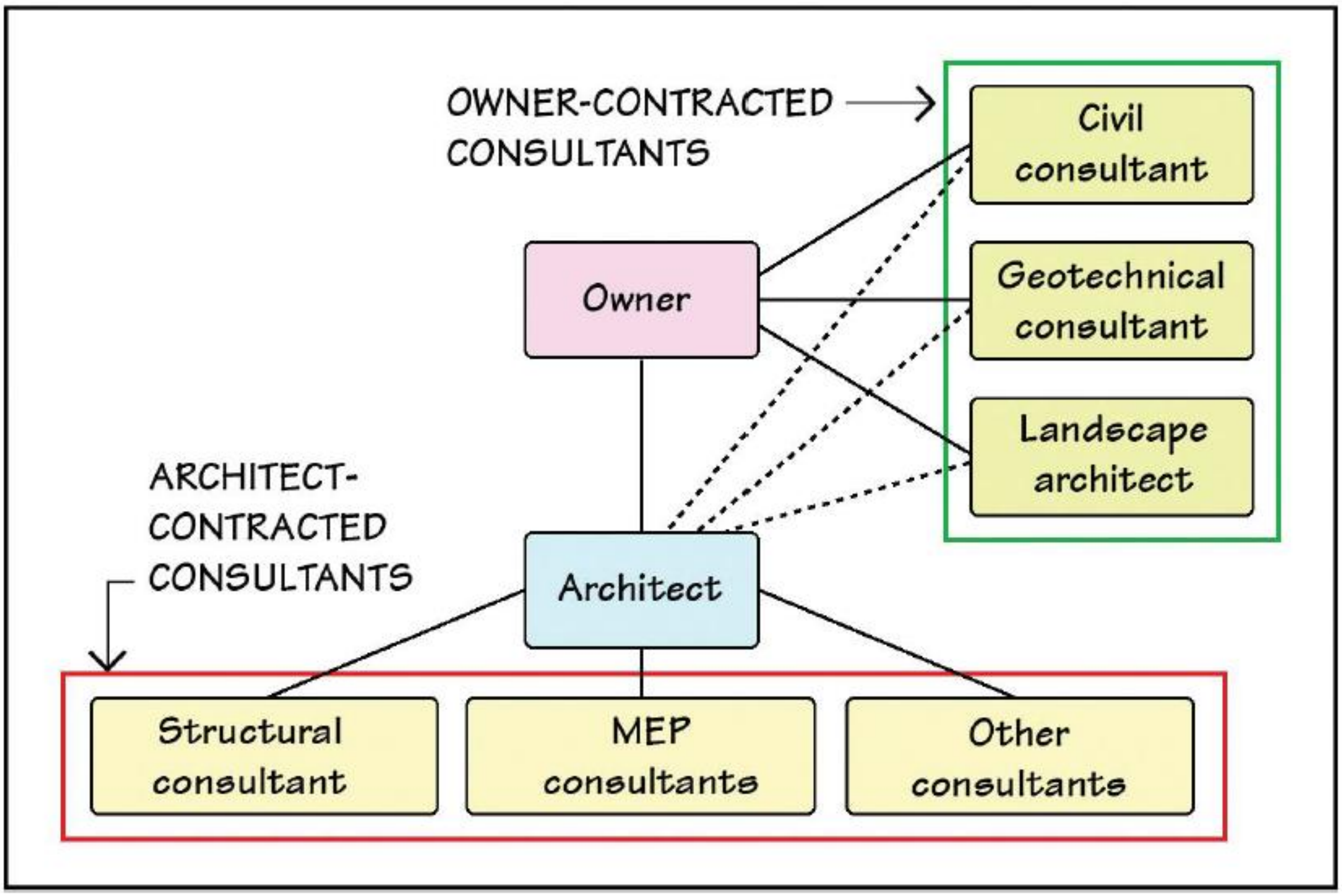


Figure 1.2 Members of the Typical Design Team, and their interrelationships with each other and the owner in a project where some consultants are contracted directly by the owner. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication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

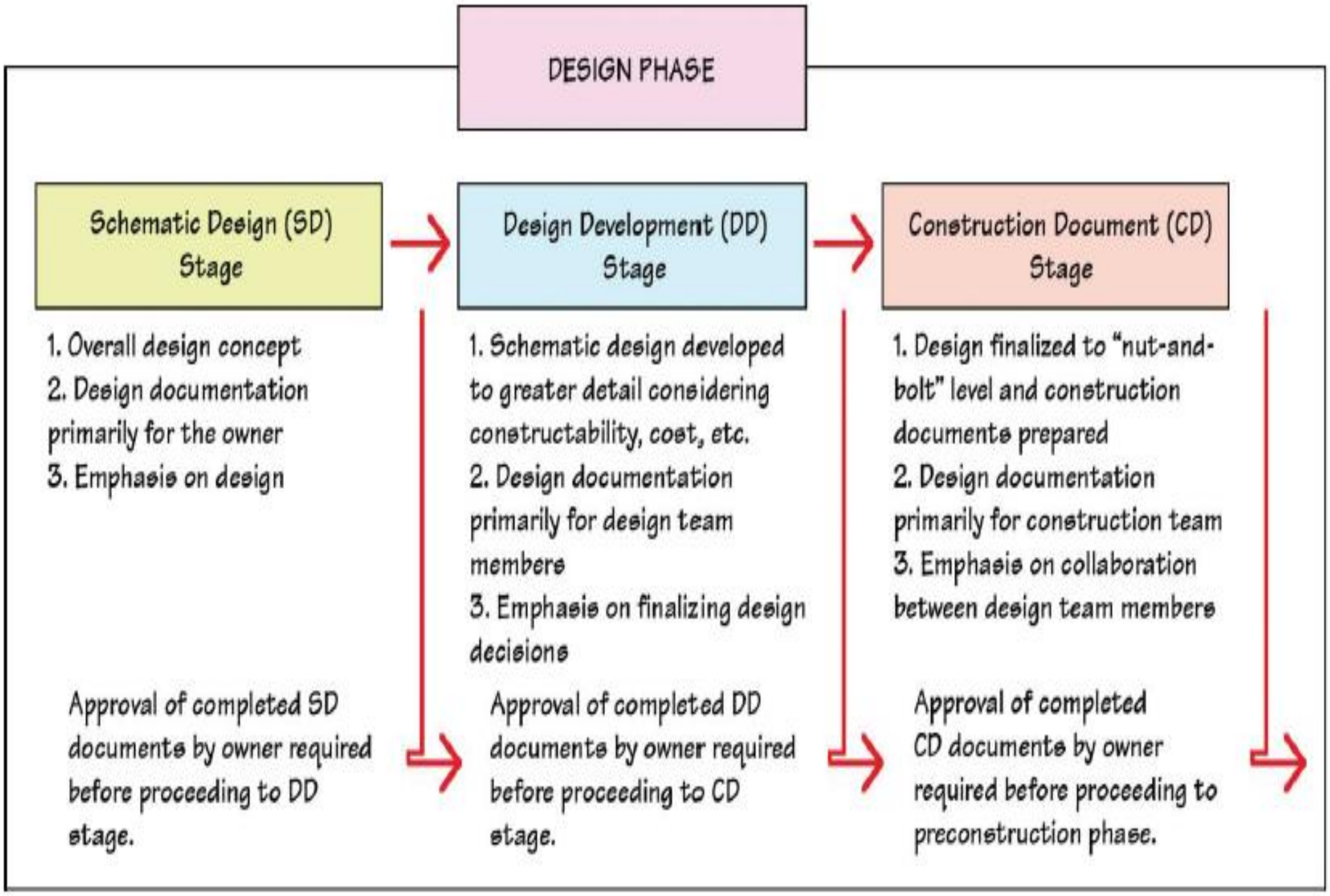


Figure 1.3 Three sequential stages, (STEPS) of the design phase and the important tasks accomplished with each stage.

Typically the 3 stages of the design phase of projects
1. Schematic design (SD) stage
2. Design development (DD) stage
3. Construction document (CD) stage

Figure 1.3 illustrates the sequence and the important tasks accomplished in each stage.
Note that at the end of each stage, a written approval from the owner is required before proceeding to the next stage, or from the design phase to the preconstruction phase.

Schematic Design Stage—Emphasis on Design
The schematic design gives graphic shape to the project program. It is an overall concept that illustrates key ideas of the design solution. The major player in this stage is the architect, who develops the design scheme (or several design options), generally with 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 for communicating the architect's design intent to the owner 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 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, pragmatic, and constructible solutions for the exterior envelope, structure, fenestration, interior systems, MEP 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 ranges from broad design aspects to finer 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 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 items:

1. Construction drawings
2. 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, geo-tech-civil and structural construction drawings, MEP 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” (means, methods, and sequencing) of construction 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.

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 can be so stated in the owner-contractor agreement.

Sequence of events of a DESIGN-BID-BUILD, (DBB), Building Project

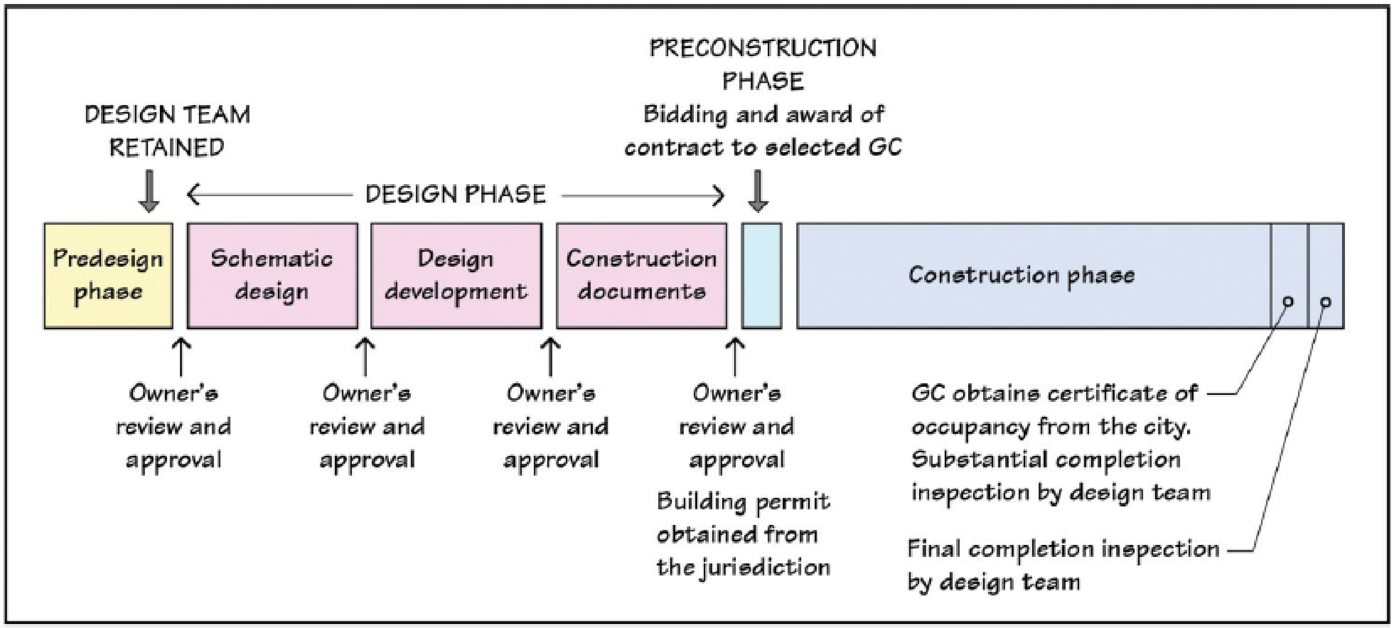


Figure 1.18 Sequence of operations in the DESIGN--BID- BUILD method of project delivery. Note that the DESIGN and BID and BUILD stages are in sequence, and the GENERAL CONTRACTOR is selected 'only' after the construction documents have been completed by the DESIGN TEAM.

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. Because the specifications are in text format (not as drawings), they are bound in book format.

A few other items are also included in this document at a later stage, and the entire bound document is called the *project manual*, described in Section 1.7.

The construction drawings plus the specifications constitute the construction document set, Figure 1.4 (see also Figure 1.11). Although hardcopy drawings and specification are common, their digital versions are being increasingly used.

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*.

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

The Goal: "Plans & Specifications" to submit local regulating Agencies for APPROVAL to Build

Relationship Between Construction Drawings, PLANS and SPECIFICATIONS

The Construction Drawings, PLANS:	**The 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, proprietary a manufacturer
Quantity indicated	Quality indicated
Location of elements established	Installation requirements of elements established
Size, shape, of building elements provided	Description, properties, finishes, materials provided

The Design and Engineering Goal is to create the Construction Plans & Specifications to Submit to the local Planning and Building Jurisdictions for 'APPROVAL' to build the new Home.

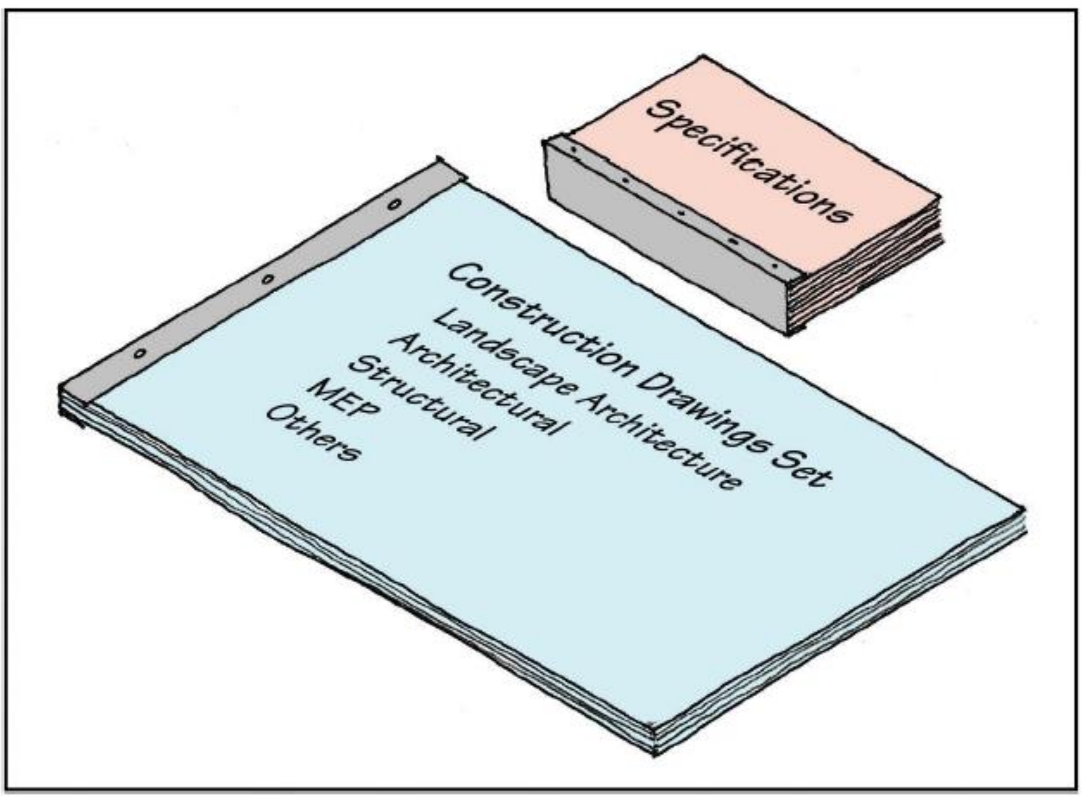


Figure 1.4 A construction document set consists of architectural and consultants' construction drawings plus the specifications prepared by the architect and the consultants. The Specifications are bound in book format along with other specified materials use to build the home.

The Standardized 'MasterFormat', used in the Building Industry

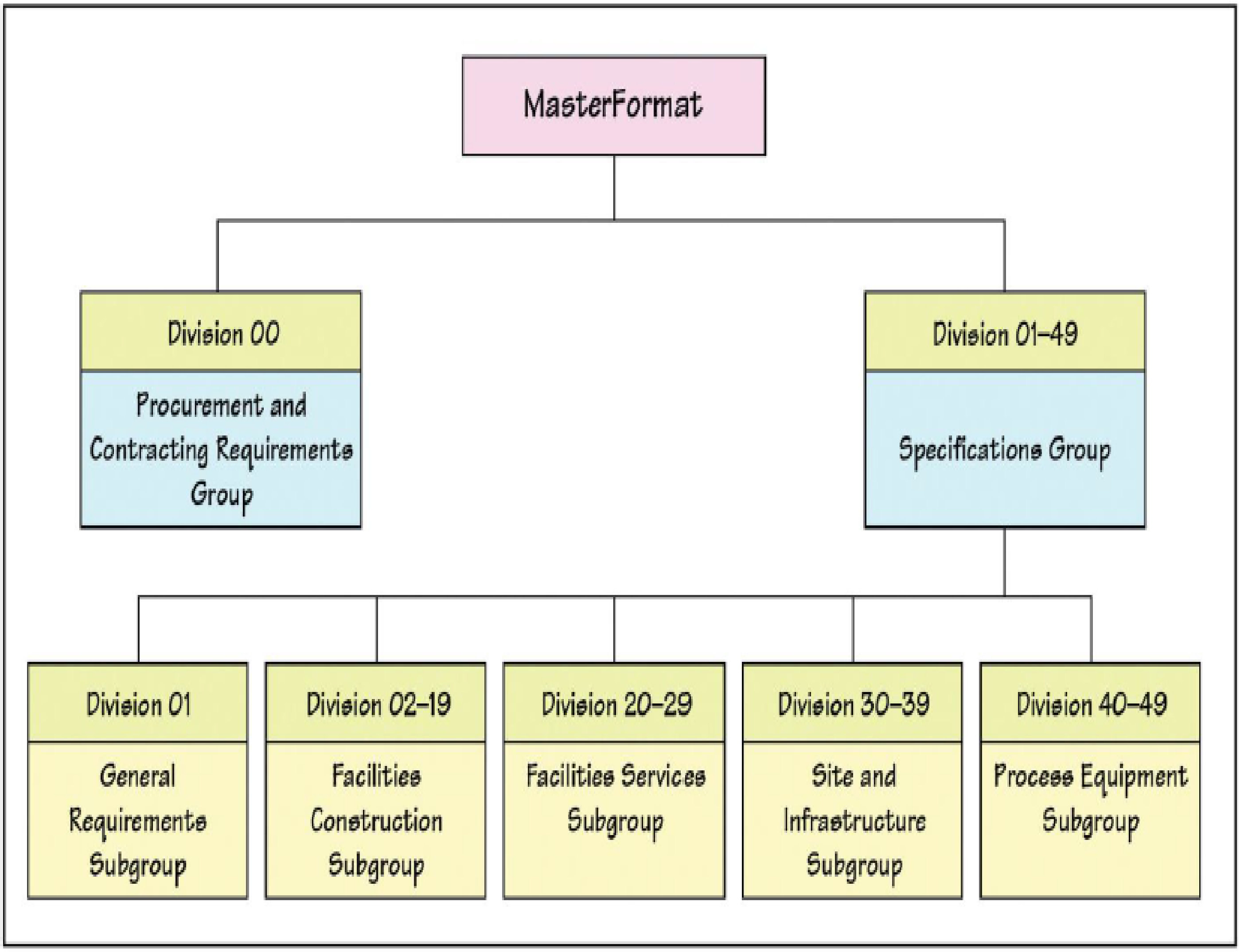


Figure 1.5 Structure of the MasterFormat, showing it's separation into two groups, 1. Procurement and Contracting Requirements group, and 2. Specifications Group. The Specifications group is divided into five subgroups. Each subgroup is divided into a number of Divisions.

MasterFormat and 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.

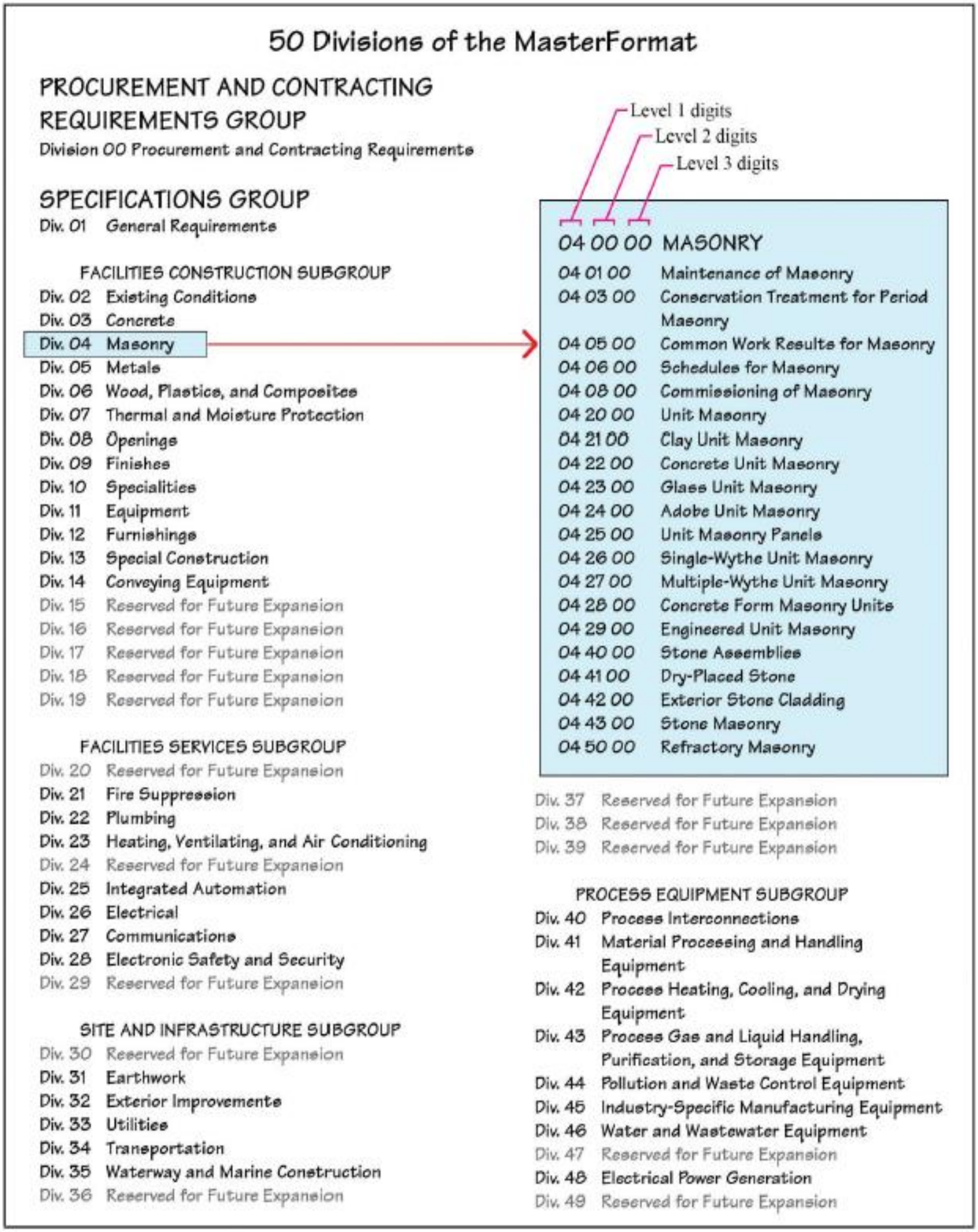


Figure 1.6 MasterFormat Divisions. The first few sections (Level 2 Details) of Masonry Division have been highlighted in a BOX. (Level 3 Details) would show further Divisions of a Section. For Example, 04 23 13 covers the specifications of the vertical glass unit masonry. 04 23 16 covers glass unit masonry Floors, and o4 23 19 covers glass units masonry skylights.

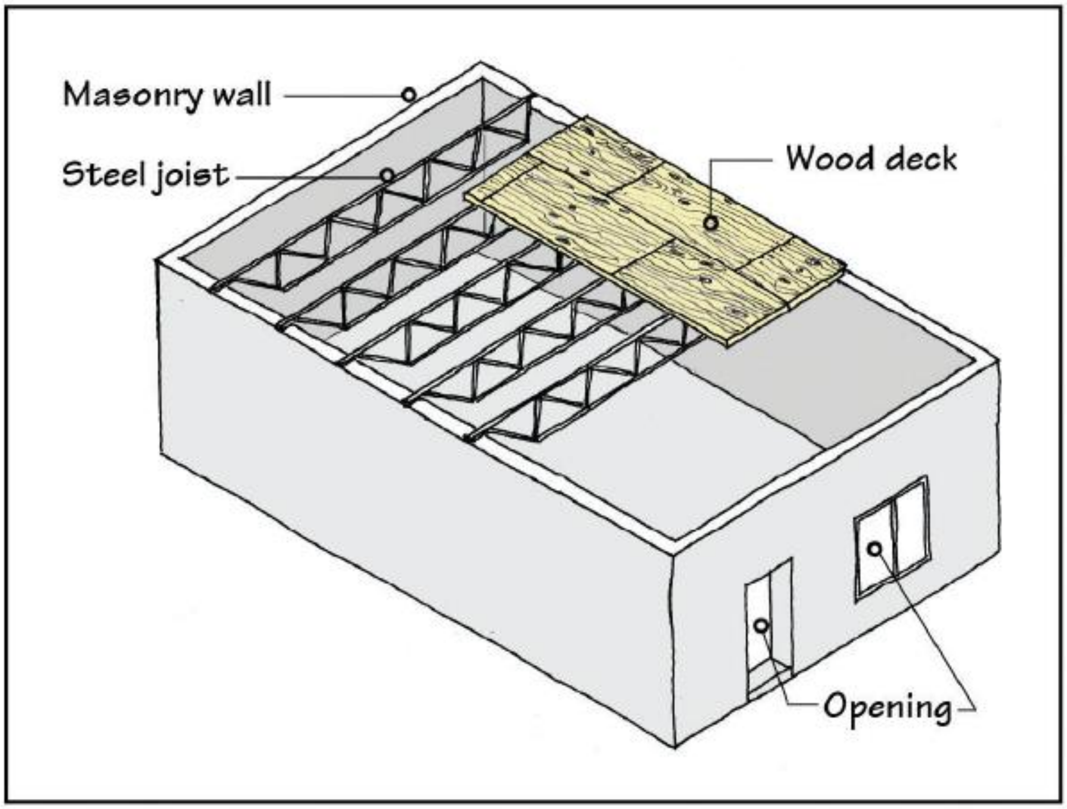


Figure 1.7 A simple Load bearing masonry wall building with steel roof joists and wood roof deck, used as an aid to recalling the sequence of the first few Divisions of the MasterFormat.

Important Items to include in Panels and Specifications

Important Items Included in Division 01: General Requirements

1. Summary of work
2. Work covered by contract documents
3. Work by owner
4. Price and payment procedure
5. Construction progress documentation
6. Change order procedure
7. Submittal procedure
8. Product substitution procedure
9. Contract modification procedure

Important Items Included in Division 02: Existing Conditions

1. Demolition and deconstruction of existing structures, roads, pavements, etc., including salvage of materials
2. Maintenance of existing structures and landscape elements
3. Contaminated site material removal
4. Geotechnical investigation, land survey, and seismicity information of site
5. Site remediation

Figure 1.8 Important Items included in MasterFormat Division 01 and Division 02

PRECONSTRUCTION PHASE: THE SURETY BONDS

It is essential that the General Contractor's(GCs), bidding for the project are qualified by virtue of their financial resources and a successful record of contracting experience to undertake the project of the size and complexity of the owner's project. Therefore, a reliable and just process of screening the GCs must be used, which is achieved by requiring the GCs to provide bonds to the owner.

A bond is a form of surety, which ensures that if the GC fails to fulfill contractual obligations, there will be a financially sound third party—referred to as the *surety* (also called the *guarantor* or *bonding company*)—available to take over those unfulfilled obligations of the GC.

The bond is, therefore, a form of insurance that the GC buys from a surety—a bonding company.

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

The three types of bonds are: (i) bid bond, (ii) performance bond, and (iii) payment bond, each with a unique purpose, as described hereunder, and illustrated in Figure 1.13.

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 (GC) 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 bonding company.

A bid bond is required at the time the GC submits the bid for the project. If the GC refuses to enter into an agreement or is unable to provide the required performance and payment bonds, the bonding company is obliged to pay a penalty (bid security amount) to the owner—usually between 5% and 10% of the project's anticipated cost.

Performance Bond

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

A performance bond protects the owner against default by the GC or by those for whose work the GC is responsible, such as the subcontractors. For that reason, the GC will generally require a performance bond from all 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 GC. 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 GC 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 GC, it is in reality paid by the owner since the GC adds the cost of the bond to the bid amount. **FIGURE 1.13**

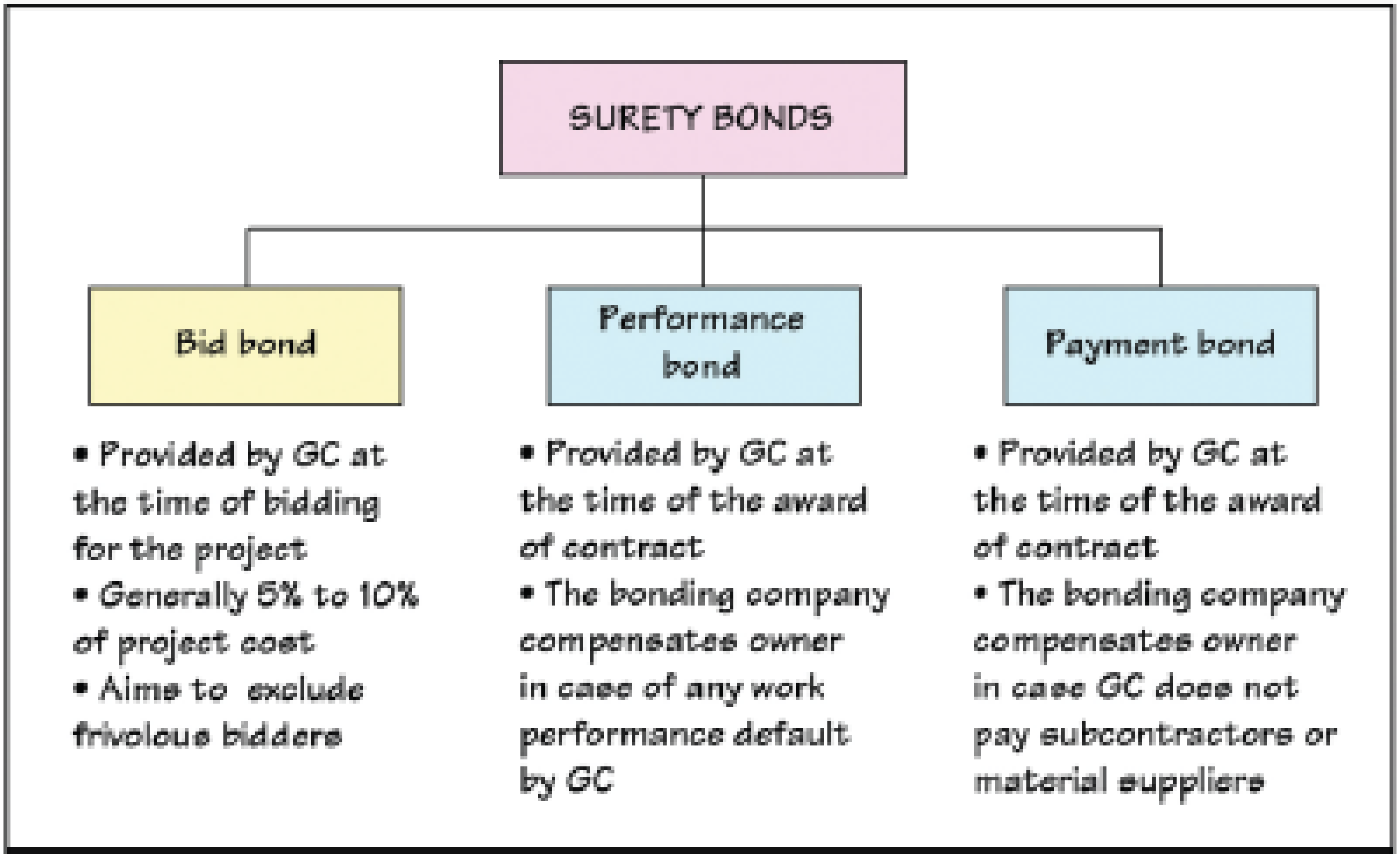


FIGURE 1.13 Details of three surety bonds used in construction projects.

The Construction Team

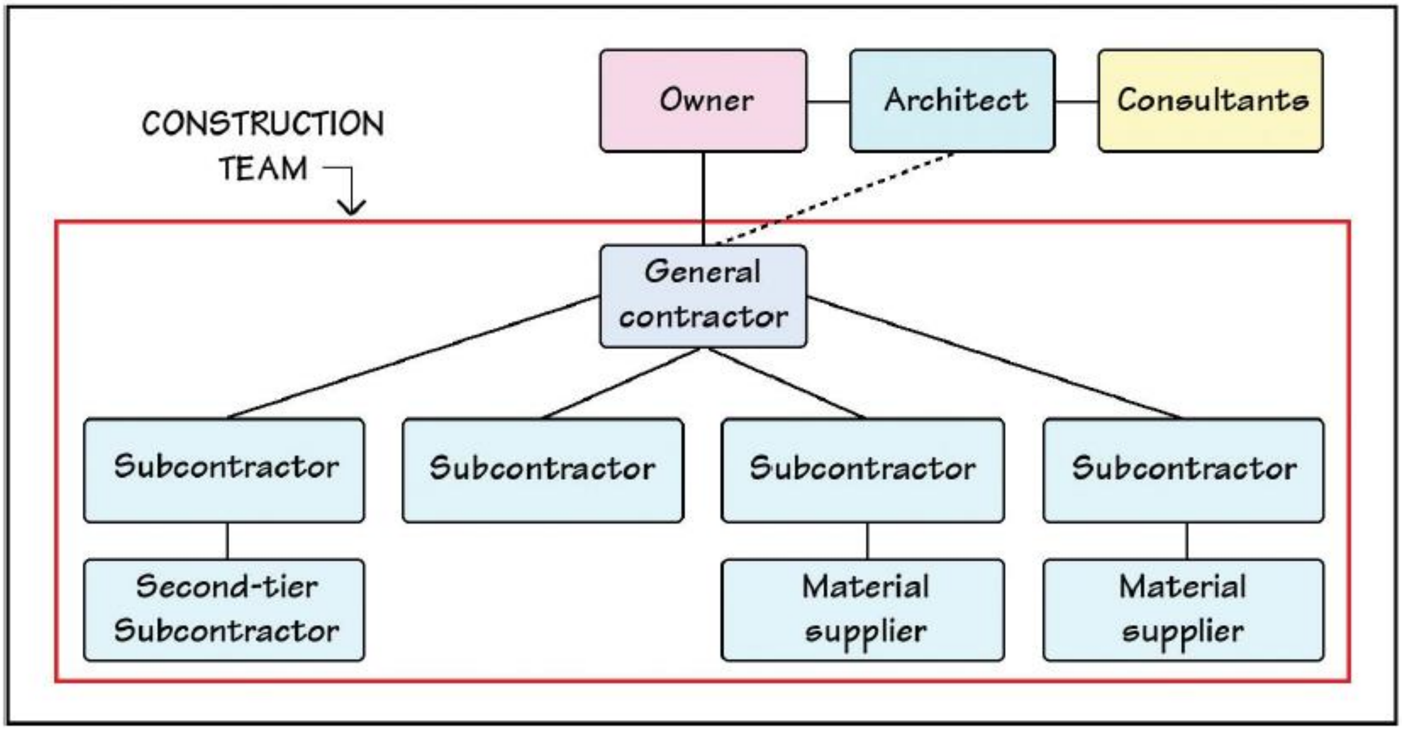


Figure 1.9 The construction team and their interrelationships with each other and the owner. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link. The relationships shown here are not absolute and may change from project to project.

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 (GC) and a number of specialty subcontractors, Figure 1.9.

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, and roof and floor slabs), 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 GC 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*. In that case, the GC deals only with the subcontractor, not the second-tier subcontractor.

Whether the GC performs part of the construction work or subcontracts the entire work, the key function of the GC 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 GC 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.

FIGURE 1.8 Important items included in MasterFormat Division 01 and Division 02.

FIGURE 1.9 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.

PRECONSTRUCTION PHASE: THE BIDDING DOCUMENTS

The preconstruction phase comprises two important activities: preparation of bidding documents (also called *bid package*) and the selection of the GC.

The bidding documents are prepared by the architect with the help of the entire design team.

They are documents that are used by the GC to bid for the construction of the project. They include (i) construction documents, which comprises construction drawings and specifications (Divisions 01 to 49) and (ii) Division 00.

Division 00, titled as *Procurement and Contracting Requirements*, contains legal and contractual information that the GC must be aware of before preparing the bids. For the ease of grasping its contents, Division 00 may be divided into four parts:
(a) bid procurement requirements,
(b) contract requirements,
(c) contract administration, and
(d) available project information,

Figure 1.10. As shown in Figure 1.10, the *bid procurement* part of Division 00 refers to items that a GC will typically not deal with after signing the contract, such as instruction to bidders, prebid meetings, and bid bond information. The *contract requirements* part contains owner-GC agreement, conditions of contract, etc.

Contract administration includes performance and payment bond details, and requirements for certificates of substantial and final completion. *Available project information* relates to land survey, geotechnical information, geophysical information, etc.

An important component of geophysical information is the degree of seismicity of the site.

The bidding documents may also contain addenda. An addendum refers to a document that is added to the original construction documents during the bidding period because of the errors or omissions observed after the bidding documents have been released to the bidders.

An addendum may also become necessary in response to questions raised during a pre-bid meeting by the prospective bidders.

After the contract has been awarded to the successful bidder, the bidding documents (with owner's and GC's signatures on documents where needed, and blank forms in Division 00 completed) become the contract documents.

The contract documents may also include modifications to owner-GC contract after the execution of the original contract.

These modifications must be mutually agreed to between the owner and the GC per contract modification procedure described in Division 01. The items included in contract documents are shown in Figure 1.11, which also illustrates the differences between construction documents, bidding documents, and contract documents.

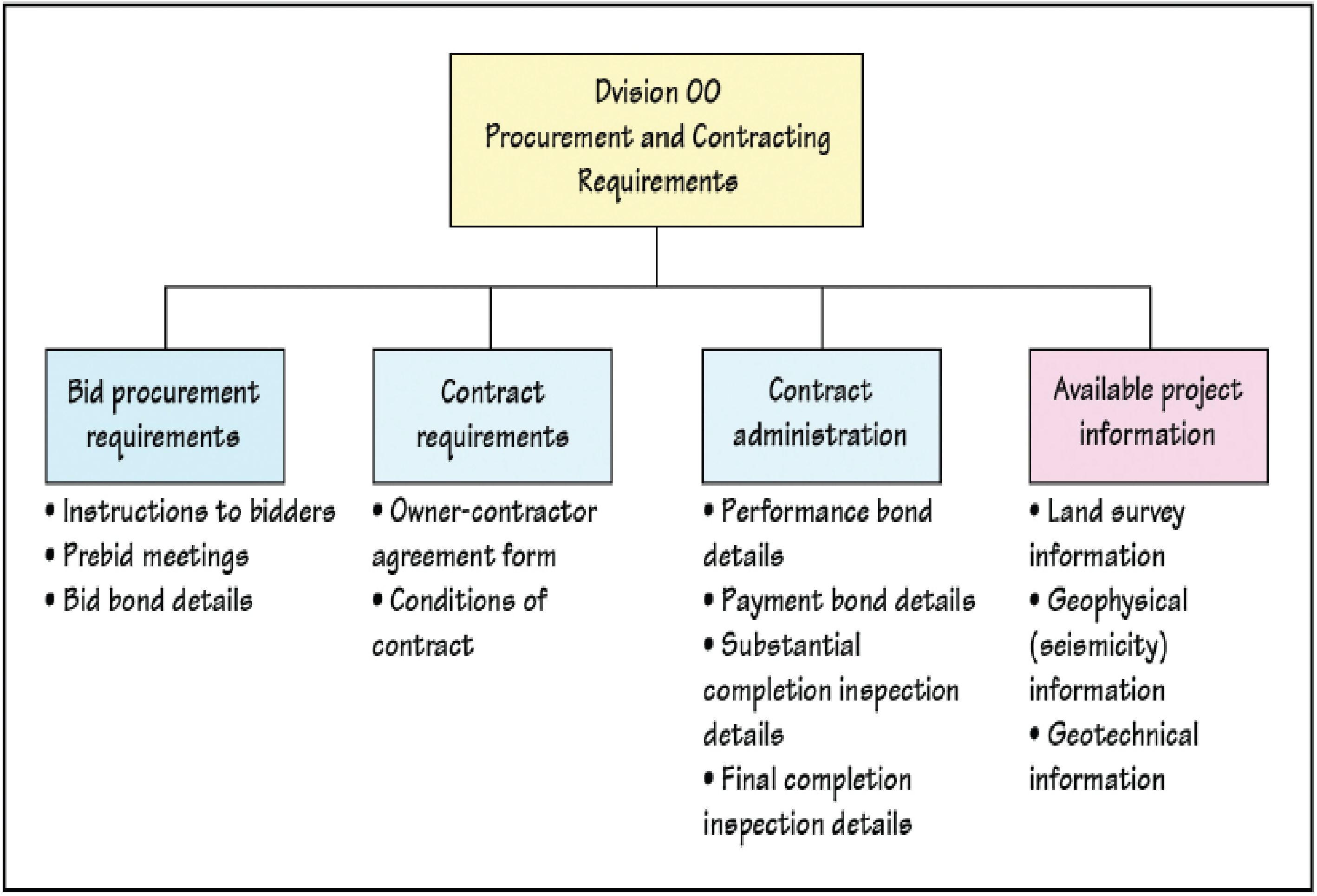


Figure 1.10 Important contents of the MasterFormat Division))

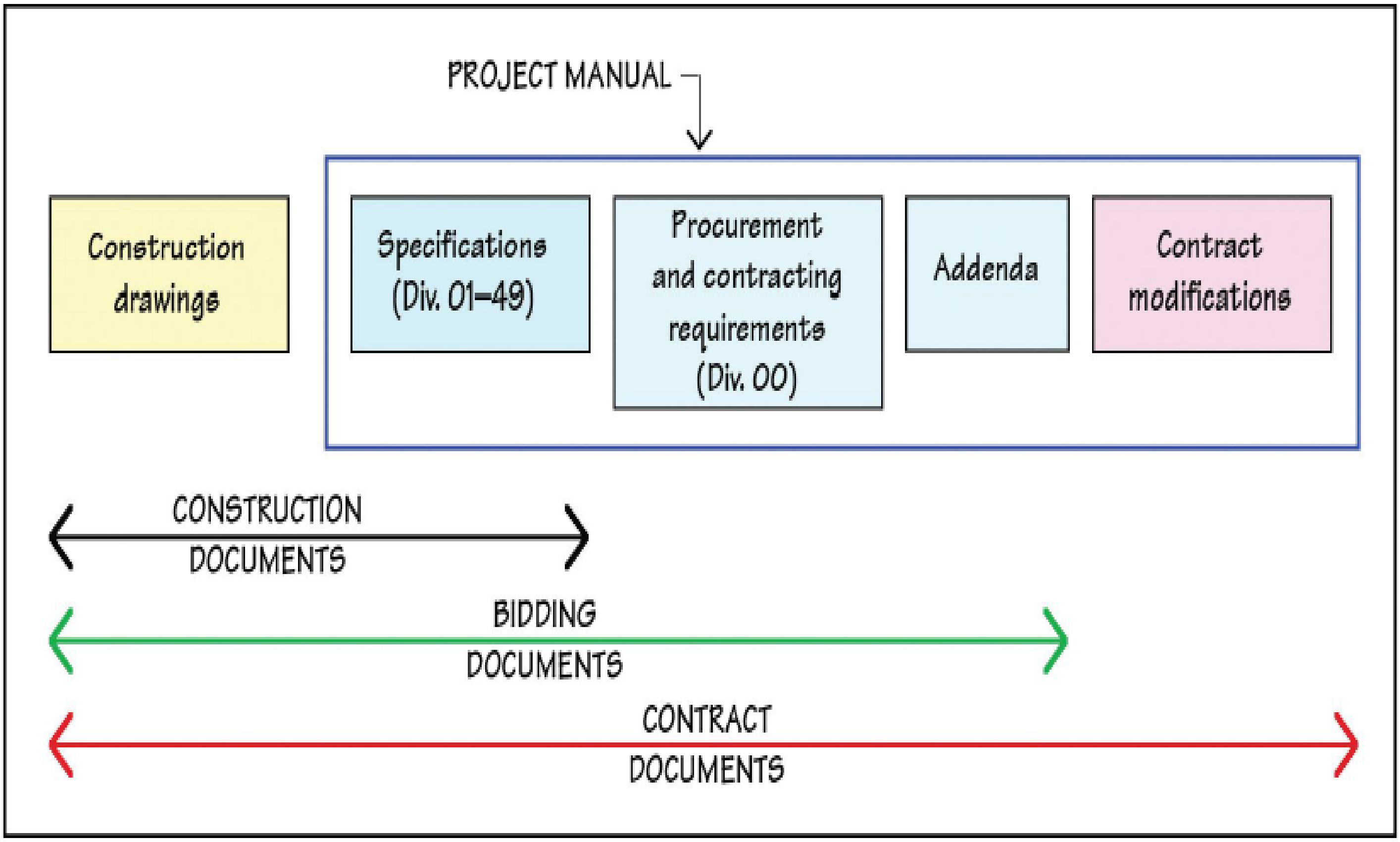


Figure 1.11 Differences among Construction Documents, BIDDING DOCUMENTS, (Also called the 'BID PACKAGE') and CONTRACT DOCUMENTS.

Typical Contents of 'PROJECT MANUAL'

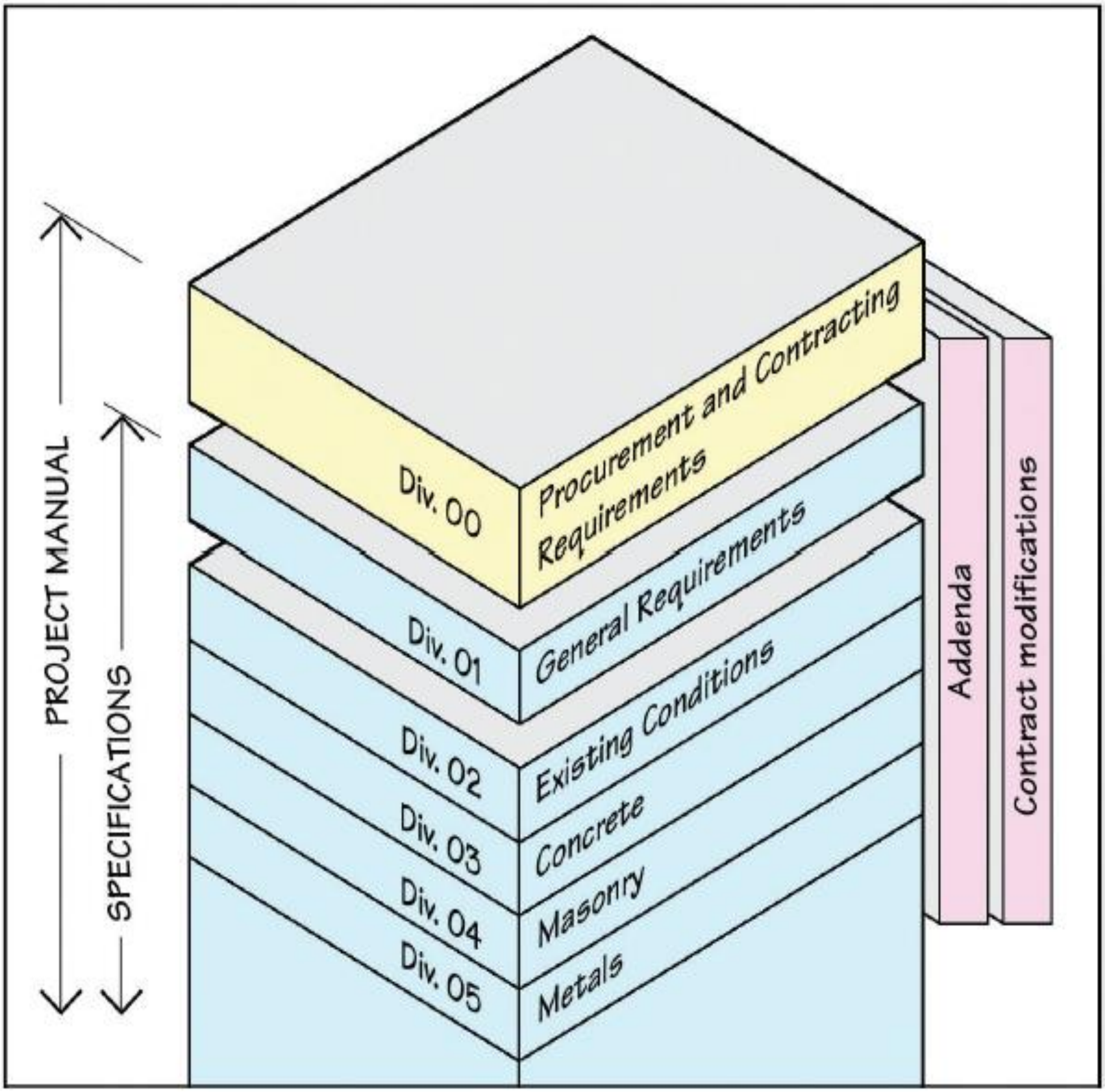


FIGURE 1.12 Contents of a typical project manual.

Some owners may from time to time, like to modify the contract, and contract modifications are not uncommon.

The reason, is that the construction of a typical custom building, unlike a manufactured product, is one-off entity, which may be subjected to unforeseen situations.

Causes such as insignificant and or significant changes in project scope (additive or deductive), and or design modifications may require contract modification.

Project Manual

Project specifications (Division 01 to 49), Division 00, addenda, and contract modifications are bound together into a document called the *project manual*,

Figure 1.12. In other words, the project manual comprises the contract documents minus the construction drawings.

The GENERAL CONTRACTOR AND PROJECT DELIVERY

After the bidding documents are ready, the selection of the GC is the next significant step forward.

A number of selection methods exist. They differ from each other depending on:

a. the basis of selection—open competition, limited competition, or negotiation with selected GCs,

b. the timing of selection—stage of the project at which the selection is made—predesign phase, design phase, or preconstruction phase,

c. the GC's role during the design phase, and

d. the level of coordination between the design and construction teams through all phases of the project.

These methods are called the *project delivery methods*.

Some of the most commonly used project delivery methods are:
• Design-bid-build (DBB) method
• Design-negotiate-build (DNB) method
• Construction manager at risk (CMAR) method
• Design-build (DB) method
• Integrated project delivery (IPD) method

The DBB is the oldest and most familiar method of project delivery. It has stood the test of time and enjoys the largest market share.

The IPD is the latest method and still evolving in details with limited amount of industry consensus.

Figure 1.14 gives the current approximate market shares of various methods, and the table "Project Delivery Methods at a Glance", provides a synopsis of their pros and cons.

The reader is urged to go through this table to obtain a bird's-eye view of various methods.

Regardless of the method selected, the essential features of construction and post construction phases are almost identical in all methods.

Therefore, the activities involved in these two phases are covered first. In this coverage, we will assume that the GC has been selected and the construction has commenced. After the discussion of construction and post construction phases, the project delivery methods are shown **FIGURE 1.21**

PROJECT DELIVERY METHODS

(a) DDB = DESIGN-BID-BUILD METHOD of Product Delivery

(b) CMAR = CONSTRUCTION MANAGER AT RISK METHOD of Product Delivery

(c) DB = DESIGN AND BUILD METHOD of Product Delivery

(d) IPD = INTERGRATED PROJECT DELIVERY METHOD of Product Delivery

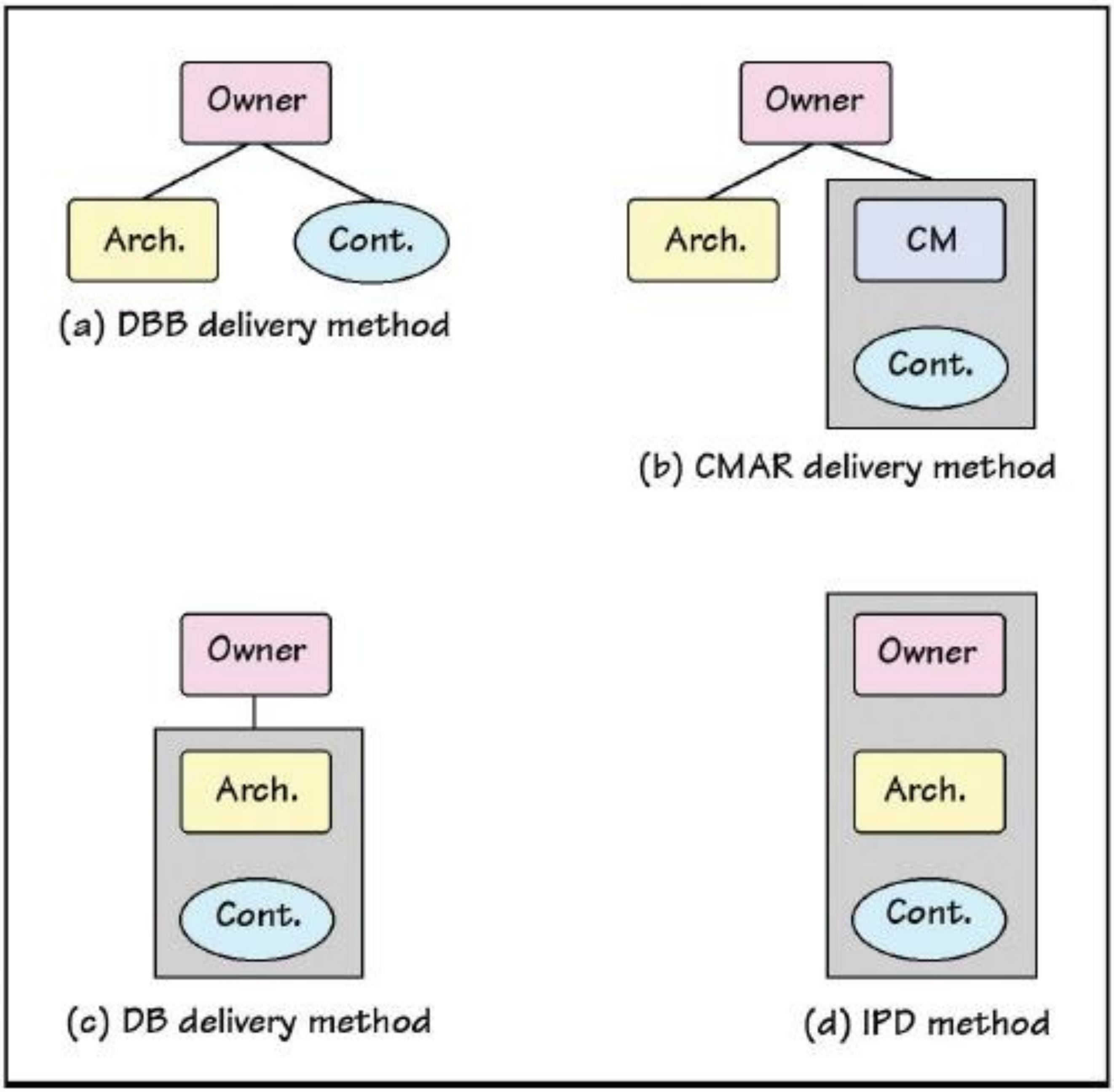


FIGURE 1.21 This illustration shows the relative integration among three major entities—owner, architect (Arch.), and contractor

PROJECT DELIVERY METHODS Market Shares of the methods

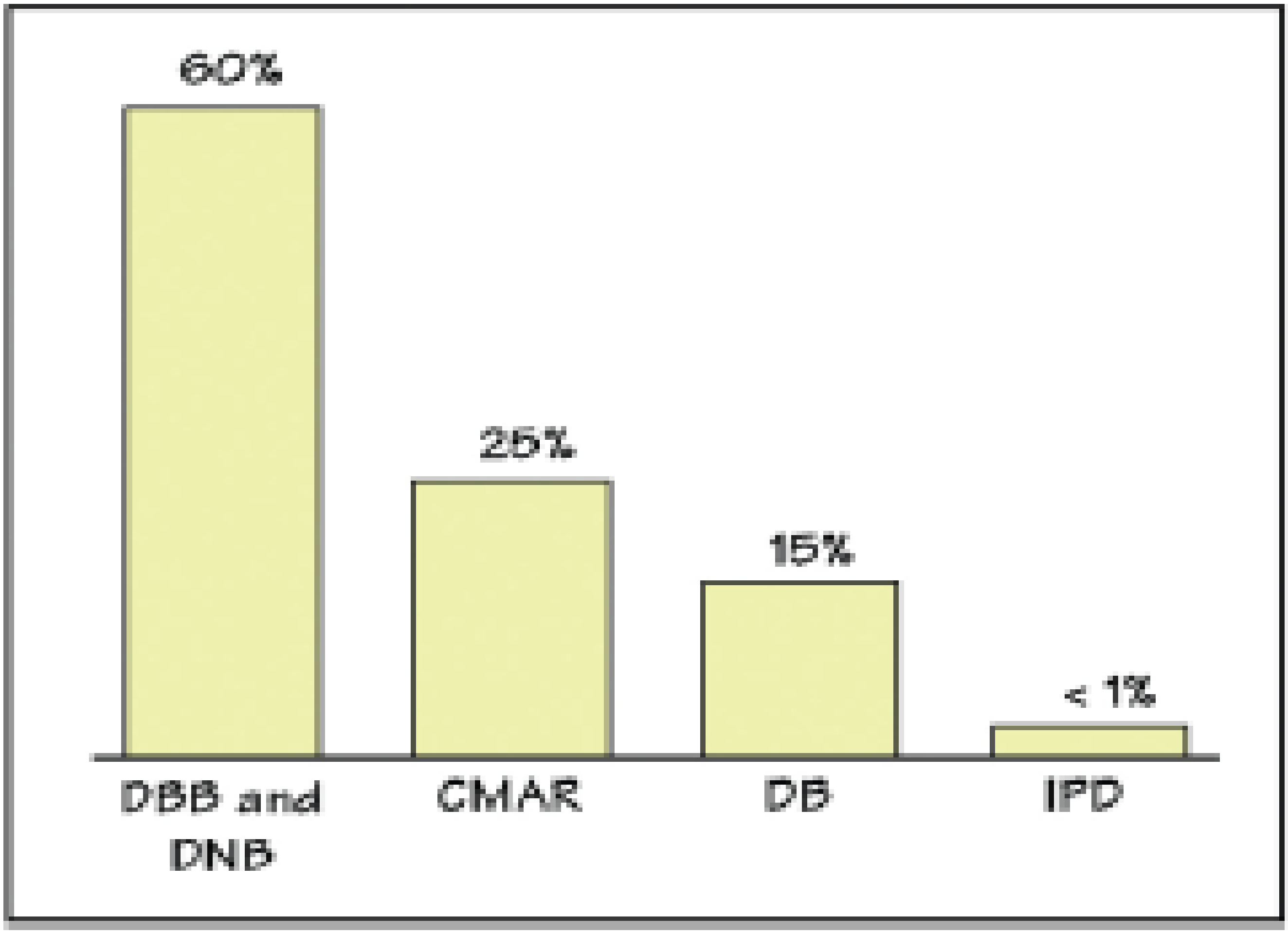


FIGURE 1.22 The current approximate market shares of various project delivery methods

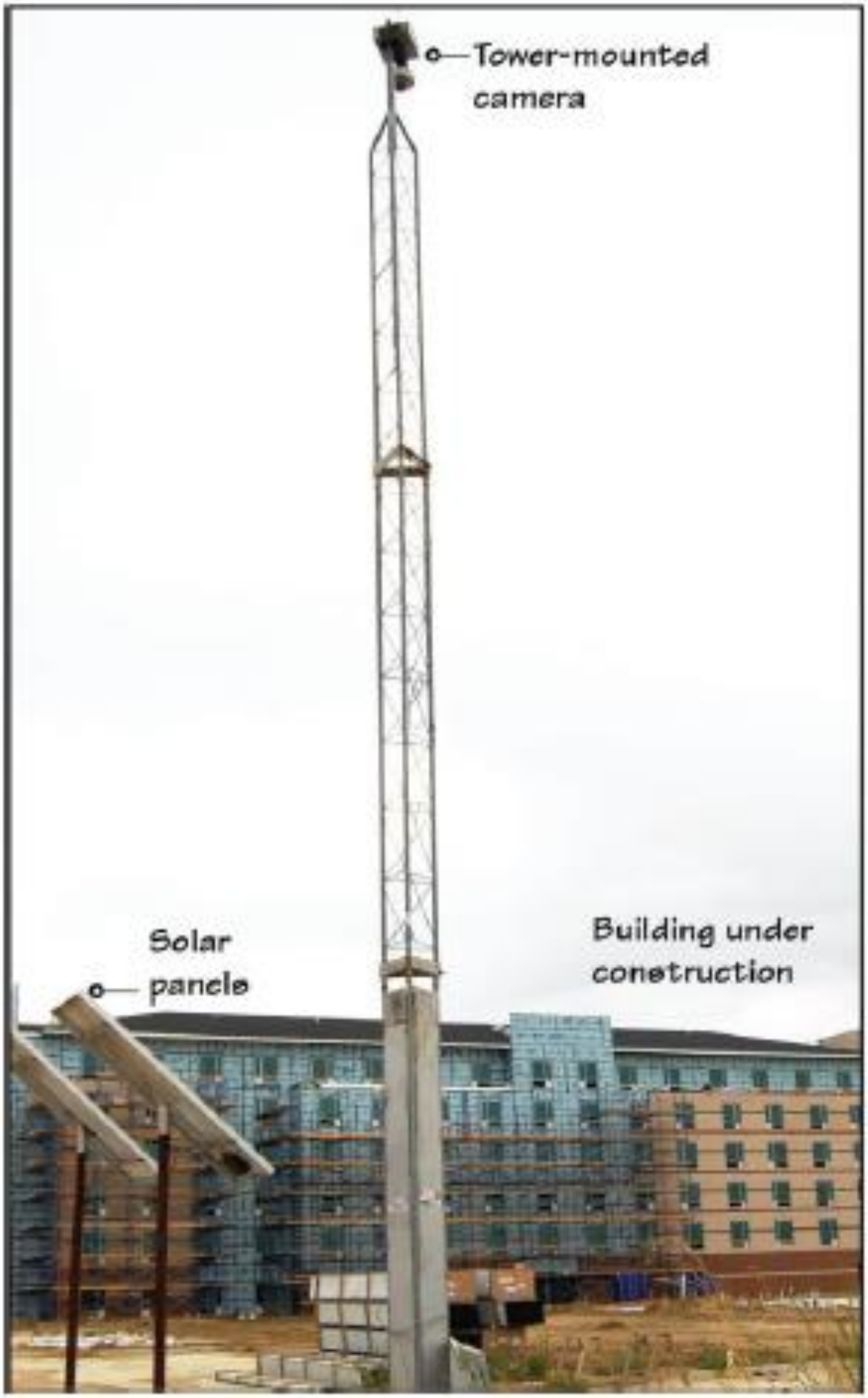


FIGURE 1.17 A tower-mounted camera takes regular photographs of the construction of the building shown. The solar panels power an array of batteries that, in turn, power the camera. The batteries are housed in a box below the panels, not visible in the photograph

Sequence of Events in the DESIGN-BID-BUILD (DBB) method of Project Delivery

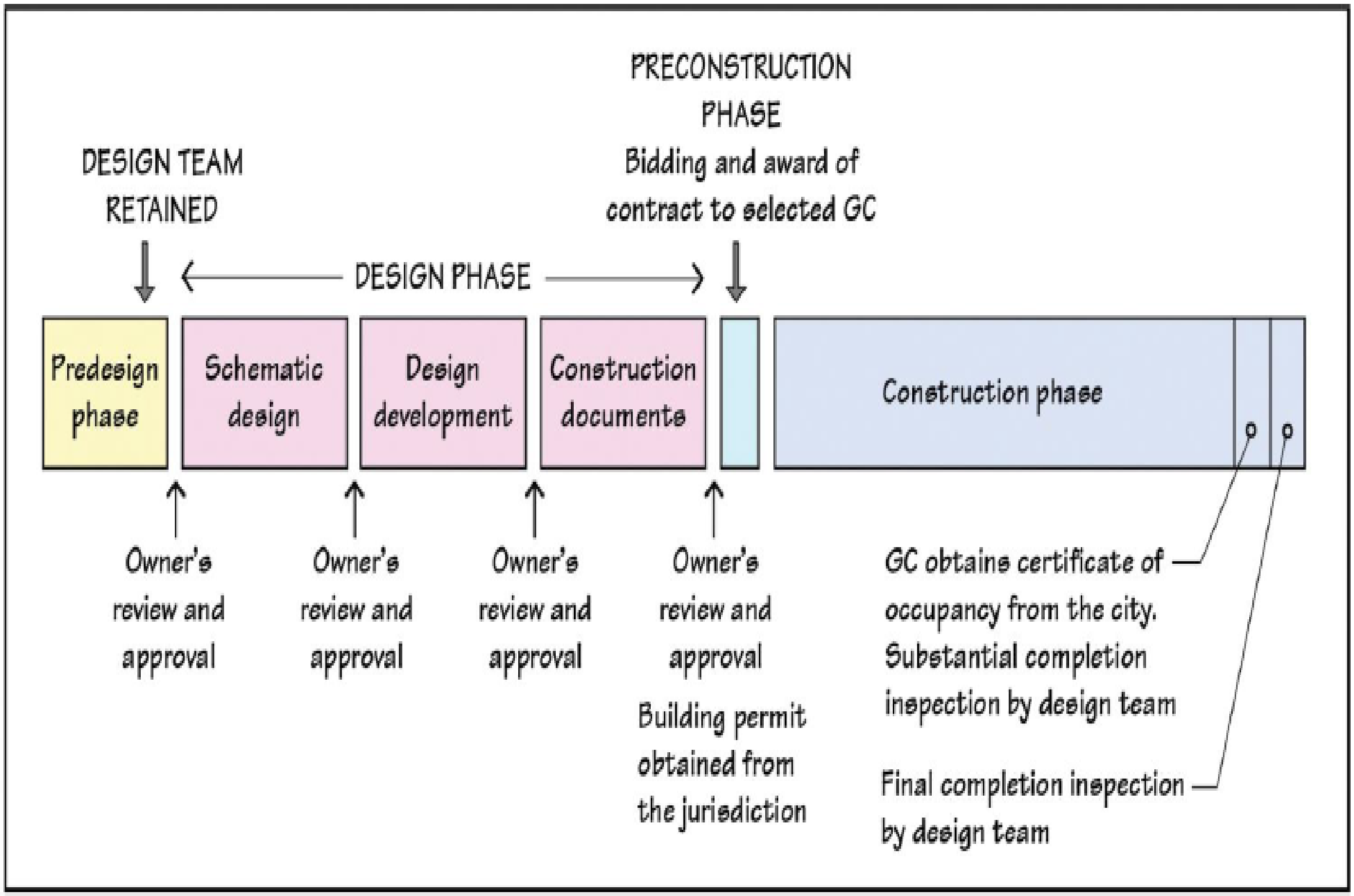


FIGURE 1.18 Sequence of operations in design-bid-build (DBB) method of project delivery. Note that design and construction phases are in sequence, and GC is selected only after the construction documents have been completed by the design team.

PROJECT DELIVERY METHOD: Design-Bid-Build

Large and Public Works Projects generally require the prequalification established through a bid bond. All 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 a qualified bidder with the lowest bid amount.

DBB Method—Competitive Sealed Proposal

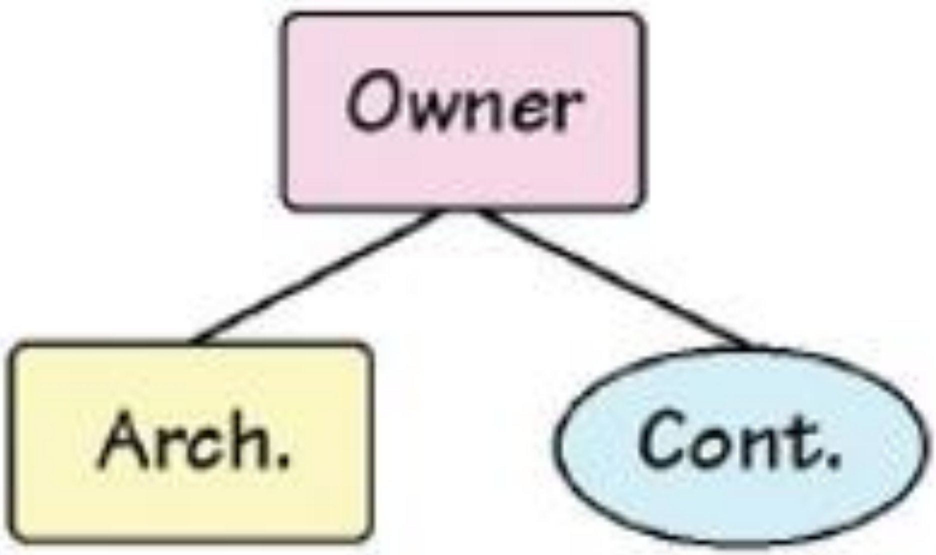
This method is similar to competitive sealed bidding and is commonly used for publicly funded projects. The difference between competitive sealed bidding and competitive sealed proposal methods is that the owner's selection of the GC is not based on price alone but also on other criteria such as the GC's past experience, safety record, proposed personnel, and project schedule. 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 the GCs who have demonstrated, based on their experience, resources, and financial standing, their qualifications to perform the work. The selected GCs are then invited to bid for the project, and the GC with the lowest bid is then awarded the contract. The Lead Design Consultant and or architect (as the owner's representative) may be involved in preselection process.

Advantages of DBB Method

As stated in Section 1.9 and shown in Figure 1.14,
the DBB method is the most popular method. In addition to being simple and well understood because of its long history, it has following advantages: (a) there is a single point of responsibility for construction, (b) the GC is selected through aggressive and open competition, and (c) the project's scope and cost are fully defined before construction starts.



(a) DBB delivery method

DESIGN-NEGOTIATE-BUILD (DNB) Building Project Method of Delivery

A major disadvantage of the DBB method is the absence of the General 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 where the owner knows of one or more reputable, competent, and trusted General Contractors. The owner simply negotiates with them concerning the overall contract price, time required for completion, and other important details of the project.

The negotiations are generally conducted with one General Contractor at a time, and after negotiations with all selected General Contractors are complete, the owner analyzes the bids, selects a GC, and awards the contract.

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 General Contractor may advise the architect of simpler, less expensive, or more sophisticated building systems to realize the architect's design intentions.

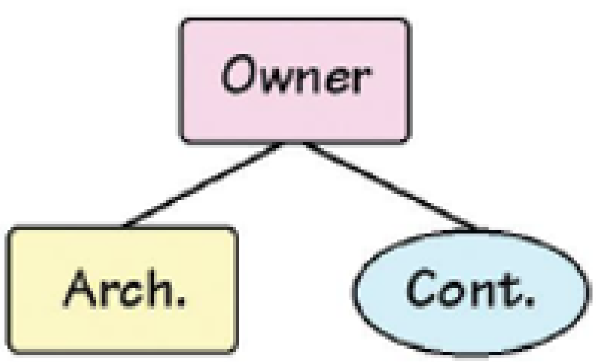
Additionally, because the General Contractor is the one who is most knowledgeable about construction costs, budget estimates can be obtained at various stages during the design phase.
This means that value engineering can proceed throughout the design phase instead of being undertaken at the end of this 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 DNB method is fairly popular for private projects.

The services offered by the General Contractor during the design phase of a negotiated contract are referred to as the General 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 generally shortens the project delivery time.



Design-Negotiate and Build Building Project Method of Delivery

CONSTRUCTION MANAGER AT RISK (CMAR) Building Project Method of Delivery

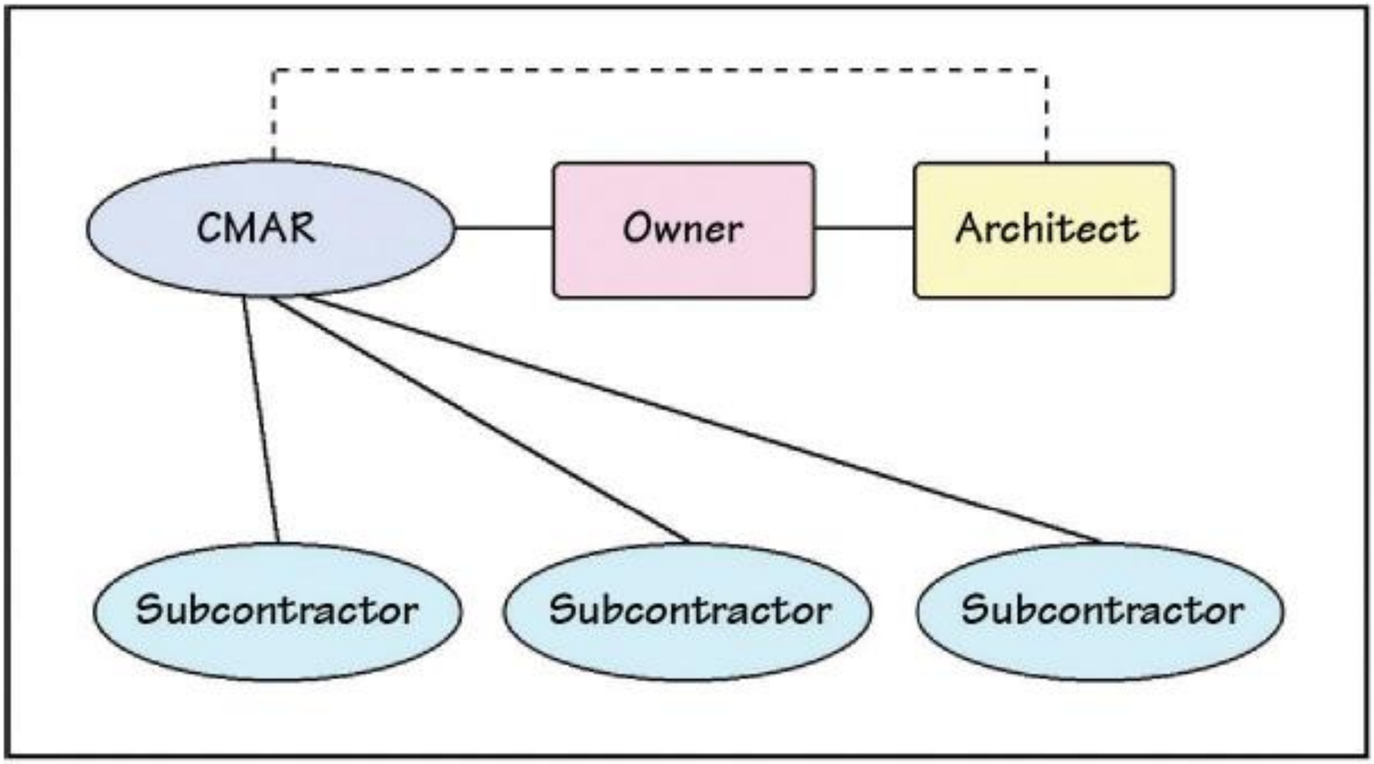


FIGURE 1.19 Contractual relationships between various parties in the CMAR method of project delivery. A solid line in this illustration indicates a contractual relationship between parties. A dashed line indicates a communication link, not a contract.

Over View CONSTRUCTION MANAGEMENT-RELATED METHODS PROJECT DELIVERY METHOD:
In the delivery methods so far discussed (DBB and DNB), the role of the Lead Design Consultant and or architect remains essentially the same: the Lead Design Consultant and or the architect designs the project, helps the owner select the GC, 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*.

Project Delivery Method: 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 GC, but a manager who plays no entrepreneurial role in the project (unlike the GC, 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 DBB, or the negotiated contract method. It exists but it is done informally and shared by the design team and the GC. The introduction of a CM on the project transfers various functions of the GC (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, and 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, and so on.

Each contractor is referred to as a *prime contractor*, who may have one or more subcontractors, Figure 1.19.

The task of scheduling and coordinating the work of all prime contractors and ensuring site safety—undertaken by the General Contractor in the DBB and DNB methods—is done by the Construction Manager 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 GC, eliminates the GC'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.

A disadvantage of the CMAA method lies in the liability risk that the owner assumes, which in the DBB method is held by the GC. 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 contractor has a direct contract with the owner.
Consequently, the Construction Manager has little leverage to ensure timely performance.

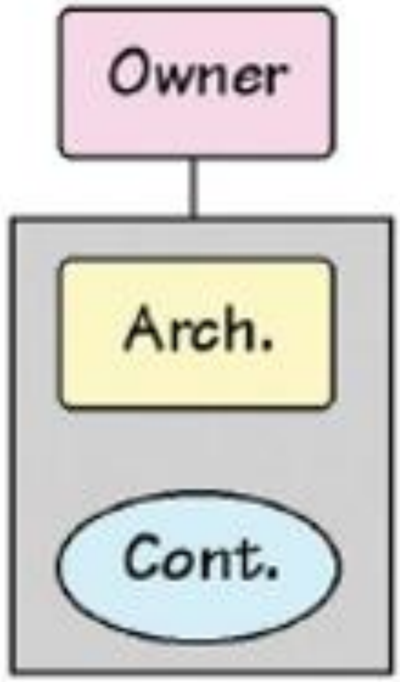
The owner must therefore exercise care in selecting the CM because the cost, timeliness, and quality of the ultimate product are heavily dependent on the expertise of the CM.

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 GC 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 to (a) provide preconstruction services during the design phase of the project for a professional fee and (b) work as he GC 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 1.21.
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 GC, 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 apartment buildings.

DESIGN-BUILD METHOD, Building Project Delivery Method



(c) DB 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 on 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 GC, which in addition to providing construction capabilities, has a design team (of architects and engineers) within the organization, or a closely allied separate design firm.

The DB method has the advantage of integrating design and construction, thus fostering teamwork between the design team and the contracting team 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.

Additionally, the architect does not represent the owner, as in other delivery methods. 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

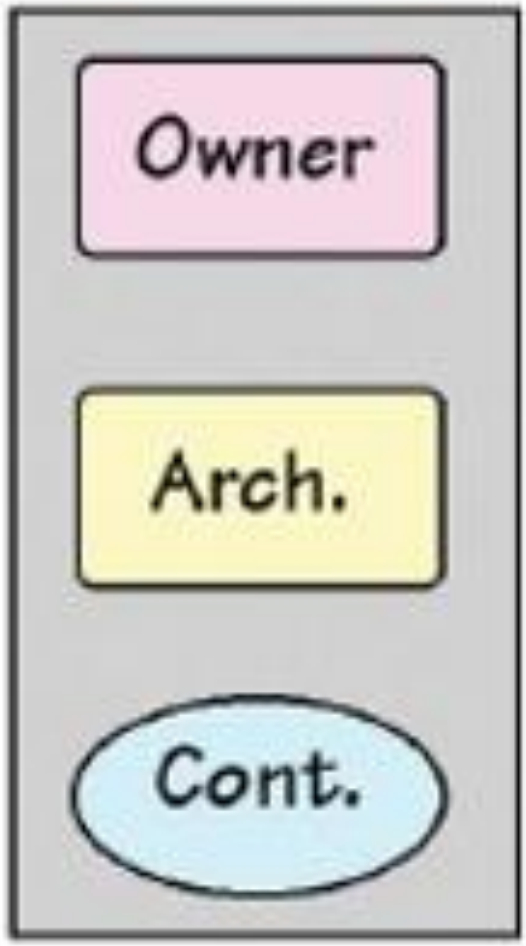
Design and Construction Contracts as Two-Party Contracts

It is important to note at this stage that all design and construction contracts are two-party contracts, such as owner-Lead Design Consultant and or the architect contract, owner-GC contract, architect-consultant contracts, and GC-subcontractor contracts.

Multiparty design or construction contracts do not exist (except in the integrated project delivery method. (DBIA) has further promoted the method.

A special version of 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.

INTERGRATED PROJECT DELIVERY (IPD) Building Project Delivery Method



(d) 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 DBB or CMAR method, and into two distinct entities in the DB method, they are integrated fully into one entity in the IPD method, See **Figure 1.21**.

Integrated Project Delivery (IPD) and 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 latest 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 1.22.

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*.

A virtual, three-dimensional model of the building is just one important feature of BIM.

Another 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.

In the 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.)

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, GC, 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 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.

Integrated Project Delivery (IPD) and Building Information Modeling (BIM)
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BIM and Detection of Clashes among Building Components

The virtual construction feature of BIM ensures that the clashes between various building systems or components are discovered during the design phase and can be eliminated as the model is constructed. For example, because of the two-dimensional nature of conventional drafting 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.

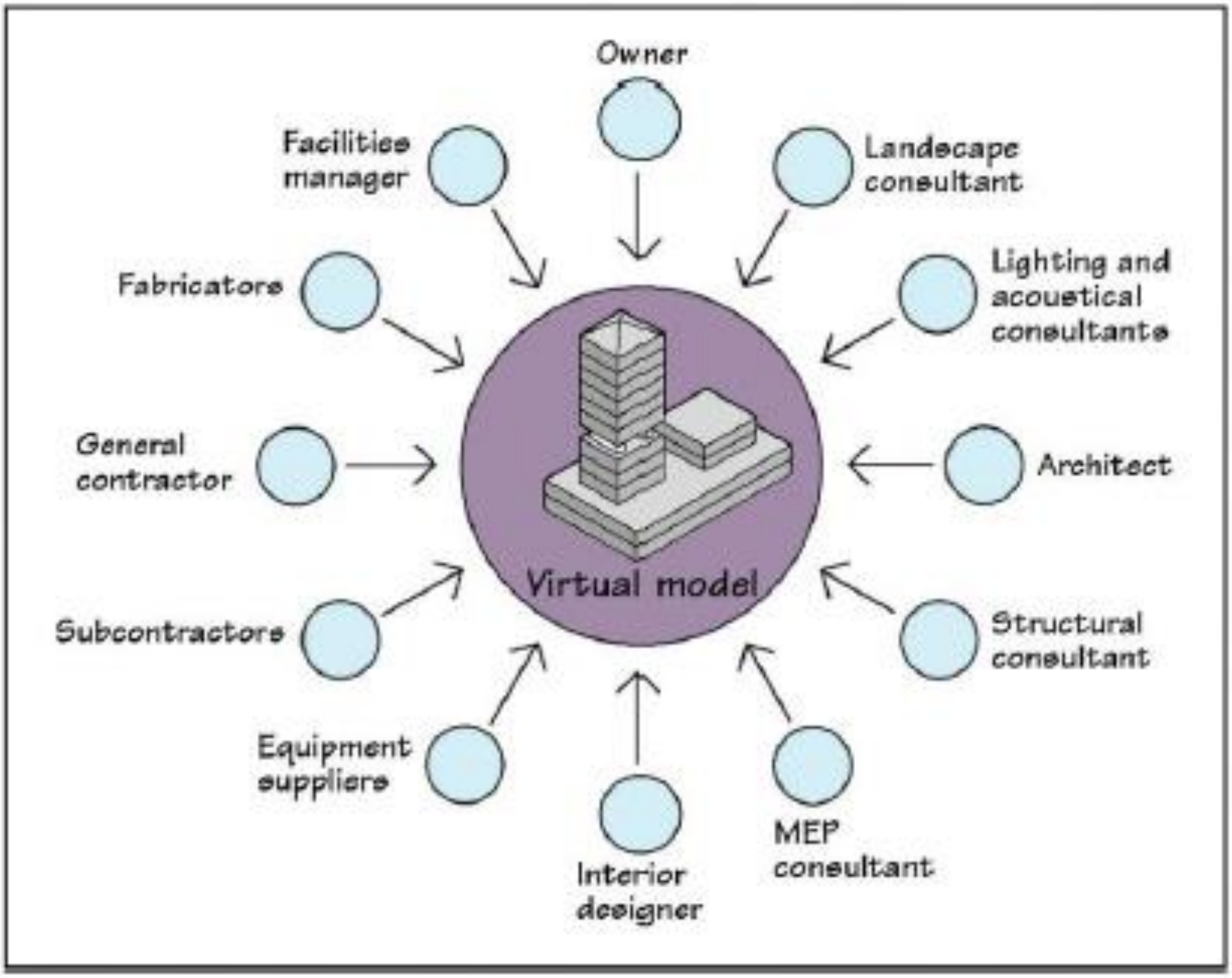

FIGURE 1.22 In an IPD method, all stakeholders in the project, such as the owner, architect, architect's consultants, general contractor, and subcontractors, contribute in constructing the virtual model.

When discovered during construction, such errors result in a blame game, request for information (RFI) from the General Contractor, change orders, increased project costs, and delayed project completion. In extreme cases, litigation is a possibility.

BIM eliminates such possibilities. 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 the construction of the virtual model is comprehensive, the time needed to complete the sketch design (SD) and design development (DD) stages using BIM technology is greater than that using the conventional drafting technology.

However, it is more than compensated by substantial reduction in the time needed for construction documentation because the model allows the extraction of two-dimensional construction documents (plans, elevations, sections, and specifications) with the press of a button, Figure 1.24.

The shift of time and effort toward design stages (SD and DD) from the documentation (CD) stage in BIM technology provides greater control over design. It also makes it easier to make design changes as compared with conventional technology because the cost of design changes during the CD stage is far greater than during SD and DD stages.

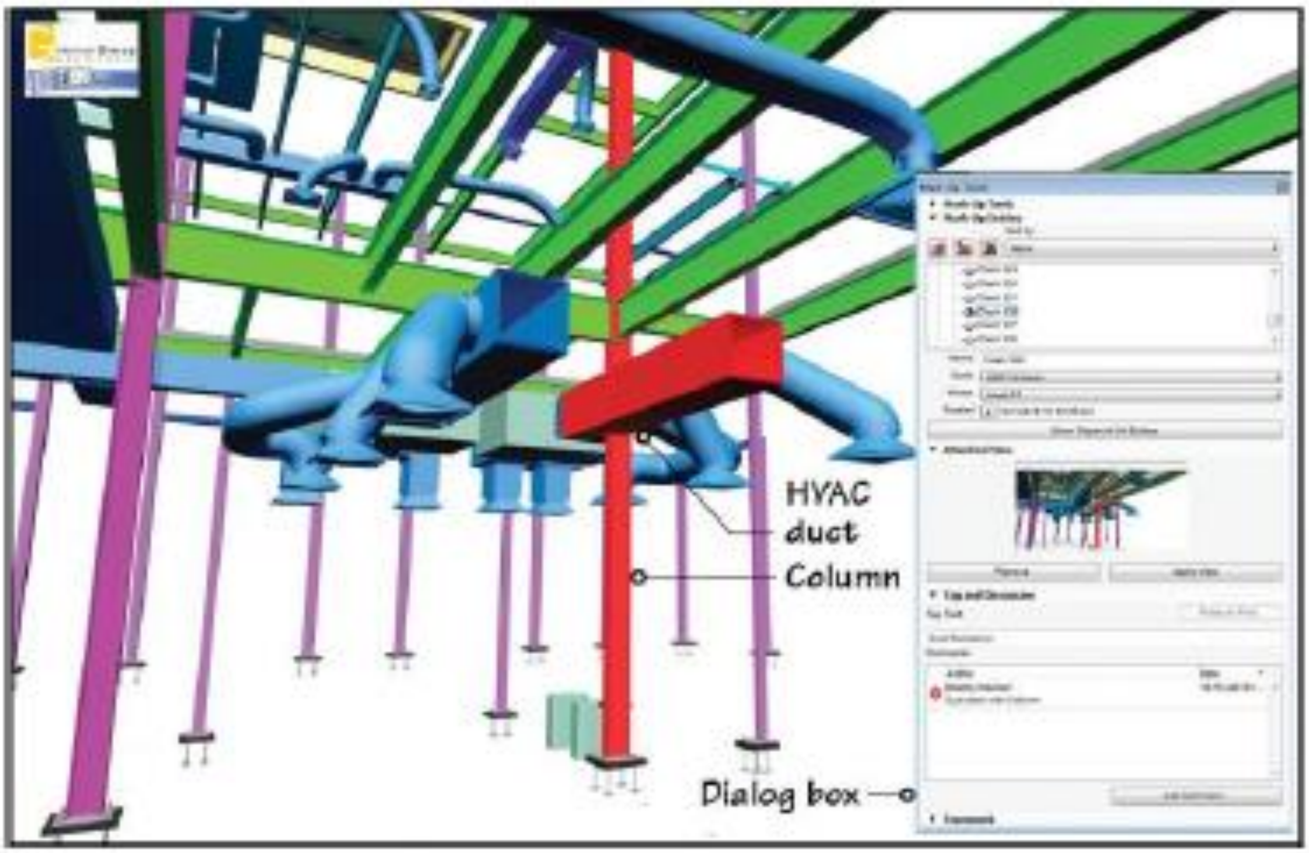

FIGURE 1.23(a) A screenshot from BIM model of a building showing the clash between a column and an HVAC duct. (Image courtesy of Hennon Group Architects and Graphisoft—the producer of ARCHICAD BIM software)

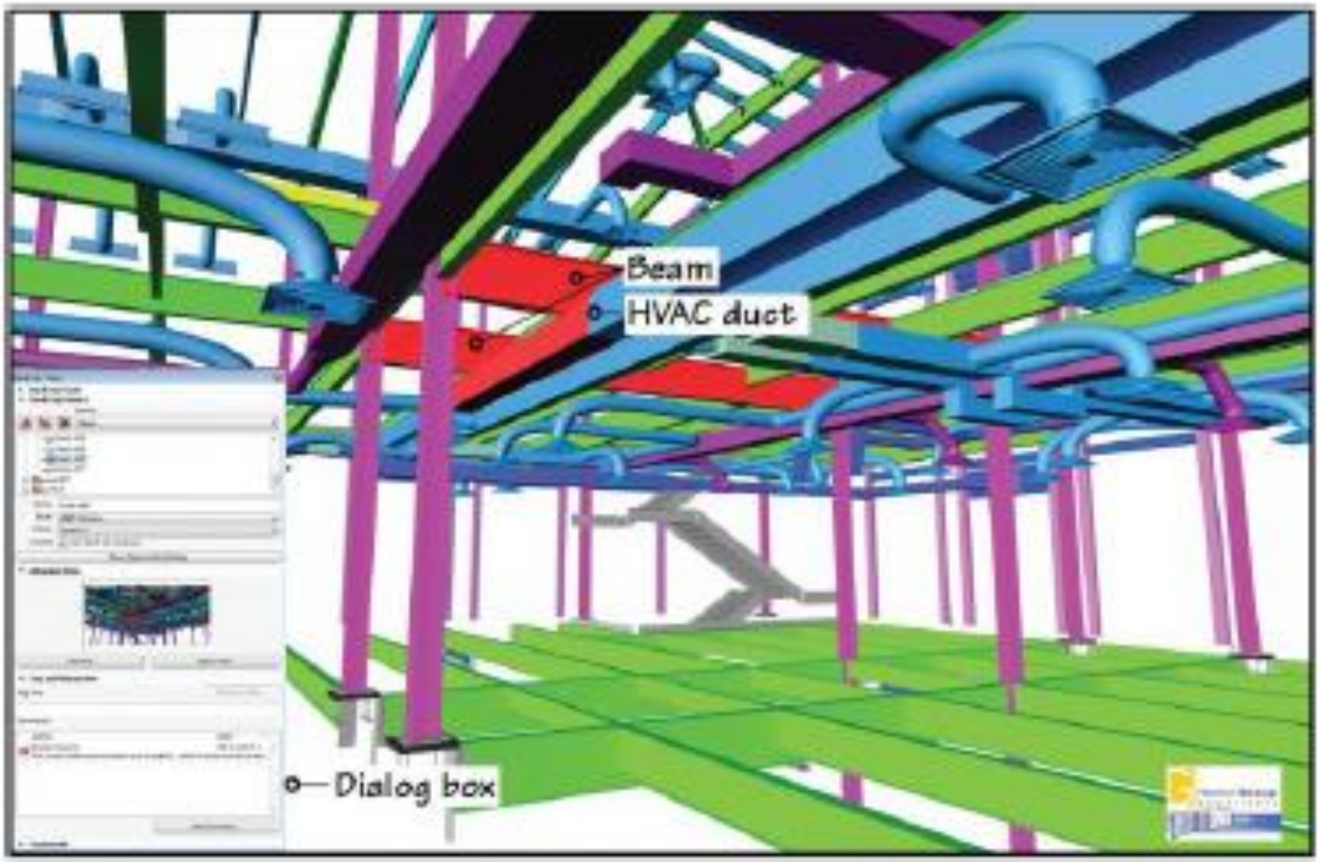

FIGURE 1.23(b) A screenshot showing the clashes between an HVAC duct and two beams. Note that the model for this image and that of Figure 1.23(a) highlights the clashing elements in red color.
The dialog box in each image shows the image in miniature, the floor level where the clash occurs, and the identification mark of the clash to distinguish it from other clashes in the building. (Image courtesy of Hennon Group Architects and Graphisoft - the producer of ARCHICAD BIM software.)

Project Comparison using CAD and BIM technologies

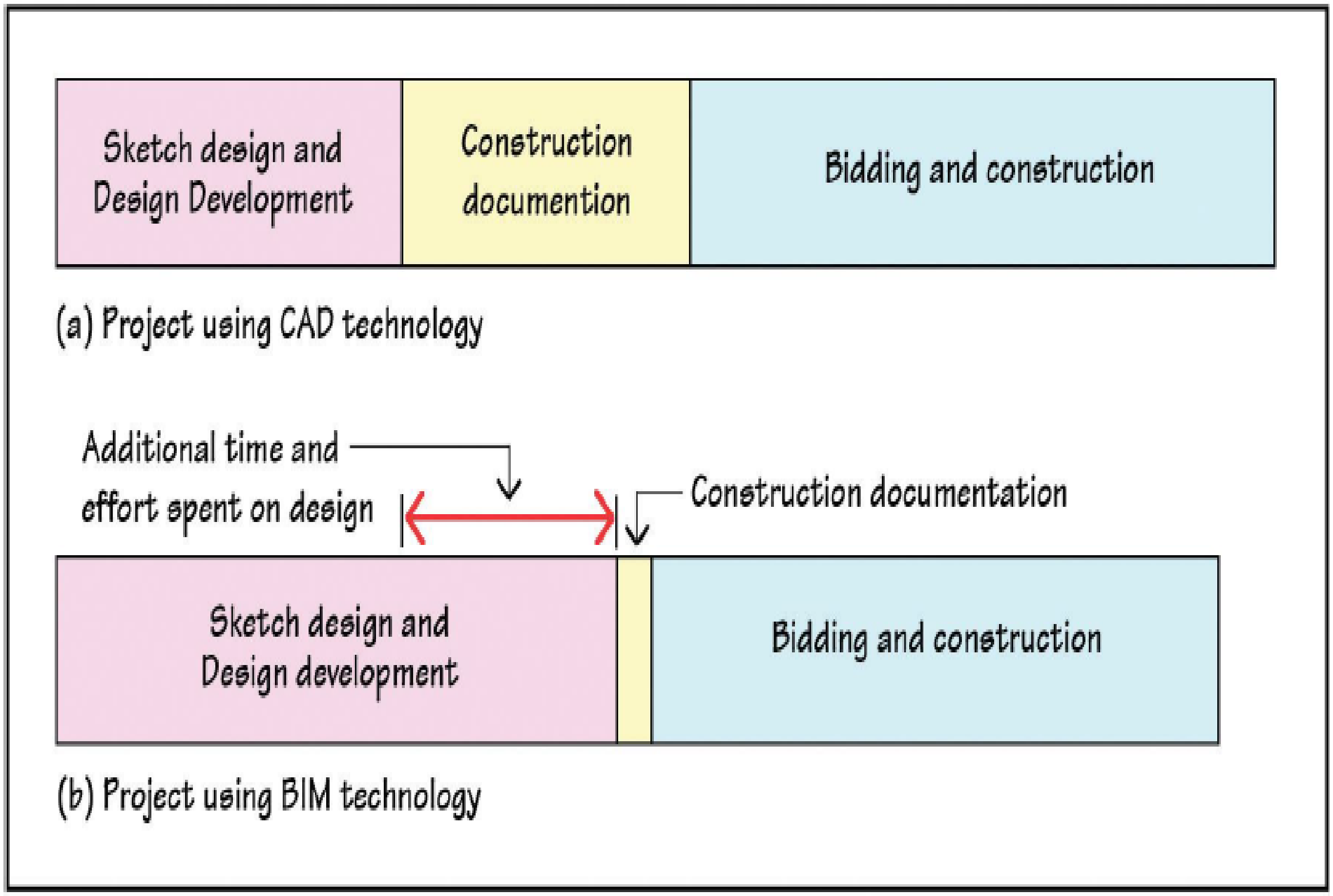

FIGURE 1.24 A comparison of the approximate overall time and effort spent in various activities in a project using CAD technology versus BIM technology.

BIM Tools and Interoperability

Various team members (shown in Figure 1.22) 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 or Graphisoft's ArchiCAD BIM), a structural engineer uses structural analysis and design software (e.g., Autodesk's Revit Structure), and so on.

These software tools are known 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 implies that a 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 and for structural design).

Life-Cycle Nature of BIM Technologies

The dynamic nature of BIM 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, and sustainability assessment.

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.

BIM and Pre-IPD Delivery Methods

Although the development of BIM technology has helped the adoption of IPD, it should be noted that BIM is not limited to IPD but can be used with any project delivery method. Increasingly, a larger number of architecture and engineering firms are using BIM software with all types of delivery methods.

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 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 1.25**.

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.

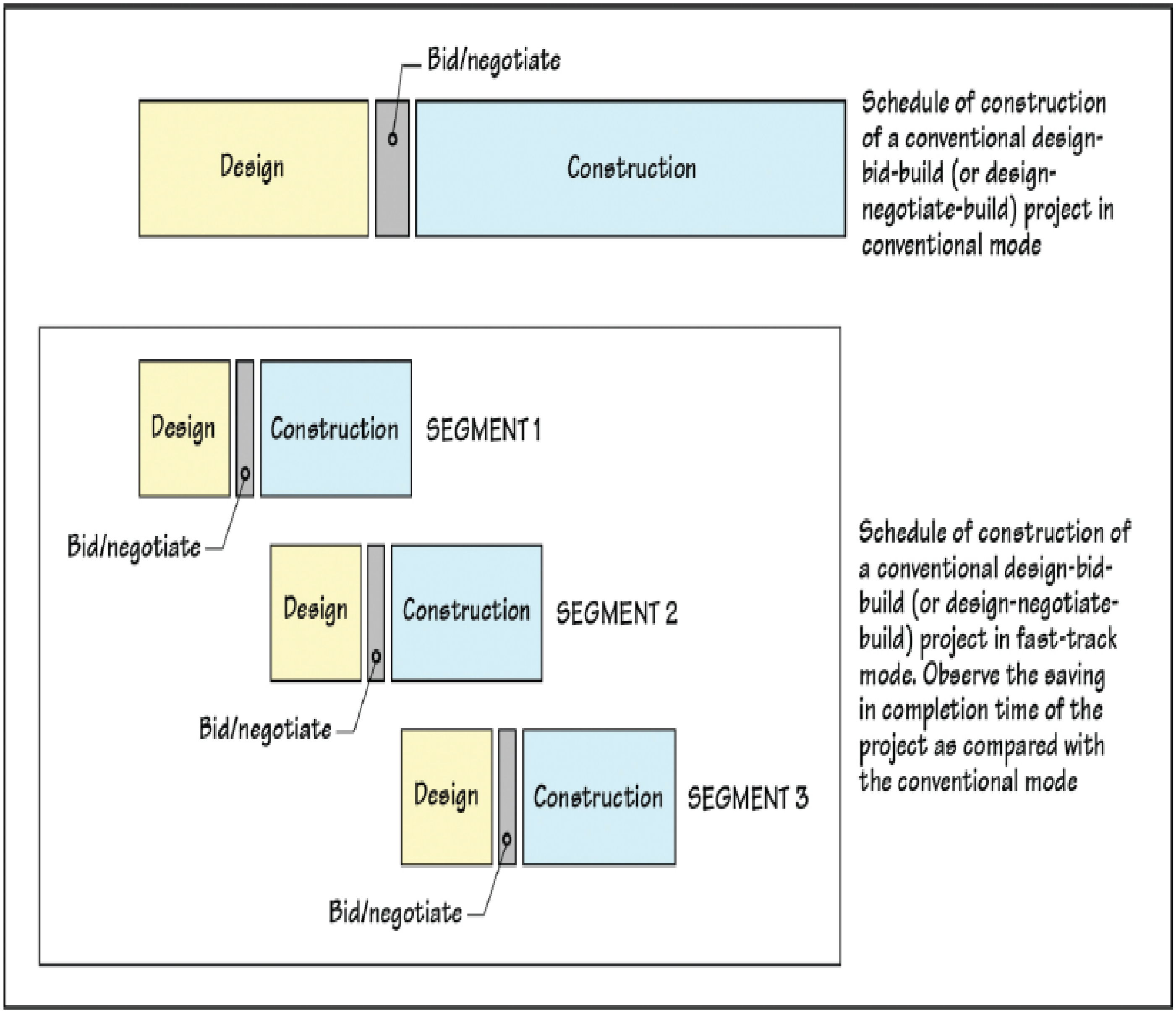

FIGURE 1.25 In fast-track scheduling, a project is segmented into parts, which overlap in time. As shown in this illustration, segmentation shortens project delivery in comparison with unsegmented scheduling. Fast-track scheduling is particularly suitable with DNB and CMAR Project delivery methods because the GC is on board during the design phase.

Summaries “Building Project Delivery Method" Descriptions

1a. 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 exact price is unknown until bidding process is complete. Commonly used for public projects.

1b. 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. of the GC’s personnel. Commonly used for public projects.

1c. 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.

1d. 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, who also provides design-phase assistance. Commonly used for private or quasi-private projects.

2a. 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 experienced in contract administration.

2b. 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 CMAR. The CMAR obtains competitive bids from subcontractors, as in a DBB method. Used for both private and public projects.

3. 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.

4. Integrated Project Delivery (IPD)

This method, which is still evolving, differs substantially from all other methods. It requires complete collaboration among 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, GC, subcontractors, fabricators, material suppliers, so on.

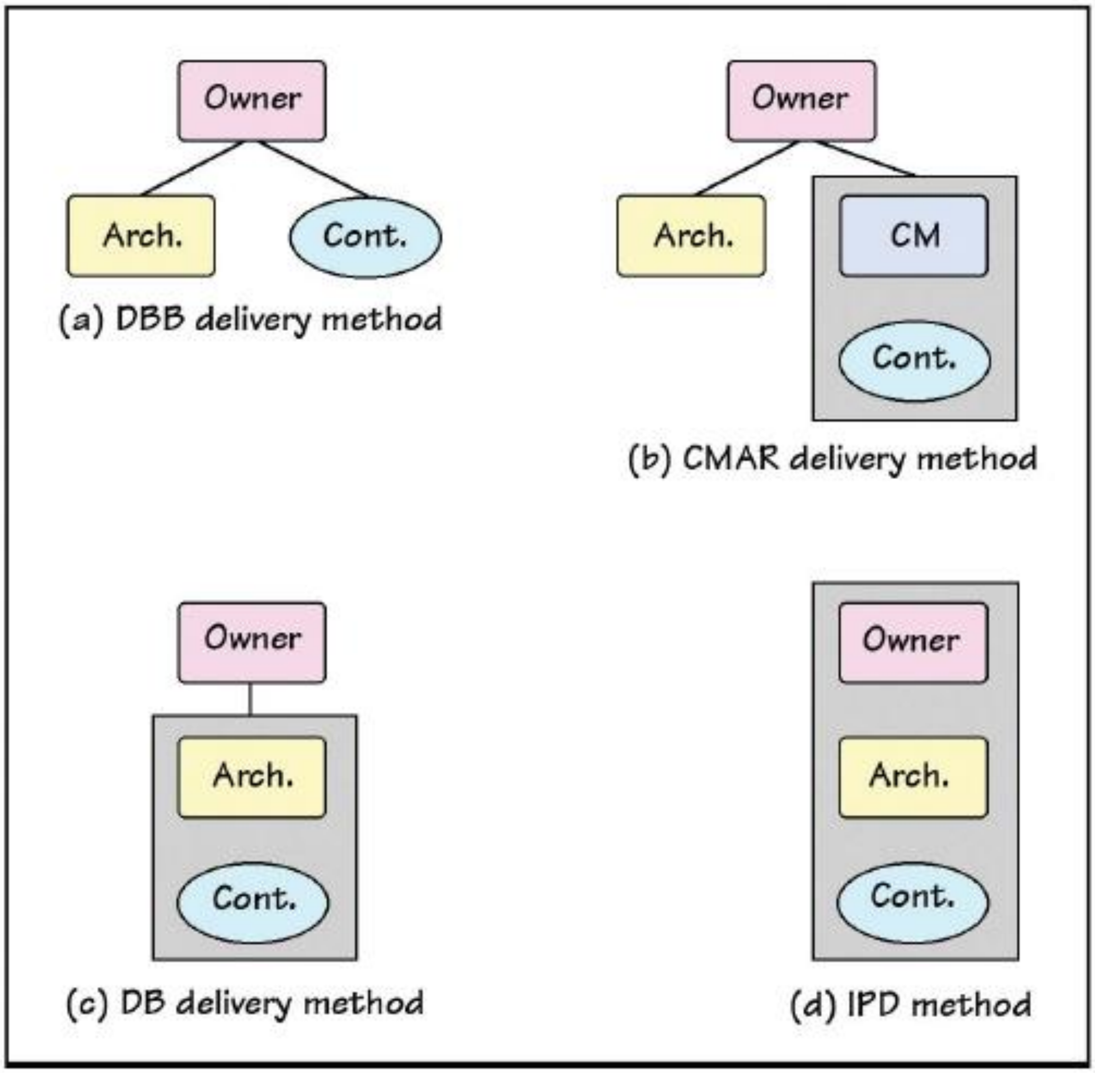

FIGURE 1.21 This illustration shows the relative integration among three major entities—owner, architect (Arch.), and contractor