DIRECTORATE GENERAL OF CIVIL AVIATION, KUWAIT

Construction Administration

Training Manual

Presented by

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Contents

Karim M. EL-DASH; PhD; PMP; CCE; AVS 1
Construction Project ADMINISTRATION 7
Construction Project Life Cycle 7
Pre-project phase 8
Planning and design phase 8
Contractor selection phase 9
Project mobilization phase 9
Project operations phase 9
Project closeout and termination phase 10
Pre-project phase 11
Selection of project delivery system 11
Traditional design–tender–build 11
Design–build 12
Construction manager 13
Project manager 15
Document and construct 16
Separate prime contracts 17
Turnkey 18
Build–own–operate–transfer 19
Joint venture 20
Force account 21
Phased construction 22
Selection of type of contract 23
Lump sum/fixed price 23
Unit price/measure and value 24
Cost plus 25
Time and materials 26

Planning and design phase 27
Planning and feasibility study stage 27
Consultant selection 27
Program development 29
Identification of alternatives 30
Site investigation 31
Constructability analysis 32
Preliminary cost estimate 33
Financial feasibility analysis 34
Design stage 35
Schematic design 35
Design development 38
Contract document development stage 39
Drawings 40
General conditions 41
Special conditions 43
Technical specifications 44
Schedule of quantities 45
Invitation to tender 45
Instructions to tenderers 46
Tender form 46
Agreement 47
Surety bond forms and insurance certificates 47
Contractor selection phase 48
Methods for contractor selection 48
Pre-qualification/post-qualification 49
Open tender 51
Invited tender 51

Negotiation 52
The contractor's tender decision 53
Considerations in deciding to tender 53
Preliminary job planning 54
Method statement 55
Constructability analysis 56
Jobsite visits and checklists 57
Preliminary schedule 58
Pre-tender meetings 59
Cost estimating 59
Levels of detail 60
Rough order of costs 60
Preliminary assessed costs 61
Firm estimate of costs 61
The estimating process 62
Elements of net project cost 63
Labor 64
Materials 65
Equipment 66
Subcontract work 67
Provisional and prime cost allowances 68
Site overheads 68
Company overheads 69
Proposal preparation, submittal and opening 70
Submittal and opening process 71
Selecting the successful contractor 72
Criteria 73
Qualifications 74

Notice to proceed and contract agreement 75
Project mobilization phase 76
Permits, consents and licenses 76
Bonding 77
Insurance 79
Work breakdown structure 81
Bar charts 83
Network schedules 85
Budgeting and cost systems 90
Project operations phase 94
Monitoring and control 94
Schedule updating 94
Cost control 96
Cost reports 96
Quantity section 97
Cost section 98
Quality management 100
Documentation and communication 103
Submittals 103
Variations 104
Measurement, progress payments and retainage 106
Contract documentation 107
Communication records 107
Project status documentation 108
Correspondence 108
Materials management 109
Financial management 109
Legal issues 110

Claims process 110
Dispute prevention and resolution 111
Dispute prevention 112
Differing site conditions 113
Delays 114
Contract termination 116
Project closeout and termination phase 119
Introduction 119
Completing the work 120
Closing out the project 124
Consent of surety 125
Final quantities 125
Request for final payment 126
Liquidated damages 126
Final payment and release of retainage 127
Final accounting and cost control completion 127
Certificates 128
As-built drawings 130
Operating and maintenance manuals 130
Records archiving and transfer 131
Training sessions 131
Warranties, guarantees and defects liability period 132
Post-project analysis, critique and report 132

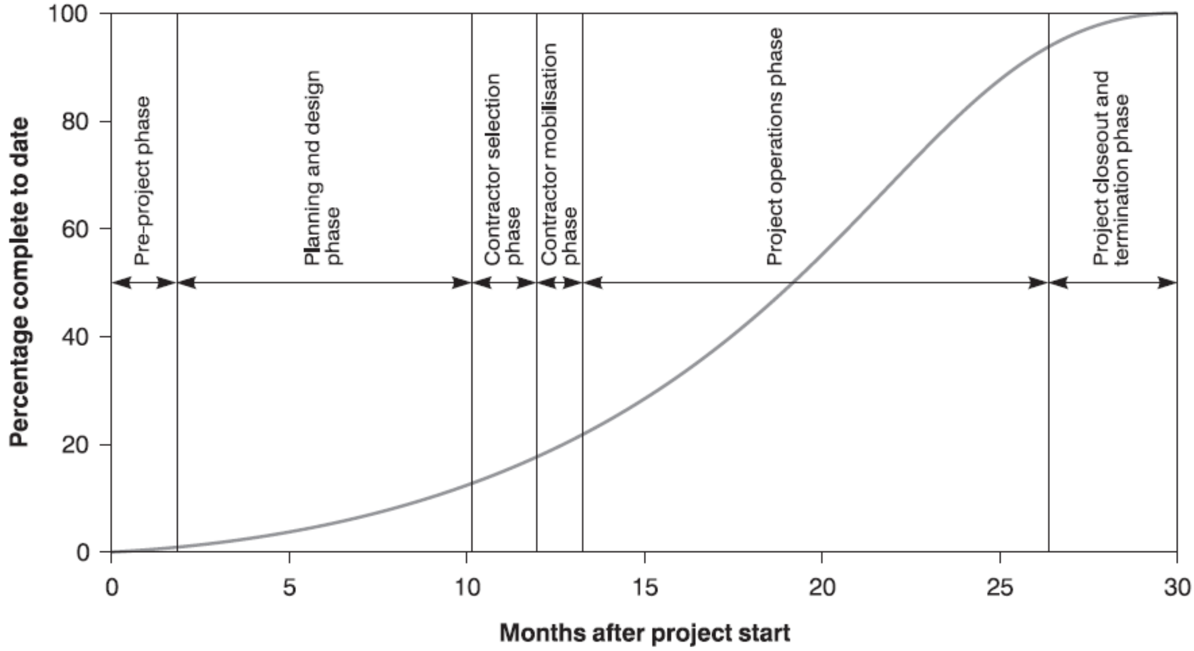
CONSTRUCTION PROJECT ADMINISTRATION

CONSTRUCTION PROJECT LIFE CYCLE

In this manual, we identify six phases in the construction project life cycle, each with its own purposes and characteristics.

1. The owner must make certain pre-project decisions.
2. Then the planning and design of the project is carried out.
3. Next, the contractor is selected.
4. The contractor mobilizes in order to carry out the field operations.
5. The field work that the lay person often considers to be 'construction' can be considered a separate phase.
6. Lastly, the project must be terminated and brought to a close.

The following figure is a conceptual diagram that shows the various phases in the typical construction project life cycle. It also shows the amount of funds the owner might commit by the end of each phase, as a percentage of the total project budget.



Pre-project phase

A construction project begins with an idea, a perceived need, a desire to improve, or add to productive capacity or the wish for more efficient provision of some public service. However, prior to that, among the first things the owner must do is to decide what sort of *project delivery system* will be used. How will the various parties be related? Will the owner engage a design professional to prepare plans and specifications and then contract separately with a construction contractor? Or, will a single entity be responsible for the entire project?

The other primary decision required by the owner early in the project relates to the *type of contract* to be used with the contractor. Will the contractor be paid a specified fixed price, regardless of the actual quantities used in the project and regardless of the contractor's actual costs? Will the quantities of materials be measured and the contractor paid on the basis of those quantities and pre-agreed-upon unit prices for each material? Or, will the contractor be reimbursed for its actual costs, plus a fee, perhaps with an agreed-upon upper limit? The owner will also need to decide the basis upon which the design professional will be paid.

Planning and design phase

The project is fully defined and made ready for contractor selection and deployment during the planning and design phase. It is convenient to divide this phase into three stages.

1. The goal of the first stage is to define the project's objectives, consider alternative ways to attain those objectives and ascertain whether the project is financially feasible.
2. In the second stage, the design professional will use the results of the planning efforts to develop schematic diagrams showing the relationships among the various project components, followed by detailed design of the structural, electrical and other systems.
3. The output from this design development effort is used in the final stage, wherein contract documents are prepared for use in contractor selection and installation work at the construction site. The design professional prepares not only the detailed construction drawings but also written contract conditions containing legal requirements, technical specifications stipulating the materials.

Contractor selection phase

In anticipation of selecting a contractor, the owner must decide whether an open invitation will be issued to all possible tenderers or whether only certain contractors will be invited to submit offers and whether any sort of pre-qualification process will be invoked to limit the number of tenders.

On the other side, contractors will have to consider a number of factors in deciding whether they will make the effort to assemble a proposal for a particular project. If a contractor finds the prospective project attractive, two major tasks will be required:

a. First, a series of planning steps will be carried out, including studies of various methods and equipment that would be employed and the development of a preliminary project program setting forth an approximate time schedule for each major activity.
b. Second, a priced proposal will be prepared, including the direct costs of labor, materials, plant and subcontractors, various overhead charges and a sufficient added amount for profit.

Project mobilization phase

After the contractor is selected, a number of activities must be completed before installation work can begin at the project site.

- Various bonds, licenses and insurances must be secured.
- A detailed program for the construction activities must be prepared.
- The cost estimate must be converted to a project budget.
- The system for tracking actual project costs must be established.
- The worksite must be organized, with provisions for temporary buildings and services, access and delivery, storage areas and site security.
- The process of obtaining materials and equipment to be incorporated into the project must be initiated and arrangements for labor.

Project operations phase

In presenting the contractor's activities on the construction site, we will suggest, perhaps too simply, that the responsibilities involve three basic areas:

1. monitoring and control,
2. resource management and
3. documentation and communication.

Four aspects of monitoring and controlling the work are important:

a. Actual schedule progress must be compared against the project program.
b. The cost status must be checked to establish how actual performance compares with the budget.
c. An important part is quality management, to assure that the work complies with the technical requirements set forth in the contract documents.
d. In addition, the contractor has an important role to play in managing the work safely and in a way that minimizes adverse environmental impacts.

In managing the project's resources:

i- The contractor will be concerned with assigning and supervising personnel and assuring that the labor effort is sufficiently productive to meet schedule, cost and quality goals.
ii- Materials and plant must be managed so that these same goals are met.
iii- Because construction projects require large amounts of paperwork, a special effort is required to manage this documentation effectively.

Project closeout and termination phase

Finally, there are the various testing and startup tasks, the final cleanup, various inspections and remedial work that may result from them and the process of closing the construction office and terminating the staff's employment.

In addition, a myriad of special paperwork is required, including approvals and certifications that allow the contractor to receive final payment, a set of as-built drawings that include all changes made to the original design, operating manuals, warranties and a final report.

PRE-PROJECT PHASE

At the very beginning of the project life cycle the owner is challenged by determination of the interrelationship among the project stakeholders. The other prime challenge is the method of payment for the main contractor

Selection of project delivery system

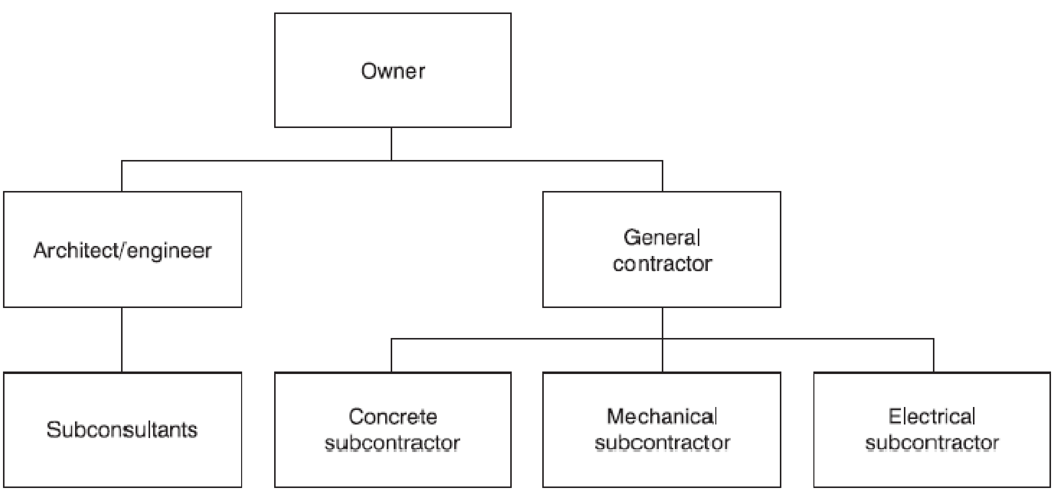
All project delivery systems include three participants; owner, designer, and construction organization, with others as well. Their relationships vary according to the different systems and ownerships. This section describes several ways in which the various parties involved in the construction contract can be related.

Traditional design–tender–build

We call this approach to construction project delivery 'traditional' because it has been the approach of choice for owners of most construction projects. With this method, the owner contracts with a design organization to perform preliminary planning, carry out design work and prepare contract documents.

Following the completion of this phase, a construction organization is selected, based upon the owner's criteria, and the owner enters into a contract with the successful contractor for the assembly of the project elements in the field.

In this method, the contract for the design work is separate from that for the construction work. Thus, the term design–tender–build implies a strict, and sometimes time-consuming, project schedule sequence – designing, followed by tendering, followed by constructing. Future chapters describe these steps in detail.

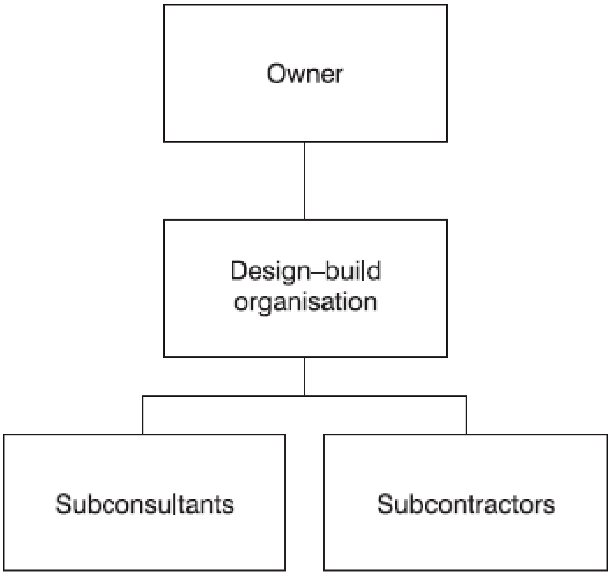


Design–build

The distinguishing characteristic of the design–build, or design–construct, method is that the owner executes a single contract with an organization that becomes responsible for both the design and the construction of the project.

The Design–Build Institute of America (1994) lists potential benefits from the design–build method as follows:

- *Singular responsibility*. There is a single point of responsibility, avoiding 'buck passing' and 'finger pointing'.
- *Quality*. The greater responsibility implicit in this method provides motivation for high quality and proper performance.
- *Cost savings*. The single entity can work together as a team to evaluate alternative methods and materials efficiently and accurately.
- *Time savings*. Design and construction can be overlapped, and bidding time after design is eliminated.
- *Potential for reduced administrative burden*. After the contract is agreed upon, the owner will have relatively little investment in coordinating and arbitrating between designer and contractor, since they are a single entity.
- *Early knowledge of firm costs*. The single design–construction entity is responsible for both design and cost estimates.
- *Risk management.* Cost, schedule and quality can be clearly defined and appropriately balanced.
- *Balanced award criteria*.

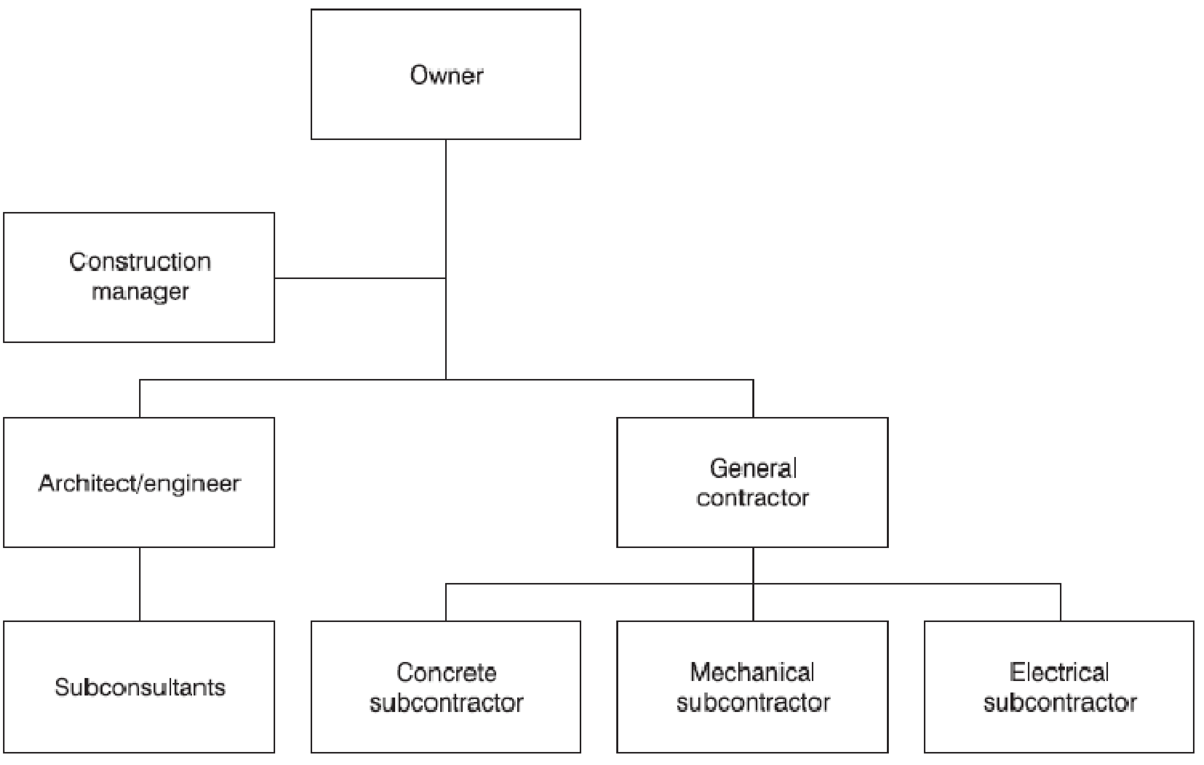


Construction manager

The owner may engage a construction manager to provide professional construction management services. The construction manager organization provides advice to the owner regarding construction matters, including cost, schedule, safety, the construction process and other considerations; such advice may be offered throughout the project life cycle or at selected portions thereof.

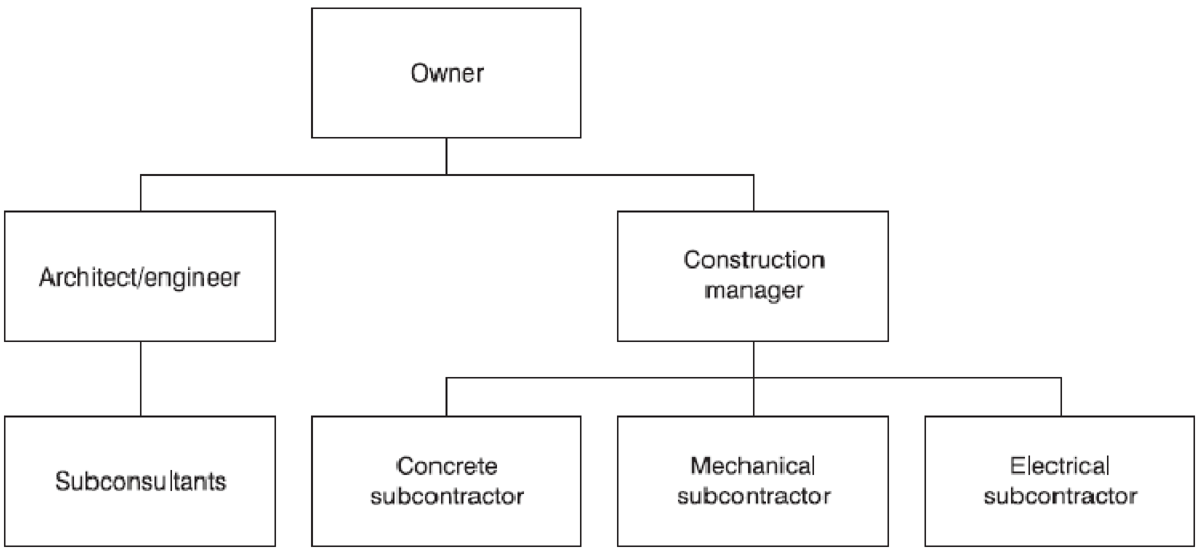
Agency construction management

In the 'agency' type of construction management arrangement, the construction manager acts as advisor to the owner for a fee and the owner engages separate contractor and designer organizations. Here, the construction manager acts as an extension of the owner's staff and assumes little risk except for that involved in fulfilling its advisory responsibilities.



At-risk construction manager

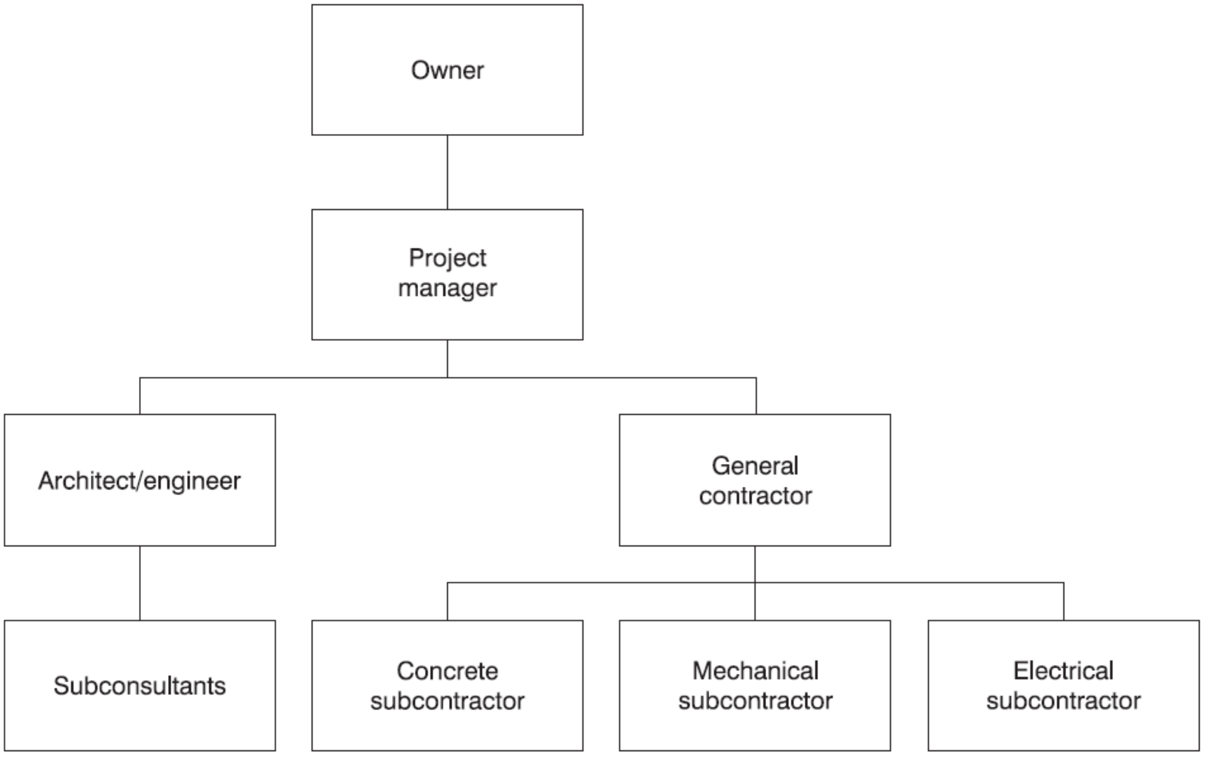
In contrast, the 'at-risk' construction manager occupies a contractual position between the owner and the execution contractors. The construction manager replaces the general contractor in holding the various trade contracts. In addition to the general contractor roles on the traditional design–tender–build approach, the at-risk construction manager provides expert advice to the owner on all matters related to the construction, usually beginning well before the field work begins.



Project manager

Sometimes the owner decides to turn the entire project over to an independent manager. As one example, a school district may have little or no in-house expertise on capital project development; rather than employ a large temporary staff to oversee planning, design and construction, they might use the 'project manager' approach.

This method adds a project manager between the owner and the architect/engineer and general contractor in the traditional contract. Thus the project manager manages the project on the owner's behalf. This arrangement implies that the project manager contracts with the designer and the general contractor.

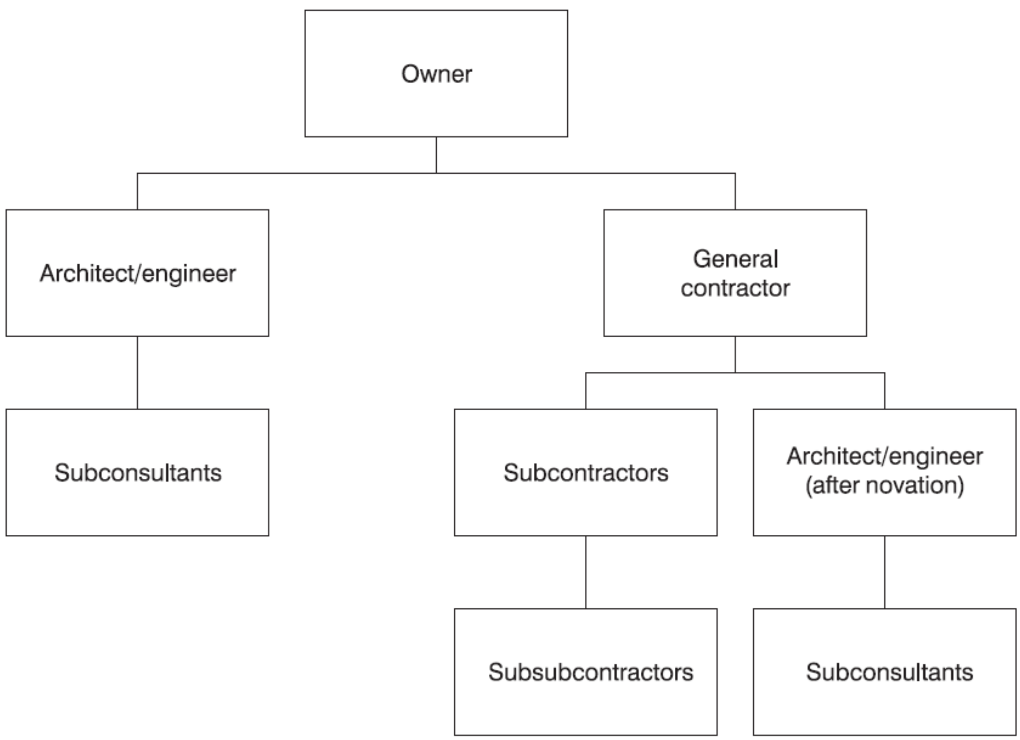


Document and construct

This is a variation of the design–build arrangement, wherein the owner engages a design team to develop a project concept, overall schematic layouts, performance specifications and other preliminary design details sufficient to select a contractor or construction manager through a tender process.

After the contractor is selected, the design consultant's contract with the owner is transferred to the contractor through a process called *novation*. The contractor then becomes responsible to the owner for completion of design, as well as construction, with the understanding that the design work will be completed by the originally selected design organization.

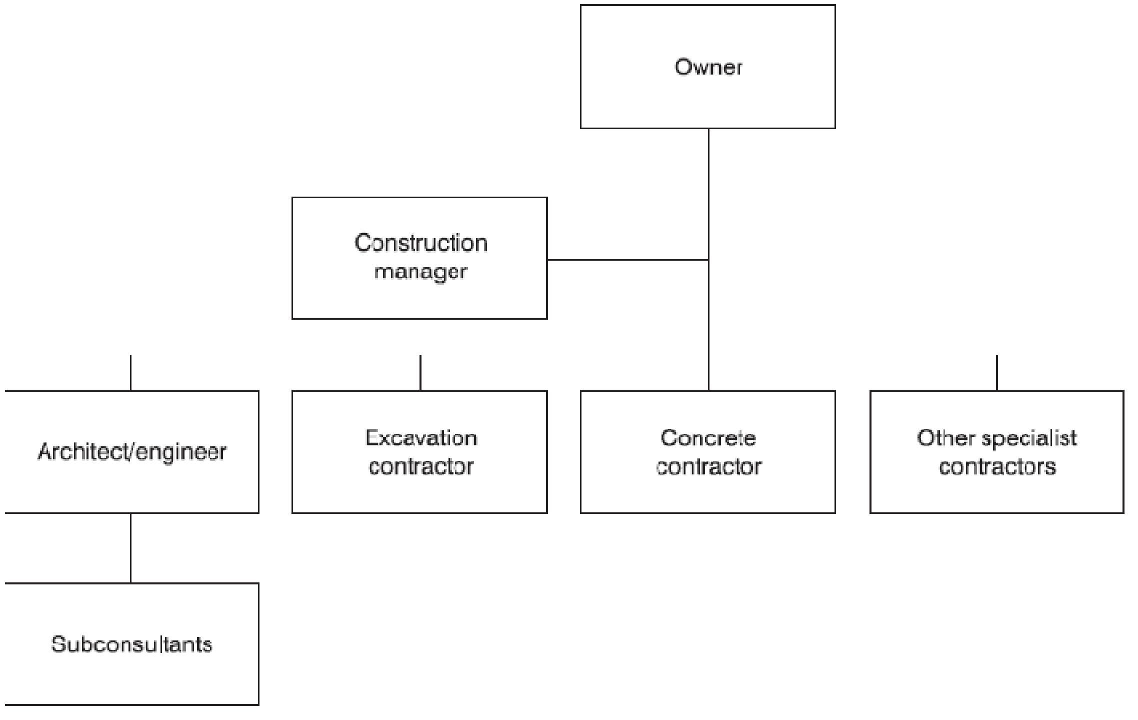
Advantages of this method include a greater control of planning and specification by the owner, as well as the advantages listed for the design–build method. The design firm bears the uncertainty of not knowing to whom they will eventually be contracted for completion of the design.



Separate prime contracts

It is an arrangement in which the owner contracts directly with individual specialty contractors, each of whom can be considered as a 'prime' contractor, because there is no single general contractor to coordinate their work.

In the provided particular example below, we include an 'agency' construction manager, who will assist the owner in this coordination, but the chart makes it clear that the construction manager is not related contractually to the several prime contractors.



Turnkey

A turnkey contract is one in which the owner and contractor agree on a fixed contract sum for a contract under which the contractor will take responsibility for the entire project.

Such agreements are often designated as EPC contracts, because of the prime responsibilities for engineering – providing basic and detailed design, procurement – supplying parts and other goods required for the project and construction – erecting and commissioning the project. The well-known and much-respected Federation Internationale des Ingenieurs-Conseils (FIDIC) designates such projects as EPC turnkey projects (F´ed´eration Internationale des Ing´enieurs-Conseils, 1999). In this type of project, it is a construction organization that usually enters into the contract with the owner (called the Employer by FIDIC and often the Principal in some countries).

At first glance, this form looks much like the design–build form discussed earlier. However, the scope of the contractor's responsibility is typically broader than basic design, procurement and construction, as it includes such services as project financing and land procurement and other tasks not generally within the design–build scope. The owner provides a brief describing desired outcome, performance criteria and standards, the parties agree on a fixed price and the contractor proceeds, with no participation by the owner in the performance of the work.

Build–own–operate–transfer

The build–own–operate–transfer (BOOT) type of project has evolved as a means of involving the private sector in the development of the public infrastructure. The concept, in use in some parts of the world for some centuries, requires the private sector to finance, design, build, operate and manage the facility and then transfer the asset to the government free of charge after a specified concession period.

The term BOT, for build–operate–transfer, was first coined by the Turkish Prime Minister in 1984 in connection with the privatization of that country's public-sector projects. The terms BOOT and BOT are used synonymously, while terms like DBO (design–build–operate) and BOO (build–own–operate) imply construction and operation but no transfer.

Typical 'concession periods' range from about 10 years, not including project development time, for some power station projects to as long as 55 years, including approximately 7 years for construction, for the Eurotunnel project.

It is apparent that such an approach requires a complex organizational structure and carries considerable long-term risk for the project sponsor, while minimizing such risk for the governmental owner.

In a typical BOOT project, the parties are likely to include the following:

- Client – usually a governmental agency;
- Constructor – responsible for both design and construction, although the general design will usually be dictated by the client and may be carried out by the client;
- Operation and maintenance contractor;
- Off takers – entities that agree to purchase the outputs of the project, such as water or electricity, usually a governmental agency;
- Suppliers of materials, equipment and so on for both the construction and long-term operation of the facility;
- Lenders and investors;
- Sponsor – a consortium of interested groups, usually including the constructor, operator and financial institution, that prepares the proposal and, if successful, contracts with the client to carry out the design, financing, construction and operation.

Joint venture

Adding further complication to our consideration of project organizational relationships is the joint venture. Such an arrangement is ‘a voluntary association of two or more parties formed to conduct a single project with a limited duration’. Joint venture agreements are formed between construction firms or between design firms and construction firms; they do not include owners. In a sense they are special purpose partnerships, because of their separate, temporary nature.

The usual purpose of such an arrangement is to spread the risks inherent in large projects and to pool resources in a way that permits the joint venture to execute a project that would be beyond the capabilities of one of the parties individually. Each party is called a coventurer, or joint adventurer; they begin with an agreement between themselves, whose purpose is to seek the contract for a project. If they are successful, the joint venture itself contracts with the project owner, with one of the coventurers stipulated as the sponsoring coventurer. The temporary combination of two or more companies allows them to pool construction equipment, personnel, office facilities, financial means and other resources. Each coventurer has an active role in performing the work and shares in any profits or losses, in accordance with their agreement.

Force account

The so-called force account approach to construction project organization is very simple – the project owner acts as the prime contractor and carries out the work with its own forces by providing field supervision, materials, equipment and labor.

This method is usually confined to relatively small, uncomplicated projects that are built for the owner's use rather than sold to another party upon completion. Examples might include a highway department that uses its own forces to perform a culvert replacement or a minor realignment and an educational institution that uses its own building services crews to renovate classrooms. Such owners usually have their own guidelines for deciding the project magnitude and complexity beyond which they choose to contract with separate construction organizations.

They must consider the tradeoffs among the extra time and expense of the formal contracting process and the possible construction cost savings, potential time savings and improved quality resulting from these competitive or negotiated contracts. Often, such small-scale projects are also designed in house by the owner's staff.

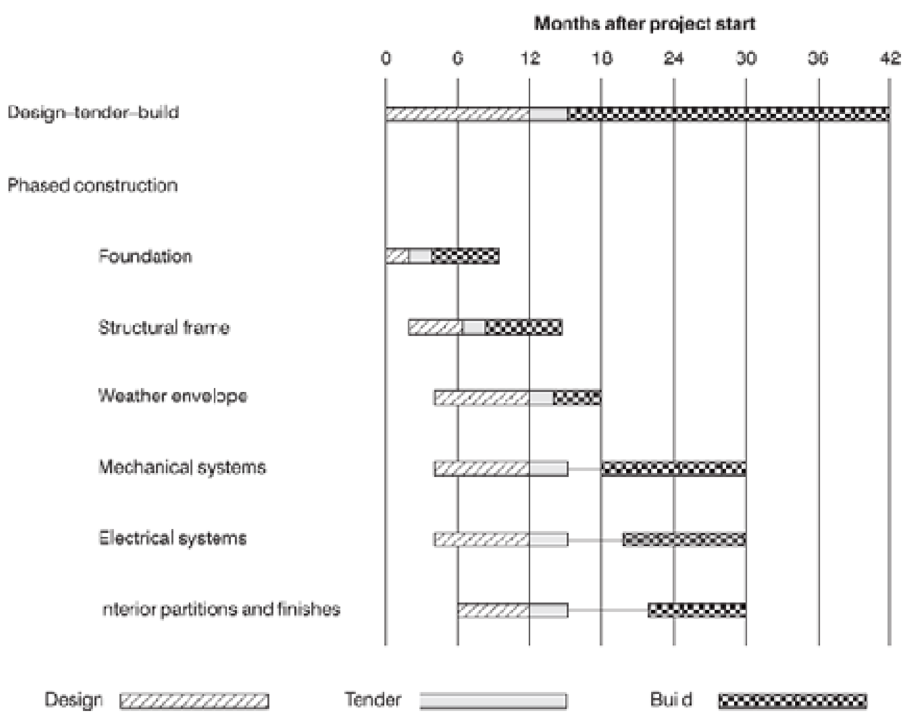
Phased construction

Although more a scheduling approach than a delivery system, we discuss phased construction, or 'fast-tracking', here because several of the delivery systems are better suited than others to this method of planning and carrying out the project schedule.

The basic idea is that some portions of the design work occur concurrently with field construction, thus achieving an overall savings in total project duration. Recall the traditional design–tender–build approach in which the entire project is fully designed prior to the calling for tenders for the construction phase. Under this method, construction does not begin until the end of the tendering and contractor selection efforts, which necessarily must follow completion of design.

Contrast this approach with a scheme under which enough design work is completed to begin field work. An example might be a building project that is designed and built in several parts.

After the foundations are designed, foundation construction begins. Design for the balance of the structure proceeds concurrently with that first construction effort. The structural frame design is completed while foundation installation work is underway, after which the structural frame is erected. The process continues, with design and construction occurring in overlapped phases.



Selection of type of contract

This section explains how the contractor is chosen and the basis for payment for each of the contract types. In a later section, we consider in detail the process for selecting and paying the contractor.

Lump sum/fixed price

Perhaps the simplest type of contract is the one under which the contractor is paid a pre-agreed fixed amount for the project, based on a contract for a specified amount of in-place finished construction work. This amount is paid without regard for the actual costs experienced by the contractor. For such a contract, the project must be completely defined by the contract documents prior to receipt of proposals, selection of the contractor and formation of the contract.

The price of the lump sum, or ‘stipulated sum’, contract must include all direct costs of labor, materials, equipment and subcontractors, as well as such indirect costs as field supervision, field office, equipment maintenance and the like, plus general company overhead, plus profit.

This type of contract is suitable for such projects as buildings, which can be completely designed and whose quantities are thus definable, at the beginning of the project. For a project involving large quantities of earthwork, it is unlikely that those quantities can be accurately predicted in advance and thus another type of contract would be more appropriate.

Two advantages to the owner of lump-sum contracts are the fact that the total cost of the project is known before construction begins and the lack of a need to monitor and approve the contractor’s costs.

On the other hand, the owner bears the risk of poor quality from a contractor trying to maximize profit within the fixed sum; other potential disadvantages to the owner include the high cost and long time required for contractors to prepare tenders; although such costs are borne by the contractor, ultimately they are built into the successful contractor’s total price.

In addition, the flexibility of this contract form is limited; any variation from the original plans and specifications requires a change order, a process that can be time consuming and expensive and may even lead to contract disputes.

Unit price/measure and value

In this type the owner pays the contractor for the measured quality as determined by the engineer of each item carried out at the rate set out in the schedule of prices.

In contrast to the lump-sum contract, this method determines the amount the contractor will be paid as the project proceeds by requiring that the actual quantities of finished product be measured and then multiplied by pre-agreed per-unit prices.

Contractors provide tenders based on estimated quantities provided by the owner, so that each tenderer's price is based on a common set of quantities. Thus, prior to the work, the tender prices are based on estimated quantities, whereas during and after the work, the payment is based on actual quantities.

Suffice it to say here that a contractor's unit prices must cover not only direct costs but also indirect costs, overheads, contingencies and profit; the contractor is paid only for items on the quantity list and paid at the pre-agreed unit prices.

For the owner, this approach has the advantage of removing some risk to the contractor, thus leading to somewhat smaller contingencies. Also, pre-tender documents may be prepared in less detail than under the lump-sum contract, although they must be in sufficient detail to allow tenderers to assess the overall magnitude and complexity of the work.

However, under the unit price/ measure-and-value method, the final project cost cannot be known with certainty until the project is complete. Furthermore, an effort is required by the owner or owner's representative to 'track' actual quantities by some means of measuring – counting truckloads, weighing steel and the like. From the contractor's viewpoint, some of the risk in the bidding process is removed, because payment is based on actual quantities rather than on a lump sum.

Cost plus

A third basic method by which the contractor may be paid is the *cost-plus method*, under which the owner pays the contractor's costs related to the project plus a fee that covers profit and non-reimbursable overhead costs.

This approach seems simple, straightforward and desirable, at first glance. However, there are some disadvantages, as we shall see. Two types of cost-plus contracts are used:

(1) cost plus a percentage of costs, under which the fee is an agreed-upon percentage of the 'costs' and

(2) cost plus fixed fee, wherein the fee does not depend on the contractor's costs.

Four important considerations to be taken into account by owners and contractors when negotiating such contracts, as follows:

1. a definite and mutually agreeable subcontract letting procedure;
2. a clearly understood agreement concerning the determination and payment of the contractor's fee;
3. an understanding regarding the accounting methods to be followed;
4. a list of job costs that will be reimbursable.

There are two categories of expense can be particularly difficult to define and manage:

I. One is contractor's general overhead. Are the costs of preparing payroll and working drawings, of engineering and other office functions, and those general administrative costs involving home office personnel reimbursable or are they to be covered by the fee?
II. The other troublesome category of reimbursable cost is that related to construction equipment; if the contractor owns equipment used on the job, some sort of charge rate must be agreed upon.

Time and materials

A time-and-materials contract is often used on small projects, perhaps a maintenance effort, a small building or a series of small projects. It has elements of both the unit-price and cost-plus approach. The owner pays the contractor based on effort expended, but there is no ‘fee’ as such.

Materials are paid at their actual cost, while labor and equipment inputs are reimbursed at pre-agreed rates. An important element of this method is that these labor and equipment rates must include all indirect and overhead expenses, profit and contingency, in lieu of the payment of any extra ‘fee’.

The contract includes a list of hourly payment rates – for carpenters, millwrights, laborers, 10 m^3 dump trucks, front loaders and the like. If carpenters are paid US$ 17.50 per hour, the hourly rate billed for their services might be US$ 42.00 to include all indirect payroll expenses and a portion of the many other overheads, plus profit and contingency.

Then, as the basis for a payment request for a given period, the contractor presents material invoices, payroll records with hours by category and similar records for equipment. Subcontract payments would normally be reimbursed at actual cost. If the request is approved, the contractor receives payment based on ‘time and materials’ – the time for each labor and equipment category multiplied by its respective rate, plus materials and subcontracts at cost.

This method is often used for design services, for which it is usually difficult to determine the total expected effort in advance, thus making a fixed-price design contract impractical.

Having reviewed two important decisions the owner must make during the pre-project phase, we now turn to the planning and design phase, where we describe the several parties and their activities and then explain the development of construction contract documents.

PLANNING AND DESIGN PHASE

Planning and feasibility study stage

Two key things should be accomplished early in the planning and feasibility study stage:

1. A clear understanding of the project's objectives, purposes, scope and nature by both the client/owner and organization responsible for carrying out the work.
2. A relationship between the client/owner and the project delivery organization must be established, with clearly defined roles and responsibilities.

Consultant selection

In order to obtain proposals from prospective consultants, the owner will sometimes begin by soliciting preliminary expressions of interest and qualification.

Such solicitations may be made available in the local newspaper, in professional publications and newsletters and by direct mailings to previously engaged firms. They will describe the proposed project in a general way and invite responses by a fixed deadline. Response may require completion of a questionnaire outlining the consultant's qualifications.

The F´ed´eration Internationale des Ing´enieurs-Conseils (FIDIC) provides a consulting firm registration form that can be filed with the F´ed´eration or used to respond to requests for expressions of interest.

After the prospective consultants express their interest, the owner selects the best suited for further consideration. These three to five firms are invited to prepare proposals. These requests for proposals contain at the least the following (F´ed´eration Internationale des Ing´enieurs- Conseils, 2001a):

- statement of work,
- areas of expertise required,
- time schedule,
- type of contract proposed,
- project budget,
- submittal date,

- information to be included in the proposal and
- expected selection date.

Qualifications-based selection (QBS) uses criteria other than price to select the consultant, with the fee decided after selection; in this case, the scope of work and project definition are usually left somewhat undefined until after the consultant is selected.

Assuming a QBS procedure, the proposals would include such elements as the following (based in part on F´ed´eration Internationale des Ing´enieurs-Conseils, 2001a):

- past experience with projects of a similar nature;
- details of organization, project control and financial control;
- size, expertise and responsibilities of staff;
- type of organization and managerial method for executing the work;
- quality assurance organization;
- knowledge of local conditions;
- local resources;
- project methodology;
- availability of resources;
- schedule;
- an indication of how well the proposer understands the project.

Evaluation of these solutions becomes another step in the selection process. Owners must weigh the advantages of potentially innovative design solutions against the expense and time required to conduct the competition.

Like construction contracts, payments for professional design services can be determined in several ways:

- percentage of construction cost
- multiple of salary cost
- multiple of salary cost plus non-salary expense
- fixed lump-sum fee
- total expense plus professional fee
- hourly or per diem charge.

It is common practice to pay the designer in installments as stages of the services are completed.

Program development

A construction project is built to achieve certain objectives, as defined in the brief of the project. Those objectives will be achieved if the elements of the program are satisfied. Thus, after the brief, a more comprehensive statement of those elements must be developed, elements that will be translated into the physical aspects of the completed project.

It is likely that several parties will be involved in program development. Consider a project to construct a new elementary school. Those contributing to the *program* might well include teachers, parents, local and district administrators, community members including near neighbors, project manager and design professional.

The result of this process will be a written document, subject perhaps to approval by the Board of Education or similar authority, describing in words what the completed project is expected to accomplish, including educational goals, community use, land use impacts and neighborhood harmony.

Identification of alternatives

There may be several feasible ways to achieve the objectives set forth in the program. If a bridge is required to carry highway traffic and utility conduits across a watercourse;

What will be its location and alignment?

Will it be a suspension bridge, a cable stayed bridge or a plate girder bridge?

Will the structural materials be primarily steel, concrete, timber or a composite?

Will it consist of a single or double deck?

For each selected alternative, the planning process proceeds through several steps. For a facility project such as our proposed elementary school, the architect will begin to develop general concepts, perhaps using proximity or bubble diagrams to show relationships among the facility's functions, leading to preliminary floor plans and renderings.

The engineer will support this process with general investigations of utilities, structural components, site work, and communication systems. For a highway or bridge project, the engineer will lead the effort to develop preliminary layouts of each alternative, their alignments and general shape.

The result of this part of the planning process will be a collection of preliminary drawings and descriptions for alternatives whose costs can be estimated, whose general timelines can be forecast and whose construction techniques can be studied, with the goal of identifying financially and technically feasible options, if any, and then selecting the preferred option.

A master plan is a document that lays outs the various physical elements of the project in their proposed locations on the project site together with general descriptions of the project features.

The identified alternatives provide a structured means of studying the options available for supplying the elements in the master plan in order to meet the project's objectives.

It should be noted that the contract with the design professional is often subdivided and agreed to in phases, in order to define the scope and services and attendant fees more accurately.

Site investigation

In parallel with other preliminary planning, investigation of the site is conducted at varying levels of detail. When several alternatives are still under consideration, the various potential sites will be studied from the standpoint of general soil conditions, topography, access and cost.

As the options are narrowed, further detail will be developed on the preferred option or options. The geotechnical specialist will provide major input at this step. Soil conditions that influence foundation types must be identified.

Environmental aspects of the site, including potential underground contaminants, wetland issues and endangered species must be studied.

Site investigation also includes options for preserving existing vegetation and existing improvements, if any, various ways for accessing the site and interfacing with off-site traffic flow, flow of people and vehicles on site, availability of utilities and various security matters.

In addition, property surveys may be needed to establish corners and boundaries and investigation into ownership records may be required to establish who owns title to the land and in what form.

Additional investigation may be needed later; at this planning phase, the site studies are oriented toward providing sufficient information to assist with decisions about feasibility and selection.

Constructability analysis

Throughout planning and design, it is essential to consider whether proposed alternatives can be built and whether they can be built efficiently. The term ‘constructability’ is used for this evaluation, which is a continuing process, perhaps more active during the design stage to be described later in this chapter. DeWitt (1999) describes constructability analysis (also called constructability review) as

. . . a process that utilizes experienced construction personnel with extensive construction knowledge early in the design stages of projects to ensure that the projects are buildable, while also being cost effective, biddable, and maintainable.

During the planning and feasibility study stage, even though the development to that point is mainly conceptual, each alternative will be studied for such things as ease of construction, impact on the project schedule, effects that different materials might have on procurement and installation, safety considerations and various coordination issues among personnel, equipment and materials.

The design professional may perform this analysis with its own forces, or it may engage a consultant with special knowledge of construction procedures. If a construction manager is a part of the project team, constructability will be a major responsibility.

Preliminary cost estimate

In order to determine whether an alternative under consideration is financially feasible, an estimate of its cost is needed. During the planning process, such an estimate cannot be made with a large degree of precision, as we indicated in our discussion of the role of the cost estimator. Usually the estimator uses some broad measures of cost to develop the estimate.

For example, the cost of a multi-storey concrete parking structure may be estimated based on the number of vehicle spaces multiplied by a historic construction cost per vehicle space for the locality; the costs of any extraordinary features such as a toll station or extra-long approach ramps would be added to the estimate. In the case of a single-storey apartment complex built of timber, an estimate based the cost per square meter of floor area might be prepared. Extras such as a swimming pool, parking areas and public common rooms would be estimated separately.

Sources of this per-vehicle space or per-square meter cost information include the planner's own records of historic data from previous projects and various published databases, either in book or electronic form. Example cost data sources are *Rawlinson's Australian Construction Handbook* (2001) in Australia and New Zealand and *Means Square Foot Cost Data 2002 Book* (2002) in the USA. The following table shows a sample preliminary cost estimate for one alternative of a hypothetical proposed hotel project.

Item number	Item	Quantity	Unit	Unit cost (US$)	Extension (US$)
1	Hotel floor space	8050	m^2	1550	12 477 500
2	Furnishings	230	Room	2300	529 000
3	Swimming pool	1	Lump sum	105 000	105 000
4	Parking	150	Vehicle	1100	165 000
5	Contingency	10%			1 327 650
6	Overhead and profit	20%			2 920 830
	Total				17 524 980

Financial feasibility analysis

The funds proposed to be invested in the project must show the potential to generate an economic return to those investing in the project that is at least equal to that available to them from other similarly risky investments.

For a private-sector manufacturing facility, the company making the investment of funds expects to generate sufficient cash flows from operating the facility to pay for the construction and the ongoing operating expenses and, in addition, have an attractive interest rate of return.

In the case of a publicly funded roadway or school facility, those ratepayers who provide the funding expect that the benefits, either in money terms or in non-quantifiable measures, will be at least equal to the funds invested in the project.

Admittedly, the benefits derived from a school building project are more difficult to estimate than are its costs. However, some consideration must be given to whether the benefits, both financial and otherwise (the 'otherwise' being more important in the case of a school!) are at least equal to the monetary costs.

All cash flows throughout the project's development and operation life cycle must be considered in making such analyses. The term *life cycle costing* refers to economic studies that include all such cash flows.

The cost of maintaining and periodically upgrading a highway and bridge project must be estimated, along with its design and construction costs, to determine whether it is likely to be feasible.

Estimates of the cost of operating and maintaining a manufacturing plant, as well as the income its operation is expected to generate, will be essential in determining financial viability.

The cost estimates over the life cycle for each alternative form the basis for these feasibility studies. Typically, some proposed options will be discarded at this stage because they are not financially viable. Those remaining will be compared with each other, considering both financial and other factors, to arrive at a recommended option.

Design stage

The planning stage usually involves considerable back-and-forth deliberation of several alternatives, as options are modified and refined, in an attempt to find the 'best' solution to the stated program objectives.

Feedback is an important part of this process, as the various parties evaluate the alternatives, suggest changes and reach tentative decisions.

Although some of this methodology continues into the design stage, for the most part the basic design decisions have been made and the task is now to refine and amplify the program in a series of steps that result in documents that will be used for the construction process.

The two parts of the design stage are:

I. *schematic design* and
II. *design development*,

after which the *contract document* development stage results in fully completed documents.

The process is a continuum, with some overlaps and considerable similarity among the topics and tasks. We begin by describing schematic design.

Schematic design

The design professional is responsible for producing a set of preliminary drawings as well as a written report, for approval by the owner.

Engineers will develop concepts of how the various systems will fit into the facility: foundation systems, cooling and heating systems and data communication systems.

These preliminary drawings may be freehand sketches, but they should illustrate the project's character and emphasize such aspects as harmony with the surrounding area and any improvements, architectural style, exterior appearance, planning and zoning requirements and overall structural concepts.

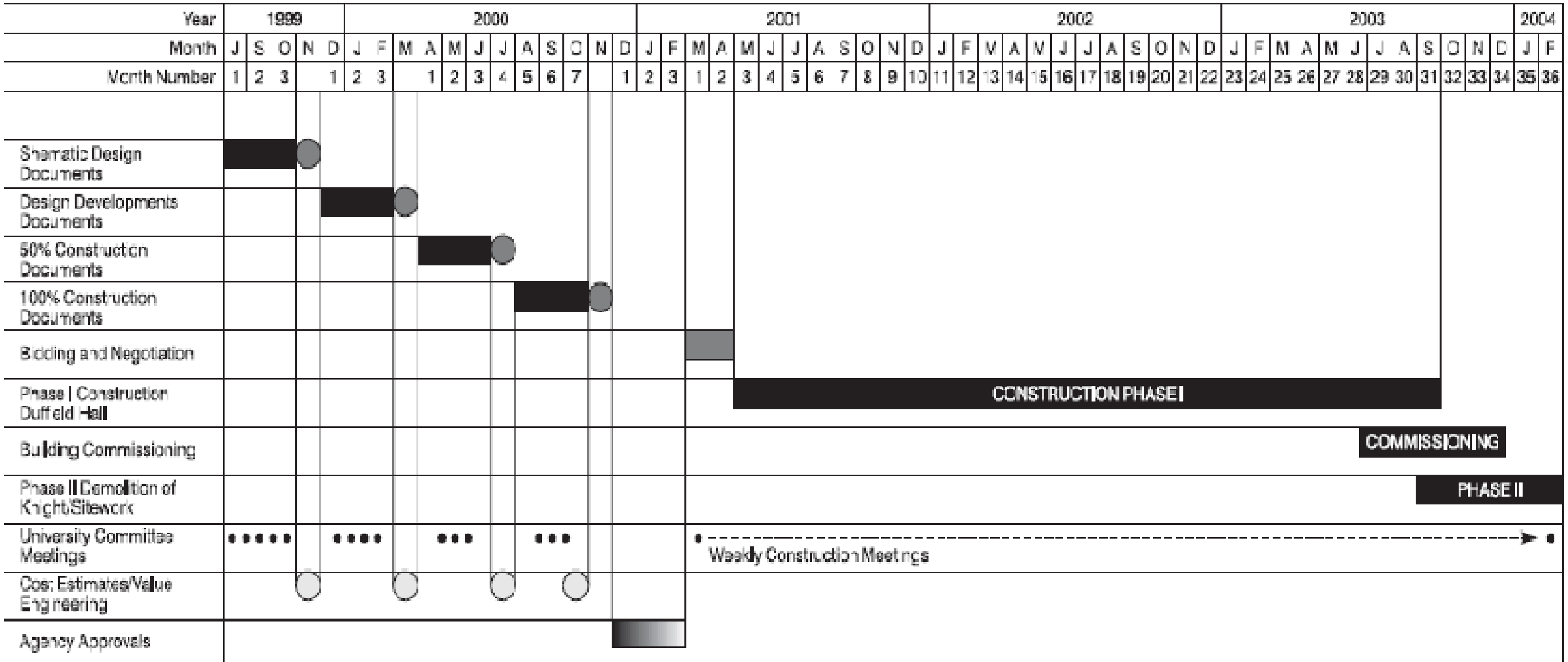
Thus, an important characteristic of schematic design is that it emphasizes the expansion of a single set of concepts rather than multiple options.

The following schematic design drawings are commonly required after approval of the design concept:

- the basic design approach drawn at an agreed-upon scale;
- site location in relationship to the existing environment;
- relationship to master plans;
- circulation;
- organization of building functions;
- functional/aesthetic aspects of the design concepts under study;
- graphic description of critical details;
- visual and functional relationship;
- compatibility of the surrounding environment.

That same agency requires the design professional to prepare narrative descriptions of the following building systems at the completion of schematic design:

- structure
- foundations
- floor grade and systems
- roof
- exterior/interior walls and partitions
- interior finishes
- sight lines
- stairs and elevators
- specialty items
- mechanical systems
- built-in equipment
- site construction.



Schematic Design	Design Development	Construction Documents	Bidding/negotiation	Construction Administration
• Design Documents Site Plan Floor Plans Exterior Elevations Building Sections HVAC Basis of Design Struct. Basis of Design • Lab. Safety Approach • Code Analysis • Site Utilities • Cost Estimate • Agency Review	• Design Documents Site Plan Floor Plans Exterior Elevations Enlarged Elevations Building Sections Wall Sections Reflected Ceiling Plans Laboratory Layout Plans Struct. Floor Plans MEP Distribution 50% Specifications • Update Code Analysis • Site Utilities • Cost Estimate • Agency Review	• Design Documents Site Plan Floor Plans Exterior Elevations Enlarged Elevations Building Sections Wall Sections Reflected Ceiling Plans Enlarged Plans Schedules, Details Laboratory Plans Struct. Plans MEP Plans & Schedules Specifications • Update Code Analysis • Site Utilities • Cost Estimate • Agency Approval	• Constructability Reviews • Pre-Bid Meetings/Addenda • Bid Evaluation Support • GC/subcontractor Selection	• Shop Drawing Review • Contractor RFI Responses • Issue Clarifications • Weekly Site Meetings • Process Change Orders • Prepare Punch Lists • Building Commissioning • Post Occupancy Reviews

Design development

Design development activities flow naturally from, and are based on, documents produced during schematic design.

In the previous figure, note the progression from schematic design to design development. Work continues on the site plan, floor plans, exterior elevations and building sections, with detailed work on wall sections, structural floor plans, reflected ceilings and laboratory layouts. Mechanical, electrical and plumbing distribution design receives major emphasis.

By comparison with schematic design, design development is specific and detailed. By the end of this step, most major decisions about the entire project are resolved. The design professional's submittal to the owner will generally consist of a written report and a set of detailed drawings.

In addition, a more refined cost estimate will be required, based on preliminary quantities of the various elements of the finished project (cubic meters of concrete, square meters of paving, linear meters of cabling and kilograms of steel), rather than overall area or volume measures as in earlier estimates.

The report will include a first try at technical specifications, particularly proposed materials, to be refined later during development of contract documents.

With the completion of design development, approximately 65% of the planning and design effort has been expended and the last step prior to contractor selection, the development of construction contract documents, can begin.

Contract document development stage

During this final stage of the design phase, all of the previous effort is transformed into documents that will form the basis for the construction contract.

When this stage is completed, the contractor, or contractors, can be selected, after which the work involved in procuring and assembling the physical parts can begin.

The term *contract* can refer either to the formal agreement signed by the parties, usually the owner and the contractor, or to this agreement plus a multitude of other documents that are referenced by the agreement.

Thus, when we talk about the *contract documents*, we include three types:

1) the *technical specifications*, which describe the project, its materials and its methods or performance requirements,
2) the so-called *up-front* documents that describe the relationships and responsibilities of the parties (including at least the agreement, general and special conditions, invitation to tender, instructions to tenderers, form for submitting the tender and bond documents) and
3) the *drawings*, which are scaled and dimensioned graphic depictions of the project features, usually with notes that explain related details.

The technical specifications and the up-front documents are typically part of a project manual distributed to prospective tenderers for use in the contractor selection process and to guide the successful tenderer during on-site construction.

On the international level, FIDIC provides many resources useful for designers preparing contract documents for construction projects. The Federation publishes standard forms of contract documents used in the procurement of building and engineering works.

Instead of using 'standard' documents such as those described above, many construction projects use non-standard documents developed by individual design or owner organizations.

Drawings

Drawings have already been produced as part of the schematic design and design development efforts.

However, the task during the contract document development stage is to provide even more detail, such that the project can be tendered and built with these drawings as the primary guidance.

Such documents prepared by the design professional are often called *design drawings* when they are prepared for tendering purposes.

The same drawings are then referred to as *contract drawings* after a construction organization has been engaged, because they become officially part of the contract by reference.

Standard classifications of drawings and prescribed orders in which they appear have evolved over time. In the case of building construction, the following sets are typical:

- general layout and civil works such as roads and parking areas, drainage and landscaping;
- architectural, showing all dimensions and locations of all features in the building;
- structural, with details of all major elements including connections and fastenings;
- mechanical, including plumbing, heating, ventilation, air conditioning and special mechanical equipment;
- electrical, with light fixtures, motors, conduit and cable, instrumentation, communication system components, junction boxes and other such details.

The sheets in each of these five sets are numbered separately and sequentially, with a special capital-letter prefix; for example, architectural drawings might be numbered A1, A2, and so on, while structural drawings would begin with S1.

For other types of construction, such as highway or utilities, the makeup and format can vary considerably.

General conditions

The *general conditions*, sometimes called the *general provisions*, set forth the rights and responsibilities of the owner and contractor and also of the surety bond provider, the authority and responsibility of the design professional and the requirements governing the various parties' business and legal relationships.

These conditions are 'general' in the sense that they can apply to any project of a certain type; sometimes they are referred to as the 'boilerplate', based on the somewhat erroneous notion that they are simply attached to the other documents with no further thought.

One helpful outline of the numerous provisions in the typical general conditions is as follows:

- definitions and abbreviations
- bidding requirements
- contract and subcontract procedure
- scope of the work
- control of the work
- legal and public relations
  - damage claims
  - laws, ordinances and regulations
  - responsibility for work
  - explosives
  - sanitary provisions
  - public safety and convenience
  - accident prevention
  - property damage
  - public utilities
  - abatement of soil erosion, water pollution and air pollution
- prosecution and progress
  - commencement and prosecution of the work
  - time of completion
  - suspension of work
  - unavoidable delays
  - annulment and default of contract
  - liquidated damages
  - extension of time

- measurement and payment
    - measurement of qualities
    - scope of payment
    - change in plans
    - payment
    - termination of contractor responsibility
    - guarantee against defective work
    - dispute resolution.

Special conditions

The *special conditions*, variously known as *special provisions*, *supplementary general conditions* or *particular conditions*, cover these project-specific matters.

These sections may either add to or amend provisions in the general conditions.

Examples of additions to the general conditions might include requirements for completion date, owner-provided materials and the name and address of the design professional.

Among the special conditions are the following:

- name and address of principal;
- type of contract;
- whether or not this is a roading contract;
- number of sets of contract documents supplied free of charge to the contractor;
- contractor's bond requirements;
- principal's bond requirements;
- date when contractor can access the site;
- name and qualification of the engineer;
- insurance requirements;
- completion date information, include allowances for inclement weather;
- producer statement requirements;
- liquidated damages amount;
- bonus payment information;
- defects liability period;
- required guarantees;
- advance payment allowances for materials, plant and temporary works not yet on site;
- progress payment retainages;
- cost fluctuation adjustments.

Technical specifications

The *technical specifications* are the portion of the documents the layperson usually thinks of when referring to the specifications, or 'specs'.

They contain the detailed technical provisions related to installation or construction of the several portions of the work and the materials incorporated therein.

The order and grouping of the technical specifications vary depending on the type of work and the organization preparing the documents, but most such materials tend to be grouped by the general order of construction.

The Construction Specifications Institute (CSI) (Construction Specifications Institute, 2004) and Construction Specifications Canada (Construction Specifications Canada–Devis du Construction Canada, 2001) have developed a format for technical specifications that is especially suited to the construction of buildings, although it has been used in other types of construction, such as heavy construction.

There may be some confusion over the inclusion of general requirements Division 1) in the technical specifications, because the totality of the documents also includes general conditions and supplementary general conditions.

The distinction is that Division 1 general requirements contain *technical* requirements that apply generally to the project and thus to more than one of the divisions.

It is common practice to refer in the technical specifications to codes and standards developed by industry associations, rather than to repeat those standards in the specifications themselves.

Schedule of quantities

The practice of providing material quantities in the contract documents varies in different parts of the world.

For all unit-price (measure-and-value) contracts, these quantities must be provided, because the tenders are based on a common set of quantities.

In the case of lump-sum contracts, however, the quantity surveyor is sometimes engaged by the design professional to prepare a schedule of quantities used by contractors as they prepare their fixed price tenders. In this case, this schedule is an important part of the project manual containing all contract documents.

The practice differs worldwide, however, with the responsibility for generating these quantities through material take-offs often falling on individual contractors and their estimating staff.

Invitation to tender

Unless the project's contractor has already been selected, owners must publicize the availability of their projects to prospective tenderers.

The procedure used on most publicly funded projects and some private ones is for the owner to issue an *invitation to tender*, also known as an *advertisement for tenders* or *notice to tenderers*, with basic information about the project.

A typical invitation contains information on the name and owner of the project, the time for receipt of tenders, the location where tender documents can be obtained and their cost, the bid deposit and bonding requirements and the name of the design professional.

Most invitations contain basic information about the magnitude of the project, the nature of its primary materials, and its estimated cost.

The invitation is published in the public media and may be sent by mail to contractors who have expressed prior interest.

With this information, contractors can determine whether they are interested in pursuing further the prospect of obtaining this work.

Instructions to tenderers

Instructions to tenderers expand on the basic information contained in the invitation to tender.

These instructions communicate to contractors the technicalities of the tendering process.

Although they repeat some of the information contained in the invitation to tender, they also provide information on such matters as modification of tenders once submitted prior to opening, alterations to the tender, tender withdrawals, tender rejections, performance guarantees, methods for handling alternative proposals and order of precedence in the case of discrepancies between numbers and words.

However, because these are general instructions, they usually must be modified through issuance of supplementary instructions.

Tender form

A complete set of construction contract documents will usually contain a form to be used by the contractor to submit the tender.

The form's details will depend upon the type of contract. For example, if the owner anticipates a lump-sum contract, the form will be rather simple, providing for the single price and a few other details.

If the contract will be a unit-price/measure-and-value type, there must be places to indicate a unit price corresponding to each bid item.

Agreement

To allow all tenderers to know the form of the agreement the successful tenderer will be asked to sign, a copy of the agreement is included with the other documents in the project manual.

Typically, the agreement contains sections setting forth the name of the owner, contractor and design professional, a list of the contract documents, a description if the work encompassed within the contract, the dates of commencement and substantial completion, the contract sum, details regarding payment procedures and provisions related to termination or suspension of the contractor.

Surety bond forms and insurance certificates

During the project mobilization phase, the contractor may be required to acquire surety bonds as a means of assuring the owner that the contractor will perform the work and pay its obligations.

We simply indicate that the forms to be used are often included in the package of contract documents, for the contractor's use if and when the contract is awarded. Likewise, the general conditions are likely to require the contractor to carry certain types of insurance and those forms may be included in the project manual as well.

CONTRACTOR SELECTION PHASE

The basic steps are generally the same, whether the contract will be lump sum, unit price or cost plus. If a project manager is involved, that party will assist the owner in choosing a contractor. The construction manager, if part of the team, will have to be chosen. If the design–build approach is used, that organization will be chosen before the design is undertaken, but some of the discussion in this chapter will apply to that selection process.

Methods for contractor selection

There are many choices for the owner in its approach to selecting a contractor:

- Will any and all interested contractors be permitted to submit proposals?
- Will the list be limited to a selected group of contractors, and, if so, how will the list be identified?
- Will the owner negotiate with only a single contractor?
- Will some sort of pre-qualification or post-qualification be used?

Pre-qualification/post-qualification

To limit the number of firms allowed to submit tenders on a project, some owners require that contractors be *pre-qualified*. They must submit information about their experience, competence and financial condition, after which the owner decides whether they are qualified.

But there are arguments on the other side as well; some feel that in a free business world, all interested contractors should be 'given a chance'.

Also, if bonding is required, one might argue that only qualified contractors will be underwritten by surety companies and these companies protect the owner sufficiently if the contractor fails to perform or fulfill its financial obligations.

In addition, pre-qualification tends to lengthen the contractor selection process by as much as a month or two and it also precludes consideration of the well-qualified contractor who appears, for some reason, at the last moment.

Three approaches can be used.

1. An owner anticipating several projects over a certain period, say a state transportation department, might pre-qualify contractors for that period. In this case, for example, highway contractors wishing to be invited to bid on projects in 2005 would submit information by a specified deadline in 2004; the qualifications would be evaluated and successful contractors would be placed on 'the list' for 2005.
2. Pre-qualification could be accomplished on a project-by-project basis; those wishing to submit tenders for a particular project would submit completed questionnaires and then await an evaluation that determines whether they are qualified to tender for that one project.
3. Each contractor submitting a tender on a particular project could be asked to submit an individualized qualification outline with its tender.

According to Russell (1996)

. . . a properly designed pre-qualification process should:

1) Assure that the constructor and major subcontractors, vendors, and material suppliers will be competent, responsible, and experienced, with adequate resources to complete the job.

2) Eliminate constructors with limited financial resources, overextended commitments, and/or inadequate or overly inexperienced organizations.
3) Maximize competition among qualified constructors and subcontractors.

The following are sample requirements for constructor qualification documents (sales documents):

- company's contact information
- firm's legal status and history
- ownership information
- names of individuals authorized to transact business
- information on affiliated, financially associated and subsidiary companies
- requested classes of work (drilling and blasting, landscaping, ….)
- prior work experience
- equipment available to the applicant
- financial information
  - balance sheet
  - gross receipts summary
  - income statement
- notarized affidavit.

Post-qualification is another option. If a contractor is the apparent low tenderer for a project, it will then be asked to submit information demonstrating its qualifications.

The disadvantages of such an approach include the potential for wasted effort throughout the tendering process, if the low bidder is found not to be qualified, and the prospect of favoritism in rejecting the low bidder by claiming unjustly that it is not qualified.

However, owners do have the right to choose 'responsive' and 'responsible' tenders, according to all well-written contract documents, so there is always the chance for claims of unfairness when the owner decides whether a contractor's tender is 'responsible'.

Open tender

The discussion of contractor qualification in the preceding section is closely related to limitations on the pool of tenderers.

If there is no pre-qualification requirement, then any interested contractors are allowed to submit tenders.

An invitation to tender is issued and tenders are received and evaluated.

Decisions regarding qualification are deferred until after receipt of tenders.

If the criteria for selection are based on price alone, the owner must decide whether the low bid is both ‘responsive’ to the tender announcement and ‘responsible’, meaning that the contractor is qualified to do the work.

Invited tender

The pre-qualification process described above, conducted prior to the submittal of tenders, will naturally lead to a limited number of firms considered qualified.

They are the firms that will be invited to offer proposals to carry out the construction work.

Once the tenders are received, they are evaluated in a fashion similar to those received though the open tender process.

Another version of the invited tender, sometimes used in the private sector, involves the owner, or its design professional or project manager, in inviting tenders from firms it believes to be qualified, based on their reputations, past experience and other criteria.

This approach lacks the formality of qualification forms and evaluations and is probably not appropriate in the public sector, where accountability to ratepayers and taxpayers requires credibility and transparency.

Negotiation

Negotiation of construction contracts can occur at two points in the process of selecting the contractor. It might be used *in lieu of* the tendering process.

1) If the owner has had good experience with a certain constructor, the owner or owner's representative can invite that one firm to prepare and offer a proposal, after which the parties negotiate the agreement, with rejections, counter-offers and other steps regarding price, scope of work and all other contract issues.
2) Negotiation may also be part of the formal tendering process. Open or invited tenders could be received and evaluated and the most highly ranked firms identified. Then the owner could negotiate with this 'short list' of, say, three firms, beginning with the top-ranked firm.

Issues such as work content, schedule, price, personnel and risk sharing might be part of this negotiation.

If an agreement is not reached with the top-ranked firm, negotiations proceed down the list until a satisfactory agreement emerges.

The contractor selection method is generally dictated by the type of delivery system and the type of contract. For example, under the 'traditional' design–tender–build delivery system, with a lump-sum or unit-price contract, it is likely that tenders, either open or invited, will be called.

If low price is the only criterion, there is likely to be no negotiation following evaluation of tenders, especially in the public sector.

Cost-plus contracts usually involve negotiation. One example might be a contract between the owner and construction manager signed before the completion of design; negotiations would consider the fee, definitions of reimbursable costs, schedule matters, scope of services and risk and liability issues.

Design–build contracts may involve either competitive proposals and evaluations or negotiation. Usually a fixed price is not specified at the time the design–build firm is chosen.

If the contract for the project is to be fixed price, a common practice is to lock into that sum at the end of preliminary design, after 30–40% of the design work is complete.

The contractor's tender decision

Initially, we ask two questions:

1) Where can contractors find out about projects they might be interested in?
2) What are some factors that contractors might consider in deciding whether to prepare and submit a tender?

Considerations in deciding to tender

It is not possible for the contractor to prepare a tender for every available project. Even in lean economic times, when jobs are scarce, some means must be employed by company management to decide whether to prepare a cost estimate and tender for a particular project. Some factors to consider are listed below:

1. Project type.
2. Project size.
3. The estimated cost of preparing the tender.
4. Project location.
5. Specialized work.
6. Construction contract document quality.
7. Contract terms related to contractor responsibility and liability.
8. Design professional reputation.
9. Owner reputation.
10. Anticipated construction problems.
11. Safety considerations.
12. Completion date.
13. Amount of other work currently underway.
14. Bonding capacity.
15. Potential for becoming involved in prestigious projects.

16. The opportunity that the project might provide for working into new markets, even though the financial reward for this project might not be great.
17. Probable competition.
18. Labor conditions and supply.

Preliminary job planning

The invitation to tender will specify where they are available – with the owner, the design professional, a plan room, or, increasingly, over the Internet – and the cost of the documents.

The major effort, if it is fixed-price or unit-price/measure-and-value contract, will be to compile an accurate estimate of the project's costs and then to convert this estimate into a priced proposal.

But there are other tasks to be undertaken, as a preliminary plan is put together, including a method statement, jobsite visits, constructability studies, initial scheduling and various meetings.

Method statement

An important part of the contractor's preliminary planning is the method statement, which sets forth in words and sketches the steps and special considerations that will be involved in assembling the project in the field, if the contractor is selected.

On the basis of this statement, the cost estimators will be able to provide the expected cost of each operation.

If the tender is successful, the method statement becomes the basis for the detailed job planning that takes place after the award of the contract and before the start of field work.

Important activities leading to the development of the statement include a constructability analysis, the development of a schedule, equipment and labor requirements analyses, environmental protection and safety planning, and transport and traffic needs forecasting.

Some of the topics to be addressed in the section on procurement, transport and assembly methods for a bridge, as follows:

- anticipated sources of supply and fabrication of major components and their method of transport to the site;
- methods for dewatering and installing bridge abutment and pier foundations;
- plans for concrete supply, either batched on site or transported from off site;
- steps required to install piers and abutments;
- steps required to install all bridge superstructure components;
- sources of embankment materials and their methods of transport and placement;
- dredging procedures down to bedrock and along the navigation channels that intersect the bridge;
- temporary navigation re-routing while obstructing the navigation channels;
- efforts not to disrupt fish migrations during construction;
- plans for removal of debris generated during construction from the sea bottom;
- contingency plans in case of ship–bridge and aircraft–bridge collisions;
- considerations of wind impacts on structural components during erection.

Constructability analysis

The method statement will contain the results of these analyses, as it will state the intended methods to be used.

The basis for these statements will be some detailed analysis of options.

In the case of the superstructure components, the analysis is likely to consider the extent of prefabrication.

There are cost advantages to producing relatively large components in a more controlled production environment, but there are also extra costs involved in the transport and lifting of these heavier elements.

The placement of under-sea concrete can be accomplished in several different ways; the contractor will want to study and evaluate these various methods.

In a similar way, alternative dredging methods, including disposal of spoil material, will warrant analysis.

Jobsite visits and checklists

To carry out meaningful preliminary job planning, intimate knowledge of the construction site is required.

If the undertaking is a highway project through a wilderness area, a visit on foot or by tracked vehicle will bring the contractor in close contact with site conditions.

After preliminary examination of the drawings and specifications, the construction site must be visited. Information is needed concerning a wide variety of site and local conditions. Some examples are as follows:

1. Project location
2. Probable weather conditions
3. Availability of electricity, water, telephone, and other services
4. Access to the site
5. Local ordinances and regulations
6. Conditions pertaining to the protection or underpinning of adjacent property
7. Storage and construction operation facilities
8. Surface topography and drainage
9. Subsurface soil, rock, and water conditions
10. Underground obstructions and services
11. Transportation and freight facilities
12. Conditions affecting the hiring, housing and feeding of workers
13. Material prices and delivery information from local material dealers
14. Rental of construction equipment
15. Local subcontractors
16. Wrecking and site clearing.

Preliminary schedule

In preparing its proposal, the contractor will need to develop a preliminary project schedule.

This schedule is not to be confused with the detailed schedule that will be prepared after the job is awarded.

This later effort is used both for in-depth planning of the multitude of individual project activities and for the control of the schedule as the project proceeds.

Instead, the preliminary schedule breaks the project into relatively few broad activities, to provide essential information to those assembling the contractor's cost estimate.

First, the tender documents often specify a project completion date or total project duration and the tenderer needs a rough idea of whether this requirement can be accomplished.

Also, many project overhead costs, such as supervision, the project office and site security, vary directly with project duration; thus an estimate of that duration is essential if these costs are to be assessed.

Furthermore, the time during which various pieces of equipment are needed must be approximated, in order to include these costs in the proposal.

In addition, there are issues regarding the sequencing of operations and their seasonal impacts.

Finally, it is likely the contractor will have to provide its own financial resources early in the project, until payments for partial completion are received from the owner.

The cost of this financing, which must be part of the cost estimate, will be proportional to those early activity levels as identified on the preliminary schedule.

Pre-tender meetings

Two types of meetings are common during the time the tender proposal is being prepared.

1) One type is internal to the contractor's organization. Attendees include the cost estimating staff, personnel expected to be in supervisory positions on the project if the contractor is selected and representatives from general company management.
2) The other type of pre-tender meeting is conducted by the owner and/or its project manager or design professional. All general contractors who have obtained contract documents, thus signifying their interest in the project, are invited; sometimes major subcontractors and material suppliers are included as well.

Cost estimating

The major effort in tender preparation for a lump-sum/fixed-price or unit price/measure-and-value contract is the development of the cost estimate.

The term *estimate* is curious. It implies that the numbers are approximations, representing someone's idea of what the final project costs will be, but subject to some limited accuracy.

All that is true, but whether accurate or not, the cost number(s) generated for a lump-sum or unit-price estimate become contractual obligations if the contractor's proposal is accepted.

The contractor agrees to do the work, not for 'about' that amount, but for *exactly* that amount!

Levels of detail

Construction cost estimates are prepared in various levels of detail for different purposes at different points of the project life cycle and we showed.

Proceeding from least detailed and least accurate to most detailed, we describe below many of the commonly used approaches.

All of them use some measure of gross unit costs from previously completed construction work, updated by the use of factors or indices that recognize cost differences due to changes over time, location variations or any peculiarities of the job being estimated.

Rough order of costs

These estimates are based on limited knowledge of the project and very little, if any, design or drawings.

They are important in determining initial feasibility of the project, assisting the owner in deciding whether to proceed with additional studies and design work.

- Cost per function. This estimate is based on historic cost data per unit of use, such as cost per vehicle in a car park or garage, per patient in a hospital facility or per 1000 books in a library.
- For a manufacturing facility, it might be based on productive capacity, such as per ton of ore processing capability or per annual number of vehicles assembled in an automobile factory.
- Unit area cost and unit volume cost. The estimate per unit area is found by multiplying the estimated gross floor area by the historic cost per area for the type of facility and its location.
- Similarly, the per-unit-volume estimate is based on the anticipated volume multiplied by a cost per unit volume. Unit-area estimates are often used in the preliminary stages of residential and other building design, while unit-volume estimates are well suited to warehouses and industrial facilities.

Preliminary assessed costs

- Panel unit cost. This method is appropriate only for buildings. It is based on per-unit costs for the several panels in the building, such as exterior perimeter length, interior partition wall length or area, roof area and floor area.
- Parameter cost. The cost of each of several building components, or parameters, is calculated, based on their estimated unit costs multiplied, respectively, by the appropriate units, such as floor area, building perimeter and storey height.

  Among the common components for buildings are site work, foundations, plumbing and roofing.

Firm estimate of costs

These estimates are based on completed, or nearly completed, construction drawings. Thus, they become the 'final' estimates of costs, from the viewpoint of the design professional or the contractor.

- Partial take-off. This estimate uses quantities of major work items from the design drawings.
- Final cost. The 'final' cost estimate is the last one prior to construction, *not* the final accounting of actual costs after the project has been completed.

  It is based on a thorough review of all work quantities necessary to carry out the construction operations and produce the end result.

  The cost information developed in this process is the principal ingredient in the contractor's tender proposal.

The estimating process

Construction estimating, by comparison, is a relatively crude process. The absence of any appreciable standardization, together with a myriad of unique site and project conditions, make the advance computation of exact construction expenditures a matter more of accident than design.

Nevertheless, a skilled and experienced estimator, using cost accounting information gleaned from previous construction work of a similar nature, can do a credible job of predicting construction disbursements despite the project imponderables normally involved.

Although every tender price contains the same basic elements, terminology describing them varies with the individual construction organization. The following outline will guide our discussion:

Total tender price

(1) Net project cost

- (1.1) Construction cost
  - (1.11) Direct costs
    - (1.111) Labor
    - (1.112) Materials
    - (1.113) Equipment
    - (1.114) Subcontract work
  - (1.12) Site or project or job overheads or on costs
- (1.2) Company, general or home office overheads

(2) Markup or margin

- (2.1) Profit
- (2.2) Contingency or risk

The 'estimate' usually means the estimated net project cost, consisting of the construction cost and company overheads.

The contractor's cost estimating staff is responsible for compiling that net project cost.

Elements of net project cost

Direct costs are those costs required to conduct operations that result directly in the installation of some component of the physical project, such as applying paint or connecting electrical cables or some other direct production work, such as soil excavation and hauling.

The 'big four' among the elements of direct cost are:

1) labor,
2) materials,
3) equipment and
4) subcontractor work.

Sources of cost data to be used in the estimates will be the contractor's historic cost records, if any, for similar work items.

Labor

Predicting the cost of *labor* for a construction activity is probably the most challenging part of the estimator's job.

Productivity varies with the size of the work crew, availability of materials and equipment, weather conditions, effectiveness of supervision, coordination with concurrent operations in the same location and the degree of caution required due to safety considerations.

To estimate the labor cost for an item of work, one of three approaches can be used. All are based on the idea that the work item will consist of an estimated number of units, or quantity, and the total labor cost will be that quantity multiplied by the estimated labor cost per unit.

Consider, for example, the calculation of the estimated labor cost of placing concrete in a cast-in-place foundation wall 2.5 m high, 0.3 m thick and 20 m long.

The total volume of concrete in the wall will be $15m^3$.

- If the contractor's cost records for placing concrete for this type of application are kept on the basis of labor US$/$m^3$, we simply multiply the $15m^3$ by the historical unit labor cost, perhaps modified to incorporate inflationary cost changes.

  Thus, if the labor cost is US$ 47.00/m^3, the labor cost estimate is simply (15 m^3) (US$ 47.00/ m^3) = US$ 705.00.

- Perhaps a better way to keep labor effort records is by labor hours instead of labor dollars.

- A third approach to this calculation is based on records of 'productivity' for the particular work item, where productivity is defined as the quantity installed per unit of input (in this case per labor hour). The productivity in our example is simply the reciprocal of the labor hours/ m^3. In the second approach, above, the 2 labor hours/ m^3 translate into a productivity of 0.5 m^3/labor hour. So, the calculations are (15 m^3) (US$ 23.50/labor hour)/ (0.5 m^3/labor hour) = US$ 705.00.

The direct cost of labor also includes *indirect labor costs* (a rather confusing terminology!).

Materials

The term 'materials' includes all physical objects that become part of the finished structure.

Thus materials include not only such common and traditional items as soil, concrete, steel, timber, paving, air ducts and electrical cable, but also various pieces of permanent equipment such as conveyors, medical diagnostic devices, bank vaults and kitchen stoves and refrigerators.

We emphasize this point because another element of direct cost, *equipment* (sometimes called *plant*) is used to refer only to construction equipment deployed to install various elements of the project but not to become part of the completed structure.

The material cost for our $15m^3$ concrete example is straightforward; we expect concrete suppliers to propose furnishing concrete meeting this specification on a $cost/m^3$ basis. If the proposed price of timber is given on a volume or area basis and if the quantity of a certain timber item is given as a length measure, some conversion of the price will be necessary. It is important that all material costs have a common basis, such as delivered and off loaded at the jobsite, with no sales tax included.

Equipment

Construction *equipment*, or *plant*, is used to move, raise, fasten, excavate and compact the various materials installed on the project.

A substantial portion of the cost of highway and heavy construction projects is for equipment, including bulldozers, scrapers, trucks, cranes and compactors.

For building projects, the proportionate cost of equipment is less. Equipment may be owned by the contractor or it may be rented or leased for the project.

Contractors rent equipment on a short-term basis, often month to month.

Leasing is for longer terms of a year or more, with a provision that the contractor has the option of purchasing the equipment at the end of the lease period.

If the contractor will use its own equipment, the contractor may have sufficiently accurate unit-cost data in its historical cost database for some of the items, but for others it will be necessary to calculate the cost.

This procedure will involve recognizing the capital recovery costs, including both acquisition and interest, and the operating costs, including fuel and oil, maintenance, insurance, storage, taxes and licensing.

Various contractors differ in their handling of the costs of equipment operators; some include these costs in the equipment category, whereas others recognize equipment operator expense as labor.

It will then have to be converted to a cost per unit for the particular work item, based on an analysis of the equipment's production rate on this item, plus some measure of nonproductive time for which the contractor must pay.

Instead of including the cost of construction equipment in each bid item, the contractor may calculate and add a single amount toward the end of the process, almost as an 'overhead' item.

Subcontract work

The final category of direct cost includes work that will be performed by *subcontractors*.

Generally, the contractor wants to engage subcontractors whose prices are lowest, but there are other considerations.

If four subcontract proposals are received for electrical work, the contractor will want to inquire about the qualifications and reputations of each, in a similar way that the owner is interested in the contractor's qualifications.

It is unlikely the electrical subcontractor will make an offer to 'provide all materials and perform all work contained in specs.

In nearly every case, subcontractors will provide qualifications or exceptions in their offers.

One may exclude all testing and any concrete bases for electrical equipment.

Another may attach a condition that the general contractor will unload any delivered materials.

While another may exclude the provision of a piece of gear it knows will be difficult to acquire and all testings.

Subcontract offers may be provided to the general contractor either on a lump-sum or unit price basis.

If a lump sum, as would be likely with electrical work, they are simply added to the other items.

If they are given on a unit-price basis, the product of that proposed price times the estimated quantity becomes the estimated cost of the item.

Provisional and prime cost allowances

If the precise nature of a portion of the work is not defined at the time of tendering, the tender documents may include a requirement that the tenderers include in their total prices a certain amount as a *provisional sum*, as recognition that the successful contractor will be required to perform this work.

All tenderers include this same amount, which is the owner's best estimate of its cost, with the understanding that the parties will change the contract amount later if the actual cost is different from the provisional sum.

Prime cost sums are similar, but they are confined to materials to be provided by the contractor or a subcontractor but whose exact nature or quantity cannot be defined at the time of tendering.

Site overheads

Construction cost includes not only the direct costs defined above but also various costs that occur on the construction site but are not directly associated with the various work items.

They are referred to as *site overheads*, *project overheads*, *job overheads* or *on costs*; some contractors use the term *indirect costs*, but the use of this term together with *indirect labor* costs described earlier can lead to considerable confusion.

Among the types of costs included here are job supervision, site office facilities, other temporary buildings, temporary utilities, permits and fees, load tests, project scheduling and surveys.

Depending on the job, such costs may range between 5 and 15% of direct costs and some contractors include a simple percentage of direct costs as their estimate for site overheads.

The importance of the preliminary schedule is evident in the preparation of such a compilation, because most of these costs are related to the durations of various portions of the schedule.

Company overheads

The final element constituting the net project cost includes a proportion of the cost of operating the company's home office.

The terms *company overheads*, *general overheads* and *home office overheads* refer to such home office costs as officer salaries, payroll processing, information technology, advertising, legal costs, office utilities, travel, dues, donations and all other costs involved in operating that facility.

They are costs incurred in supporting the company's overall construction program that cannot be charged to any particular project.

The costs of tender preparation are usually considered part of company overhead, because those efforts support the company's overall efforts to acquire project work, not just the projects it is successful in tendering.

Depending on the number of projects underway in a year, the company's total home office expenses are likely to be between 2 and 8% of the company's annual business volume.

Proposal preparation, submittal and opening

The factors that may be involved in setting the markup amount have some resemblance to the factors the contractor considers in making the decision whether to spend the effort to prepare the tender, discussed earlier in this chapter.

The factors are related to the contractor's potential risk if the project is won, the degree of need and desire to win the project and the expected competition. Among all the factors a contractor might take into account are the following:

- The owner and design professional and the likelihood they will cause difficulties for the contractor.
- Stipulations in the contract documents for delays in payments or retention of moneys owed to the contractor.
- Disclaimer clauses that place on the contractor most or all of the risk for unknown physical conditions at the site, especially underground conditions.
- Clauses making the contractor responsible for any delay in the project, even if not caused by the contractor.
- Other clauses providing for procedures the contractor may believe to be unreasonable, for such matters as change orders (variations), contract claims and the rendering of binding decisions in case of disputes.
- The extent to which the contractor may be liable for any worker safety-and-health problems or labor law violations.
- The project's location, size and complexity.
- The amount of work to be done by the contractor's own forces in comparison to work to be done by subcontractors.
- How 'hungry' the contractor is, based on the number of projects the contractor already has under contract and the potential for other new projects.
- The expected competition, including the number of tenderers and the characteristics of each.

Submittal and opening process

All of the contractor's efforts described so far have been targeted towards the tender-opening occasion!

There are three important points in the tender submittal:

(1) the nature of the envelope that contains the tender,

(2) the time and place of the opening and

(3) the fact that there will be a public opening of the offers.

The contractor completes the required tender proposal form and places it in a sealed envelope, addressed as stipulated and labeled as a proposal for the specified project.

If the form of the tender proposal has been included with the construction contract documents, the contractor is obligated to use it for its submission.

The total submission will include that form, a certified cheque or tender bond as security to assure the owner that the contractor will sign the contract without delay if the contractor is selected and, if required, information about the contractor and its plans for the project that will assist the owner in evaluating the non-price aspects of the proposal.

The contractor is responsible for delivering the envelope on time and at the specified place for the tender opening.

If the tender is late, even by a few minutes, many jurisdictions in the public sector disallow its being considered.

Public opening of tenders is a requirement in nearly all public contract policy and it is common on private projects as well.

The meeting is usually attended by general contractors who have submitted tenders, subcontractors, material suppliers, the design professional, the owner and others who may be interested in the project.

The process involves the owner, or its representative, opening each envelope in turn and reading pertinent information, including the total offer price and, in the case of a unit price contract, the amount of each item.

Selecting the successful contractor

For some construction projects, selection of the contractor is based on the lowest tender price, provided the contractor is qualified. For others, the criteria are wider than price alone.

On public work, for example, despite contract provisions that include words such as 'the owner reserves the right to reject any and all bids, and to award the contract to other than the lowest bidder', it is unusual for the owner to award to other than the low bidder, if that low bidder is qualified.

Many legal battles have resulted when contractors with lowest proposed prices have been rejected; the key in these proceedings is the court's interpretation and application of the term 'qualified'.

Privately funded projects give the owner more flexibility in evaluating proposals.

Criteria

First, we consider the use of *price alone* as the selection criteria. If those contractors submitting tenders have already been pre-qualified, the owner may simply compare their prices and select that contractor with the lowest price.

Even in that case, the invitation for tenders may have requested that proposals include prices for alternatives, in addition to the basic work.

If the available funds make it possible to include some of those alternatives, in addition to the basic work, the owner may analyze combinations of several alternatives to decide which proposal can provide the greatest benefits at the lowest price consistent with available funds.

If no prequalification process has been used to identify qualified contractors, the owner might still award to the low tenderer, but it is more likely that a post-qualification process would be used to ascertain the lowest qualified tenderer.

Often, the contract is awarded to the *lowest qualified tenderer*.

Sometimes tendering documents will specify that the contract will be awarded to the 'lowest, responsive, responsible tenderer'.

These three adjectives have special meaning:

1) *Lowest* means the lowest price, either for the basic work or for the basic work plus some or all of the alternatives.
2) *Responsive* means that the tender submittal is completely regular, with all signatures in place, all blanks filled in, all attachments such as the tender bond included and all addenda acknowledged and that it was on time.
3) *Responsible* means qualified in the sense we have already used the term.

The third and final approach to evaluating contractors' tenders is on a *best-value* basis, wherein factors other than low price are considered.

In this case, a series of criteria are set forth, to which tenderers respond, in a manner similar to the method we described for the selection of design consultants.

Those responsible for the evaluation assign a mark to each item in each response and compile the overall scores. After review, the project is awarded to the contractor with the most favorable score.

Qualifications

In preparing and submitting their tenders, contractors may find that they would like to change some of the requirements or conditions specified for the project and thus 'qualify' their proposals.

In some settings, whether public or private, contractors regularly attach such *qualifications*, or *tags*, to their proposals.

One example is a proposal to furnish a lighting system not allowed in the specifications because it would be manufactured by a company not listed in the documents; the contractor might qualify its tender by saying that the use of a locally manufactured system would lower the tender price by a certain amount.

In places where qualifications are not allowed, the owner would probably reject a tender containing such tags by saying it is not 'responsive' to the invitation for tenders.

Notice to proceed and contract agreement

After the tenders have been opened, the owner begins a period of evaluation.

So as not to hold contractors 'in limbo' for an excessive time, most tender conditions provide for an acceptance period, often 60 or 90 calendar days long.

During this time, submitted tenders may not be withdrawn.

The owner must send a notice to the successful tenderer during this period; if it does not, the tenderers are released from their proposals.

The *notice to proceed* is the document that notifies the contractor of the acceptance of its proposal and directs the contractor to commence work, often within a specified time such as 10 calendar days.

The notice to proceed also 'starts the clock' by establishing the reference date from which the project duration is measured; often the contract will stipulate that work will be completed a stated number of calendar days after the contractor receives its notice to proceed.

The notice to proceed implies that the site is free of encumbrances and thus available for the contractor's use.

If this is not the case, because some unresolved property ownership or other matters are outstanding, the owner may issue a *letter of intent*, stating that it intends to contract with the contractor as soon as the unresolved issues are settled.

The final step in the contractor selection phase is the issuance of the formal *contract agreement*.

In a single document, it binds the owner and the contractor and includes, by reference, the drawings, general and special conditions and technical specifications.

PROJECT MOBILIZATION PHASE

This section deals with many of the activities that take place between the award of the construction contract and the beginning of construction work in the field. Some of this work may have begun prior to the award and much of it will continue during which fieldwork is beginning.

But these are the actions that prepare for and set the stage for what the layperson considers 'construction', the things that people and machines do to assemble the project in the field.

Permits, consents and licenses

Local, regional and sometimes national authorities may require the issuance of *permits* for various aspects of the project.

Approval of applications for these permits, called *consents* in some countries, must be secured prior to specified stages of the project.

Whether the contractor is directly involved depends on regulations and the owner's wishes.

If not already obtained by the design professional, the contractor will be required to obtain a building permit.

Work authorized by such a permit might include the building structure, plumbing and drainage work, site works, demolition and relocation of existing buildings, or separate plumbing and electrical permits may be required.

Although most licenses are not issued for the project itself, the contractor may become involved in licensing.

For example, a contractor's contracting license and its business license, if any, are usually issued for a time period such as a year and they must be current at the time of tendering and throughout the job.

Also, the contractor will be expected to assure that its subcontractors have current licenses; these might include both business and specialty contractors' licenses, depending upon the jurisdiction.

Bonding

A *surety bond* is a legal instrument issued by a third party to guarantee the obligations of a first party to a second party.

This *suretyship* can be thought of as a guarantee of performance.

In the realm of construction, the first party, or the one that takes on the obligation, is the contractor, or the *principal*.

The second party, the owner with whom the contractor enters, or anticipates entering, into a contract is the *obligee*.

The third party, the bonding company that guarantees the obligation, is the *surety*.

A surety bond differs from an insurance policy in that an insurance underwriter expects some percentage of its coverages to experience losses, whereas, in surety, no losses are contemplated; the premium paid in surety is a service fee for the use of the surety's credit.

If the principal (contractor) fails to carry out its obligations, the surety makes good the loss to the owner, but the surety then has recourse to the contractor for reimbursement if possible.

The *tender bond* (or *bid bond*, or *proposal bond*) is issued during the contractor selection phase.

The *performance bond* and the *labor and material payment bond*, are obtained during project mobilization.

Thus we see that:

1. the bid (tender) bond is but one way of providing bid security, the other, less common way being a certified or a cashier's cheque and
2. the bid bond guarantees two things if the bidder is selected: the contractor will sign the contract and will provide the other required bonds.

Although the 5% of the total tender specified in the above example is a typical amount, it can be as high as 20% in some contract documents.

Sometimes general contractors require that subcontractors furnish tender bonds, as a check on their financial stability.

If a surety is willing to provide such a bond, the general contractor has some assurance that the subcontractor will enter into an agreement if the owner awards the contract to the general contractor.

A *performance bond* acts to protect the owner from nonperformance by the contractor.

Upon signing the contract, the owner is entitled to receive what it contracted for: a completed project in substantial accordance with the contract documents.

If the contractor (the *principal*) defaults by not delivering in accordance with the contract, the surety is responsible to the owner (*obligee*) to complete the project or have it completed, at the price agreed upon between the owner and the defaulting contractor, provided that the owner has met its obligations under the contract.

Normally a performance bond extends through any warranty period required by the construction contract such as 1 or 2 years.

A performance bond has a face value which sets the upper limit of the surety's obligation in case of the contractor's default; a 100% performance bond, for example, provides protection up to the total contract price.

A *labor and material payment bond* also provides protection to the owner, but in a different way.

Such a bond protects the owner against claims from subcontractors, material suppliers, workers and others that the contractor has not paid those moneys due.

If the contractor fails to pay outstanding charges incurred in connection with the project, the surety will pay those debts.

Tender bonds are furnished with the tender.

The usual practice among sureties is to provide tender bonds at no charge and then to charge the successful tenderer for the performance and payment bonds.

Bond costs for relatively small projects are higher as percentages of the project budget than are those for larger projects.

Costs also depend on the contractor's financial strength and its experience and the charges also vary among different sureties.

Insurance

An insurance policy is an agreement under which the insurer agrees to assume financial responsibility for a loss or liability covered by the policy.

The insurance company has the duty:

1. to defend the contractor if a claim covered by the policy is brought against the contractor and
2. to protect the contractor against loss covered by the policy.

As consideration for the insurance company's promise to provide such protection, the contractor pays a fee, called a *premium*.

The contractor's loss record is an important determinant of the premium rates.

This record is reflected in an *experience rating*.

The contract with the owner will specify certain types of required insurance coverage to be purchased and maintained by the contractor.

Beyond that, some insurance may be a legal requirement even if not stipulated in the contract.

It is helpful to divide the types of construction insurance into:

- property insurance,
- liability insurance,
- employee insurance and
- other types.

Property insurance is of two basic types, covering the contract works underway during construction and the contractor's own plant and other property.

I. Builder's risk insurance provides coverage on the contract works.

   Such insurance may be of the all-risk type, under which protection is afforded against all risks of physical loss or damage to the works or associated materials, due to any external cause, unless an exception is stated.

   Or it may be a standard builder's-risk policy, covering only stated threats such as fire and lightning, vandalism and windstorm.

II. Insurance against the contractor’s own plant and other property will probably not be required by the contract, but the contractor may choose to purchase this coverage.

Crime insurance is a special category that protects the contractor against loss of office equipment, money and other valuables due to theft, burglary, destruction and other crimes.

Liability insurance is comprehensive general liability insurance, which protects the contractor, in a single policy, against liability to the public.

It covers injuries to people not employed on the project and damage to the property of others arising from operations on the project.

Various other kinds of coverage may be included, such as liability to the public due to actions of subcontractors, completed-operations coverage for work handed over to the owner, professional liability insurance for design and other professional services rendered by the contractor and protection for injury and property damage caused by the contractor’s vehicles.

Employee insurance, some of which may be required as part of a collective bargaining contract, are employee benefit insurance, covering medical and hospital costs beyond those provided by workers’ compensation, or similar government programs that provide retirement, disability and survivor benefits to insured workers and unemployment insurance, normally a government-operated program offering benefits during periods of unemployment between jobs.

Other insurance category such as business-interruption insurance, covering losses due to times of business inactivity, key person life insurance, used to reimburse the company for financial loss due to the death of a major officer or other designated essential employee and corporate continuity insurance, providing cash to purchase a deceased stockholder’s corporate stock as a means of preventing that stock from being purchased by a party unfriendly or otherwise undesirable to the business.

Work breakdown structure

To begin the preparation of a detailed project schedule, the contractor will prepare a *work breakdown structure* (WBS).

Its purpose is to define the various work tasks that must be completed.

The WBS has been variously defined as 'a product-oriented "family tree" of work effort that provides a level-by-level subdivision of the work to be performed in a contract' and 'a "picture" of the project subdivided into hierarchical units of work'.

At the highest level of the hierarchy, we show the project itself.

At the next level, the project's major subdivisions are shown.

Each major subdivision is further subdivided into additional levels as required to identify in sufficient detail all of the work involved in the project.

By defining the various work packages, the WBS allows the construction manager to:

1) plan and schedule the work and thus describe the project's total program,
2) estimate costs and budgets,
3) authorize parcels of work and assign responsibilities and
4) track schedule, cost and quality performance as the project proceeds.

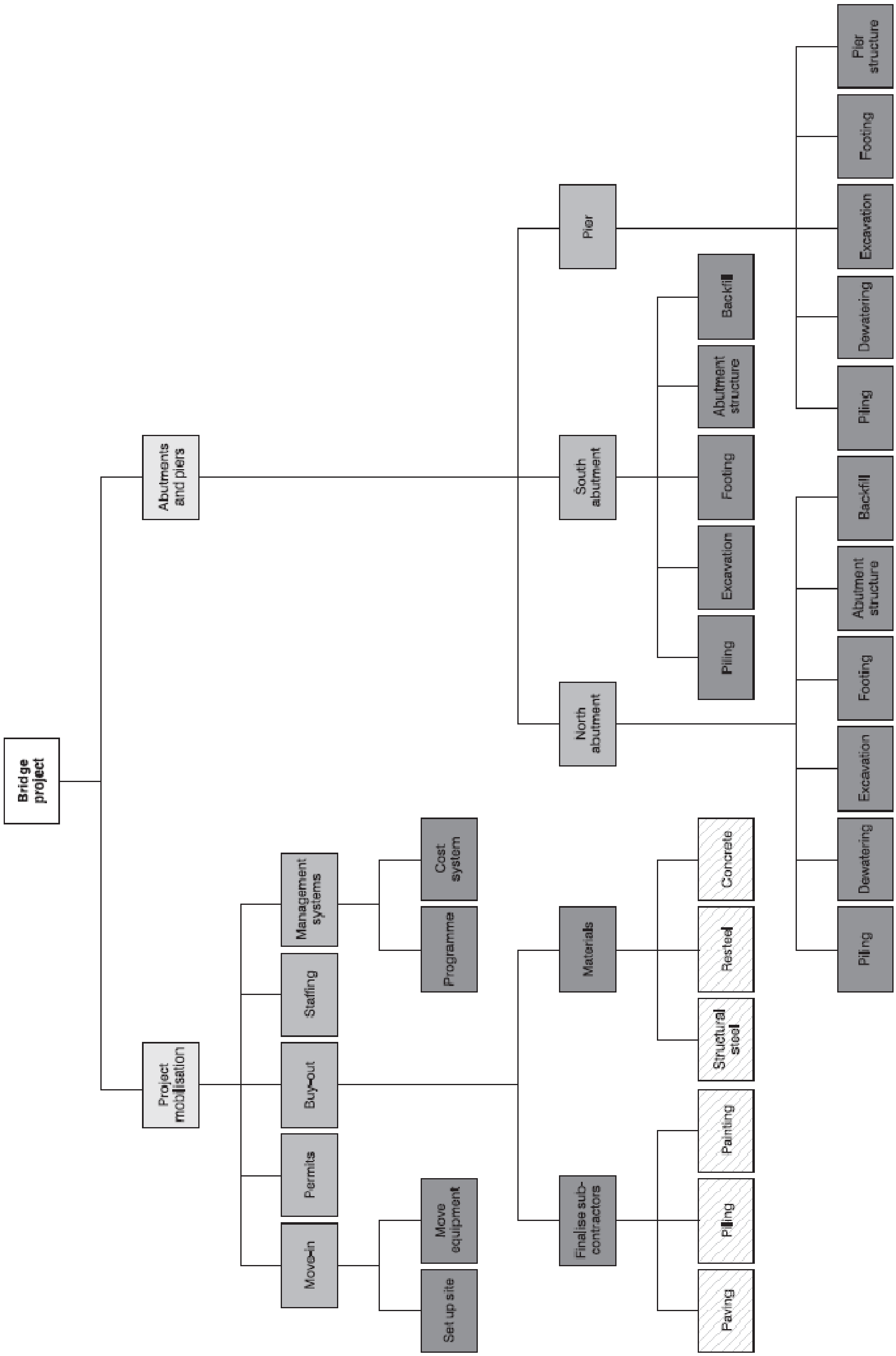
For any given project, numerous hierarchy designs could be used.

To capture all project work elements, it may be necessary to employ a combination of approaches.

The manager must rely on judgment and experience when deciding on the proper amount of work breakdown schedule detail.

This WBS also illustrates that not all branches in the hierarchy have equal numbers of levels; the 'finish work' element has only one level below it, while the 'project mobilization' element leads to three additional levels.

The lowest level elements in each branch then become the work packages that are the basis for the program, for the assignment of tasks and for the monitoring of time and cost.



Bridge project
Project mobilisation
Abutments and piers
Move-in
Permits
Buy-out
Staffing
Management systems
Set up site
Move equipment
Programme
Cost system
Finalise sub-contractors
Materials
Paving
Piling
Painting
Structural steel
Rebar
Concrete
North abutment
South abutment
Pier
Piling
Excavation
Footing
Abutment structure
Backfill
Piling
Dewatering
Excavation
Footing
Abutment structure
Backfill
Piling
Dewatering
Excavation
Footing
Pier structure

Bar charts

Bar charts have been the most popular methods for presenting construction project schedules, especially for small projects.

Even today, many contract documents require the contractor to furnish the owner with a bar chart indicating how the various activities will be carried out so as to complete the project by the target completion date.

The term *Gantt chart* is also used, named after Henry L. Gantt, an American engineer and social scientist who began using bar charts as a production control tool in 1917.

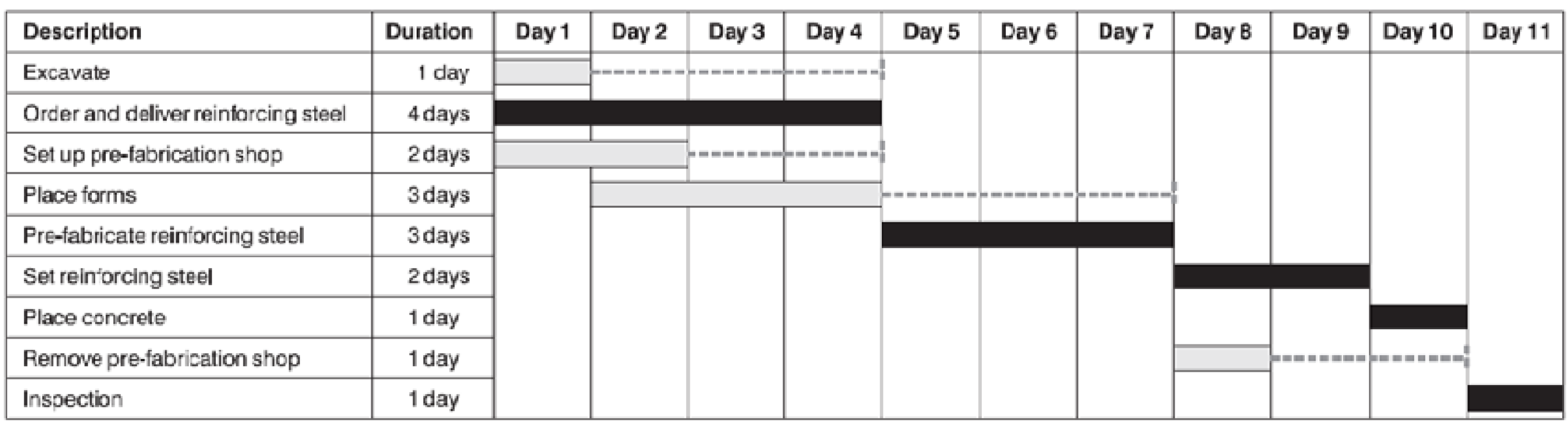
If a bar chart is used as the basis of the project schedule without first performing a network schedule analysis of the type to be described in the next section, the planner simply places the element's bar on the chart in the proper position relative to those for the other elements.

Bennett (1996) lists the following advantages of the bar charting approach to project:

1) simple to construct and easy to comprehend
2) convenient organization by work breakdown structure elements
3) with computer capability, easy to update and show project progress
4) relatively inexpensive to use
5) summaries at any desired WBS level.

However, there are also disadvantages in the use of bar charts without also performing a network analysis (Bennett, 1996).

1) There is no indication of interrelationships among activities.
2) In developing the bar chart, the analyst tends to fit the tasks into the available timeframe rather than analyzing closely how much time will actually be required.
3) The chart shows expected time requirements but not level of effort requirements.
4) Bar charts are impractical for complex projects with many tasks.
5) Without a computer-driven plot generator, updating of the schedule is time consuming.


Description
Duration
Day 1
Day 2
Day 3
Day 4
Day 5
Day 6
Day 7
Day 8
Day 9
Day 10
Day 11
Excavate
1 day
Order and deliver reinforcing steel
4 days
Set up pre-fabrication shop
2 days
Place forms
3 days
Pre-fabricate reinforcing steel
3 days
Set reinforcing steel
2 days
Place concrete
1 day
Remove pre-fabrication shop
1 day
Inspection
1 day

Network schedules

Since the late 1950s, a network-based approach to developing schedules has seen increasing use for all kinds of projects, including construction projects.

Project activities are related to each other on a network, showing the order in which they are intended to be performed.

The duration of each activity is estimated and calculations determine the time frame within which each activity can be performed and the time at which the project can be completed.

In addition, the calculations identify those activities that are most critical in establishing that completion time.

Two methods have been used to develop project networks:

1) One method uses arrows to represent the activities, with their endpoints depicting their relationships to other activities.
2) The other method uses boxes or similar nodes to signify activities and arrows or lines to connect the nodes in the order in which the activities are planned to be carried out.

General concepts

In drawing the network, we consider three questions for each activity:

1. What activity or activities, if any, must take place directly prior to this activity?
2. What activity or activities, if any, must take place directly following this activity?
3. What activity or activities, if any, can take place concurrently with this activity?

Each activity is represented by a node, a rectangle in this case.

Arrows connect the nodes to show the order in which the work is to flow.

Generally the sequencing is from left to right; in a complicated network, such sequencing might be violated, but the direction of the arrow always clarifies the work flow direction.

Nodes with no arrows entering from the left represent activities that can start at the beginning of the project; they have no predecessors.

Likewise, nodes with no arrows leaving from the right depict the final activities in the project; they have no successors.

While the planning function has many aspects, certainly one of the most important is this activity work flow definition.

Once this diagram is complete, we proceed from this part of *planning* to the *scheduling* of the activities.

These times result from some basic calculations that will lead to an estimate of the overall project duration.

An activity's *early start* time is the earliest it can begin, based on the early completions of all preceding activities; its *early finish* time is its early start time plus its duration.

For activities that can begin at the start of the project (those with no predecessors), we assign an early start time of 0.

For all other activities, the early start time is the latest early finish time of its immediate predecessor activities.

It is the *latest* early finish time because *all* predecessor activities must be completed before the activity under consideration can be started.

Thus, for any activity,

ES = early start time = 0 for all 'begin' activities; otherwise = max (early finishes of all immediate predecessors);

EF = early finish time = ES + duration.

We proceed through the network from beginning to end, in a process sometimes called the *forward pass*, until we reach the end of the project.

If the network included more than one finish activity (that is, if another activity or activities could proceed concurrently with 'inspection'), the project duration would be defined as the maximum of the early finishes for all finish activities.

Note carefully that an activity's early start and finish times are the earliest the activity *can s*tart and finish, based on prior activities.

The next set of calculations determines the *latest* an activity can occur without overrunning the target project completion time. First, we must designate a finish time for the project.

We perform a set of *backward pass* calculations to determine a latest start and latest finish time for each activity, beginning at the end of the project.

Figure 5.10 includes the results of these calculations, with late starts and late finishes shown under the lower left and right hand corners, respectively, of each node.

An activity's *late finish* time is the latest the activity must finish in order not to overrun the target completion time.

It equals the target project completion time if it is a finish activity; otherwise, the late finish is the earliest of the late starts for all of the activity's immediate successors.

It is the *earliest* late start time because this activity must be completed prior to the start of *all* successor activities.

The *late start* time is the late finish time minus the activity's duration. Thus,

LF = late finish time = target completion time for all 'finish' activities; otherwise = min (late starts of all immediate successors);

LS = late start time = LF – duration.

The difference between the late start and early start is a measure of the activity's criticality or of how 'tight' is it, schedule wise.

We call this difference the activity's *slack*, or *float*.

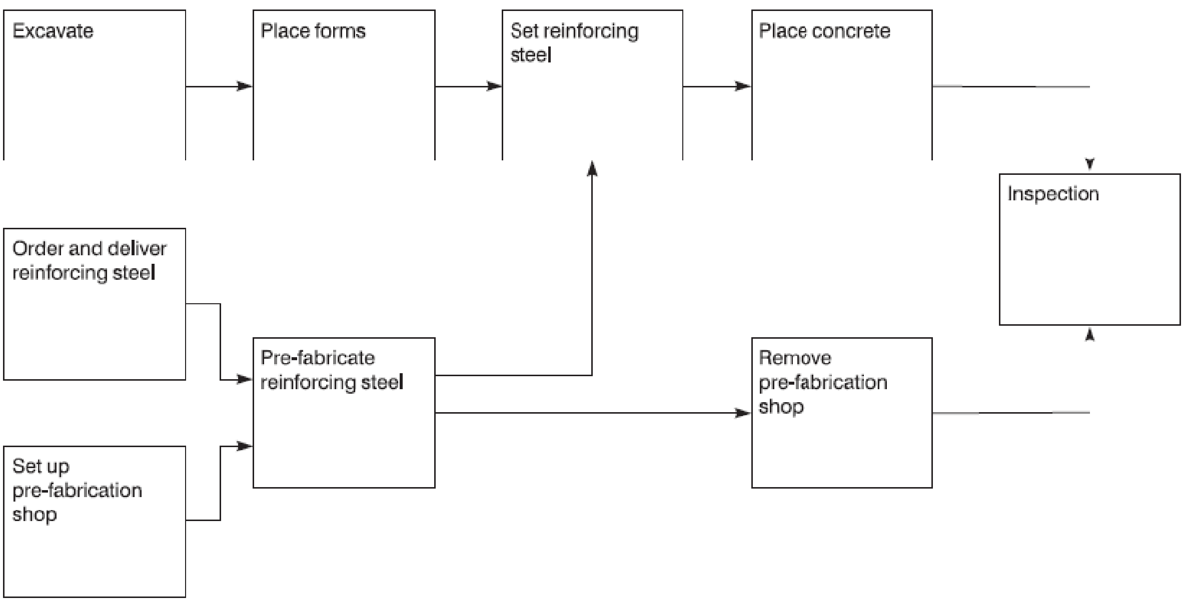
For any activity, a formal definition is SL = slack = LS – ES.

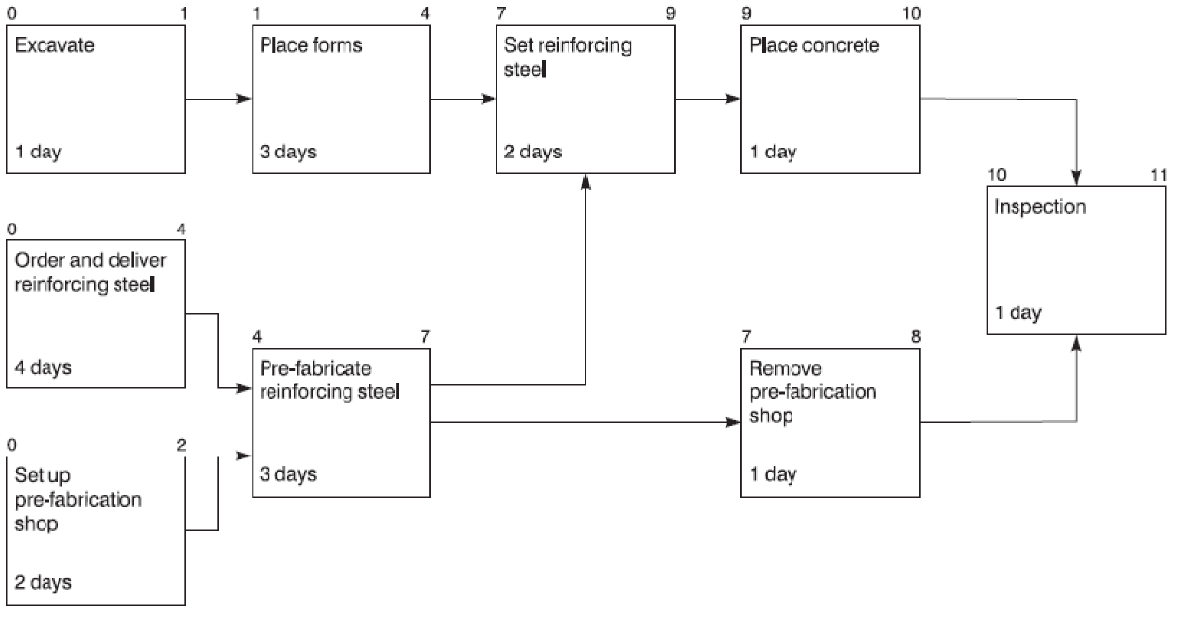
It can also be calculated as SL = LF – EF or as SL = LF – ES – duration. In practical terms, slack is the amount of time an activity can slip beyond its early times without causing an extension of the total project duration.

If an activity has slack equal to 0, it is said to be *critical*.

Critical activities cannot be allowed to slip beyond their early times with causing an overrun of the project's target completion time, because as their slacks equal 0, their late start and finish times are equal to their early start and finish times, respectively.

Furthermore, if it is desired to shorten the total project duration, one must focus on one or more of the critical activities; shortening only a non-critical activity, by working overtime, assigning more workers or otherwise improving its completion rate, will not result in any reduction in total project duration.




0
1
Excavate
1 day
1
4
Place forms
3 days
7
9
Set reinforcing steel
2 days
9
10
Place concrete
1 day
10
11
Inspection
1 day
0
4
Order and deliver reinforcing steel
4 days
4
7
Pre-fabricate reinforcing steel
3 days
7
8
Remove pre-fabrication shop
1 day
0
2
Set up pre-fabrication shop
2 days

Budgeting and cost systems

The basis for the contractor's priced proposal was the quantity survey and cost estimate.

The cost estimate becomes the basis for the contractor's project budget and the system that will assist in monitoring and controlling costs.

We describe in this section the process of converting the estimate into a budget and the preparation of cash flow curves that show the estimated pattern of expenses over the project's life.

From estimate to budget

If the cost estimate is produced properly, the conversion from estimate to budget should be accomplished with little difficulty.

The various work items that are the basis of the cost estimate will also form the basic structure of the budget, which is a plan for the financial aspects of the project against which actual financial performance can be measured and compared.

In the mobilization stage, the budget and the framework for cost control will be established.

The three purposes of construction cost control systems are:

1. to provide a means for comparing actual with budgeted expenses and thus draw attention, in a timely manner, to operations that are deviating from the project budget,
2. to develop a database of productivity and cost performance data for use in estimating the costs of subsequent projects, and
3. to generate data for valuing variations and changes to the contract and potential claims for additional payments.

The *cost accounting code system* must be simple enough to be understood and used in the field and also sufficiently comprehensive to acquire the data necessary to fulfill the three purposes listed above.

It is generally believed that a single cost-coding system should be used for all projects throughout the contractor's organization.

Cash flow projection

In addition to establishing the overall project budget and the cost accounting scheme, the contractor must be concerned with the *timing* of expenses and revenues.

To project these cash flows over the project's life will give the owner information about when to expect payment requests and in what amounts.

The preparation of a *cash flow projection curve* also provides the basis for one means of tracking overall project costs as the project proceeds.

In cash flow graph, activities were assigned their costs and values and, assuming that each activity will proceed on its early start–early finish schedule, these amounts were prorated across their respective durations and then summed for each day/week.

The resulting 'lazy S' curve is a typical representation of project progress as a function of time.

The project begins slowly and gradually increases its rate of progress, with the greatest rate occurring during the middle of the project, followed by slower progress toward the end.

An empirical rule for a typical project is that approximately 50% of project progress occurs during the middle third of the project, with 25% occurring during each of the first and last thirds (Pilcher, 1992).

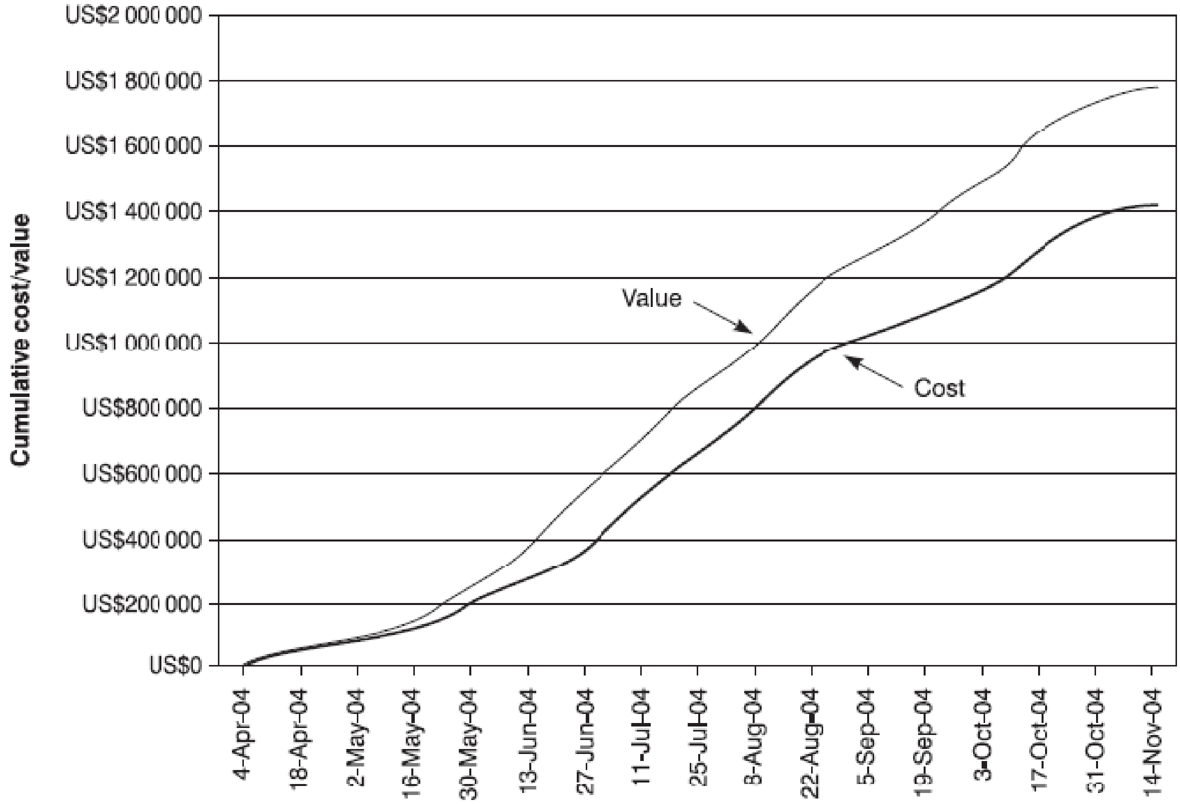
Note that the shown graph contains two curves. The curve of 'costs' forecasts estimated expenses over the life of the project, based on the quantities of work in each item and their unit costs as developed in the estimate.

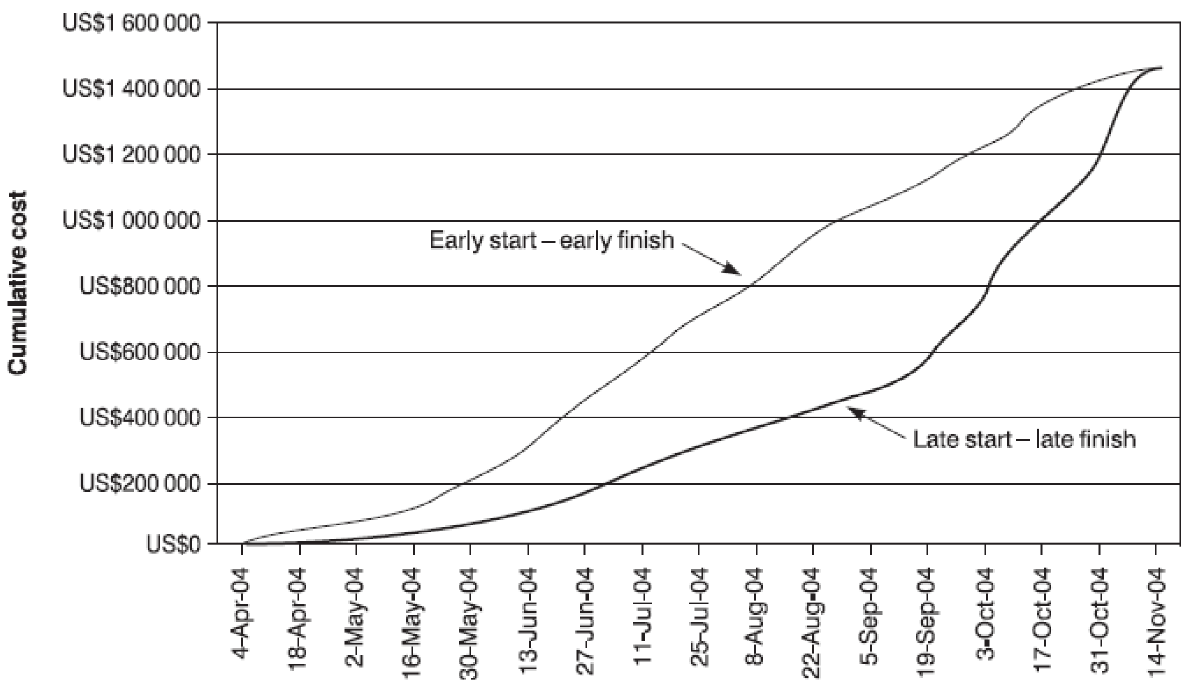
The second curve, of 'values', is a forecast of the value of the work in place, or contractor's gross earnings, at the end of each month.

In this example, it have been assumed a margin of 25% above costs to determine the amount the contractor will have earned as of the end of each period.

This 'value' curve and the cost curve, taken together, are important in assisting the contractor to plan its cash flow needs.

In actuality, this planning is more complicated than this figure implies, because there is usually a delay between the time an amount is earned by the contractor and the time of receipt of payment.


US$2 000 000
US$1 800 000
US$1 600 000
US$1 400 000
US$1 200 000
US$1 000 000
US$800 000
US$600 000
US$400 000
US$200 000
US$0
Cumulative cost/value
Value
Cost
4-Apr-04
18-Apr-04
2-May-04
16-May-04
30-May-04
13-Jun-04
27-Jun-04
11-Jul-04
25-Jul-04
8-Aug-04
22-Aug-04
5-Sep-04
19-Sep-04
3-Oct-04
17-Oct-04
31-Oct-04
14-Nov-04


US$1 600 000
US$1 400 000
US$1 200 000
US$1 000 000
US$800 000
US$600 000
US$400 000
US$200 000
US$0
Cumulative cost
Early start – early finish
Late start – late finish
4-Apr-04
18-Apr-04
2-May-04
16-May-04
30-May-04
13-Jun-04
27-Jun-04
11-Jul-04
25-Jul-04
8-Aug-04
22-Aug-04
5-Sep-04
19-Sep-04
3-Oct-04
17-Oct-04
31-Oct-04
14-Nov-04

This delay, which can be one or more months, and the fact that the owner may retain a portion of the earnings as an incentive for the contractor to keep producing, lead to situations in which the contractor's costs to date have exceeded revenues by a considerable amount, especially early in the project.

The cost curve is a convenient basis for comparing actual total project costs to date with the estimated costs on the curve.

The contractor can simply plot the actual costs and compare with the estimates.

At first glance, it would seem that if *actual* costs at a certain point in time are less than the *estimated* costs as of that same point in time, the project is in control, cost wise.

But delays may have caused smaller-than-planned progress and the work actually accomplished may have cost more than estimated.

Furthermore, the curve has been developed on the assumption that all activities will start and finish at their early times.

We know that non-critical activities have some amount of slack that allows them to be delayed without impacting project progress adversely.

Such delays can result in actual total costs to date that are lower than those shown on the curve, with no unfavorable consequences, provided that critical activities are on schedule.

In the second figure we have added a second cost curve to show the cumulative costs at the end of each week under the assumption that all activities proceed as late as possible.

The combination of the two curves is an envelope that gives a better indication of what the overall cost status ought to be throughout the project.

PROJECT OPERATIONS PHASE

Monitoring and control

The project program represents the plan for the schedule of the work.

Likewise, the budget is the plan for the cost aspects of the work.

In a similar way, the contractor will have plans for the management of quality, safety and environmental concerns.

During project operations, it is essential that actual performance be compared with planned performance in all of these areas and action taken to remedy any indicated deficiencies.

This responsibility is termed *monitoring and control*, where *monitoring* refers to methods for comparing actual with planned performance and *control* denotes the actions taken to attempt to bring deficient aspects of the project into conformance.

Schedule updating

Periodically, perhaps monthly, the contractor will compare schedule progress with that shown on the project program.

Often this task is carried out in conjunction with requests for payment prepared for the owner; sometimes such a schedule updating is a condition precedent to the approval of the payment request.

If the contractor is using only a simple bar chart for the program, actual progress can be plotted underneath each work item bar indicating, for active work, when each item started and when it finished if it did.

The network-based project schedule provides a convenient means for periodic monitoring and control.

Each activity is examined to determine its status, as of the updating date.

For those activities that have been completed since the last updating, their 'remaining durations' are set to zero.

For an activity currently underway at the time of the updating, the remaining duration will be the estimated time required to complete it.

The updating process also affords an opportunity to look at, and revise if appropriate, the durations of activities not yet started.

Even if an activity has not yet been started, new information that alters these assumptions may result in revised activity durations.

Furthermore, revised activity sequencing may also be called for during the schedule update, based on more information or decisions to alter methods used.

After activity duration and sequence data have been modified to reflect current conditions, the basic network calculations are performed, just as they were for the original schedule.

And, as before, the results indicate the early and late start and finish times and the slack for each activity that has not been completed, the critical path and the current estimated project completion date.

If the results are compared with the original program, the manager can easily tell whether the project is on schedule.

There may be legitimate reasons for a projected overrun of the original project completion date, such as owner requests for additional work or allowable delays due to weather or labor problems.

If the project is truly behind schedule, the contractor can employ a variety of methods to try to bring it back into conformance.

Among these methods are the following:

(1) altering the activity sequences so as to compress the schedule by carrying out some activities earlier than originally planned and shortening the critical path;
(2) reducing the durations of some of the activities currently underway, by implementing such approaches as increasing crew sizes, changing methods or adding shifts; and
(3) attempting to gain time later in the project by re-evaluating future activities. The third method may be the easiest to plan but the most difficult to carry out; it is easy to rationalize that things will get better!

Monitoring is relatively easy! Control, or bringing the project program back into conformance, is the challenge!

Cost control

In this section, we focus on the monitoring and control of costs during the construction operations phase, based on whatever system was established during project mobilization.

Two related outcomes are expected from the periodic monitoring of costs:

(1) identification of any work items whose actual costs are exceeding their budgeted costs, with subsequent actions to try to bring those costs into conformance with the budget and

(2) estimating the total cost of the project at completion, based on the cost record so far and expectations of the cost to complete unfinished items.

Cost reports

Cost reports are intended to provide timely information about the status of the project budget so that managers can take any actions indicated to attempt to bring the project into compliance with the original budget.

They must be timely, being available soon after the end of the period they cover.

They must be as accurate as possible while meeting the requirement for timeliness.

They must be simple and concise so that they will be used and understood by those charged with interpreting and acting upon them.

The level of detail provided by the cost accounting scheme ought to balance the considerations of concern in the above quotation.

Another consideration is the frequency of report generation.

If a report is produced only every several months, the opportunities to correct out-of-control items are diminished and the effort to produce such a report may result in its delay well beyond the end of the reporting period.

The amount of detail shown on a cost status report is dependent on the people who will use the report; summary reports by major cost classification will suffice for company executive personnel, while as much detail as possible is important for operating personnel in the field.

Quantity section

- The "*total*" values are the estimated quantities taken directly from the estimate sheet.
- The "*end-of-previous-week*" values are the quantities completed during and reported at the end of the previous week.
- The "*this-week*" values are those quantities installed during the finished week, as determined by physical measurements and delivery data.
- The "*to-date*" values are calculated by adding the "*this-week*" values to the "*end-of-previous-week*" values.
- The "*% complete to date*" for each item is its "*to-date*" quantity divided by its "*total*" quantity, with the result expressed as a percentage.

Cost section

- The "*total-budget*" values are the estimated cost of each item, taken directly from the estimate sheet.
- The "*end-of-previous-week*" values are the actual costs of each item taken from the report for the end of week one.
- The "*this-week*" values are the actual costs of labor, material, equipment and subcontracts for each item, as reported via time sheets, material invoices and similar documents.
- The "*to-date*" values are calculated by adding the "*end-of-previous-week*" and "*this-week*" values for the respective items.
- The *estimate-to-complete* values represent the judgment of project management staff for the cost required to complete the remaining work on the item.
- If an item is 100% complete, of course, its *estimate to complete* will be US$ 0.
- For an item that is partially complete, it is possible to assume that the cost to complete the item will be in proportion to its cost to date and its current completion percentage.

Seldom will a simple proportionate estimate be appropriate. If an item has not been started, the "*estimate to complete*" is likely to be the "*total budget*", although information about requirements or methods received after preparation of the estimate may require that this value be revised at this time.

- The "*estimate-at-completion*" values are calculated by adding the to-date and "*estimate-to-complete*" values.
- The estimated "*variance at completion*" is the difference between the "*estimate at completion*" and the original "*total budget*".

Unit cost section

It is useful in determining how much the completed work should have cost and is also useful as one measure of project progress, as we shall see.

The *budgeted cost of work performed (*usually called *"Earned Value")* is a simple weighted average, found by multiplying each item's total budget by its completion percentage and then summing these products for all items.

A report could be prepared for each of the elements of cost or they could all be shown in detail on a single report.

Or a report with less detail might be prepared, perhaps for upper management, including only the completion percentage, budget, estimate at completion and variance for each item.

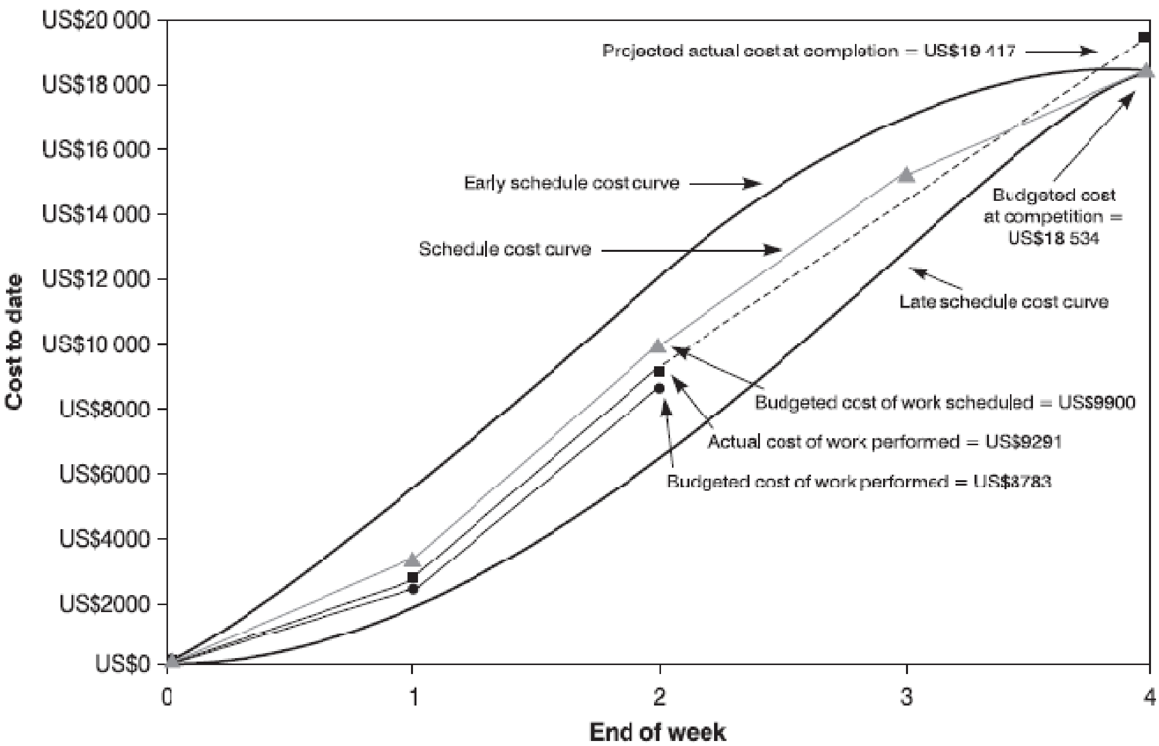
schedule variance (SV) = BCWP – BCWS

cost variance (CV) = BCWP - ACWP

The sum of these two variances is called the total variance, where

total variance (TV) = CV + SV

= (BCWP - ACWP) + (BCWP – BCWS)



Quality management

If monitoring and control are about schedule and cost, they are also surely about the management of quality.

First, what is quality? There are many definitions. The Institute of Quality Assurance (2002) says this about quality:

"In its broadest sense, quality is a degree of excellence: the extent to which something is fit for its purpose. In the narrow sense, product or service quality is defined as conformance with requirement, freedom from defects or contamination, or simply a degree of customer satisfaction."

If we utilize this understanding of quality, then we see that the contractor's task in managing quality is to assure compliance with the technical requirements of the project, as described in the contract documents, through a series of steps that plan, execute, monitor and control the physical aspects of the work.

The approach, if viewed in this way, is thus parallel to the management of the project's program and budget.

The contractor's activities in assuring quality are said to involve both quality assurance and quality control.

Quality assurance may be defined as "planned and systematic actions focused on providing the members of the project team with confidence that components are designed and constructed in accordance with applicable standards and as specified by contract."

Quality control is "the review of services provided and completed work, together with management and documentation practices, that are geared to ensure that project services and work meet contractual requirements".

Thus a contractor's *quality assurance* program includes all activities that "assure quality" including (but certainly not limited to) selection of subcontractors, training of the workforce, use of proper methodology and the various testing activities.

Quality control is one aspect of quality assurance, the aspect that:

(1) 'reviews' work done to determine whether it conforms to requirements
(2) brings it into conformance if the examination identifies defects.

Total quality management can be defined as "a cooperative form of doing business that relies on the talents and capabilities of both labor and management to continually improve quality and productivity using teams with the ultimate goal of delighting both internal and external customers” (Bennett, 1996).

The F´ed´eration Internationale des Ing´enieurs-Conseils (FIDIC) has identified decreasing quality of construction as a worldwide problem.

A 2001 report suggests that ‘the squeeze on costs, both of construction and supervision, is having an adverse effect on construction quality, as can be predicted’ (F´ed´eration Internationale des Ing´enieurs-Conseils, 2001).

One means of attempting to alleviate construction quality problems and assuring quality performance by construction contractors is certification by the International Organisation for Standardization.

That organization uses the designation ISO to refer to all of its standards, the term being derived from the Greek *isos*, meaning *equal*; thus its standards apply equally or universally for a given situation or condition.

The ISO standards related to quality are known as the ISO 9000 series of standards.

The ISO 9001 standards are for organizations that design, produce, install and service products, while the ISO 9002 standards apply to organizations that only produce, install and service products.

The standards apply to all kinds of organizations. In the realm of construction, ISO 9002 certification is sought by contractors who do not perform design services, while design–build contractors fall under the ISO 9001 guidelines.

Even before the project begins, the contractor is expected to have its company-wide quality assurance/quality control program in place.

Quality in the Constructed Project: A Guide for Owners, Designers and Constructors (American Society of Civil Engineers, 2000) lists the following elements as appropriate for such a program:

- Recruiting and assigning a skilled workforce
- Quality control organization
- Project progress schedule
- Submittal schedule
- Inspections
- Quality control testing plan
- Documentation of quality control activities

- Procedures for corrective action when quality control and/or acceptance criteria are not met.

Among the project-specific requirements of the contractor's quality assurance/quality control program are the following (American Society of Civil Engineers, 2000):

- Use of qualified subcontractors
- Inspection, control, and timely delivery of purchased materials, equipment, and Services
- Identification, inventory, and storage of materials, parts, and components pending incorporation into the project
- Control of measuring and test equipment
- Segregation and disposition of nonconforming materials, equipment, or components
- Maintenance of records specified by contract and required by the contractor's QA/QC program to furnish evidence of activities affecting quality.

Documentation and communication

The on-site management of a construction project involves great amounts of paperwork, even for relatively small projects.

The purpose is to communicate directions, questions, answers, approvals, general information and other material to appropriate members of the project team, so that the project can proceed in a timely, cost-effective and quality manner.

Submittals

The drawings and specifications prepared by the design professional are the basis for determining the contract price and for overall job planning, but in many cases they are not sufficient for the fabrication and installation of the various job elements.

Further details are provided by supplemental documents furnished by subcontractors, material suppliers and in some case the contractor itself.

The term "*submittals*" refers to the totality of the shop drawings, product data and samples; all of these documents are submitted to the owner or owner's representative for approval prior to fabrication and manufacture of the items they represent.

Note well that the contractor is responsible for managing the submittal process, including the incorporation of all submittals into the network-based project program (network analysis system).

Shop drawings are the supplier's or fabricator's version of information shown on the drawings already prepared by the design professional.

Product data can consist of manufacturer's catalogue sheets, brochures, diagrams, performance charts and illustrations.

In the case of an electric motor, for example, the data might include dimensions, weight and required clearances, plus such performance data as revs per minute, power characteristics and consumption and noise level curves.

Samples are especially important for demonstrating that the contractor will furnish the various required architectural features to the satisfaction of the design professional.

Technical specifications usually stipulate in detail the quantity, size and contents of shop drawings and other submittals.

In the case of a single prime general contractor, all of this information flows through the general contractor.

Scheduling the approval process for each material must contain sufficient contingencies to permit revision and resubmittal if needed.

If done properly, the project program will identify as critical, or nearly so, those approval sequences whose timing must be managed most closely.

Often the contract documents will specify the amount of time allocated for review.

A "*submittal log*" is the document that is the backbone of this process.

Used in conjunction with the overall procurement schedule, it records the scheduled and actual dates and actions taken by each party to the process, for each submittal.

Variations

During the execution of the construction contract, one matter that requires careful documentation and thorough communication is the case of changes in the work.

Changes, also known as *variations*, arise for many reasons: the owner may decide to add some new item to the project, delete some portion of it or add to, reduce or modify an already defined part of the job.

Unexpected site conditions discovered during the course of construction, including soil conditions, archaeological findings, endangered species or hazardous materials, may require a change.

Discrepancies may be discovered in the contract documents.

Codes or regulations may change after the contract is signed, requiring a change in the contract.

When the owner desires to initiate a variation in a lump-sum construction contract, the process is somewhat more complicated.

The contract contains detailed language outlining the process to be followed and the various types of documentation required.

The process begins with a decision by the owner or design professional to consider a change in the work, for any of the reasons listed above.

The design professional then prepares a *variation (change order) request*, outlining the work to be added, deleted or modified and forwards the request to the contractor.

The contractor estimates the cost impact of the change (either an addition or reduction) as well as the effect on the schedule, completes a *variation (change order) proposal* and forwards the proposal to the design professional.

Some contracts restrict the contractor's proposed price to its estimated costs plus a stipulated percentage for overhead and profit.

If the design professional and owner agree that the proposal should be accepted, a *variation (change order)* is written and forwarded to the contractor.

If there is disagreement, the parties may negotiate in an attempt to resolve differences.

The contract may provide that, if agreement cannot be reached at this stage and if the change is required, the owner or its representative can direct the contractor to carry out the work, with the final terms of payment and schedule impact to be decided later.

In some cases, the contractor may be directed to do the work, with payment to be based on the actual costs plus a fee or on a time and materials basis.

It is important that the contractor does not proceed with a change until the written variation is issued.

To do so may make it impossible to obtain payment for any extra work.

The term "*constructive change*", as opposed to a "*directed change*", refers to an informal action by the owner or its representative that result in a de facto change in the contract requirements.

If the on-site owner's representative provides an interpretation of defective drawings or specifications or conducts a faulty inspection, these actions may result in increased costs to the contractor.

Even in the absence of a written variation, the contractor may be entitled to extra compensation.

Measurement, progress payments and retainage

The basis for payment depends upon the type of contract.

In every case, some sort of measurement is carried out to assess the amount of work completed.

It is common practice to prepare payment requests every month.

In the case of a cost-plus contract, the 'measurement' consists of the various documents that demonstrate that the contractor has incurred the costs during the period.

With its requests, the contractor will submit audited material and equipment invoices, certificates of material taken from inventory, audited payroll information, billings for any construction plant whose expenses are allowed as 'costs' and approved subcontractor billings.

The contract documents ought to clarify which expenses are allowable as reimbursable and which must be covered by the fixed or percentage fee.

A summary page is used to total the several costs, after which the appropriate fee is added to determine the total amount earned in that period.

If the project is being constructed under a measure-and-value (unit-price) contract, careful measures of each pay item must be made as the work is installed.

The quantity surveyor is often involved in these measurements.

Contract documentation

- The contract itself, as amended by variations (change orders) during the project.
- Drawings. Design drawings from the design professional, as revised throughout the project, with any supplementary sketches.
- Specifications. Technical specifications, plus general and special conditions and other parts of the project documents manual.
- Subcontracts. Copies of agreements with all subcontractors.
- Insurance. Certificates of all insurance carried by the contractor, as well as certificates for insurance required to be carried by all subcontractors.
- Bonds. Contractor’s copies of its performance and payment bonds, plus proof that subcontractors have furnished surety bonds.

Communication records

- Meeting minutes. Records of all meetings held at the jobsite or elsewhere if pertaining to the project; regularly scheduled general and safety meetings.
- Telephone records. Brief records of all telephone calls placed or received at the jobsite.
- Conversation records. Often simply a memorandum to the file to record an understanding resulting from a conversation that was less formal than a meeting.

Project status documentation

- Daily reports. A standard report that includes weather conditions, work in progress, number of direct employees and subcontractor personnel on site, visitors, equipment on site, material deliveries and special issues.
- Weekly and/or monthly reports. Summary of accomplishments for the period, comparison of actual with planned schedule progress, cost status, change orders and special issues.
- Progress photography. Periodic still and video photography that records project progress.

Correspondence

- Letters. All letters written by the contractor, as well as those received at the jobsite office.
- Field memoranda. Various types of correspondence, less formal than letters, issued at the jobsite to subcontractors, forepersons and other individuals; job directives, safety issues and disciplinary matters.
- Transmittals. Accompany submittals to owner's representative, subcontractors and material suppliers, accompany requests for payment and accompany certificates and other documentation at project closeout.
- Requests for information (RFIs) issued from contractor to design professional or owner for clarification of design information or to present any other questions.

Materials management

- Purchase orders. Issued to material suppliers, as explained in an earlier section.
- Submittals. Shop drawings, product information and samples, plus status information on their review and approval.
- Expediting and delivery information. Status of manufacturing, shipping and delivery of each material item, with comparisons against project schedule.
- Material inventory status. Inventory of all stored materials, with quantities and dates when items were added and withdrawn.
- Quality control reports. Concrete test reports, soil laboratory results, off-site testing of steel components and so on.
- Invoices. Also part of cost system. All requests for payment of materials, with summary log of status of each.

Financial management

- Requests for payment. Prepared by contractor to request periodic payments as the project progresses, as explained earlier.
- Cost and budget tracking reports. Comparisons of actual costs to date against planned costs, for individual work items and the project as a whole; analysis of cost trends.
- Variation requests. Requests from the owner for proposals for changes in the work; summary log of status of each.
- Variation proposals. Prepared by the contractor for the owner, in response to variation requests; summary log of status of each.
- Variations. Orders from the owner authorizing changes in the work; summary log of status of each. Note that one log may suffice for variation requests, variation proposals and variations.

Legal issues

In this final section of our consideration of the contractor's activities and responsibilities during the project operations phase, we must confront the fact that legal matters often arise as the fieldwork progresses.

We begin by describing a typical process for filing a claim, usually against the owner.

Because the claims process sometimes escalates into a contract dispute, we next discuss means for preventing disputes and then present various approaches to their resolution.

Claims process

The issues that are the subjects of claims tend to depend upon the type of contract.

For example, in a fixed-price contract, a claim may be filed by the contractor if it finds conditions at the site to be different from those represented by the contract documents, whereas the contractor in a cost-plus contract is not likely to file a claim in that case.

A more common claim under a cost-plus contract arises out of the interpretation of the term *reimbursable costs*; the contractor may claim that the costs were incurred but were not allowed as reimbursable, while the owner may counter that such costs are to be covered by the fee.

The kinds of conditions giving rise to claims by the contractor include late payments, changes in the work, constructive changes, changed conditions, delay or interference by the owner, acceleration by the owner resulting in loss of productivity, errors or omissions in design, suspension of the work, variations in bid-item quantities, failure to agree on variation pricing and rejection of requested substitutions.

Many are resolved quickly, to the satisfaction of both parties. If an unforeseen condition is encountered, say an unexpectedly difficult soil layer, with proper documentation the contractor may convince the owner or its representative rather easily that additional compensation and/or time should be granted. When a claim cannot be resolved through such a process, the issue can be said to have become a *dispute*, which is a legal disagreement involving two or more parties.

Dispute prevention and resolution

A construction contract dispute arises when one of the parties is unsatisfied with the result of a claim.

In the example of the discovery of an unexpected soil layer cited previously, the owner may deny the contractor's claim for additional compensation or time or may grant only part of what the contractor sought.

If so, the contractor may choose to pursue the matter further, using a process outlined in the contract documents or some other process. When the decision is made to pursue the matter further, the issue becomes a *dispute*.

The contractor is well advised to remember that it must have exhausted the claims process before it pursues the dispute resolution process.

Any authority in charge of conducting a formal dispute resolution will inquire whether all the required steps have already been followed to resolve the claim.

If they have not, it is likely the request for consideration of the dispute will be denied.

The contractor who 'files a lawsuit' immediately when a potential claim arises will be told to follow the rules and then come to the court if still unsatisfied.

An application for arbitration is also likely to be denied under the same circumstances.

It is helpful to divide such construction contract disputes into two aspects, legal and technical.

The legal aspect has to do with whether the party seeking redress has any legal entitlement to a remedy, based on interpretation of the contract and other documents.

If so, the technical data is used to ascertain the magnitude of the recompense.

Most disputes contain both of these aspects.

Dispute prevention

The following list suggests ways by which construction contract disputes can be prevented or at least minimized.

- Accurate, complete design documents. The more clearly the project is defined through the documents, the less likely there will be conflicts.
- Good design can be enhanced through design reviews: internally, by the owner and by independent peers.
- Contract provisions that allocate risk equitably among the parties.

  Contracts that make the contractor entirely responsible for such risks as weather, unforeseen conditions, delay by the owner, labor unrest, material shortages and inflation are likely to be more dispute prone than those that spread such risks among the parties.
- Constructability reviews. We have encouraged the use of such reviews during the design process, utilizing experts on practical aspects of construction to advise on the plausibility of the design from the contractor's point of view, including the cost and schedule impacts of various alternatives.
- Partnering. It is a means of fostering cooperation throughout the building process.

  The parties anticipate problems and design an approach that commits them to resolving issues before disputes arise.
- A reasonable, sufficiently detailed project program and adherence to the program by all parties.

  Adequate flexibility must be part of the management of the program, to enable the parties to deal with unforeseen circumstances.
- Maintenance of thorough project records.

  Each party must maintain appropriate documentation, from minutes of discussions to variations; distribution of records to those authorized and needing to know is a wise means of minimizing misunderstanding.
- Minimizing the number of contract changes.

  This suggestion can be realized through the careful and complete design.
- Dispute review boards or single experts for smaller projects.

Differing site conditions

An especially perplexing problem in the drafting and interpretation of construction contracts is the handling of unexpected conditions at the building site.

The terms *differing site conditions* and *changed conditions* are both used to refer to this situation.

While the majority of unforeseen and differing conditions are found in subsurface work such as tunneling and foundation construction, such situations can also arise in rehabilitation and restoration work, retrofitting to meet revised seismic codes and projects that improve energy efficiency.

These latter cases often involve a lack of as-built drawings or any plans and specifications from the original work.

Whether the contractor is entitled to any sort of relief in these situations is often dependent on whether the owner or owner's representative was given proper notice of the discovery of the condition.

The importance of timely notice and the availability of an 'equitable adjustment' to the contract are important aspects of the clause cited above.

It is important to distinguish between two types of conditions for which relief may be granted. These types have come to be known as *Categories I and II*, in which Category I is 'a condition encountered at the work site that is different from that represented in the contract documents'.

Simon (1989) refers to this category as 'the administrative equivalent to a breach of contract', because the owner essentially failed to provide what it promised when entering into the contract.

Category II is 'a condition that is materially different from what a contractor would reasonably expect to encounter on the project.

In this case, relief is predicated on having a clause in the contract that spells out how such relief is to be provided'.

The contractor is expected to conduct a reasonable site inspection prior to submitting its tender.

Delays

Two types of delays are of special interest to the contractor during the project operations phase.

1. The first is that which has been, or may have been, caused by the contractor and for which the owner expects some sort of compensation.
2. The second type is caused by the owner; in this case the contractor may expect both additional time to complete the project and some amount of monetary payment.

Each of these types of delays can result in complicated legal entanglements.

Not all delays are compensable

Delays on construction projects can be complicated and difficult to analyze.

A far from exhaustive list of causes includes failure to make the site available as planned, weather, labor strife, fabrication problems, shipping problems, lack of timely review and approval of documents, lack of other timely decisions, poor overall planning, poor schedule monitoring and control, ineffective jobsite coordination of personnel and materials and low labor and equipment productivity due to many reasons discussed earlier.

There may be overlapping or concurrent delays.

Their origins, their impacts and the respective responsible parties may be difficult to identify.

If the contractor fails to complete the project within the time stipulated in the contract or possible additional time allowed due to variations or contract-specified excusable delays, the contractor may be subject to the assessment of *liquidated damages*.

Three points regarding liquidated damages are especially important.

1. First, such contract provisions are held to be enforceable only if *time is of the essence*.

   In US law, courts have consistently decided that time is not considered to be 'of the essence' unless there is a statement in the contract to that effect; an owner wishing to be able to enforce a liquidated damages provision must be sure the contract is complete in this regard.

2. Second, *liquidated* damages are not intended to penalize the contractor but to compensate the owner.

   Thus, a liquidated damages clause that is in reality a penalty clause will not be enforceable unless the contract includes a companion clause providing a bonus for early completion.

3. The third point about liquidated damages is that they must be a reasonable approximation of the actual damages the owner would suffer due to late completion.

The law distinguishes between excusable delays, for which the contractor is not held responsible and non-excusable delays, which are those caused by the contractor and for which liquidated damages tend to be assessed.

If the contractor is delayed due to some act of the owner, such as lack of availability of the building site or late arrival of owner-furnished materials, what remedies are available to the contractor?

Certainly a time extension is likely to be granted, as provided in a contract section such as that quoted just above and thus no liquidated damages assessed, if it can be shown that the contractor was not at fault.

But what about some extra money to cover lower productivity while waiting, extra overhead costs and possibly other expenses?

Some contracts contain explicit *no damages for delay* clauses.

A helpful distinction in considering excusable delays is to label them *compensable*, if they are caused by the owner (a no-damages-for-delay clause absent) and *non-compensable*, such as an act of God or an epidemic, for which only a time extension is usually granted.

Is there such a thing as a 'reasonable delay'?

Suppose the contractor fails to have the project ready for a subcontractor's activities on the date specified in the subcontract; is the subcontractor entitled to some sort of relief?

The answer probably turns on the specific language in that subcontract, such as whether it contains a no-damages-for-delay clause in favor of the prime contractor.

Different courts have produced different outcomes.

Contract termination

1. One of the reasons that parties to construction contracts do not more frequently exercise their rights to terminate is the serious consequences that can occur to the party initiating the termination if it is later found that the termination was without proper cause.

   Usually a construction contract gives both the owner and the contractor the right to terminate the contract before completion under certain circumstances.

   However, it is much more common for the owner to initiate the action. The grounds for contractor-initiated termination are generally limited to stoppage of work by the owner for at least a specified number of days, through no fault of the contractor, stoppage of work due to non-issuance of a certificate of payment and failure of the owner to provide evidence that it will fulfill its financial obligations.

2. The second of these reasons is most common; 'rarely does anything but non-payment justify termination by the contractor'.

   It is also important to understand that termination can occur through mutual agreement of the parties; there may be good reason for both sides to want to 'call the deal off' part way through.

   The two sides can agree to 'unmake' their bargain, just as they have agreed to make it.

   Because this type of termination is also rare, the balance of this discussion is devoted to termination actions initiated by the owner against the contractor.

A well-made construction contract will include language that provides the grounds and the process for termination of the contract by the owner and by the contractor.

Under a typical contract, the owner is entitled to terminate the contract for *default* and for *convenience*.

The usual *default* acts or omissions by the contractor, which entitle the owner, at its option, to terminate, include the following:

- substandard, defective or non-conforming work;
- failure to pay subcontractors and suppliers;

- failure to pursue the work diligently, including failing to supply enough workers with proper skills and enough materials and failing to comply reasonably with the project program;
- violation of laws, ordinances and regulations, including non-payment of various taxes, failure to secure required permits and licences and non-compliance with safety laws;
- other substantial breaches of the contract.

The owner or its representative must give proper notice of the termination to the contractor and to its surety, if there is one, allowing a specified amount of time for the contractor to 'cure' the default.

If, after this time period, the contractor is still in default, the contract can be terminated.

The owner can then take possession of the site, any unused materials, plant and tools, retain some or all of the subcontractors and complete the project in any manner it wishes.

If a surety is involved, the performance bond will provide for the surety to have responsibility for project completion, either with its own forces or agents; with a contractor selected by the surety through a normal selection process, to be paid by the owner with reimbursement to the owner by the surety up to the amount of the bond; or by simply paying the owner the amount of its liability.

The contract may provide the owner the right to terminate the contract for its convenience.

A manufacturer may decide to build a new factory and then, while the project is underway, decide the project is no longer financially feasible.

Perhaps a laboratory facility becomes outmoded even while under construction.

Or funding for a school construction project may be withdrawn unexpectedly.

If a *termination-for-convenience* clause is absent from the contract, the owner would be in default if it simply told the contractor to stop work and ceased making payments.

If the owner invokes such a clause, the contractor is normally required to stop work, cease placing orders, cancel orders currently outstanding and do all else needed to conclude performance of the contract.

Certainly the contractor will be dealt with less harshly than if the contract is terminated for default. Payment to the contractor includes reimbursement for work performed to date, unavoidable losses it may have suffered, expenses required to protect the property and profits on work performed (and, in some contracts, profits on work *not* performed!).

Finally, we note that the law may operate to allow termination of the contract even if the contract is silent regarding termination rights.

An examination of the facts, circumstances and intent of the parties will try to determine whether there has been a 'material breach' that would lead fairly to a termination.

An owner of some land entered into a contract with a builder who agreed to construct a house and dig water well.

A dispute arose over additional costs for drilling and casing the well to a depth greater than anticipated.

The owner refused to pay these extra billings and the builder terminated the contract.

Was the work stoppage by the builder a breach of the contract?

If so, was it 'material'?

The court noted that the owner was deprived of the benefits of receiving a completed home and the builder had no intention of curing its failure to perform.

It concluded that the builder's breach 'constituted a material failure of performance' and thus absolved the owner from all liability under the contract.

PROJECT CLOSEOUT AND TERMINATION PHASE

Introduction

A sage observer of project management has said 'Projects proceed smoothly until 95% complete, and then they remain at 95% forever!

Another observed '90% of the effort is expended on the first 90% of the project, and the other 90% is expended on the other 10% of the project.'

Often termed *commissioning*, this phase must be planned and programmed, tasks must be assigned, the phase must be executed effectively and its costs, schedule and quality must be controlled.

We have chosen to divide the tasks into two categories:

(1) completing the work, which includes the physical activities that must be accomplished on the site and

(2) closing out the project, involving the multitude of required documents and other paperwork issues, some related obviously to finances but others to certificates, project records and provision to the owner of the required training, operational information, spare parts and the like.

Completing the work

Testing and startup

Depending on the nature of the project, there may be substantial amounts of testing and initial startup of various systems, especially mechanical and electrical systems.

The installer of each system will have made them operational, but the specifications will usually require that they be started and tested under operational conditions at the end of the project.

This latter work may be performed by the prime contractor, subcontractor, manufacturer's representative, special testing consultant or owner's personnel.

In any case, the owner will be represented on site during the test.

Proper records of the test will include the date and location, the persons involved, the methods and the results (Mincks and Johnston, 1998).

Cleanup

At the end of the project, however, much more thorough cleaning is required.

This cleanup includes, for a building project, the scouring of walls and ceilings, shampooing of carpets, cleaning of exterior walls, window washing and any other cleaning required to remove dust, grease and other accumulations and render the facility usable and attractive to the user and the general public.

Specialist cleaning contractors may be employed to provide these services.

Cleanup also includes the removal of various temporary facilities such as haul roads, security fencing, utilities, storage sheds and offices, as well as surplus materials, scrap and construction plant. Disturbed landscaping, walkways and drainage facilities may need to be put back to their original condition and any off-site streets used by the those working on the project may need to be repaired and cleaned. While subcontractors may be legally obligated to the contractor to provide their share of the cleanup effort, the owner looks to the contractor for the satisfactory completion of this work, just as with other work on the project.

Preliminary punch lists

The strange term *punch list*, also known as a *snagging list* or an *inspection list*, refers to a list of work items yet to be completed, including repairs and discrepancies, in order to fulfill the contract's requirements.

Punch lists are prepared in various forms, but all contain the location of the needed work, its description, and the party responsible for the correction, with some means to indicate when the item has been remedied.

If a preliminary punch list is used, it is typically prepared by the contractor for the use of its own personnel and its subcontractors, based on a preliminary inspection by the contractor.

Pre-final inspection

When the preliminary punch list items have been completed to the contractor's satisfaction, the design professional and the owner are notified that the project is ready for its *pre-final inspection*.

Representatives from all the design disciplines, from the owner's organization and from all major subcontractors as well as the prime contractor participate in this inspection, which is in the charge of the owner and its representatives.

Some of the testing and startup activities may take place at this time, although there must be reasonable assurance that the components being tested have already been subjected to some checking.

Final punch list

It is likely that the pre-final inspection will identify some remaining deficiencies.

The result is a *final punch list* containing those items still requiring effort in order for the project to be accepted.

The owner's on-site representative may be involved in inspecting and signing off on individual items on the final punch list. If some items are still defective, the punch list must be revised.

Numbering and dating each item and dating each version of the list are essential to maintaining an accurate record of the process of correcting deficiencies.

Final inspection

When the contractor believes that all punch list items have been taken care of, the owner is notified that the project is ready for its *final inspection*.

This inspection is less time consuming than the pre-final inspection, as it involves ascertaining only whether those items on the final punch list have been corrected.

Fewer people are likely to be involved, although surely the contractor, a member of the design professional team and an owner's representative will participate.

Personnel actions

By definition, a project is a temporary endeavour and thus it is no surprise that the project team must be dissembled, but such partings nonetheless are often difficult.

For the contractor's management personnel, there is likely to be employment on other projects.

If no project is immediately in need of a person's services, they may be assigned a temporary position, perhaps in the home office, depending on the company's employment agreement with that person.

Some personnel may seek employment with other organizations.

People hired from within the local community are likely to stay there, although the contractor may choose to offer permanent positions to particularly well-qualified and effective personnel it has hired for the project locally.

In the case of those people whose employment is being terminated, the necessary paperwork must be completed, with sufficient notice of termination (even though termination should not be a surprise!).

For employees who are being transferred, arrangements for salary, travel pay, starting date, job description and other matters must be coordinated both with the employee and the new project.

Closing out the project

In closing out the project, the contractor pursues several activities concurrently.

We describe, first, the sequence of efforts related to project financing, followed by a number of other matters involving documentation required before the project is finally complete.

Subcontractor payment

One of the things the contractor must do before it can receive its final payment, including any retainage that has been withheld, is to complete paying its subcontractors.

Thus, as the project nears completion, the contractor must work with each subcontractor to determine the amount of work remaining and its value, the approximate completion dates for the remaining work, the amount of payment due, including any retainage amounts withheld by the contractor and any disputed claims or payments.

The contractor may have performed services for a subcontractor, such as providing short-term use of lifting equipment or performing cleanup or hauling services for the subcontractor.

The usual practice is for the contractor to *backcharge* the subcontractor by reducing its payment by the value of the services.

Likewise, subcontractors may backcharge the general contractor for miscellaneous services not covered by their subcontracts.

When all issues have been resolved, final payment can be made to subcontractors, allowing the contractor to certify that such payments have been made.

Consent of surety

On projects that require a payment bond from the contractor, the owner normally requires a *consent of surety for final payment* prior to making final payment to the contractor.

This completed form is issued by the bonding company and assures the owner that the surety company approves of the payment to the contractor.

The surety can audit the contractor's records to verify that no unexpected financial obligations exist prior to issuing the release.

Final quantities

The type of contract determines whether the contractor and owner must monitor and agree upon quantities placed into the project. Under a lump-sum/fixed-price contract, the contractor will be paid its contract price adjusted for variations (change orders) regardless of the actual quantities used.

If the contract is of the cost-plus type, the contractor must provide documentation for its actual reimbursable costs, as provided in the contract.

In the case of a unit-price/measure-and value contract, the parties must measure the quantities actually put in place, for periodic payments throughout the project and for the final payment.

Request for final payment

No matter what kind of contract, the contractor’s final payment is equal to the total contract price minus the total of all previous periodic payments made by the owner.

In addition to the testing and startup work, final cleanup, completion of punch list items, locks and keys, closure of the construction office, subcontractor payments, lien release and consent of surety already described, various other certificates and documents will be needed.

Other evidence that may be required includes affidavits stating that all payments related to the project have been made and a certificate indicating that any required insurance will be in effect for the stipulated time period after project completion.

The work covered by the request for final payment will include any work resulting from variations (change orders).

Claims and disputes ought to be resolved by the time of this request; if they are not, the request must contain a statement that it is presented subject to the resolution of these matters.

Liquidated damages

Once the beneficial occupancy date has been established, the parties can determine whether *liquidated damages* are to be assessed against the contractor, by comparing that date with the completion date established in the original contract or by any extensions thereto.

The amount of these damages, to be assessed by reducing the final payment, is calculated simply as the product of the daily liquidated damages amount stated in the contract and the number of days late.

If the contract provides for a *bonus for early completion*, that amount will be calculated in the same manner and will be added to the final payment. In some contracts, liquidated damages are assessed against portions of the work and bonus payments may be figured in the same way.

Final payment and release of retainage

If all punch list items have been completed, all certificates, affidavits and other documents submitted and in good order and all other obligations completed, the contractor's request for final payment ought, finally, to be honored.

Included with this payment should be the retainage that has been held by the owner pending satisfactory completion.

Note that if 10% has been retained throughout the project the released retainage will be a substantial portion of the project budget.

Many contracts provide, however, for reduced amounts of retainage as the project nears completion.

When the owner makes final payment and releases retainage to the contractor, both parties waive most of their rights to make further claims against the other.

Final accounting and cost control completion

An effective cost control system will be able to compare the actual cost of each work item with its estimate and identify the reasons for any variances, which may be either quantity or rate variances.

A quantity variance results from an actual quantity different from that estimated, whereas a rate variance occurs because the cost per hour, per pound or per linear meter is different from the estimate.

Note that quantity variances are less important to the contractor in unit-price (measure-and-value) contracts and cost-plus contracts than they are in fixed-price/lump-sum contracts.

Because the actual costs become part of the historic cost database, unusual conditions that led to large variances need to be recorded, so that future tender estimates do not rely too greatly on these abnormally high or low costs.

Certificates

In connection with the procedures described above, several certificates may be issued. We describe five such documents.

Certificate for payment

The *General Conditions of the Contract for Construction* provide for the architect to issue this certificate in response to the contractor's request for payment, if the architect believes that 'the work has progressed to the point indicated' and the 'quality of the work is in accordance with the contract documents'.

Contractor's certificate of completion

Some contracts provide this form as a means for the contractor to notify the owner formally that the project is complete.

A producer statement provides the same function; one version allows the contractor to notify the owner that either all of the project or a portion described by appropriate attachments is complete.

Certificate of substantial completion

Substantial completion is that stage in the progress of the work when the work or designated portion thereof is sufficiently complete in accordance with the contract documents so the owner can occupy or utilize the work for its intended use.

By this definition, substantial completion marks the beginning of beneficial occupancy.

Issuance of this certificate by the owner or its design professional follows the final inspection.

The notion of 'substantial' completion is that some punch list items remain to be completed after the final inspection; thus the project is not yet fully complete, even though the owner can use it for its intended purpose.

The certificate of substantial completion includes this list of items yet to be completed.

The term *practical completion* is used in some contracts to refer to this same point in the project closeout and termination phase.

Certificate of completion

When any deficiencies noted on the certificate of substantial completion have been remedied, a certificate of completion may be issued.

This certificate is similar to the previous one, except that it contains no list of deficiencies.

If the final inspection concludes that no deficiencies exist, the certificate of substantial completion will not be needed.

Certificate of occupancy

Some localities or other jurisdictions require inspections by public agency officials of such life safety parts of the work as lifts, fire protection systems, handicapped access and sewage systems.

In this case, the regulations require that the appropriate authority issue a certificate of occupancy prior to occupancy by the owner if it finds the facility acceptable.

As-built drawings

Most contracts require that the contractor maintain a set of *record drawings*, commonly known as *as-built*, as the project progresses.

On these documents are recorded actual locations, dimensions and features that are different from the original contract drawings.

When the drawings are in electronic format, the contractor may be required to modify the drawing files and highlight the modifications.

It is convenient and useful for the contractor to keep as-built drawings current as the project proceeds; it is a condition of final payment that a complete and accurate set be forwarded to the owner prior to payment.

Operating and maintenance manuals

A typical contract provision requires that the contractor furnish operating and maintenance manuals for all of the project's equipment and operating systems.

The main effort involves simply gathering and organizing the documents as they are received from the manufacturers.

Often they are shipped with the equipment itself and can be easily lost during unpacking.

Records archiving and transfer

Project records are essential parts of the project's history and are also important in the operation and maintenance of the finished work.

The contractor has two primary obligations in this regard.

1. First, it must organize and store all relevant project records in a secure and convenient location for future use by its own personnel.
2. The contractor's other obligation with respect to project records is to transfer required documents to the owner and/or the design professional in an organized and complete manner.

In addition to the as-built drawings, operating and maintenance manuals, keying schedules and certificates discussed above, such records might include progress photographs, material and system test inspection results and any other documents required by the contract.

Training sessions

Yet another obligation sometimes required of the contractor is to conduct training sessions for the owner's operating personnel. Imagine a large dam project, with various gate motors, pumps and computerized control, flow monitoring and communications systems.

Although the contractor may not be expert on their operations, the contract may require that training be provided.

Thus, it is the contractor's responsibility to arrange such sessions, probably led by manufacturers' and/or subcontractors' representatives, after the various components are installed and prior to owner occupancy.

Warranties, guarantees and defects liability period

The terms *warranty* and *guarantee* tend to be used interchangeably in construction contracts to designate the obligations the contractor assumes for repairing defects in its work for a specified period after the commencement of beneficial occupancy.

The general conditions cover the overall obligation and the time period, called the *defects liability period or the maintenance period*.

Post-project analysis, critique and report

Internally, the contractor will want to analyze the entire project to determine what it has learnt that can be applied to the next such endeavor.

This step is probably one of the most neglected aspects of construction project management, as there is always pressure to look ahead to the next job rather than backward toward the work just completed.

However, a day, or even a few hours, spent with key members of the project team in a post-project critique, followed by the creation of a written report, will pay dividends in the future.

The meeting also provides an occasion to thank the members of the team for their efforts and to mark, in some fitting manner, those whose contributions have been especially noteworthy.

Once the various elements of the discussion and written analyses have been completed, the project manager is responsible for compiling the written report, which becomes a part of the company's historical record, together with the various costs, schedule and other reports.