Construction Management

Third Edition

Daniel W. Halpin

Purdue University

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Dedicated to My Wife, Maria
. . . for Her Insights and
Constant Support

Preface (3rd Edition)

INTRODUCTION

The first and second editions of this text book have enjoyed a good deal of success and been translated into a number of foreign languages. The third edition builds upon the core material that was well received in the first two editions.

I hope that this text will give those interested in construction engineering a broad coverage of some of the many topics which construction engineers deal with on a daily basis. As I stated in previous editions, a construction manager is like an Olympic decathlon athlete who must show great competence in a multitude of areas ranging from design of construction operations to labor relations. The successful construction manager must be "a jack of many skills and master of all."

Construction, as an engineering discipline, is well characterized by a former President of the United States who was a respected engineer in his own right. Herbert Hoover stated:

> *"It is a great profession. There is the fascination of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realization in stone or metal or energy. Then it brings jobs and homes to men. Then it elevates the standards of living and adds to the comforts of life. That is the engineer's high privilege."*

As noted in Chapter 6, another U. S. President, Dwight D. Eisenhower, renowned for his ability to manage, stated a concept that is a good guide to all:

> *"Plans are nothing. Planning is everything!"*

NEW MATERIAL IN THIS EDITION INCLUDES:

- Chapter openers added at the beginning of each chapter, describing new technologies or supplemental materials that are relevant to the topic of the chapter.
- Section 1.5, *Construction versus Manufacturing Processes*, which discusses the difference between purchasing construction and purchasing manufactured speculative products.
- Expanded coverage of Value Engineering (Chapter 3), including a demonstration example.
- Additional explanations and a discussion of Product Delivery Systems (Chapter 4), illustrating the different systems available. This material helps students see the benefits/weaknesses of various contract formats and when it is best to use one over another.
- The concept of "scope of work" defining the project and break-down of the project into "work packages" in the context of a "Work Breakdown Structure" (Chapter 6). This material is designed to help students break a project into its component parts and analyze project progress in terms of earned value (Chapter 15). This prepares the student for topics in the Scheduling Chapter (Chapter 7). One of the problems

students have with scheduling is how to break a project into pieces/activities. This material helps answer the question, ”Where do I start in developing a schedule?”

- In the “Project Scheduling” Chapter 7, the work packaging material is used to develop the activities in the network schedule. This chapter opens with a discussion of the precedence notation (Activity on Node or AON) since this is the basis of present practice.
- Earned value analysis is included in Chapter 15.
- Chapter 18, covering Construction Operations, is on the book website at www.wiley.com/college/halpin. This chapter involves the actual placement of construction in the field, using resources such as equipment and labor.
- Dated material is cut or moved to an appendix, in order to reflect current practice. For example, arrow notation scheduling has been moved to an appendix.
- Web-based resources including Web CYCLONE (permits simulation of construction operations), and examples showing how to build models, from masonry to bridges, are included on the book web site.

STUDENT RESOURCES

The following resources are available from the book website at www.wiley.com/college/halpin. Visit the Student section of the website.

- Information about and support materials for the two leading scheduling software programs, Primavera, and Microsoft Project.
- The author’s website “Emerging Construction Technologies”
- Chapter 18, covering Construction Operations. This chapter involves the actual placement of construction in the field, using resources such as equipment and labor. This material covers the business of placing the construction physically in the field, what is done to actually build the project (e.g. putting concrete in place with a crane and bucket and pump) and the sequence of when tasks need to be done. The chapter discusses the concept of sequence and technical logic. It addresses the questions “How and in what sequence am I going to build?” and “What resources will I use”
- The book web site includes a comprehensive Simulation Homepage. This homepage includes material regarding construction process simulation and describing glossary/definition terms specific to CYCLONE modeling format.
- A web-based program, Web CYCLONE permits simulation of construction operations. The web site also includes extensive material regarding the CYCLONE construction modeling system.
- Examples showing how to build models (e.g. a masonry model, an asphalt paving model and a concrete supply model.)

INSTRUCTOR RESOURCES

All instructor resources are available from the book website at www.wiley.com/college/halpin, available only to instructors who adopt the text:

- Solutions Manual
- Image Gallery of Text Figures
- Text Figures in PowerPoint format
- All resources from Student section of the website.

These resources are password-protected. Visit the Instructor section of the book website to register for a password to access these materials.

ACKNOWLEDGEMENTS

I would like to acknowledge my co-author in previous editions, Ron Woodhead, Emeritus Professor at the U. of New South Wales, Australia. Without his vision, this book would not have become a reality.

I would also like to thank the many colleagues and numerous students who have provided valuable feedback regarding various aspects of this text. It is safe to say that well over 100,000 students have used this text in some fashion since it was originally published. I would like to say "many thanks" to all who have provided comments and constructive feedback over the years, including the following instructors who reviewed or provided feedback for this edition:

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Finally and most importantly, I would like to acknowledge my wife, Maria, for her incomparable support. Our many lively discussions, full of questions and insight, have shaped my thinking over the past 40 years. Her interest and support has been the most significant force in realizing this and a lifetime of exciting projects.

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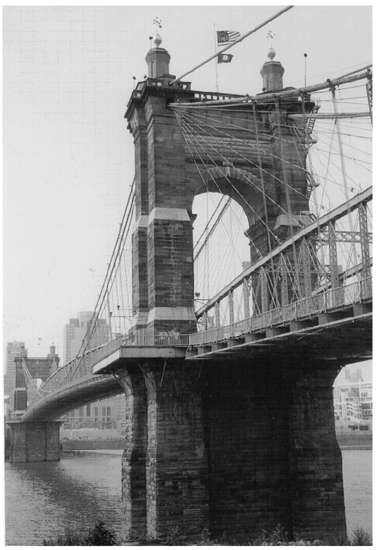
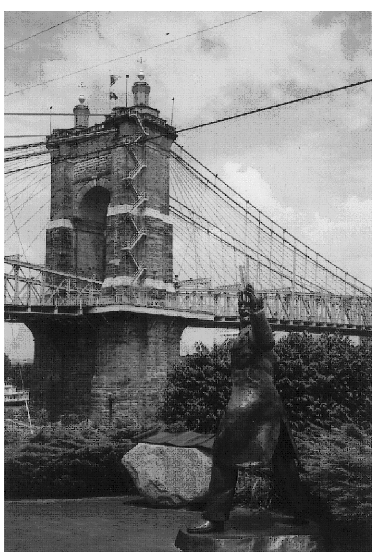
Chapter 1

History and Basic Concepts





John A. Roebling Bridge
Covington, Ky. Side

Bridges and History

Water crossings have always been seen as great engineering challenges. Since Roman times, bridges and various river crossings have been linked with great engineering achievements. Apollodorus was chief engineer for the Emperor Trajan and built a bridge across the Danube River in the second century A.D. This bridge allowed Trajan to invade Dacia and annex the territory of modern day Romania.

The length of clear span bridging was greatly increased by the development of the cable supported suspension bridge. The oldest vehicular steel cable suspension bridge in the world in continuous use was built by John A. Roebling in Cincinnati, Ohio during the Civil War. It is still one of the major arteries connecting Cincinnati with Covington, Kentucky.

When construction started in 1856, the charter authorizing the construction required a clear span of 1,000 feet between two towers, with the deck located a minimum of 100 feet above the water's surface. The bridge was completed in December 1866. The 1,057-foot main span was, at the time, the longest in the world. It was one of the first suspension bridges to use both vertical suspenders and diagonal cable stays which radiated from the top of each tower. This innovative use of cable stays gave the bridge great rigidity and resistance to movement during high winds. Roebling used this same concept later when building the Brooklyn Bridge.

The bridge was upgraded to its present configuration in 1894. A second set of 10.5-inch cables were added to carry heavier decks. This reconstruction increased the carrying capacity of the bridge to a 30-ton limit. As a native of Covington, the author rode both trolley (street) cars and electrically powered buses hundreds of times to the transit terminal in Cincinnati located at the north end of the bridge. In 1984 the bridge was renamed the John A. Roebling Bridge.

Bridges Today

World famous bridges have become a symbol of Civil Engineering. The Golden Gate Bridge in San Francisco has not only been hailed a tremendous engineering achievement, but also a beautifully balanced aesthetic achievement. Plans are now underway to bridge the famous Straits of Messina between the toe of Italy and the Island of Sicily. This bridge will have a clear span of almost 2 miles, approximately 10 times the span of the Roebling Bridge in Cincinnati. It will also be designed to resist hurricane-force winds. Construction of this bridge will rival the construction of the Channel Tunnel connecting England and France.

Figure 1.1 The Parthenon in Athens.

1.1 HISTORICAL PERSPECTIVE

Construction and the ability to build things is one of the most ancient of human skills. In prehistorical times, it was one of the talents that set *Homo sapiens* apart from other species. Humans struggled to survive and sought shelter from the elements and the hostile environment that surrounded them by building protective structures. Using natural materials such as earth, stone, wood, and animal skins, humans were able to fabricate housing that provided both shelter and a degree of protection.

As society became more organized, the ability to build things became a hallmark of the sophistication of ancient civilizations. The wonders of the ancient world reflect an astounding ability to build not only structures for shelter but monuments of gigantic scale. The pyramids and Greek temples such as the Parthenon (Fig. 1.1) are an impressive testimony to the building skills of the civilizations of antiquity. Great structures punctuate the march of time and many of the structures of ancient times are impressive even by modern standards. The great Church of Hagia Sophia in Constantinople, constructed during the sixth century, was the greatest domed structure in the world for nine centuries. It is an impressive example of the ingenuity of the builders of that time and their mastery of how forces can be carried to the ground using arches in one dimension and in three dimensions as domes.

In modern times, the Brooklyn Bridge and the Panama Canal stand as legendary feats of engineering achievement. They are also testimonies to the fact that realizing a construction project involves solving a multitude of problems, many of which are not technical. In both the Brooklyn Bridge and Panama Canal projects, people problems requiring great innovation and leadership were just as formidable as the technical problems encountered. To solve them, the engineers involved accomplished “heroic” feats.

1.2 GREAT CAPTAINS OF CONSTRUCTION

The Roebling family as a group can be credited with building the Brooklyn Bridge between 1869 and 1883. It was the greatest project of its time and required the use of technology

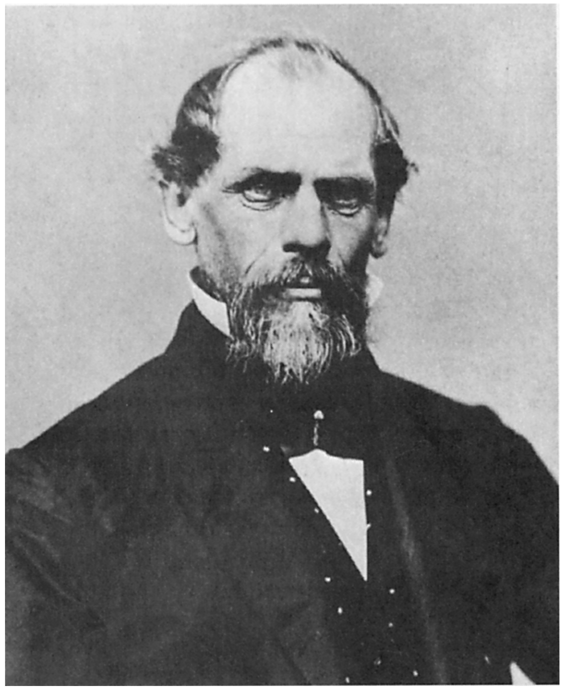


Figure 1.2 John A. Roebling, designer of the Brooklyn Bridge. (American Society of Civil Engineers)

at a scale never before tried. The concept of a cable-supported suspension bridge was literally invented by John A. Roebling (see Fig. 1.2). Roebling was born in Germany and was the favorite student of the famous philosopher Hegel. Roebling was a man of tremendous energy and powerful intellect. He built a number of suspension bridges, notably the John A. Roebling Bridge in Cincinnati (which is still in daily use), that demonstrated the cable-supported concept prior to designing the Brooklyn Bridge. Upon his death (precipitated by an accident that occurred during the initial survey of the centerline of the bridge) his son Washington took charge.

Washington Roebling (see Fig. 1.3) was a decorated hero of the Civil War who had received his training in civil engineering at Rensselaer Polytechnic Institute. Like his father he was a man of great vision and courage. He refined the concepts of caisson construction and solved numerous problems as the great towers of the bridge rose above New York City (see Fig. 1.4). Since he would not require anyone to work under unsafe conditions, he entered the caissons and supervised the work personally. He ultimately suffered from a mysterious illness related to the fact that the work was carried out under elevated air pressure in the caissons. We now know that this illness, called "the bends," was caused by the absorption and rapid exit of nitrogen from the bloodstream when workers entered and exited the pressurized caissons.

Although incapacitated, Washington continued to supervise the work from an apartment that overlooked the site. At this point, Emily, Washington's wife and the sister of an army general, entered the picture (see Fig. 1.5). Emily carried information to Roebling's supervising engineers on the site. She became the surrogate chief engineer and gave directives in the name of her husband. She was able to gain the confidence and respect of the site engineers and was instrumental in carrying the project through to successful accomplishment. The tale of the building of the great bridge (see *The Great Bridge* by McCullough, 1972) is one of the most extraordinary stories of technical innovation and personal achievement in the annals of American history.

Figure 1.3 Washington A. Roebling, chief engineer of the Brooklyn Bridge. (Special Collections and University Archives, Rutgers University Libraries)

1.3 PANAMA CANAL

The end of the nineteenth century was a time of visionaries who conceived of projects that would change the history of humankind. Since the time Balboa crossed Panama and discovered a great ocean, planners had conceived of the idea of a water link between the Atlantic and the Pacific Oceans. Having successfully connected the Mediterranean with the Red Sea at Suez, in 1882 the French began work on a canal across the narrow isthmus of Panama, which at that time was part of Colombia. After struggling for 9 years, the French were ultimately defeated by the formidable technical difficulties as well as the hostile climate and the scourge of yellow fever.

Theodore Roosevelt became president during this period and his administration decided to take up the canal project and carry it to completion. Using what would be referred to as “gun-boat” diplomacy, Roosevelt precipitated a revolution that led to the formation of the Republic of Panama. Having clarified the political situation with this stratagem, the famous “Teddy” then looked for the right man to actually construct the canal. That right man turned out to be John F. Stevens, a railroad engineer who had made his reputation building the Great Northern Railroad (see Fig. 1.6). Stevens proved to be the right man at the right time.

Stevens understood the organizational aspects of large projects. He immediately realized that the working conditions of the laborers had to be improved. He also understood that measures had to be taken to eradicate the fear of yellow fever. To address the first problem, he constructed large and functional camps for the workers in which good food was available. To deal with the problem of yellow fever, he enlisted the help of an army doctor named William C. Gorgas. Prior to being assigned to Panama, Dr. Gorgas had worked with Dr. Walter Reed in wiping out yellow fever in Havana, Cuba. He had come to understand that the key to controlling and eliminating this disease was, as Dr. Reed had shown, the control of the mosquitoes that carried the dreaded infection and the elimination of their breeding places (see *The Microbe Hunters* by Paul DeKruif). Gorgas was successful in effectively controlling the threat of yellow fever, but his success would not have been possible without the total commitment and support of John Stevens.

Figure 1.4 Brooklyn Bridge under construction 1881. (Museum of the City of NewYork, Print Archives, Gift of the Essex Institute.)

Having established an organizational framework for the project and provided a safe and reasonably comfortable environment for the workers, Stevens addressed the technical problems presented by the project. The French had initially conceived of a canal built at sea level and similar to the Suez Canal. That is, the initial technical concept was to build a canal at one elevation. Due to the high ground and low mountains of the interior portion of the isthmus, it became apparent that this approach would not work. To solve the problem

Figure 1.5 Emily Warren Roebling, wife of Washington Roebling. (Special Collections and University Archives, Rutgers University Libraries)

of moving ships over the "hump" of the interior, it was decided that a set of water steps, or locks, would be needed to lift the ships transiting the canal up and over the high ground of Central Panama and down to the elevation of the opposite side. The construction of this system of locks presented a formidable challenge. Particularly on the Atlantic side of the canal, the situation was complicated by the presence of the wild Chagres River, which flowed in torrents during the rainy season and dropped to a much lower elevation during the dry season.

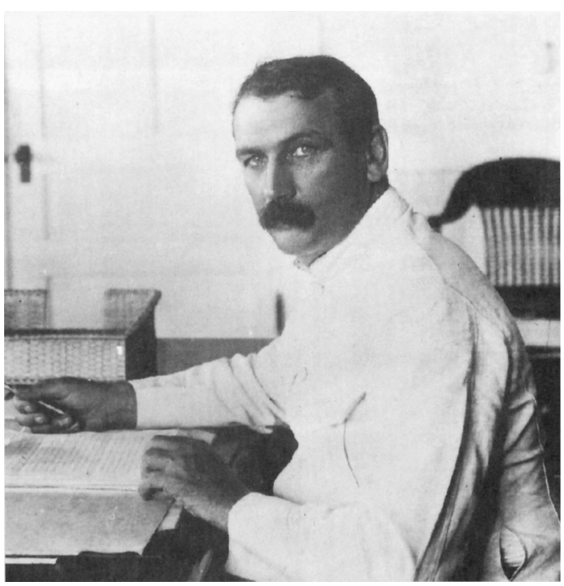


Figure 1.6 John F. Stevens, chief engineer of the Panama Canal. (National Archives, Washington, D.C.)

The decision was made to control the Chagres by constructing a great dam that would impound its water and allow for control of its flow. The dam would create a large lake that would become one of the levels in the set of steps used to move ships through the canal. The damming of the Chagres and the creation of Lake Gatun itself was a project of immense proportions requiring concrete and earthwork structures of unprecedented size (see Fig. 1.7).

The other major problem had to do with the excavation of a great cut through the highest area of the canal. The Culebra cut, as this part of the canal was called, required the excavation of earthwork quantities that even by today's standards stretch the imagination. Stevens viewed this part of the project as the construction of a gigantic railroad system that would operate continuously (24 hours a day) moving earth from the area of the cut to the

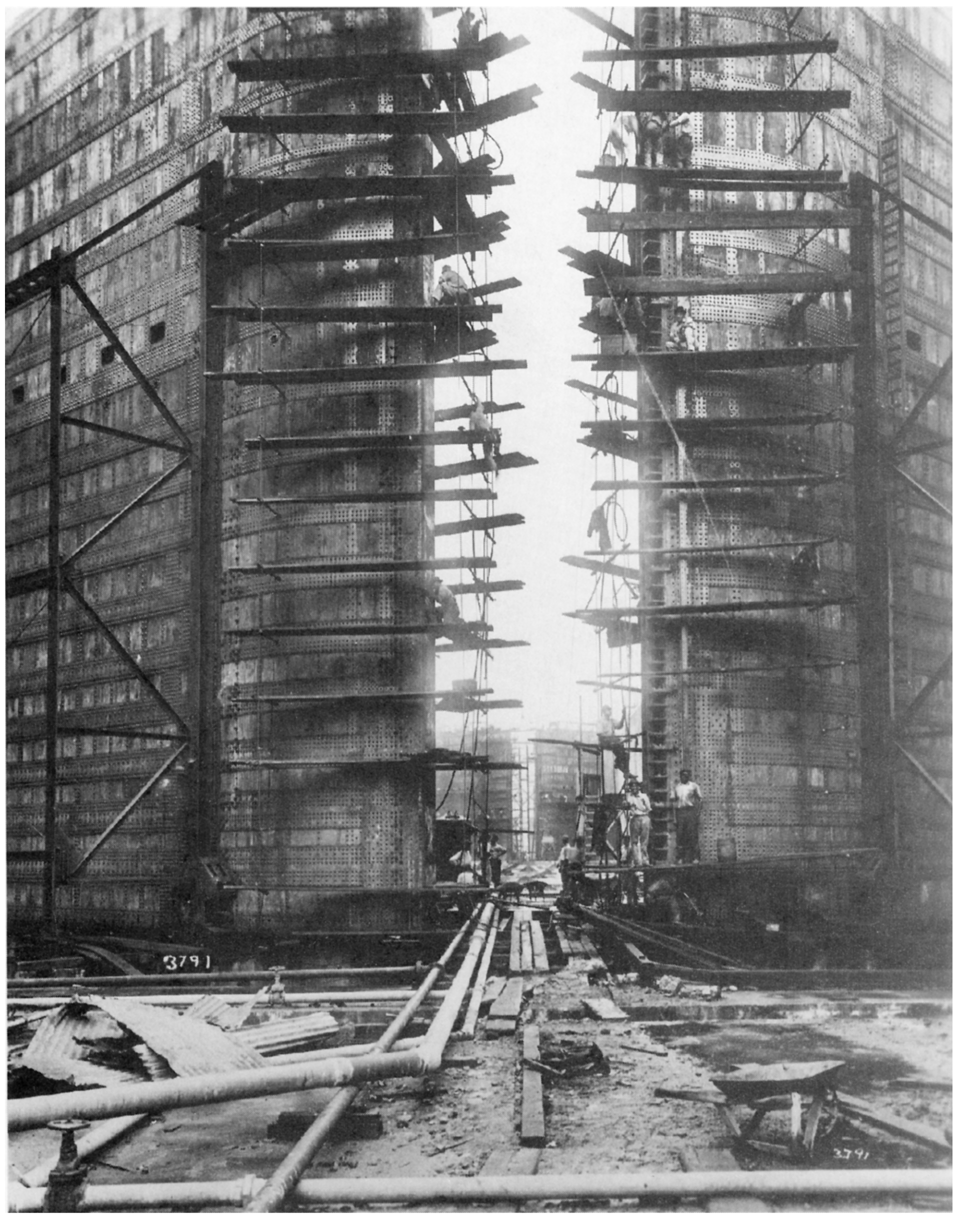


Figure 1.7 Work in progress on the Great Gatun lock gates. (The Bettmann Archive)

Chagres dam construction site. The material removed from the cut would provide the fill for the dam. It was an ingenious idea.

To realize this system, Stevens built one of the great rail systems of the world at that time. Steam-driven excavators (shovel fronts) worked continuously loading railcars. The excavators worked on flexible rail spurs that could be repositioned by labor crews to maintain contact with the work face. In effect, the shovels worked on sidings that could be moved many times each day to facilitate access to the work face. The railcars passed continuously under these shovels on parallel rail lines.

Stevens's qualities as a great engineer and leader were on a level with those of the Roeblings'. As an engineer, he understood that planning must be done to provide a climate and environment for success. Based on his railroading experience, he knew that a project of this magnitude could not be accomplished by committing resources in a piecemeal fashion. He took the required time to organize and mass his forces. He also intuitively understood that the problem of disease had to be confronted and conquered. Some credit for Stevens's success must go to Theodore Roosevelt and his secretary of war, William Howard Taft. Taft gave Stevens a free hand to make decisions on the spot and, in effect, gave him total control of the project. Stevens was able to be decisive and was not held in check by a committee of bureaucrats located in Washington (i.e., the situation present prior to his taking charge of the job).

Having set the course that would ultimately lead to successful completion of the canal. Stevens abruptly resigned. It is not clear why he decided not to carry the project through to completion. President Roosevelt reacted to his resignation by appointing a man who, as Roosevelt would say, "could not resign." Roosevelt selected an army colonel and West Point graduate named George Washington Goethals to succeed Stevens. Goethals had the managerial and organizational skills needed to push the job to successful completion. Rightfully so, General Goethals received a great deal of credit for the construction of the Panama Canal. However, primary credit for pulling the job "out of the mud," getting it on track, and developing the technical concept of the canal that ultimately led to success must be given to Stevens—a great engineer and a great construction manager.

1.4 OTHER HISTORIC PROJECTS

Much can he learned from reading about and understanding projects like the Brooklyn Bridge and the Panama Canal. David McCullough's books *The Great Bridge* and *The Path Between the Seas* are as exciting and gripping as any spy novel. They also reflect the many dimensions of great and small construction projects. Other projects such as the building of the Hoover Dam on the Colorado River have the same sweep of adventure and challenge as the construction of the Panama Canal. The construction of the Golden Gate Bridge in San Francisco was just as challenging a project as the construction of the Brooklyn Bridge in its time.

The construction of the Empire State Building in only 18 months is another example of a heroic engineering accomplishment. Realization of great skyscrapers such as the Empire State Building and the Chrysler Building in New York was made possible by the development of technologies and techniques in the construction of earlier projects. The construction of the Eiffel Tower in Paris and the towers of the "miracle mile" in Chicago in the early 1900s demonstrated the feasibility of building tall steel-frame-supported structures. Until the advent of the steel frame with its enclosing "curtain" walls, the height of buildings had been limited based on the strength of materials used in the bearing walls, which carried loads to the ground.

The perfection of the concept of steel-frame-supported structures and the development of the elevator as a means of moving people vertically in tall buildings provided the necessary technologies for the construction of the tall buildings that we take for granted today. Modern-day city skylines would not have been possible without these engineering innovations.

More recently, a project of historical proportions was realized with the completion of the Eurotunnel connecting the British Isles and France. This project has been dreamed of for many centuries. Through the skill and leadership of a large team of engineers and managers, it has now become a reality. Great projects are still being proposed and constructed. For the interested reader, brief coverage of many historical projects is given in *The Builders—Marvels of Engineering* published by the National Geographic Society (editor: Elizabeth L. Newhouse, 1992).

1.5 CONSTRUCTION VERSUS MANUFACTURING PROCESSES

Construction is the largest product-based (as opposed to service-oriented) industry in the U.S. The dollar volume of the industry is on the order of one trillion (1,000 billion) dollars annually. The process of realizing a constructed facility such as a road, bridge, or building, however, is quite different from that involved in manufacturing an automobile or a television set.

Manufactured products are typically designed and produced without a designated purchaser. In other words, products (e.g., automobiles or TV sets) are produced and then presented for sale to any potential purchaser. The product is produced on the speculation that a purchaser will be found for the item produced. A manufacturer of bicycles, for instance, must determine the size of the market, design a bicycle which appeals to the potential purchaser, and then manufacture the number of units which market studies indicate can be sold. Design and production are done prior to sale. In order to attract possible buyers, advertising is required and is an important cost center.

Many variables exist in this undertaking, and the manufacturer is "at risk" of failing to recover the money invested once a decision is made to proceed with design and production of the end item. The market may not respond to the product at the price offered. Units may remain unsold or sell at or below the cost of production (i.e., yielding no profit). If the product cannot be sold so as to recover the cost of manufacture, a loss is incurred and the enterprise is unprofitable. When pricing a given product, the manufacturer must not only recover the direct (labor, materials, etc.) cost of manufacturing, but also the so-called indirect and General and Administrative (G&A) costs such as the cost of management and the implementation of the production process (e.g., legal costs, marketing costs, supervisory costs, etc.). Finally, unless the enterprise is a "non-profit," the desire of the manufacturer is to increase the value of the firm. Therefore, profit must be added to the direct, indirect, and G&A costs of manufacturing.

Manufacturers offer their products for sale either directly to individuals (e.g., by mail order or directly over the web), to wholesalers who purchase in quantity and provide units to specific sales outlets, or to retailers who sell directly to the public. This sales network approach has developed as the framework for moving products to the eventual purchaser. (See if you can think of some manufacturers who sell products directly to the end user, sell to wholesalers, and/or sell to retail stores.)

In construction, projects are sold to the client in a different way. The process of purchase begins with a client who has need for a facility. The purchaser typically approaches a design professional to more specifically define the nature of the project. This leads to a conceptual definition of the scope of work required to build the desired facility. Prior to the age of mass production, purchasers presented plans of the end object (e.g., a piece of furniture) to a craftsman for manufacture. The craftsman then proceeded to produce the desired object. For example, if King Louis XIV desired a desk at which he could work, an artisan would design the object, and a craftsman would be selected to complete the construction of the desk. In this situation, the purchaser (King Louis XIV) contracts with a specialist to construct a unique object. The end item is not available for inspection until it is fabricated. That is, since the object is unique, it is not sitting on the show room floor and must be specially fabricated.

Due to the "one of a kind" unique nature of constructed facilities, this is still the method used for building construction projects. The purchaser approaches a set of potential contractors. Once an agreement is reached among the parties (e.g., clients, designers, etc.) as to the scope of work to be performed, the details of the project or end item are designed and constructed. Purchase is made based on a graphical and verbal description of the end item, rather than the completed item itself. This is the opposite of the speculative process where design and manufacture of the product are done prior to identifying specific purchasers. A constructed facility is not commenced until the purchaser has been identified. For instance, it would be hard to imagine building a bridge without having identified the potential buyer. (Can you think of a construction situation where the construction is completed prior to identifying the buyer?)

The nature of risk is influenced by this process of purchasing construction. For the manufacturer of a refrigerator, risk relates primarily to being able to produce units at a competitive price. For the purchaser of the refrigerator, the risk involves mainly whether the appliance operates as advertised.

In construction, since the item purchased is to be produced (rather than being in a finished state), there are many complex issues which can lead to failure to complete the project in a functional and/or timely manner. The number of stake holders and issues that must be dealt with prior to project completion lead to a complex level of risk for all parties involved (e.g., designers, constructors, government authorities, real estate brokers, etc.). A manufactured product is, so to say, "a bird in the hand." A construction project is "a bird in the bush."

The risks of the manufacturing process to the consumer are somewhat like those incurred when a person goes to the store and buys a music CD. If the recording is good and the disk is serviceable, the risk is reduced to whether the customer is satisfied with the musical group's performance. The client in a construction project is more like a musical director who must assemble an orchestra and do a live performance hoping that the recording will be acceptable. The risks of a failure in this case are infinitely greater. A chronological diagram of the events involved in the manufacturing process versus those in the construction process are shown schematically in Figure 1.8.

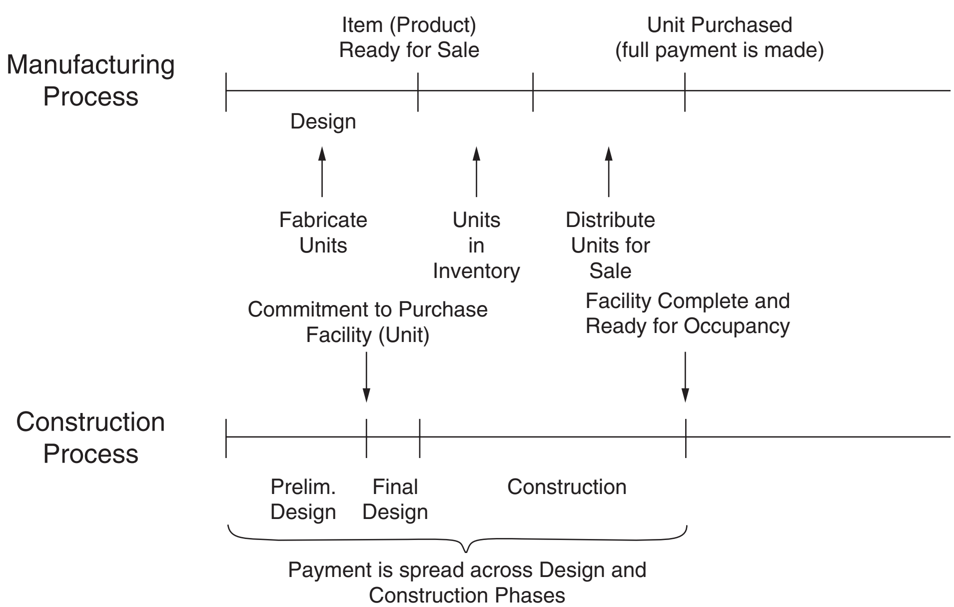


Figure 1.8 Manufacturing versus Construction Process.

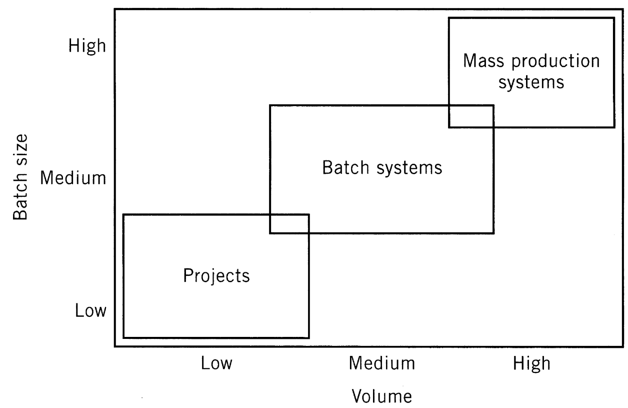


Figure 1.9 Comparison of production systems.

1.6 PROJECT FORMAT

In contrast to other manufacturing industries that fabricate large numbers of units such as automobiles or television sets, the construction industry is generally focused on the production of a single and unique end product. That is, the product of the construction industry is a facility that is usually unique in design and method of fabrication. It is a single "one-off" item that is stylized in terms of its function, appearance, and location. In certain cases, basically similar units are constructed as in the case of town houses or fast-food restaurants. But even in this case, the units must be site adapted and stylized to some degree.

Mass production is typical of most manufacturing activities. Some manufacturing sectors make large numbers of similar units or batches of units that are exactly the same. A single item is designed to be fabricated many times. Firms manufacture many repetitions of the same item (e.g., telephone instruments, thermos bottles, etc.) and sell large numbers to achieve a profit. In certain cases, a limited number or batch of units of a product is required. For instance, a specially designed transformer or hydropower turbine may be fabricated in limited numbers (e.g., 2, 3, or 10) to meet the special requirements of a specific client. This production of a limited number of similar units is referred to as batch production.

Mass production and batch production are not typical of the construction industry (see Fig. 1.9). Since the industry is oriented to the production of single unique units, the format in which these one-off units are achieved is called the project format. Both the design and production of constructed facilities are realized in the framework of a project. That is, one speaks of a project that addresses the realization of a single constructed facility.

The focus of construction management is the planning and control of resources within the framework of a project. This is in contrast to other manufacturing sectors that are interested in the application of resources over the life of an extended production run of many units.

1.7 PROJECT DEVELOPMENT

Construction projects develop in a clearly sequential or linear fashion. The general steps involved are as follows:

- A need for a facility is identified by the owner.
- Initial feasibility and cost projections are developed.
- The decision to proceed with conceptual design is made, and a design professional is retained.

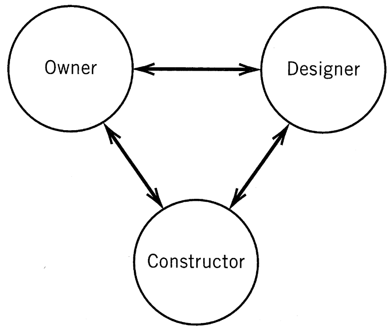


Figure 1.10 Relationship between owner, designer, and constructor.

- The conceptual design and scope of work are developed to include an approximate estimate of cost.
- The decision is made to proceed with the development of final design documents, which fully define the project for purposes of construction.
- Based on the final design documents, the project is advertised and proposals to include quotations for construction of the work are solicited.
- Based on proposals received, a constructor is selected and a notice to the constructor to proceed with the work is given. The proposal and the acceptance of the proposal on the part of the owner constitute the formation of a contract for the work.
- The process of constructing the facility is initiated. Work is completed, and the facility is available for acceptance and occupancy/utilization.
- In complex projects, a period of testing decides if the facility operates as designed and planned. This period is typical of industrial projects and is referred to as project start-up.
- The facility operates and is maintained during a specified service life.
- The facility is disposed of if appropriate or maintained in perpetuity.

These steps must be modified on a case-by-case basis to address the special aspects of a given project. Topics relating to items 1 through 8 will be discussed in detail in Chapters 2 and 3.

The key players in this developmental sequence are:

1. The owner
2. The designer or design professional
3. The constructor

The interaction of these three major entities is shown in Figure 1.10.

Although other entities such as regulators, subcontractors, materials vendors, and so forth are important supporting players in this sequence, the major development of the project revolves about these three major entities. The legal definition of this interaction is established in the general conditions of the contract. This interaction will be described in detail in the following chapters.

1.8 CONSTRUCTION TECHNOLOGY AND CONSTRUCTION MANAGEMENT

The study of construction as a discipline can be broadly structured into two general themes:

1. Construction technology
2. Construction management

As the name implies, construction technology relates to the methods or techniques used to place the physical materials and elements of construction at the job site. The word *technology* can be broken into two subwords—*technical* from "techno" and *logic*. *Logic* addresses the concept of sequence or procedure. That is, logic addresses the order of things—something is done first, another thing second, and so on until a result is achieved. Adding *technical* to this leads to the idea that technology has to do with the technical sequence in which something is done to produce an end result. It is possible to talk about a technology that applies to placing concrete, cladding a building, excavating a tunnel, and so on.

Once a project has been defined, one of the most critical questions facing the construction manager is "What construction technique or method should be selected?" The types of methods for placing construction are diverse. New methods are continuously being perfected, and a construction manager must weigh the advantages and disadvantages of a given method or technique.

In contrast to construction technology, construction management addresses how the resources available to the manager can be best applied. Typically, when speaking of resources for construction, we think of the four **M**s of construction: **m**anpower, **m**achines, **m**aterials, and **m**oney. Management involves the timely and efficient application of the four Ms to construct a project. Many issues must be considered when managing a project and successfully applying the four Ms. Some are technical (e.g., design of formwork, capacities of excavators, weather tightness of exterior finishes, etc.). Many issues, however, are more qualitative in nature and deal with the motivation of workers, labor relations, the form of contracts, legal liability, and safety on the job site. As noted, in discussing the Panama Canal, organizational issues can be very critical to the success of any project. This book will focus mainly on the topic of construction management. Therefore, we will be talking about the four Ms and subjects that relate to management and the timely and cost-effective realization of a project.

1.9 CONSTRUCTION MANAGEMENT IS RESOURCE DRIVEN

The job of a construction manager is to efficiently and economically apply the required resources to realize a constructed facility of acceptable quality within the time frame and budgeted cost specified. Among the many watch words within the construction industry is the expression "on time and within budget." More recently, the concept of quality as a requirement has become an increasingly important aspect of the construction process. So this old adage can be expanded to say "a quality facility on time and within budget."

The construction manager is provided with resources such as labor, equipment, and materials and is expected to build a facility that meets the specifications and is consistent with the drawings provided for the project. The mission of construction is constrained in terms of the available time and amount of money available. The challenge faced by the construction manager is to apply the resources of workers, machines, and materials within the limited funding (money) and time available. This is the essence of construction.

The manager must be clever and innovative in the utilization of resources available. Somewhat like a general in battle, the manager must develop a plan of action and then direct and control forces (resources) in a coordinated and timely fashion so that the objective is achieved.

This requires a variety of skills. A high level of competency is needed in a broad range of qualitative and quantitative subjects. A manager must be like a decathlon athlete. A strong ability in many areas is a necessity. Being outstanding in one area (e.g., engineering) but weak in a number of others (e.g., interpersonal relationships, contract law, labor relations, etc.) is not enough to be a successful construction manager. A strong performance across the board is required.

1.10 CONSTRUCTION INDUSTRY

The construction industry has been referred to as the engine that drives the overall economy. It represents one of the largest economic sectors in the United States. Until the early 1980s the construction industry accounted for the largest percent of the gross domestic product (GDP) and had the highest dollar turnover of any U.S. industry. Presently, construction is still the largest manufacturing industry in the United States. New construction accounts for approximately 8% of the GDP and retrofit projects contribute an additional 5%. As noted above, the total annual volume of activity in the construction sector is estimated to be well in excess of $800 billion. More than a million firms operate in the construction sector, and the number of people employed in construction is estimated to be 10 million.

The industry consists of very large and very small firms. The largest firms sign contracts in excess of $20 billion annually and consist of thousands of employees. Many of the largest firms work both domestically and in the international market. In contrast to the large companies, statistics indicate that over two-thirds of the firms have less than five employees. The spectrum of work ranges from the construction of large power plants and interstate highways costing billions of dollars to the construction of single-family houses and the paving of driveways and sidewalks. The high quality of life available in the United States is possible in large part because of the highly developed infrastructure. The American infrastructure, which consists of the roads, tunnels, bridges, communications systems, power plants and distribution networks, water treatment systems, and all of the structures and facilities that support daily life, is without peer. The infrastructure is constructed and maintained by the construction industry. Without it, the country would not be able to function.

1.11 STRUCTURE OF THE CONSTRUCTION INDUSTRY

Since the construction sector is so diverse, it is helpful to look at the major types of projects typical of construction in order to understand the structure of the industry. Construction projects can be broadly classified as (1) building construction, (2) engineered construction, and (3) industrial construction, depending on whether they are associated with housing, public works, or manufacturing processes.

The building construction category includes facilities commonly built for habitational, institutional, educational, light industrial (e.g., warehousing, etc.), commercial, social, and recreational purposes. Typical building construction projects include office buildings, shopping centers, sports complexes, banks, and automobile dealerships. Building construction projects are usually designed by architects or architect/engineers (A/Es). The materials required for the construction emphasize the architectural aspects of the construction (e.g., interior and exterior finishes).

Engineered construction usually involves structures that are planned and designed primarily by trained professional engineers (in contrast to architects). Normally, engineered construction projects provide facilities that have a public function relating to the infrastructure and, therefore, public or semipublic (e.g., utilities) owners generate the requirements for such projects. This category of construction is commonly subdivided into two major subcategories; thus, engineered construction is also referred to as (1) highway construction and (2) heavy construction.

Highway projects are generally designed by state or local highway departments. These projects commonly require excavation, fill, paving, and the construction of bridges and drainage structures. Consequently, highway construction differs from building construction in terms of the division of activity between owner, designer, and constructor. In highway construction, owners may use in-house designers and design teams to perform the design so that both owner and designer are public entities.

Heavy construction projects are also typically funded by public or quasi-public agencies and include sewage plants, flood protection projects, dams, transportation projects (other than highways), pipelines, and waterways. The owner and design firm can be either public or private depending on the situation. In the United States, for instance, the U.S. Army Corps of Engineers (a public agency) has, in the past, used its in-house design force to engineer public flood protection structures (i.e., dams, dikes) and waterway navigational structures (e.g., river dams, locks, etc.). Due to the trend toward downsizing government agencies, more design work is now being subcontracted to private design engineering firms. Public electrical power companies use private engineering firms to design their power plants. Public mass-transit authorities also call on private design firms (design professionals) for assistance in the engineering of rapid-transit projects.

Industrial construction usually involves highly technical projects in manufacturing and processing of products. Private clients retain engineering firms to design such facilities. In some cases, specialty firms perform both design and construction under a single contract for the owner/client.

1.12 DIFFERING APPROACHES TO INDUSTRY BREAKDOWN

Figure 1.11 represents one of many ways in which the industry can be divided into a number of sectors. This breakdown includes single-family houses within the residential construction sector. In some breakdowns, one- and two-family houses are considered to be a separate industry, and this residential activity is not reported as part of the construction industry. As can be seen from the pie chart, residential and building construction account for between 65 and 75% of the industry. Industrial construction and heavy engineering construction (which are more closely related to the infrastructure) account for 25 to 35% of industry activity.

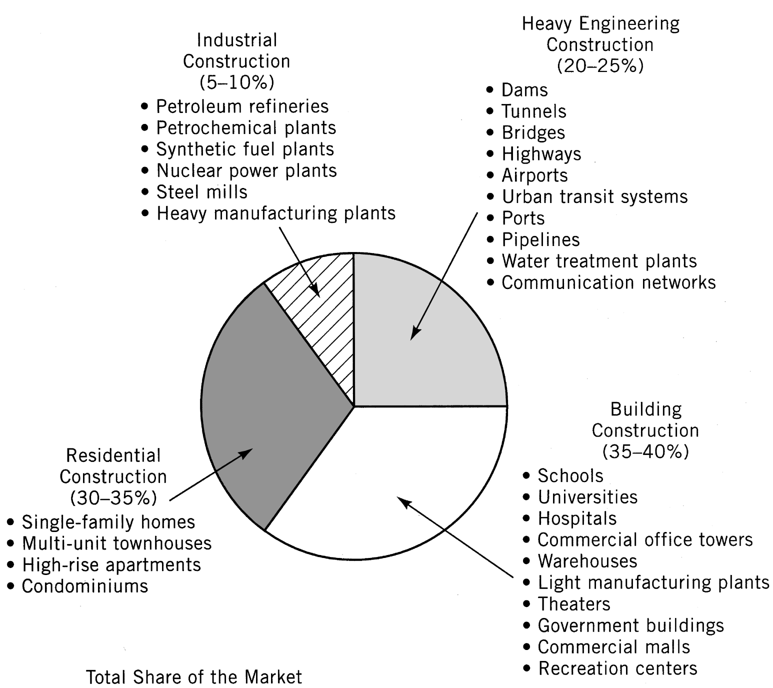


Figure 1.11 Breakdown of construction industry segments.

A slightly different approach to project classification is used by the *Engineering News Record* (ENR) magazine, which reflects the weekly dynamics of the construction industry in the U.S. This breakdown identifies three major construction categories as follows:

1. Heavy and highway
2. Nonresidential building
3. Multiunit housing

The nonresidential building category includes building and industrial construction as defined above. These overall categories are further dissected to reflect the major areas of specialization within the construction industry. The ENR publishes a web-based update of information based on this set of construction categories each week.

1.13 MANAGEMENT LEVELS OF CONSTRUCTION

Organizational considerations lead to a number of hierarchical levels that can be identified in construction. This derives from the project format. Decision making at levels above the project relate to company management considerations. Decisions within the project relate to operational considerations (e.g., selection of production methods) as well as the application of resources to the various construction production processes and work tasks selected to realize the constructed facility. Specifically, four levels of hierarchy can be identified as follows:

1. ***Organizational*** The organizational level is concerned with the legal and business structure of a firm, the various functional areas of management, and the interaction between head office and field managers performing these management functions.
2. ***Project Project-level*** Vocabulary is dominated by terms relating to the breakdown of the project for the purpose of time and cost control (e.g., the project activity and the project cost account). Also, the concept of resources is defined and related to the activity as either an added descriptive attribute of the activity or for resource scheduling purposes.
3. ***Operation (and Process)*** The construction operation and process level is concerned with the technology and details of how construction is performed. It focuses on work at the field level. Usually a construction operation is so complex that it encompasses several distinct processes, each having its own technology and work task sequences. However, for simple situations involving a single process, the terms are synonymous.
4. ***Task*** The task level is concerned with the identification and assignment of elemental portions of work to field units and work crews.

The relative hierarchical breakout and description of these levels in construction management are shown in Figure 1.12. It is clear that the organizational, project, and activity levels have a basic project and top management focus, while the operation, process, and work task levels have a basic work focus.

To illustrate the definitions given above, consider a glazing subcontract for the installation of glass and exterior opaque panels on the four concourses of Hartsfield International Airport in Atlanta, Georgia. This was a project requiring the installation of five panels per bay on 72 bays of each of the four concourses. Figure 1.13 shows a schematic diagram of the project. A breakout of typical items of activity at each level of hierarchy is given in Table 1.1. At the project level, activities within the schedule relate to the glass and panel installation in certain areas of the concourses. At the work task level, unloading, stripping, and other crew-related activity is required.

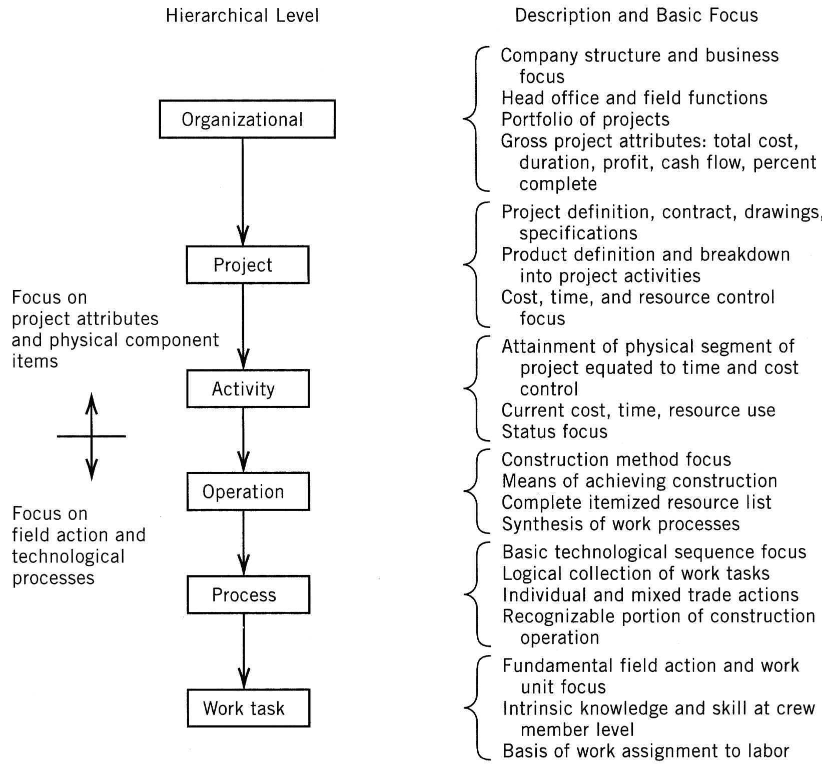


Figure 1.12 Management levels in construction.

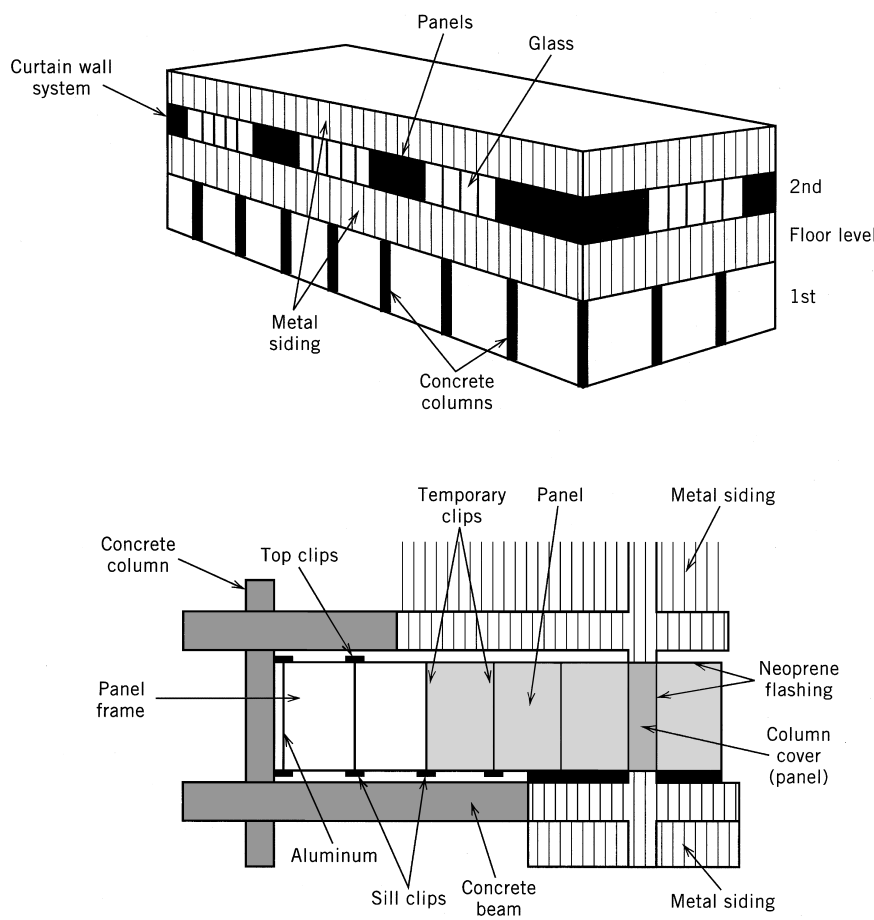


Figure 1.13 Schematic of concourse building.

Table 1.1 Example of Hierarchical Terms

Project	Installation of all exterior glass and panel wall construction on Concourses A–D of the Hartsfield International Airport, Atlanta, GA
Activity	Glass and panel installation on Concourse A, Bays 65–72
Operation	Frame installation to include preparation and installation of five panel frames in each concourse bay; column cover plate installation
Process	Sill clip placement; mullion strips installation
	Glass placement in frame; move and adjust hanging scaffold
Work task	Locate and drill clip fastener; unload and position mullion strips; strip protective cover from glass panel; secure scaffold in travel position

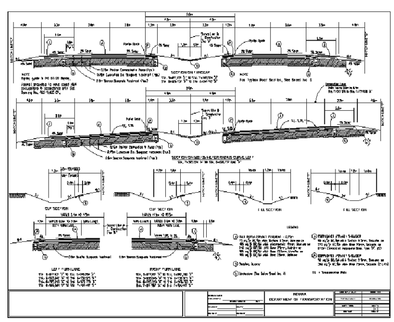
Chapter 2

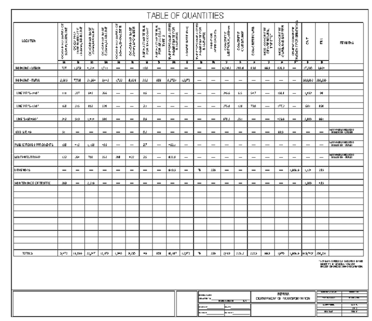
Preparing the Bid Package

Online Plan Room

The Need

Plan rooms are typically conveniently located and can be visited by contractors in large cities. These facilities provide access to bidding documents in order to facilitate the bidding process. Sets of project plans, specifications, bidding information, and general contractor lists for jobs being let for bid are available at plan rooms. However, utilizing these plan room services can be time consuming and costly due to the need to travel to the physical location of the plan room. Even though many plan rooms mail their members a weekly newsletter for project update, a visit to the facility is required to check out the project information in detail.





The Technology

Online plan rooms enable their members to conveniently view plan room projects 24 hours a day, seven days a week from the member's home or office location via the Internet. Members can access, look, and download useful information for various construction projects, and even print out actual plans using plotters or printers. Contractors and estimators can get information and prepare for a bid in a timely and efficient manner. In addition, establishing an online plan room enables owners, architects, and contractors to control and manage their bid process more effectively.

Additional features augmenting the online plan room services include Internet access to the plan room via secure login, computerized estimating tools, worksheet build-up function, real-time bidder notification system (email/fax), project search with specific criteria, and blueprint measurement on-screen, etc.

Utilization of these online plan rooms provides prospective bidders with 24 hour accessibility. They also make the bidding process efficient and well-organized, which leads to reduced costs.

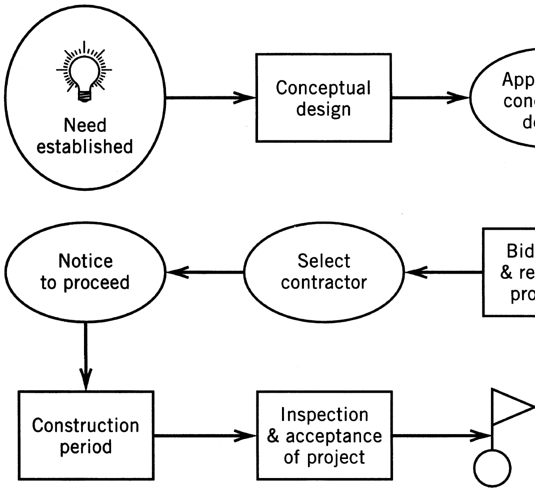


Figure 2.1 Project development cycle (new).

2.1 PROJECT CONCEPT AND NEED

Since the constructed environment in which we live is realized in a project format, the construction process can be best understood by examining the steps required to realize a complete project. In Chapters 2 and 3, we will examine the step-by-step development of a project. A schematic flow diagram of the sequential actions required to realize a project is shown in Figure 2.1. The framework for this discussion will be the development of a project for competitive bid. As we will see in Chapter 4, this is the delivery system characteristic of publicly contracted work. This approach requires that a full set of project documents be developed before the project is offered for bid and construction.

Each project has a life cycle triggered by the recognition of a need that can best be addressed with the construction of a facility. In a complex society, the number of entities generating needs that will shape the built environment is very diverse. Private individuals seek to construct housing that is functional and comfortable (e.g., home or residential construction). Public entities such as city, state, and federal governments construct buildings and required public structures to enhance the quality of life. Many public projects relate to the development of the infrastructure. Bridges, tunnels, transportation facilities, dikes, and dams are typical of public projects designed to meet the needs of a community and the society in general.

Private entities such as commercial firms build facilities that provide goods and services to the economy. These entities are typically driven by the objective of realizing a profit. Facilities constructed by private owners include manufacturing plants, hospitals, research laboratories, hotels and commercial buildings, communications networks, and a host of other project types.

2.2 ESTABLISHING NEED

The first step in any project is the establishment of a need and a conceptual definition and refinement of the facility that will meet that need. If the need has a commercial basis, it is normally defined in terms of a market analysis that establishes the profitability of the proposed project. For instance, if the need relates to the construction of a chemical plant in Spain, the firm constructing the plant will want to establish that a market exists that can be profitably accessed once the plant is in operation.

The economic basis for the plant must be established based on market studies projecting the demand for the plant's product mix across the planning horizon under consideration. In many cases, these studies recommend optimal time frames for the plant construction to meet the market in advance of competition. Plant size, site location, availability of labor and supporting resources such as energy, water, and shipping connections are considered. This study is sometimes referred to as a feasibility study.

This type of information must be developed so that planning decisions by senior management within the company can be made. Typically, feasibility information and supporting cost analyses are submitted to the board of directors. The board then must decide whether the investment required to build a plant is justified.

Similar analysis is necessary for any project. If a group of entrepreneurs decides to build a hotel in Phoenix, Arizona, the basic economic considerations to determine the potential profitability of this venture must be examined. If the economic study supports the idea of a hotel, a need is established. In this case, the financial institutions that lend the money for the development of the hotel typically require certain justification before providing the financing. Therefore, the structure of the feasibility study is dictated, in large part, by the requirements of the lending institution. The types of information required for developing a commercial building project will be addressed in Chapter 10.

Public and community-service-related projects do not typically involve profit and, therefore, are triggered by other considerations. If the church board of the Smallville Methodist Church decides to add a wing to provide a larger area for the Sunday school, this decision is based on improving the quality of services provided by the church. Since funds must be developed for such an addition, the church board will seek the assistance of a consultant (e.g., architect or architect/engineer) to better define the scope of the new addition. Design and cost information are required to approach a bank or lending agency regarding financing. Based on information from design and cost consultants, the church board must decide whether to proceed to development of final design documents or place the project on hold.

Public entities such as city, state, and federal governments are continuously reviewing societal needs. The annual cycle of activity for public agencies looks at the changing demands of constituents with the objective of developing a plan (e.g., a set of projects) that will improve services. State highway departments, for instance, have annual budgets based on existing strategic plans. These master plans envision the construction of new roads and bridges and the maintenance of existing infrastructure. Such plans are reviewed annually and projects to repair and enhance the transportation network of each state are budgeted. In this situation, the needs of the state are under continuous review. A balance between funds available and transportation needs must be maintained.

2.3 FORMAL NEED EVALUATION

In deciding whether or not to proceed with preliminary and final design of a given project, three items should be developed during the conceptual portion of the project cycle. The following elements provide input to the decision process:

1. Cost/benefit analysis
2. Graphical representation of the project (e.g., sketch or artist's rendering) and a layout diagram of the facility
3. Cost estimate based on the conceptual-level information available

These documents assist the key decision maker(s) in deciding whether to proceed with a proposed project.

The cost/benefit analysis in the case of commercial or profit-based projects is simply a comparison of the estimated cost of the project against the revenues that can be reasonably expected to be generated. In public and other non-profit-based projects (e.g., monuments, churches, museums, etc.), development of the benefit to be achieved is more difficult to pin down.

For instance, if a dam is to be constructed on the Colorado River, part of the benefit will be tangible (i.e., developed in dollars) and part will be intangible (i.e., related to the quality of life). If power is to be generated by the dam, the sale of the electricity and the revenues generated therefrom are tangible and definable in dollars amounts. Much of the benefit may, however, derive from control of the river and the changing of the environment. This dam will prevent flooding of downstream communities and form a lake that can be used as a recreational resource.

The recreational aspects of the project and the protection of communities from flooding are difficult to characterize in dollars and cents. They can be viewed as intangible benefits related to improvement of the quality of life. Protocols for converting intangible aspects of a dam project into benefits have been developed by the Bureau of Reclamation and the Army Corps of Engineers (both government agencies involved in water resource development). At best, however, evaluating intangibles is a judgment call and subject to review and criticism.

2.4 CONCEPTUAL DRAWINGS AND ESTIMATES

In seeking funding for entrepreneurial projects such as hotels, apartment buildings and complexes, shopping malls, and office structures, it is common practice to present conceptual documentation to potential funding sources (e.g., banks and investors). In addition to a cost/benefit analysis, graphical information to include architect's renderings or sketches as well as layout drawings and 3D computer models assist the potential investor in better understanding the project. For this reason, such concept drawings and models are typically part of the conceptual design package. A cost estimate based on the conceptual drawings and other design information (e.g., square footage of roof area, floor space, size of heating and air conditioning units, etc.) is prepared.

Government projects at the federal level require similar supporting analysis and are submitted with budget requests each year for congressional action. Supporting documentation includes layout sketches and outline specifications such as those shown in Figure 2.2. The supporting budget for this project is shown in Figure 2.3. These projects are included as line items in the budget of the government agency requesting funding. In this case, the requestor would be the post engineer, Fort Campbell, Kentucky. This request would be consolidated with requests at the Army and Department of Defense level and forwarded to the Bureau of the Budget to be included in the budget submitted to Congress.

It is of interest to note that since the post office project will not be built for at least a year (assuming it is approved), a projection of cost to the future date on which construction will begin is required. The projection is made using the *Engineering News Record* (ENR) indexes of basic construction cost. Construction cost indexes such as the ENR index allow estimators to project costs into the future. The building and construction cost indexes through March 2005 are shown in Figure 2.4.

The summary on the last page of the estimate indicates that the baseline cost of the project will be $909,050. The reserve for contingency is 10% of the base cost, or $90,900. The amount budgeted for supervision of the work by the Corps of Engineers is $54,800. The design cost is projected to be $70,000.

The amount of conceptual design documentation varies based on the complexity of the project. Fairly simple building projects such as the Sunday school addition or the military post office can be conceptually defined in terms of drawings, guide specifications, and a cost estimate such as those shown in Figures 2.2 and 2.3. Large and complex projects such as

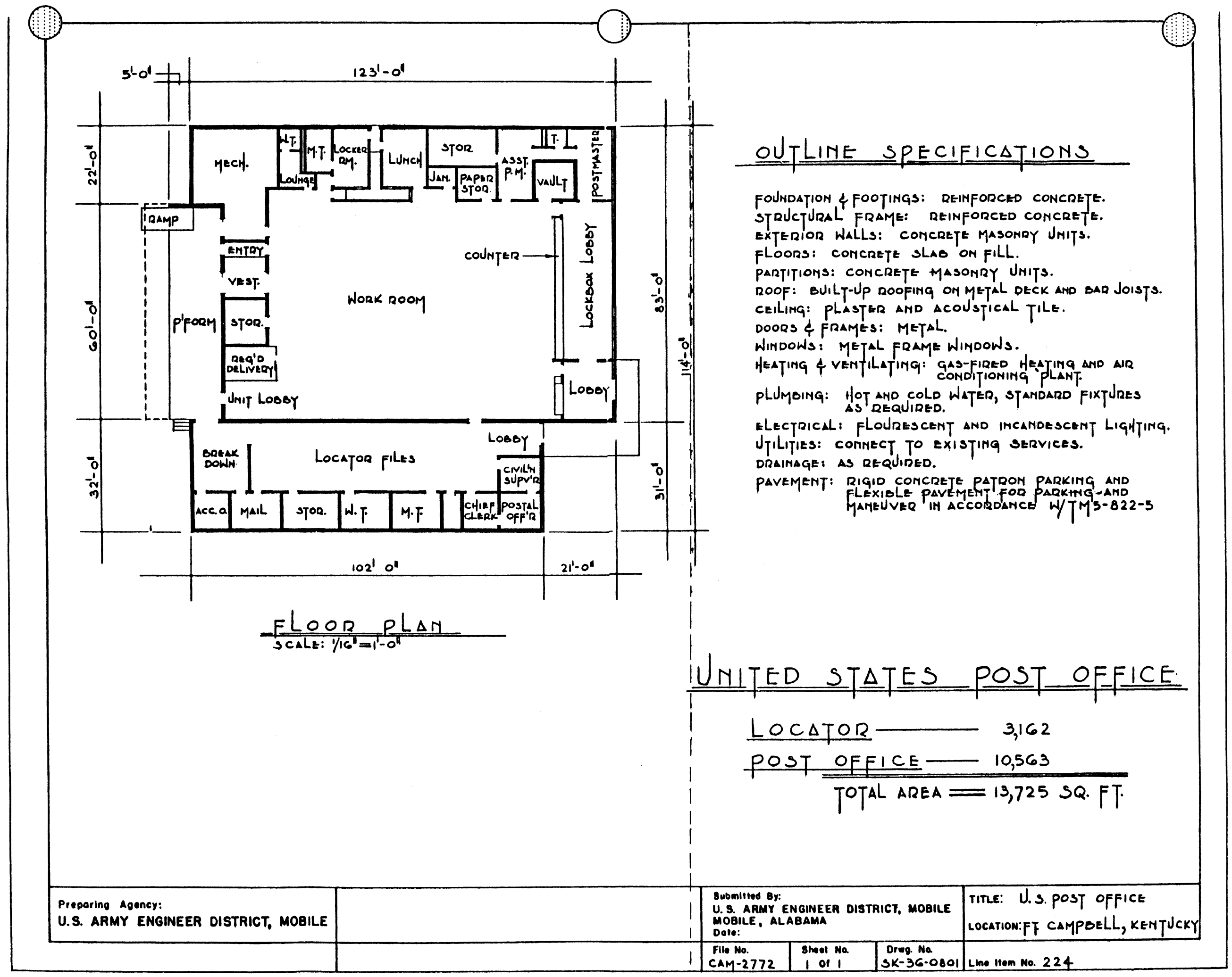


Figure 2.2 Project proposal: layout sketch and outline specifications.

TO: Chief of Engineers Department of the Army Washington, D.C.	FROM: Louisville District Corps of Engineers Louisville, KY
Fiscal Year 2XXX	Date Prepared: 14 Oct 2XXX
Name and Address of A.E. N.A.	
Basis of Estimate Budget Sketch & 1391	A.E. Fee N.A.
Name and Location of Installation Ft. Campbell, Kentucky	Type of Construction Permanent
Status of Design Preliminary 0% complete	Final 0% complete
Line Item Number 224	Description of Facility Post Office
Final Design Completion Date Not Authorized	

Description	Quantity	Unit	Unit Price	Totals ($000)
1. *Building*				
General construction	13,725	Sq ft	$42.24	$579.7
Plumbing	13,725	Sq ft	2.42	33.2
Heating and ventilating	13,725	Sq ft	2.68	36.8
Air conditioning (50-ton)	13,725	Sq ft	7.62	104.6
Electrical	13,725	Sq ft	5.76	79.0
Subtotal	13,725	Sq ft	60.72	833.3
2. *Utilities*				
a. *Electrical*				
Transformers	112.5	kVA	50	5.6
Poles with X-arms, pins, insulation, etc.	4	Each	720	2.9
Dead ends	6	Each	80	.5
Down guys and anchors	4	Each	180	.7
Fused cutouts and L.A.	6	Each	60	.4
#6 Bar Cu. conductor	2,400	lin ft	.30	0.7
#3/0 Neoprene covered service	160	lin ft	1.48	0.2
Parking area lights on aluminum pole	7	Each	933.41	6.5
3C #8 DB 600-V				

TO: Chief of Engineers Department of the Army Washington, D.C.	FROM: Louisville District Corps of Engineers Louisville, KY

Figure 2.3 Current working estimate for budget purposes.

Description	Quantity	Unit	Unit Price	Totals ($000)
3-in. duct conc.				
encased U.G.	100	lin ft	4.75	0.5
Subtotal				19.3
b. *Water*				
3-in. Water line	365	lin ft	8.60	3.1
3-in. Gate valve and				
box	1	Each	200.00	.2
Fire hydrants	2	Each	1000.00	2.0
Connections to				
existing lines	3	Each	500.00	1.5
Subtotal				6.8
c. *Sewer*				
6-in. sanitary sewer	215	lin ft	12.00	2.6
8-in. sanitary sewer	375	lin ft	14.00	5.3
Manhole	2	Each	1000.00	2.0
Connection to exist.				
manhole	1	Each	250.00	.25
Subtotal				10.15
d. *Gas*				
$1\frac{1}{4}$ in. gas line	1,000	lin ft	6.00	6.0
$1\frac{1}{4}$ in. plug valve				
and box	1	Each	200.00	0.2
Connect to existing	1	Each	237.60	0.2
street and parking				
area crossing	280	lin ft	2.0	0.6
Subtotal				7.0
3. *Site Work*				
Clearing and grubbing	2.4	Acre	500	1.2
Borrow excavation	10,000	cu yd	8.00	80.0
Remove B. T. paving	1,070	sq yd	4.00	4.3
Subtotal				85.3
4. *Paving*				
Paving-$1\frac{1}{2}$ A.C. and				
8-in. stab.	3,950	sq yd	10.00	39.5
aggr. base	2,250	lin ft	8.50	19.2
6-in. P.C. concrete				
paving	380	sq yd	20.00	7.6
3-in. painted parking				
lines	1,680	lin ft	8.50	0.9
Concrete sidewalk	440	sq yd	18.00	7.9
Subtotal				75.1
5. *Storm Damage*				
15-in. concrete Cl. II pipe	40	lin ft	18.00	0.7
15-in. concrete Cl. III pipe	20	lin ft	20.00	0.4
Reinf. drainage structure				
concrete	8	cu yd	300.00	2.4
C.I. grates and frames	1,900	lb	1.00	1.9
Subtotal				5.4
6. *Landscaping*				

Figure 2.3

Description	Quantity	Unit	Unit Price	Totals ($000)
Sprigging and seeding	1.6	Acre	$1500.00	2.4
Landscaping		Job		3.8
Subtotal				6.2
7. *Communications*				
a. Telephone		LS	$1400.00	1.4
b. Support (within building)				
100 Pr. DB Pic Cable	600	LF	1.26	0.8
51 Pr. DB Pic Cable	550	LF	0.72	0.4
Splicing sleeves and material		LS	$900.00	0.9
Labor		LS		2.5
Subtotal				6.0
Total estimated cost (excluding design, but including reserve for contingencies and supervision and administration (S&A)				1054.75
1. Estimated contract cost				909.05
2. Reserve for contingencies	10	percent		90.90
3. Supervision and administration (S&A); total estimated cost (excluding design, but including reserve for contingencies and supervision and administration)				54.8
				1054.75
4. *Design*				
District expenses (preliminary and final)				70.0
Subtotal				70.0

Figure 2.3

petrochemical plants and power generation facilities require expanded documentation (e.g., hundreds of pages) to define the scope of work. For this reason, the number of engineering man-hours required to develop conceptual design documentation for the chemical plant in Spain would be significantly greater than that required for a small commercial building.

2.5 PRELIMINARY AND DETAIL DESIGN

Once the concept of the project has been approved, the *owner* desiring the construction retains an engineer, an architect, or a combination of the two, called an architect/engineer (A/E).[1] The end product of the design phase of project development is a set of plans and specifications that define the project to be constructed. The drawings are a graphical

[1] The A/E is typically a firm and is commonly referred to as "the design professional."

Building Cost Index History (1923-2005)

▶ **HOW ENR BUILDS THE INDEX:** **68.38 hours of skilled labor** at the 20-city average of bricklayers, carpenters and structural ironworkers rates, plus **25 cwt of standard structural steel shapes** at the mill price prior to 1996 and the fabricated 20-city price from 1996, plus **1.128 tons of portland cement** at the 20-city price, plus **1,088 board ft of 2x4 lumber** at the 20-city price.

ANNUAL AVERAGE

1923	186	1946	262	1969	790
1924	186	1947	313	1970	836
1925	183	1948	341	1971	948
1926	185	1949	352	1972	1048
1927	186	1950	375	1973	1138
1928	188	1951	401	1974	1205
1929	191	1952	416	1975	1306
1930	185	1953	431	1976	1425
1931	168	1954	446	1977	1545
1932	131	1955	469	1978	1674
1933	148	1956	491	1979	1819
1934	167	1957	509	1980	1941
1935	166	1958	525	1981	2097
1936	172	1959	548	1982	2234
1937	196	1960	559	1983	2284
1938	197	1961	568	1984	2417
1939	197	1962	580	1985	2428
1940	203	1963	594	1986	2483
1941	211	1964	612	1987	2541
1942	222	1965	627	1988	2598
1943	229	1966	650		
1944	235	1967	676		
1945	239	1968	721		

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AVG.
1989	2615	2608	2612	2615	2616	2623	2627	2637	2660	2662	2665	2669	2634
1990	2664	2668	2673	2676	2691	2715	2716	2716	2730	2728	2730	2720	2702
1991	2720	2716	2715	2709	2723	2733	2757	2792	2785	2786	2791	2784	2751
1992	2784	2775	2799	2809	2828	2838	2845	2854	2857	2867	2873	2875	2834
1993	2886	2886	2915	2976	3071	3066	3038	3014	3009	3016	3029	3046	2996
1994	3071	3106	3116	3127	3125	3115	3107	3109	3116	3116	3109	3110	3111
1995	3112	3111	3103	3100	3096	3095	3114	3121	3109	3117	3131	3128	3111
1996	3127	3131	3135	3148	3161	3178	3190	3223	3246	3284	3304	3311	3203
1997	3332	3333	3323	3364	3377	3396	3392	3385	3378	3372	3350	3370	3364
1998	3363	3372	3368	3375	3374	3379	3382	3391	3414	3423	3424	3419	3391
1999	3425	3417	3411	3421	3422	3433	3460	3474	3504	3505	3498	3497	3456
2000	3503	3523	3536	3534	3558	3553	3545	3546	3539	3547	3541	3548	3539
2001	3545	3536	3541	3541	3547	3572	3625	3605	3597	3602	3596	3577	3574
2002	3581	3581	3597	3583	3612	3624	3652	3648	3655	3651	3654	3640	3623
2003	3648	3655	3649	3652	3660	3677	3684	3712	3717	3745	3766	3758	3694
2004	3767	3802	3859	3908	3955	3996	4013	4027	4103	4129	4128	4123	3984
2005	4112	4116	4127										

BASE: 1913=100.

(a)

Construction Cost Index History (1918-2005)

▶ **HOW ENR BUILDS THE INDEX:** **200 hours of common labor** at the 20-city average of common labor rates, plus **25 cwt of standard structural steel shapes** at the mill price prior to 1996 and the fabricated 20-city price from 1996, plus **1.128 tons of portland cement** at the 20-city price, plus **1,088 board ft of 2x4 lumber** at the 20-city price.

ANNUAL AVERAGE

1918	189	1942	276	1966	1019
1919	198	1943	290	1967	1074
1920	251	1944	299	1968	1155
1921	202	1945	308	1969	1269
1922	174	1946	346	1970	1381
1923	214	1947	413	1971	1581
1924	215	1948	461	1972	1753
1925	207	1949	477	1973	1895
1926	208	1950	510	1974	2020
1927	206	1951	543	1975	2212
1928	207	1952	569	1976	2401
1929	207	1953	600	1977	2576
1930	203	1954	628	1978	2776
1931	181	1955	660	1979	3003
1932	157	1956	692	1980	3237
1933	170	1957	724	1981	3535
1934	198	1958	759	1982	3825
1935	196	1959	797	1983	4066
1936	206	1960	824	1984	4066
1937	235	1961	847	1985	4066
1938	236	1962	872	1986	4295
1939	236	1963	901	1987	4406
1940	242	1964	936	1988	4519
1941	258	1965	971		

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	ANNUAL AVG.
1989	4580	4573	4574	4577	4578	4599	4608	4618	4658	4658	4668	4685	4615
1990	4680	4685	4691	4693	4707	4732	4734	4752	4774	4771	4787	4777	4732
1991	4777	4773	4772	4766	4801	4818	4854	4892	4891	4892	4896	4889	4835
1992	4888	4884	4927	4946	4965	4973	4992	5032	5042	5052	5058	5059	4985
1993	5071	5070	5106	5167	5262	5260	5252	5230	5255	5264	5278	5310	5210
1994	5336	5371	5381	5405	5405	5408	5409	5424	5437	5437	5439	5439	5408
1995	5443	5444	5435	5432	5433	5432	5484	5506	5491	5511	5519	5524	5471
1996	5523	5532	5537	5550	5572	5597	5617	5652	5683	5719	5740	5744	5620
1997	5765	5769	5759	5799	5837	5860	5863	5854	5851	5848	5838	5858	5826
1998	5852	5874	5875	5883	5881	5895	5921	5929	5963	5986	5995	5991	5920
1999	6000	5992	5986	6008	6006	6039	6076	6091	6128	6134	6127	6127	6059
2000	6130	6160	6202	6201	6233	6238	6225	6233	6224	6259	6266	6283	6221
2001	6281	6272	6279	6286	6288	6318	6404	6389	6391	6397	6410	6390	6334
2002	6462	6462	6502	6480	6512	6532	6605	6592	6589	6579	6578	6563	6538
2003	6581	6640	6627	6635	6642	6694	6696	6733	6741	6771	6794	6782	6695
2004	6825	6861	6957	7017	7064	7109	7126	7188	7298	7314	7312	7308	7115
2005	7297	7298	7309										

BASE: 1913=100.

(b)

Figure 2.4 *Engineering News Record* Construction Cost Indexes (a) Building Cost Index (b) Construction Cost Index (Reprinted from Engineering News-Record, copyright McGraw-Hill Companies Inc., 21 March 2005, All rights reserved.)

or schematic indication of the work to be accomplished. The specifications are a verbal or word description of what is to he constructed and to what levels of quality. When completed, they are included as legally binding elements of the contract. The production of the plans and specifications usually proceeds in two steps. The first step is called *preliminary design* and offers the owner a pause in which to review the plan before detail design commences. A common time for this review to take place is at 40% completion of the total design. The preliminary design extends the concept documentation. In most projects, a design team leader concept is utilized. The design team leader coordinates the efforts of architects and engineers from differing disciplines. The disciplines normally identified are architectural, civil and structural, mechanical, and electrical. The architect or architectural engineer, for instance, is responsible for the development of floor plans and general layout drawings as well as considerations such as building cladding, exterior effects, and interior finish. The mechanical engineer is concerned with the heating, ventilating, and air conditioning (HVAC), as well as service water systems. At preliminary design, decisions regarding size and location of air conditioning and heating units as well as primary water distribution components (e.g., pumps) are made. Similar decisions regarding the electrical system are made at this point by the electrical engineers. The structural and civil engineers develop the preliminary design of the structural frame and the subsurface foundation support. All of these designs are interlinked. The architectural layout impacts the weight support characteristics of the floor structure and, hence, the selection of structural system. The structural superstructure influences the way in which the foundation of the structure can be handled. The floor plan also determines the positioning of pipes and ducts and the space available for service mains.

Once the preliminary design has been approved by the owner, final or *detail design* is accomplished. This is the second step in the production of the plans and specifications. For the architectural engineer this focuses on the interior finishes, which include walls, floors, ceilings, and glazing. Details required to install special finish items are designed. Precise locations and layout of electrical and mechanical systems as well as the detail design of structural members and connections are accomplished by the appropriate engineers. As noted, the detail design phase culminates in the plans and specifications that are given to the constructor for bidding purposes. In addition to these detailed design documents, the architect/engineer produces a final "owner's" estimate indicating the total job cost minus markup. This estimate should achieve approximately $\pm 3\%$ accuracy, since the total design is now available. The owner's estimate is used (1) to ensure the design produced is within the owner's financial resources to construct (i.e., the architect /engineer has not designed a gold-plated project), and (2) to establish a reference point in evaluating the bids submitted by the competing contractors. In some cases, when all contractor bids greatly exceed the owner's estimate, all bids are rejected and the project is withdrawn for redesign or reconsideration. Once detailed design is completed, the owner again approves the design prior to advertising the project to prospective bidders.

2.6 NOTICE TO BIDDERS

The document announcing to prospective bidders that design documents are available for consideration and that the owner is ready to receive bids is called the *notice to bidders*. Because of his commitment to the owner to design a facility that can be constructed within a given budget and at an acceptable level of quality, the architect/engineer wants to be sure that the lowest bid price is achieved. To ensure this, the job is advertised to those contractors who are capable of completing the work at a reasonable price. All A/E firms maintain mailing lists that contain qualified bidders. When design is complete, a notice to bidders, such as the one shown in Figure 2.5, is sent to all prospective bidders. The notice to bidders contains information regarding the general type and size of the project, the availability of plans and specifications for review, and the time, place, and date of the bid opening. Normally, sets of plans and specifications are available for perusal at the A/E office as well as at *plan rooms*, which are conveniently located and can be visited by contractors in large cities. These facilities have copies of plans and specifications for a large number of jobs being let for bid. They afford contractors the opportunity to go to a central location and look at several jobs without having to drive to the office locations of each architect/engineer. The expenditure on the part of the contractors in going to the A/E office or plans rooms to look at the contract documents amounts only to the price of gas and a small amount of time. If they should decide to bid on a particular job, their commitment increases sharply in terms of money and time invested.

In addition to the mailings made available by the A/E firm as the owner's representative, contractors have other methods of learning about jobs that are available for bid. In some large cities, a builder's exchange may operate to serve the contracting community and keep it appraised of the status of design and bid activity within a given area. In addition to operating plans rooms, these exchanges often publish newsletters such as the one shown in Figure 2.6. These reports indicate what jobs are available for bidding, and architect/engineers make use of such facilities to gain maximum coverage in advertising their jobs. In addition to the basic information describing the job and the time and place of bid opening, these reports include, following each announcement, a statement that the plans are on file, along with the bin location.

Nationwide services such as the Dodge Reporting System are web-based and provide information on projects being let for bid. For a subscription fee such services provide information regarding jobs sorted by type of construction, geographical location, job size, and other parameters directly to the contractor. The information announcements indicate whether the job is under design, ready for bid, or awarded. In the cases of jobs that have been awarded, the low bid and other bid prices submitted are furnished so that the contractor can detect bidding trends in the market. A typical Dodge Reporting System web-based announcement is shown in Figure 2.7.

NOTICE TO BIDDERS
FOR
CONSTRUCTING SEWERAGE SYSTEM IMPROVEMENTS
CONTRACT "B"
CENTRAL STATE HOSPITAL
FOR THE
GEORGIA BUILDING AUTHORITY (HOSPITAL)
STATE CAPITOL—ATLANTA, GEORGIA

Sealed proposals will be received for Constructing Sewerage System Improvements, Contract "B," for the Georgia Building Authority (Hospital), State Capitol, Atlanta, Georgia, at Room 315, State Health Building, 47 Trinity Avenue, S.W., Atlanta, Georgia, until 2:00 P.M., E.S.T., February, 18 __, at which time and place they will be publicly opened and read. Bidding information on equipment in Section No. 10 shall be submitted on or before February 4 __.

Work to Be Done: The work to be done consists of furnishing all materials, equipment, and labor and constructing:

Division One. Approximately 12,400 L.F. 36″ Sewer Pipe, 5,650 L.F. 30″ Sewer Pipe, 7,300 L.F. 24″ Sewer Pipe, 1,160 L.F. 15″ Sewer Pipe, 3,170 L.F. 12″ Sewer Pipe, 300 L.F. 8″ Sewer Pipe, 418 L.F. 36″ C.I. Pipe Sewer, 324 L.F. 30″ C.I. Pipe Sewer, 1,150 L.F. 30″ C.I. Force Main, 333 L.F. 24″ C.I. Force Main, 686 L.F. 24″ C.I. Pipe Sewer, and all other appurtenances for sewers.
Division Two. One Sewage Pumping Station—"Main Pump Station."
Division Three. One Sewage Pumping Station—"Fishing Creek Pump Station."
Division Four. One Sewage Pumping Station—"Camp Creek Pump Station."

Bids may be made on any or all Divisions, any of which may be awarded individually or in any combination.

Figure 2.5 Notice to bidders (courtesy of Georgia Building Authority).

Proposals. Proposals shall contain prices, in words and figures, for the work bid on. All Proposals must be accompanied by a certified check, or a bid bond of a reputable bonding company authorized to do business in the State of Georgia, in an amount equal to at least five (5%) percent of the total amount of the bid.

Upon the proper execution of the contract and required bonds, the checks or bid bonds of all bidders will be returned to them.

If Proposals are submitted via mail rather than delivery they should be addressed to Mr. Smith, Director, Department of Administration and Finance, Georgia Department of Public Health, Room 519, State Health Building, 47 Trinity Avenue, S.W., Atlanta, Georgia 30334.

Performance and Payment Bonds: A contract performance bond and payment bond, each in an amount equal to one hundred (100%) percent of the contract amount, will be required of the successful bidder.

Withdrawal of Bids: No submitted bid may be withdrawn for a period of sixty (60) days after the scheduled closing time for the receipt of bids.

Plans, Specifications, and Contract Documents: Plans, Specifications and Contract Documents are open to inspection at the Office of the Georgia Building Authority (Hospital), State Capitol, Atlanta, Georgia, or may be obtained from Wiedeman and Singleton, Engineers, P.O. Box 1878, Atlanta, Georgia 30301, upon deposit of the following amounts.

Division One: $45.00 for Plans and Specifications.
Divisions Two, Three and Four (*Combined*). $50.00 for Plans and Specifications.
Divisions One to Four, Inclusive. $75.00 for Plans and Specifications.
All Divisions. $20.00 for Specifications only.

Upon the return of all documents in undamaged condition within thirty (30) days after the date of opening of bids, one-half of the deposit will be refunded. No refunds will be made for plans and documents after thirty (30) days.

Wage Schedule: The schedule of minimum hourly rates of wages required to be paid to the various laborers and mechanics employed directly upon the site of the work embraced by the Plans and Specifications as determined by the Secretary of the U.S. Department of Labor, Decision No. AI-971, is included in the General Conditions of the Specifications. This decision, expiring prior to the receipt of bids, will be superceded by a new decision to be incorporated in the Contract before the award is made to the successful bidder.

Acceptance or Rejection of Bids: The right is reserved to accept or reject any or all bids and to waive informalities.

THIS PROJECT WILL BE FINANCED IN PART BY A GRANT FROM THE FEDERAL WATER POLLUTION CONTROL ADMINISTRATION AND WILL BE REFERRED TO AS PROJECT WPC-GA-157.

BIDDERS ON THIS WORK WILL BE REQUIRED TO COMPLY WITH THE PRESIDENT'S EXECUTIVE ORDERS NO. 11246 and NO. 11375. THE REQUIREMENTS FOR BIDDERS AND CONTRACTORS UNDER THESE ORDERS ARE EXPLAINED IN THE SPECIFICATIONS.

GEORGIA BUILDING AUTHORITY (HOSPITAL)

By: ____________________
Secretary–Treasurer

Figure 2.5

bids

Replace Roof,
Building 3245
Ft Benning, GA

2 PM August 20

REPLACE ROOF, BLDG 3245 (B-0037), FT BENNING, GA (CHATTAHOOCHEE CO)
Submit Bids To .... Directorate of Contracting, Bldg 6 (Meloy Hall), Mailroom 207, ATZB-KTD, Ft Benning GA 31905-5000 (Isaac D Larry, contact) 706/545-2193 2 PM August 20
Plans Available From .... Owner
Bond Info .... 20% bid bond. 50% pymt bond. 100% perf bond.
Div 2 .... demol
Div 5 .... misc mtl
Div 6 .... rough carp
Div 7 .... roof insul, b/u rfg, sht mtl wk, caulking & sealants
Div 9 .... ptg
PLANS ON FILE .... ATL Bin 56 - #107293

bids

Family Life
Center for First
Assembly of God
Griffin, GA

2 PM August 22

FAMILY LIFE CENTER FOR FIRST ASSEMBLY OF GOD (2000 W McIntosh Rd) GRIFFIN, GA (SPALDING CO)
Submit Bids To .... First Assembly of God, Griffin, GA 2 PM August 22
Archt .... Rardin & Carroll Architects, 6105 Preservation Drive, Ste A, Chattanooga, TN 37416 423/(894-2839) 894-3242
Civil Engr .... Breelove Land Planners, Atlanta, GA
Struct Engr .... Robinson & Associates, Atlanta, GA
Mech/Elect/Plbg Engr ...... Brewer & Skala Engineers, Atlanta, GA
Plans Available From .... Archt $100 plan dep to GC's, one set ref to bona fide GC's within 10 days, all others non-ref cost of reprod.
Bond Info .... 5% bid bond. 100% pymt/perf bond.
Est Cost $1,400,000
Scope .... Approx 26,000 s.f. 1 story classrooms, offices & gym
Div 2 .... sel demol, site clrg & prep, earthwk, termite control
Div 3 .... cast-in-place conc, cementitious wood fiber decking
Div 4 .... unit masonry, precast conc window stool
Div 5 .... struct stl, open web joists, composite roof deck assemb, light gauge stl frmg, mtl handrails
Div 6 .... rough carp, struct glued laminated timber, finish carp & millwk
Div 7 .... waterprfg, dampprfg, bldg insul, masonry insul, EIFS, roof insul over wood deck, firestpg, fiberglass shingles, vinyl siding, rubber membrane rfg, flash & s/m, int caulking, ext sealant
Div 8 .... hol mtl wk, alum doors & frames, wood doors, counter doors, alum windows, glass & glzg
Div 9 .... gyp wallbd, acoust ceilings, poured in place synth sports flrg, resil flrg, cpt (owner provided), ptg, vinyl-coated fabric
Div 10 .... laminated plastic toilet partns, solid phenolic core partns, toilet & bath acces, fire extin & cabinets
Div 11 .... athletic equip
Div 15 .... hvac, ductwk & acces, computerized damper (VVT) sys, louvers-grilles-registers & diffusers, unitary exhaust & supply fans & vents, split sys a/c, refrigerant piping, pkg rooftop htg & vent units, auto controls, high efficiecy gas-fired duct heater, kitchen vent equip, test & balance, plbg, natl gas piping sys, fire prot, roof curbs
Div 16 .... elect, lighting, fire alarm sys
PLANS ON FILE .... ATL Bin 38 - #107182

bids

Misc Elect,
Bldg 2752
Ft Benning, GA

2 PM August 22

MISCELLANEOUS ELECTRICAL REPAIRS, BLDG 2752 (B-0051), FT BENNING, GA (CHATTAHOOCHEE CO)
Submit Bids To .... Directorate of Contracting, Bldg 6 (Meloy Hall), Mailroom 207, ATZB-KTD, Ft Benning GA 31905-5000 (Sabra A Boynton, contact) 706/545-2221 2 PM August 22
Plans Available From .... Owner
Bond Info .... 20% bid bond. 50% pymt bond. 100% perf bond.
Div 2 .... demol
Div 16 .... int elect wk
PLANS ON FILE .... ATL Bin 55 - #107292

Figure 2.6 Typical Daily Building Report.

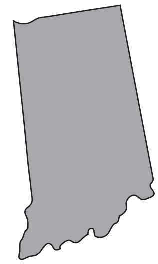
2.7 BID PACKAGE

The documents that are available to the contractor and on which he must make a decision to bid or not to bid are those in the *bid package*. In addition to the plans and technical specifications, the bid package prepared by the A/E consists of a *proposal* form, *general conditions* that cover procedures common to all construction contracts, and *special conditions*, which pertain to procedures to be used that are unique to this particular project. All supporting

Welcome!
Please select the reports that you would like to view or purchase, or you may redefine your search criteria by using the advanced search option to the left!
(Please remember to print your viewed reports.)

Indiana Projects
(In the bidding stages only)
308 #General Building
262 #Engineering
81 #Utility
13 #Projects Residential
78 #Bidding in 7 Days
983 $(mil)Bidding in 7 Days

- ***Bidders List Now Available.***
- Unlimited searching.
- Find the jobs you want to bid on.
- Pay only for what you want. Not what you don't.



195 projects were retrieved

D.R. #	Last Update	Bid Date	Project Type	Valuation	State	County	Sub Projects
2004-0083-2502	03/22/05 11:03 AM	03/31/05	Primary School	500,000	IN	Boone	0
2005-0066-9864	03/22/05 11:03 AM	04/07/05	Warehouse (Refrigerated)	1,500,000	IN	Spencer	0
2005-0065-5840	03/22/05 09:03 AM	03/24/05	Food-Beverage Service	90,000	IN	Lake	0
2004-0078-6586	03/22/05 08:03 AM	03/30/05	Supermarket-Convenience Store	700,000	IN	La Porte	10
2005-0066-5962	03/22/05 08:03 AM	04/07/05	College-University	95,000	IN	Lake	0
2005-0063-6114	03/22/05 08:03 AM	03/29/05	Office	1,500,000	IN	Tippecanoe	0
2004-0088-5958	03/22/05 04:03 PM	03/18/05	Retail (Other)	5,000,000	IN	Porter	0
2005-0066-8774	03/22/05 04:03 PM	04/05/05	Primary School	300,000	IN	Porter	0
2005-0060-8359	03/22/05 04:03 PM	03/30/05	Testing-Research-Development Lab	4,000,000	IN	St Joseph	0
2001-0077-8164	03/22/05 03:03 PM	03/24/05	Museum	1,000,000	IN	Jefferson	0

Home **View Next 10**

Figure 2.7 Typical Web-Based Dodge Reporting System announcement (copyright © 2005 McGraw-Hill Companies, Inc.).

documents are included by reference in the proposal form. The bid package layout is shown schematically in Figure 2.8.

The proposal form as designed and laid out by the A/E is the document that, when completed and submitted by the contractor, indicates the contractor's desire to perform the work and the price at which he will construct the project. A typical example of a proposal is shown in Figure 2.9.

The proposal form establishes intent on the part of the contractor to enter into a contract to complete the work specified at the cost indicated in the proposal. It is an offer and by itself is not a formal contract. If, however, the owner responds by awarding the contract based on the proposal, an acceptance of the offer results and a contractual relationship is established. The prices at which the work will be constructed can be stated either as lump-sum or as

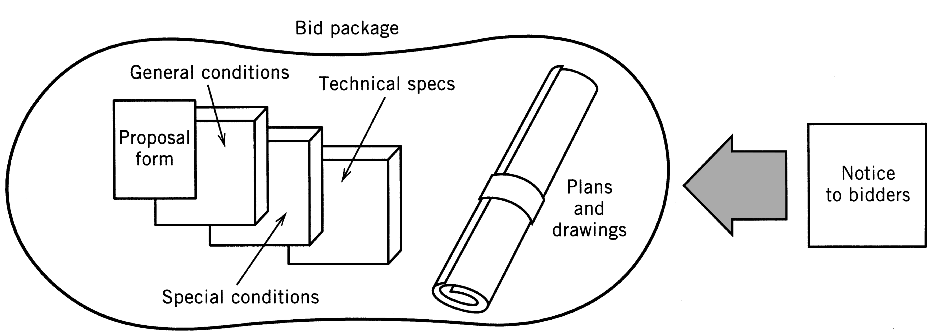


Figure 2.8 Bid package documents.

PROPOSAL
TO THE GEORGIA BUILDING AUTHORITY (HOSPITAL)
STATE CAPITOL
ATLANTA, GEORGIA

Submitted: ______(date)______, 2XXX

The undersigned, as Bidder, hereby declares that the only person or persons interested in the Proposal as principal or principals is or are named herein and that no other person than herein mentioned has any interest in this Proposal or in the Contract to be entered into; that this Proposal is made without connection with any other person, company, or parties making a bid or Proposal; and that it is in all respects fair and in good faith without collusion or fraud.

The Bidder further declares that he has examined the site of the work and informed himself fully in regard to all conditions pertaining to the place where the work is to be done; that he has examined the plans and specifications for the work and contractual documents relative thereto, and has read all Special Provisions and General Conditions furnished prior to the opening of bids; and that he has satisfied himself relative to the work to be performed.

The Bidder proposes and agrees, if this Proposal is accepted, to contract with the Georgia Building Authority (Hospital), Atlanta, Georgia, in the form of contract specified, to furnish all necessary material, equipment, machinery, tools, apparatus, means of transportation, and labor, and to finish the construction of the work in complete accordance with the shown, noted, described, and reasonable intended requirements of the plans and specifications and contract documents to the full and entire satisfaction of the Authority with a definite understanding that no money will be allowed for extra work except as set forth in the attached General Conditions and Contract Documents, for the following prices:

CAMP CREEK PUMP STATION

Section 1: Unit Price Work

(For part payment—except rock excavation—by unit prices, to establish price for variation in quantities. Include balance of quantities for these items—except rock excavation—in lump sum bid for Section 2.)

Item Number	Quantity	Unit	Description	Unit Price	Total Amount
1.	550	cubic yard (cu yd)	Rock excavation (for structures and pipes only)	$______	$______
2.	50	linear foot (lin ft)	8″ C.I. force main	$______	$______
3.	20	cubic yard (cu yd)	Trench excavation for pipes	$______	$______
4.	200	square yard (sq yd)	Paving	$______	$______

Subtotal, Section 1, Item Nos. 1 to 4, Inclusive ______________________

______________________ Dollars ($______________)

Figure 2.9 A typical proposal (courtesy of Georgia Building Authority).

Section 2: Lump Sum Work

Item No.	Description		Total Amount
5.	Excavation and Fill		
	(a) Access Roadway	$________	
	(b) Structure Excavation and Backfill	$________	
	(c) Finish Grading	$________	
	Total for Item No. 5		$________
6.	Paving		
	(a) Access Roadway	$________	
	(b) Station Area	$________	
	Total for Item No. 6		$________
7.	Concrete Work		$________

The Bidder further proposes and agrees hereby to commence work under his contract, with adequate force and equipment, on a date to be specified in a written order of the Engineer, and shall fully complete all work thereunder within the time stipulated, from and including said date, in 300 consecutive calendar days.

The Bidder further declares that he understands that the quantities shown in the Proposal are subject to adjustment by either increase or decrease, and that should the quantities of any of the items of work be increased, the Bidder proposes to do the additional work at the unit prices stated herein; and should the quantities be decreased, the Bidder also understands that payment will be made on the basis of actual quantities at the unit price bid and will make no claim for anticipated profits for any decrease in quantities, and that actual quantities will be determined upon completion of the work, at which time adjustment will be made to the Contract amount by direct increase or decrease.

The Bidder further agrees that, in case of failure on his part to execute the Construction Agreement and the Bonds within ten (10) consecutive calendar days after written notice being given of the award of the Contract, the check or bid bond accompanying this bid, and the monies payable thereon, shall be paid into the funds of the Georgia Building Authority (Hospital), Atlanta, Georgia, as liquidated damages for such failure, otherwise the check or bid bond accompanying his Proposal shall be returned to the undersigned.

Attached hereto is a bid bond by the ________________________
__________________________________ in the amount of
____
________________________ Dollars ($________________)
made payable to the Georgia Building Authority (Hospital), Atlanta, Georgia, in accordance with the conditions of the Advertisement for Bids and the provisions herein.

Submitted: ________________ L.S.

By: ________________ L.S.

Title: ________________

Note: If the Bidder is a corporation, the Proposal shall be signed by an officer of the corporation; if a partnership, it shall be signed by a partner. If signed by others, authority for signature shall be attached.

ADDRESS: ____________________________________
____

Figure 2.9

unit-price figures. Only a portion of the price schedule (see Fig. 2.9) is shown in this example proposal. As shown in the figure, two methods (lump sum and unit price) of quoting price are illustrated. Items 1 to 4 require the bidder to specify unit price (i.e., dollar per unit) for the guide quantities specified. Therefore, if the contractor will do the rock excavation for $80.00 per cubic yard, this price is entered along with the total price (550 × $80.00 = $44,000). Items 5, 6, and 7 require lump- or stipulated-sum quotations. Therefore, the contractor states a single price for the access road, finish grading, and so on.

In the proposal form shown in Figure 2.9, the contract duration is also specified, although this is not always the case. In many instances, the project duration in working or calendar days is specified in the *special conditions* portion of the bid package. The proposal form indicates also that the contractor is to begin work within 10 calendar days after receipt of written notice of award of contract. Award of contract is usually communicated to the contractor in the form of a *notice to proceed*. Response by the owner to the contractor's *proposal* with a notice to proceed establishes a legally binding contractual relationship. Legal signatures (L.S.) by individuals empowered to represent (i.e., commit contractually) the firm making the proposal must be affixed to the proposal.

2.8 GENERAL CONDITIONS

Certain stipulations regarding how a contract is to be administered and the relationships between the parties involved are often the same for all contracts. An organization that enters into a large number of contracts each year normally evolves a standard set of stipulations that establishes these procedures and applies them to all construction contracts. This set of provisions is normally referred to as the *general conditions*. Large government contracting organizations such as the U.S. Army Corps of Engineers, the Bureau of Reclamation, and the General Services Administration (Public Building Service) have a standard set of *general provisions*. For those organizations that enter into construction contracts on a less frequent basis, professional and trade organizations publish standards that are commonly used in the industry. A committee for engineer documents has been formed jointly by the American Consulting Engineers Council, the National Society of Professional Engineers, and the American Society of Civil Engineers to prepare standard contract documents. The committee is called the Engineers Joint Contract Documents Committee (EJCDC). These documents have been endorsed by the Associated General Contractors (AGC) of America and the Construction Specifications Institute (CSI). Some topics that are typically considered in the general conditions are shown in Table 2.1. The rights, privileges, and responsibilities

Table 2.1 Topics Typically Addressed in General Conditions

1. Definitions
2. Preliminary matters
3. Contract documents
4. Bonds and insurance
5. Contractor's responsibilities
6. Owner's responsibilities
7. Engineer's responsibilities
8. Changes in the work
9. Change of contract price
10. Change of contract times
11. Tests and inspections
12. Payments to contractor and completion
13. Suspension of work and termination
14. Dispute resolution

that accrue to the primary contractual parties in any construction contract are also defined in the general conditions. Therefore, sections pertaining to the (1) owner, (2) architect (or architect/ engineer), (3) contractor, and (4) subcontractors are typically found in the general conditions. Most contractors become thoroughly familiar with the standard forms of general conditions (i.e., Corps of Engineers, etc.) and can immediately pick up any additions or changes. Each of the provisions of a standard set of general conditions has legal implications, and the wording cannot be changed without careful consideration. The contract language embodied in the general conditions has been hammered out over the years from countless test cases and precedents in both claims and civil courts. The wording has evolved to establish a fair and equitable balance of protection for all parties concerned. In cases where a contractor finds considerable deviation from the standard language, he may decline the opportunity to bid fearing costs of litigation in clarifying contractual problems. In areas where small deviation is possible, the language of a given standard form may tend to be protective of one party (e.g., the architect) and to hold others responsible when gray areas arise. Predictably, the AGC standard subcontract protects the contractor in areas in which responsibility is unclear or subject to interpretation.

2.9 SUPPLEMENTARY CONDITIONS

Those aspects of the contractual relationship that are peculiar or unique to a given project are given in the *supplementary conditions*. Items such as the duration of the project, additional instructions regarding commencement of work, owner-procured materials, mandatory wage rates characteristic of the local area, format required for project progress reporting (e.g., a network schedule), and amount of liquidated damages are typical of the provisions included in the supplementary conditions. Items contained in supplementary conditions are of two types:

1. Modifications to the basic articles of the general condition in the form of additions, deletions, or substitutions
2. Additional articles of a contractual-legal nature that may be desirable or necessary for a particular project

Since some of the provisions are extensions or interpretations of the general conditions, some of the major paragraph titles are similar to those used in the general conditions. The contents of a typical set of supplementary or special conditions for a Corps of Engineers channel improvement project are shown in Figure 2.10.

2.10 TECHNICAL SPECIFICATIONS

The contract documents must convey the requirements of the project to potential bidders and establish a legally precise picture of the technical aspects of the work to be performed. This is accomplished visually through the use of drawings. A verbal description of the technical requirements is established in the *technical specifications*. These provisions pertain in large part to the establishment of quality levels. Standards of workmanship and material standards are defined in the specifications. For materials and equipment, this is often done by citing a specific brand name and model number as the desired item for installation. In government procurement, where competitive procurement must take place, a similar approach is utilized. Government specifications usually cite a specific brand or model and then establish the requirement that this or an equal item be used. The fact that equality exists must be established by the bidder.

Often the quality required will be established by reference to an accepted practice or quality specification. The American Concrete Institute (ACI), the American Welding

PART II
SPECIAL CONDITIONS
INDEX

Figure 2.10 Special conditions: typical index of special conditions (courtesy of the Army Corps of Engineers).

Society (AWS), the American Association of State Highway and Transportation Officials (AASHTO), the American Society for Testing and Materials (ASTM), as well as federal procurement agencies publish recognized specifications and guides. A list of some typical references is given in Figure 2.11. The organization of the technical specifications section usually follows the sequence of construction. Therefore, specifications regarding concrete placement precede those pertaining to mechanical installation. A typical index of specifications for a heavy construction project might appear as follows:

Section

1	Clearing and grubbing
2	Removal of existing structures
3	Excavation and fill
4	Sheet steel piling
5	Stone protection
6	Concrete
7	Miscellaneous items of work
8	Metal work fabrication
9	Water supply facilities
10	Painting
11	Seeding

As with the general conditions, most contractors are familiar with the appearance and provisions of typical technical specifications. A contractor can quickly review the specifications to determine whether there appears to be any extraordinary or nonstandard aspects that will have an impact on cost. These clauses or nonstandard provisions are underlined or highlighted to be studied carefully.

2.11 ADDENDA

The bid package documents represent a description of the project to be constructed. They also spell out the responsibilities of the various parties to the contract and the manner in which the contract will be administered. These documents establish the basis for determining the bid price and influence the willingness of the prospective bidder to bid or enter into a contract. It is important, therefore, that the bid package documents accurately reflect the project to be constructed and the contract administration intentions of this owner or of the owner's representative. Any changes in detail, additions, corrections, and contract conditions that arise before bids are opened that are intended to become part of the bid package and the basis for bidding are incorporated into the bid package through *addenda*.

An *addendum* thus becomes part of the contract documents and provides the vehicle for the owner (or the owner's representative) to modify the scope and detail of a contract before it is finalized. It is important therefore that addenda details be rapidly communicated to all potential bidders prior to bid submission. Since addenda serve notice on the prospective bidder of changes in the scope or interpretation of the proposed contract, steps must be taken to ensure that all bidders have received all issued addenda. Consequently, addenda delivery is either documented through certified mail receipts or confirmed on bid submission through the bidder's submission of a signed document listing receipt of each duly identified addendum.

Once a contract has been signed, future changes in the scope or details of a contract may form the basis for a new financial relationship between contracting parties. The original

American Concrete Institute

ACI 211.1-91 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

ACI 211.2-98 Standard Practice for Selecting Proportions for Structural Lightweight Concrete

ACI 211.4R-93 Guide for Selecting Proportions for High-Strength Concrete with Portland Cement and Fly Ash

ACI 214-77 Recommended Practice for Evaluation of Strength Test Results of Concrete

ACI 304R-00 Guide for Measuring, Mixing, Transporting, and Placing Concrete

ACI 305R-99 Hot Weather Concreting

ACI 306R-88 Cold Weather Concreting

ACI SP-2-99 ACI Manual of Concrete Inspection

ACI 318-02/318R-02 Building Code Requirements for Structural Concrete and Commentary

ACI 421.1R-99 Shear Reinforcement for Slabs

ACI 550R-96 Design Recommendations for Precast Concrete Structures

American Society for Testing and Materials

ASTM A36/A36M-04 Standard Specification for Carbon Structural Steel

ASTM A82-02 Standard Specification for Steel Wire, Plain, for Concrete Reinforcement

ASTM A185-02 Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

ASTM A496-02 Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement

ASTM A996/A996M-04 Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A706/706M-04a Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement

ASTM C33-03 Standard Specification for Concrete Aggregates

ASTM C39/C39M-03 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

ASTM C42/C42M-03 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

ASTM C55-03 Standard Specification for Concrete Brick

ASTM C90-03 Standard Specification for Loadbearing Concrete Masonry Units

ASTM C94/C94M-04 Standard Specification for Ready-Mixed Concrete

ASTM C109/C109M-02 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

ASTM C140-03 Standard Methods for Sampling and Testing Concrete Masonry Units and Related Units

ASTM C270-03b Standard Specification for Mortar for Unit Masonry

ASTM D2000-03a Standard Classification System for Rubber Products in Automotive Applications

American Welding Society

AWS D1.4-98 Structural Welding Code—Reinforcing Steel

American Society of Civil Engineers

ASCE 7-02 Minimum Design Loads for Buildings and Other Structures

Building Seismic Safety Council

NEHRP Recommended Provisions for Seismic Regulations for New Building and Other Structures (2003 Edition)
Part One: Provisions
Part Two: Commentary

National Ready Mix Concrete Association

Concrete Plant Standards of Concrete Plant Manufacturers Bureau (12th Revision, 2000)

Truck Mixer, Agitator and Front Discharge Concrete Carrier (15th Revision, 2001)

Concrete Reinforcing Steel Institute

Reinforcement Anchorages and Splices (4th Edition, 1997)

Figure 2.11 Typical references to structural inspection and testing standards.

contract, in such cases, can no longer be accepted as forming the basis for a full description of the project. Such changes are referred to as *change orders* (see Section 3.5).

2.12 DECISION TO BID

After investigating the plans and specifications at the architect's office or a plans room, the contractor must make a major decision-whether or not to bid the job. This is a major financial decision, since it implies incurring substantial cost that may not be recovered. Bidding the job requires a commitment of man-hours by the contractor for the development of the estimate.

Estimating is the process of looking into the future and trying to predict project costs and various resource requirements. The key to this entire process is the fact that these predictions are made based on past experiences and the ability of the estimator to sense potential trouble spots that will affect field costs. The accuracy of the result is a direct function of the skill of the estimator and the accuracy and suitability of the method by which these past experiences were recorded. Since the estimate is the basis for determining the bid price of a project, it is important that the estimate be carefully prepared. Studies reveal the fact that the most frequent causes of contractor failure are incorrect and unrealistic estimating and bidding practices.

The quantities of materials must be developed from the drawings by an expert in quantity takeoff. The process of determining the required material quantities on a job is referred to as quantity takeoff or quantity surveying. Once quantities are established, estimators who have access to pricing information use these quantities and their knowledge of construction methods and productivities to establish estimates of the *direct costs* of performing each construction task. They then add to the totaled project direct costs those *indirect costs* that cannot be assigned directly to a particular estimating item (e.g., project supervising costs). Finally, the bid price is established by adding the management and overhead costs, allowances for contingencies, and a suitable profit margin. Appendix A gives typical considerations affecting the decision to bid.

The cost of the time and effort expended to develop a total bid price and submit a proposal is only recovered in the event the contractor receives the contract. A common rule of thumb states that the contractor's estimating cost will be approximately 0.25% of the total bid price. This varies, of course, based on the complexity of the job. Based on this rule, an estimating cost of $25,000 can be anticipated for a job with a total bid cost in the vicinity of $10 million. Expending this amount of money to prepare and submit a bid with only a probability of being awarded the work is a major monetary decision. Therefore, most contractors consider it carefully. In order to recover bidding costs for jobs not awarded, contractors place a charge in all bids to cover bid preparation costs. This charge is based on their frequency of contract award. That is, if a contractor, on the average, is the selected bidder on one in four of the contracts bid, he will adjust the bid cost included in each proposal to recover costs for the three in four jobs not awarded. In addition to the direct costs of bid preparation, the contractor may be required by the architect to pay a deposit for or purchase each set of plans and specifications used. Other costs include telephone charges related to obtaining quotations from subcontractors and vendors and the administrative costs of getting these quotations in writing. A small fee must be paid for a *bid bond* (see Section 2.15) and the administrative aspects of submitting the proposal in conformance with the *instructions to bidders*.

2.13 PREQUALIFICATION

In some cases the complexity of the work dictates that the owner must be certain that the selected contractor is capable of performing the work described. Therefore, before considering a bid, the owner may decide to prequalify all bidders. This is announced in the instructions to bidders. Each contractor interested in preparing and submitting a bid is asked to submit documents that establish his firm's expertise and capability in accomplishing similar types of construction. In effect, the owner asks the firm to submit its "resume" for consideration. If the owner has doubts regarding the contractor's ability to successfully complete the work, the owner can simply withhold qualification.

This is helpful to both parties. The contractor does not prepare a bid and incur the inherent cost unless he can qualify. On the other hand, the owner does not find himself in the position of being under pressure to accept a low bid from a firm he feels cannot perform the work. In the extreme case, a small firm with experience only on single-family residential housing may bid low on a complex radar-tracking station. If the owner feels the contractor will not be able to successfully pursue the work, he can fail to prequalify the contractor.

2.14 SUBCONTRACTOR AND VENDOR QUOTATIONS/CONTRACTS

As already noted, estimating section personnel will establish costs directly for those items to be constructed by the prime contractor with in-house forces. For specialty areas such as electrical work, interior finish, and roofing, the prime contractor solicits quotations from subcontractors with whom he has successfully worked in the past. Material price quotations are also developed from vendors. These quotations are normally taken telephonically and included in the bid. It is good business practice to use a subcontractor/vendor bid quotation form that includes a legal signature as well as the bid quotation. The contractor soliciting the quotation should request that the bid be faxed with the quotation and a signature binding the bidder to the quoted price. Alternatively, signed documentation of the quotation can be submitted as an email attachment.

The contractor integrates these quotations into the total bid price. Until the contractor has a firm subcontract or purchase order, the only protection against the vendor or subcontractor reneging on or changing the quoted price is the price submitted by fax or signed email attachment quotation form. Prior to the availability of electronically transmitted methods of submission, the contractor had only a telephone quote and the subcontractor's word that he would sign a formal agreement at the stated price. The use of electronically transmitted documents and signed quotations has greatly improved this situation and eliminated potential misunderstandings.

Following award of the contract, the prime contractor has his purchasing or procurement group move immediately to establish subcontracts with the appropriate specialty firms. Both the Associated General Contractors (AGC) and the EJCDC have standard forms for this purpose.

2.15 BID BOND

Various defaults are possible in the relationship between owner and contractor. The concept of a bond allows one party to protect itself against default in a relationship with a second party. A third party, referred to as the surety, provides protection such that, if a default between two parties occurs that results in damage (e.g., loss of money or other value), the surety protects the damaged party. This protection is typically in the form of offsetting or covering the damage involved. A construction bond, therefore, involves a relationship between three parties-the principal or party who might default, the obligee or party who may be damaged or lose some advantage, and the surety who will offset the damage or loss of advantage. For this reason, a bond is referred to as a three-party instrument establishing a three-parry relationship (see Fig. 2.12).

A similar relationship exists if a person of limited means attempts to borrow money at the bank. If the bank is concerned about the ability of the borrower to pay back the borrowed

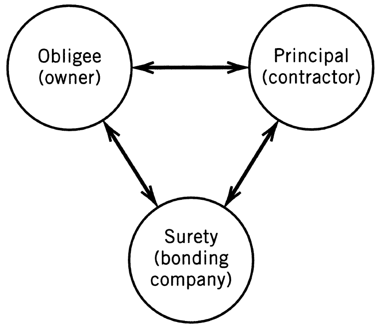


Figure 2.12 Bonding relationship (three-party).

money, it may require that a separate individual cosign the note or instrument of the loan. The cosigner is required to pay back the borrowed money in the event that the primary borrower defaults in repayment. In this situation, the bank is in the position of the obligee, the borrower is the principal, and the cosigner acts as the surety.

During the bidding process, the owner usually requires a *bid security*. The security is required to offset a "damage" occurring in the event that the firm selected fails to begin the project as directed. This may occur in the event that the selected bidder realizes that he has underbid the project and that pursuing the work will result in a financial loss.

In such cases, the owner would incur a damage, since he would be forced to contract with the next lowest bidder. If, for instance, a contractor bidding $3 million refuses to enter into contract, and the next low bid is $3,080,000, the owner is damaged in the amount of $80,000. A typical bid bond form is shown in Figure 2.13. Notice that the responsibility of the surety is indemnified (covered) by the principal. If the principal fails to enter into contract,

> *the Principal shall pay to the Obligee the difference not to exceed the penalty hereof between the amount specified in said bid and such larger amount for which the Obligee may in good faith contract with another party to perform the work.*

If the principal is unable to pay this amount, the surety must step in and cover the damage.

In most cases, the surety firm will not issue a bid bond unless it is very sure the assets of the principal will offset any default occurring due to failure to enter into a contract. Therefore, if issued at all, the bid bond is issued for a small administrative fee. From the bonding company's point of view, the importance of the bid bond is not the fee paid by the contractor for its issuance, but instead its implication that if the contract is awarded, the surety will issue performance and payment bonds. The bid bond is a "lead parachute," which pulls these two bonds out of the main pack. Typical performance and payment bonds are shown in Appendix B. The performance bond protects the owner against default on the contractor's part in completing the project in accordance with the contract documents. The payment bond protects the owner against failure on the part of the prime contractor to pay all subcontractors or vendors having outstanding charges against the project. If the surety fails to issue these bonds (required in the contract documents), the contractor is prevented from entering into contract and the surety could be forced to cover damages resulting from this default.

As an alternative to a bid bond, the owner will sometimes specify (in the notice to bidders or the proposal) acceptance of a cashier's check in a specified amount made out to the owner to secure the bid. If the contractor fails to enter into the contract, he forfeits this check and the owner can use it to defray the cost of entering into contract with the second lowest bidder at a higher bid price. This method of bid security is indicated in the notice to

Commonwealth of Puerto Rico
Department of Transportation and Public Works
HIGHWAY AUTHORITY

BID BOND

KNOW ALL MEN BY THESE PRESENTS, that we
(Here insert full name and address or legal title of Contractor)

as Principal, hereinafter called the Principal, and
(Here insert full name and address or legal title of Surety)

a corporation duly organized under the laws of the State of
as Surety, hereinafter called the Surety, are held and firmly bound unto the Executive Director of the Puerto Rico Highway Authority as Obligee, hereinafter called the Obligee, in the sum of
Dollars ($),
for the payment of which sum well and truly to be made, the said Principal and the said Surety, bind ourselves, our heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

WHEREAS, the Principal has submitted a bid for
(Here insert full name, address and description of project)

NOW, THEREFORE, if the Obligee shall accept the bid of the Principal and the Principal shall enter into a Contract with the Obligee in accordance with the terms of such bid, and give such bond or bonds as may be specified in the bidding or Contract Documents with good and sufficient surety for the faithful performance of such Contract and for the prompt payment of labor and material furnished in the prosecution thereof, or in the event of the failure of the Principal to enter such Contract and give such bond or bonds, if the Principal shall pay to the Obligee the difference not to exceed the penalty hereof between the amount specified in said bid and such larger amount for which the Obligee may in good faith contract with another party to perform the Work covered by said bid, then this obligation shall be null and void, otherwise to remain in full force and effect.

Signed and sealed this day of 19

(Principal) (Seal)

(Witness)

(Title)

(Surety) (Seal)

(Witness)

(Title)

Figure 2.13 Typical bid bond.

bidders in Figure 2.5. The notice to bidders states: "All Proposals must be accompanied by a *certified check*, or a bid bond of a reputable bonding company authorized to do business in the State of Georgia, in an amount equal to at least five (5%) percent of the total amount of the bid."

This procedure is further explained in the proposal form (Figure 2.9): "The bidder further agrees that, in case of failure on his part to execute the Construction Agreement and the Bonds[2] within ten (10) consecutive days after written notice being given of the award of the Contract, the check or bid bond accompanying this bid, and monies payable thereon, shall be paid into the funds of the {owner}."

All government construction contracts require a bid bond that is normally for 20% of the bid price. Private construction agencies for which bid bonds are required generally designate that the bid bond be for 5 or 10% of the bid price. For this reason, residential and commercial construction contractors are different from public construction contractors to a surety. A contractor failing to enter into contract after acceptance of his low bid in public construction places a surety at greater risk because of the larger bid bond for government contracts.

2.16 PERFORMANCE AND PAYMENTS BONDS

If the contractor is awarded the contract, performance and payment bonds are issued. A performance bond is issued to a contractor to guarantee the owner that the contract work will be completed and that it will comply with project specifications. In other words, a performance bond protects the owner against default on the part of the contractor in performing the project as required. If the contractor fails to perform the work as required, the surety must provide for completion of the project in compliance with the plans and specifications at the price originally quoted by the defaulting contractor.

A payment bond is issued to guarantee the owner protection against any liens or charges against the project that are unpaid as a result of the contractor's default. That is, if the contractor fails to pay outstanding liens and charges against the project occurring as a result of the construction work, the surety will pay these debts. If the contractor does not pay subcontracts or suppliers, the surety must protect the owner from their claims. Typical bonding forms for performance and payment bonds are shown in Appendix B.

Because of the potential cost and trouble involved in taking over the work of a contractor about to default, the surety may elect to negotiate short-term financing for a contractor who has current liquidity problems. The surety may grant loans directly or assist the contractor in getting additional loans for the construction. In the event of default, there is no surety payment until the contractor's funds are completely exhausted. Then the surety will normally rebid the job, at a cost to itself and delay to the owner. For these reasons, a surety will often seek to assist a contractor overcome temporary cash shortages.

Surety companies typically have a list of troubleshooters who have a proven record of quickly taking over projects that are in trouble and bringing them to successful completion. In certain cases, the surety will replace the defaulting contractor's management team with a team of troubleshooters and attempt to complete the job with the existing work force. In other cases, the surety may negotiate with a second contractor to complete the work at a fixed price that is acceptable under the circumstances. The owner's interest is that the loss of time and disruption occurring because of default is minimized.

2.17 COST AND REQUIREMENTS FOR BONDS

Performance and payment bonds are issued for a service charge. The common rate is 1% or $10 per $1000 on the first $200,000 of contract cost. At higher contract costs, the rate

[2] Performance and Payment bonds.

is reduced incrementally. Based on the size of the project and past performance of the contractor, rates fluctuate between 0.5% and 3%. Normally, the surety is not at any great risk, since the bond includes an indemnity agreement on the part of the contractor. In other words, the contracting corporation, partnership, or proprietorship must pledge to pay back any monies expended by the surety on its behalf. Since the contractor or principal in a construction bond is required to indemnify the surety against any loss as a result of the bond, the protection of personal wealth and assets of corporate stockholders typical of closely held corporations is not in force. Key personnel may be required to sign that they will back the bond with their personal wealth in the case of closely held corporations or limited partnerships.

The Miller Act (enacted in 1935) establishes the level of bonding required for federally funded projects. Performance bonds must cover 100% of the contractor amount while payment bonds are required based on a sliding scale as follows:

50% if the contract is $1,000,000 or less

40% if the contract is between $1,000,000 and $5,000,000

Fixed amount of $2,500,000 if the contract is greater than $5,000,000

A surety seeks to keep itself well informed of a contractor's progress on bonded projects and with the contractor's changing business and financial status. In order to help with this, the contractor makes periodic reports on the work in progress with particular emphasis on costs, payments, and disputes associated with uncompleted work. Based on these reports, the contractor's bonding capacity can be determined. This is calculated as a multiple of the net quick assets of the contractor as reflected in the company balance sheet. The net quick assets are the contractor's assets that can quickly be converted to cash or negotiable instruments to cover the cost of default. Such items as cash on hand, demand deposits, accounts receivable, and similar highly liquidable assets are available to the surety in case of a default.

The multiple to determine bonding capacity is based on the contractor's performance over the years. New contractors with no track record will have a low multiple such as 5 or 6. Old and reliable contractors may have a multiple of 40 or greater. Based on a multiple of 40, a reliable firm with *net quick assets* of $140,000 would have a bonding capacity of $5,600,000. In this case, the surety would provide bonding on work in progress (new jobs plus remaining value in jobs under way) up to the amount of $5,600,000. In other words, the firm will be able to pursue work for which bonds are required up to a total amount of $5,600,000.

Bonding companies have experienced larger than normal losses since the year 2000, and have raised rates and reduced the dollar amount available for writing new bonds. Many surety companies have raised premium rates by 10 to 30% since 2002 on performance and payment bonds. This has made it much more difficult for construction firms to find bonding. This has impacted operations and bid costs for firms working in markets which require bonds.

REVIEW QUESTIONS AND EXERCISES

2.1 What are the three major types of construction bonds? Why are they required? Name three items that affect bonding capacity.

2.2 In what major section of the contract is the time duration of the project normally specified?

2.3 Who are the three basic parties involved in any construction bonding arrangement?

2.4 What type of bond guarantees that if a contractor goes broke on a project the surety will pay the necessary amount to complete the job?

2.5 What is the purpose of the following documents in a construction contract?

a. General conditions

b. Special conditions

c. Addenda

d. Technical specifications

2.6 Why is the contractor normally required to submit a bid bond when making a proposal to an owner on a competitively bid contract?

2.7 What is the Miller Act and what does it specify regarding government contracts?

2.8 What is the purpose of the notice to bidders?

2.9 List the various specialty groups that are normally involved in the design of a high-rise building project.

2.10 How much money is the contractor investing in an advertised project available for bid at the time of:

a. Going to the architect/engineer's office to look at the plans and specifications?

b. Deciding to take the drawings to his home office for further consideration?

c. Deciding to make initial quantity take-off?

d. Full preparation of bid for submittal?

2.11 What are the major parameters to be considered in the prequalification assessment of a contractor? Investigate the local criteria used in the pre-qualification of both small housing and general contractors.

2.12 Obtain sample specification clauses relating to the quality of finish of an item such as face brick, exterior concrete, or paint surfaces. Who has the major responsibility for the definition, achievement in the field, and paid acceptance?

2.13 Read those clauses of the general conditions of the contract for construction that refer to the owner, architect, contractor, and subcontractor. Then list the major responsibilities of these agents with respect to the following:

a. The definition, or attention to, the scope of the project

b. The financial transactions on the project

c. The finished quality of the work

Chapter 3

Issues During Construction Phase

Project Rework Reduction

The Need

Rework, and particularly field rework, continues to be one of the major sources of unplanned cost growth on industrial construction projects. Rework occurs when the installed work does not comply with or meet required specifications. According to Construction Industry Institute research, if field rework alone can be significantly reduced, or even eliminated, as much as 10% of overall project costs can be saved. The savings are expected to be substantially greater across an entire project cycle, which includes engineering and procurement.

Field rework is not caused solely by construction site activities in isolation. In order for the field rework to be reduced, a substantial effort must be made to improve the effectiveness of the prior project phases with a view to preventing all to frequent 'catch-up' work during the site construction and commissioning phases. A number of computer-based tools have been developed to combat project-wide reworks.

3.1 ACCEPTANCE PERIOD/WITHDRAWAL

In formal competitive bid situations, the timing of various activities has legal implications. The issuance of the notice to bidders opens the bidding period. The date and time at which the bid opening is to take place mark the formal end of the bidding period. Usually a bid box is established at some central location. Bids that have not been received at the bid box by the appointed date and hour are late and are normally disqualified. Prior to the close of the bidding (i.e., bid opening), contractors are free to withdraw their bids without penalty. If they have noted a mistake, they can also submit a correction to their original bid. Once bid opening has commenced, these prerogatives are no longer available. If bids have been opened and the low bidder declares a mistake in bid, procedures are available to reconcile this problem. If it can be clearly established that a mathematical error has occurred, the owner usually will reject the bid. However, if the mistake appears contrived to establish a basis for withdrawal of the bid, the owner will not reject. Then the contractor must enter into contract or forfeit his bid security. The chronology of the bid procedure is shown in Figure 3.1.

The bid security protects the owner from failure by the contractor to enter into a formal construction agreement. The contractor is protected by the acceptance period. The notice to bidders specifies a period following bid opening during which the proposed bids are to remain in force. The indication is that, if the owner does not act in this period to accept one

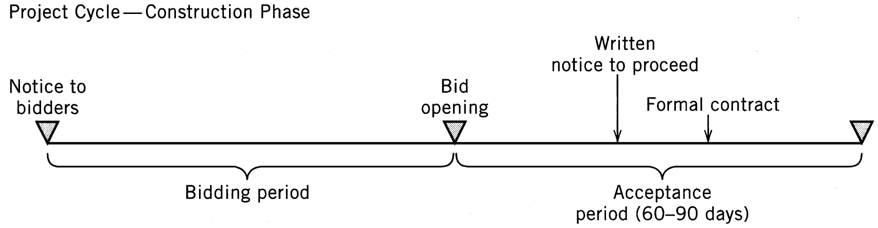


Figure 3.1 Chronology of bid procedure.

of the bids, then the contractors can withdraw or adjust their bids. This is indicated in the notice to bidders (Fig. 2.5) as follows:

Withdrawal of Bids *No submitted bid may be withdrawn for a period of sixty (60) days after the scheduled closing time for the receipt of bid.*

This is designed to protect the bidder, since otherwise the owner could hold the contractors to their bids for an unspecified period. If the expected financing or appropriation for the project does not materialize, the owner could, in theory, say "Wait until next year, and I will enter into contract with you at this price." This, of course, would be potentially disadvantageous to the bidder. Therefore, the owner must send written notice of award (e.g., notice to proceed) to the selected contractor during the acceptance period or the bidders are released from their original proposals.

3.2 AWARD OF CONTRACT/NOTICE TO PROCEED

Notification of award of contract is normally accomplished by a letter indicating selection and directing the contractor to proceed with the work. This notice to proceed consummates the contractual relationship from a legal viewpoint despite the fact that a formal agreement has not been signed. The proposal (offer)–acceptance protocol of contractual law is satisfied by the issuance of this letter. The letter also implies that the site is free of encumbrances and that the contractor can occupy the site for work purposes. Provisions of the contract usually direct that selected bidders commence work on the site within a specified period of time, such as 10 days.

The notice to proceed has an additional significance. The date of the notice to proceed establishes the reference date from which the beginning of the project is calculated. Therefore, based on the stipulated duration of the project as specified in the supplementary conditions, the projected end of the project can be established. As will be discussed later, time extensions may increase the duration of the project, but the end of project beyond which damages will be assessed for failure to complete the project on time is referenced to the date of the notice to proceed. This might be specified as follows:

> *Work shall be completed not later than one thousand fifty (1050) calendar days after the date of receipt by the Contractor of Notice to Proceed.*

Calendar days are used since they simplify the calculation of the end-of-project date. In certain cases, the duration of the project is specified in working days. The general conditions normally specify working days as Monday through Friday. Therefore, each week contains five working days.

In some projects, all encumbrances to entry of the construction site have not been reconciled. Therefore, the owner cannot issue a notice to proceed since he cannot authorize the contractor to enter the site. In such cases, in order to indicate selection and acceptance of a proposal, the owner may send the selected bidder a *letter of intent*. This letter will indicate the nature of encumbrance and establish the owner's intent to enter into contracts as soon as barriers to the site availability have been removed.

3.3 CONTRACT AGREEMENT

Although the issuance of the notice to proceed establishes the elements of a contract, this is formalized by the signing of a *contract agreement*. In a legal sense, the formal contract agreement is the single document that binds the parties and by reference describes the work to be performed for a consideration. It pulls together under one cover all documents to include (1) the drawings, (2) the general conditions, (3) the supplementary conditions, (4) the technical specifications, and (5) any addenda describing changes published to these original contract documents. As with other bid package components, standard forms for the contract agreement for a variety of contractual formats are available from various professional organizations. Forms for the *stipulated (lump) sum* and *negotiated* (cost of work plus a fee) type contract are given in Appendixes C and D.

3.4 TIME EXTENSIONS

Once the formal contract has been signed, certain aspects of the contractor's activity during construction must be considered. Often circumstances beyond the contractor's control, which could not have been reasonably anticipated at the time of bidding, lead to delays. These delays make it difficult or impossible to meet the project completion date. In such cases the contractor will request an extension of time to offset the delay. These time extensions, if granted, act to increase the duration of the project. Procedures for dealing with time extensions are established in the general conditions of the contract. Claims for extension of time must be based on delays that are caused by the owner or the owner's agents or on delays due to acts of God. Delays that result from design errors or changes are typical of owner-assignable delays and are not uncommon. A study of delay sources on government contracts indicated that a large percent of all delays can be traced to the reconciliation of design-related problems (see Table 3.1). Weather delays are typical of the so-called act of God type delay. Normal weather, however, is not justification for the granting of a time extension. Most general conditions state specifically that only "adverse weather conditions not reasonably anticipatable" qualify as a basis for time extensions. This means that a contractor working in Minnesota in January who requests a 15-day time extension due to frozen ground that could not be excavated will probably not be granted a time extension. Since frozen ground is typical of Minnesota in January, the contractor should have "reasonably anticipated" this condition and scheduled around it. Weather is a continuing question of debate, and many

Table 3.1 Average Percent Extension by Extension Type

Facility	Design problem	Owner modification	Weather	Strike	Late delivery	Other
Airfield paving/lighting	7.2	1.3	2.3	0.0	10.5	4.9
Airfield buildings	12.1	2.3	3.7	3.2	0.8	29.9
Training facilities	6.2	20.8	2.9	0.0	0.6	4.6
Aircraft maintenance facilities	12.0	2.0	8.4	1.0	2.2	0.2
Automotive maintenance facilities	12.9	2.3	3.4	1.4	0.7	0.4
Hospital buildings	16.0	3.4	2.6	0.6	0.6	0.9
Community facilities	6.7	5.4	2.3	1.7	1.5	0.3

Source: From D. W. Halpin and R. D. Neathammer, "Construction Time Overruns," Technical Report P-l6, Construction Engineering Research Laboratory, Champaign, IL, August 1973.

contractors will submit a request for time extension automatically each month with their progress pay request, if the weather is the least bit out of the ordinary.

Time extensions are added to the original duration so that if 62 days of time extension are granted to an original duration of 1050 days, the project must be completed by 1112 calendar days after notice to proceed. If the contractor exceeds this duration, liquidated damages (see Section 3.9) are assessed on a daily basis for each day of overrun. The question of what constitutes completion can be answered as follows:

The Date of Substantial Completion of the Work or designated portion thereof is the Date certified by the owner's representative when construction is sufficiently complete, in accordance with the Contract Documents, so the Owner can occupy, or utilize the Work or designated portion thereof for the use for which it is intended.

This is often referred to as the beneficial occupancy date, or BOD. Once the owner occupies the facility, he relinquishes a large portion of the legal leverage he has in making the contractor complete outstanding deficiencies. Usually, a mutually acceptable date is established when substantial completion appears to have been reached. On this date an inspection of the facility is conducted. The owner's representative (normally the architect/engineer) and the contractor conduct this inspection recording deficiencies that exist and noting items for correction. Correction of these items will satisfy the owner's requirement for substantial completion. This deficiency list is referred to in the industry as the punch list. Theoretically, once the contractor satisfactorily corrects the deficiencies noted on the punch list, the owner will accept the facility as complete. If the rapport between owner and contractor is good, this phase of the work is accomplished smoothly. If not, this turnover phase can lead to claims for damages on both sides.

An indication of the amounts of time extension granted for various reasons on some typical government projects is given in Table 3.1. The types of delay sources categorized were due to (1) design problems, (2) owner modification, (3) weather, (4) strike, (5) late delivery, and (6) other. The percentages presented were calculated as % extension = (no. of days of time extension granted ÷ originally specified project duration) × 100.

3.5 CHANGE ORDERS

Since the contract documents are included by reference in the formal agreement, the lines on the drawings, the words in the technical specifications, and all other aspects of the contract documentation are legally binding. Any alteration of these documents constitutes an alteration of the contract. As will be discussed in Chapter 4 certain contractual formats such as the unit-price contract have a degree of flexibility. However, the stipulated or lump-sum contract has virtually no leeway for change or interpretation. At the time it is presented to the bidders for consideration (i.e., is advertised), it represents a statement of the project scope and design as precise as the final drawings for an airplane or a violin. Changes that are dictated, for any reason, during construction represent an alteration of a legal arrangement and, therefore, must be formally handled as a modification to the contract. These modifications to the original contract, which themselves are small augmenting contracts, are called *change orders*.

Procedures for implementing change orders are specified in the general conditions of the contract. Since change orders are minicontracts, their implementation has many of the elements of the original contract bid cycle. The major difference is that there is no competition, since the contractor has already been selected. Normally, a formal communication of the change to include scope and supporting technical documents is sent to the contractor. The contractor responds with a price quotation for performing the work, which constitutes his offer. The owner can accept the offer or attempt to negotiate (i.e., make a counteroffer). This is, of course, the classical contractual cycle. Usually, the contractor is justified in increasing the price to recover costs due to disruption of the work and possible loss of job rhythm. If the original contract documents were poorly scoped and prepared, the project can turn into a patchwork of change orders. This can lead to a sharpening of the adversary roles of the contractor and the owner and can substantially disrupt job activities.

3.6 CHANGED CONDITIONS

Engineering designs are based on the project site conditions as they are perceived by the architect/engineer or designer. For structural and finish items as well as mechanical and electrical systems above ground, the conditions are constant and easily determined. Variation in wind patterns leading to deviation from original design criteria may pose a problem. But normally, elements of the superstructure of a facility are constructed in a highly predictable environment.

This is not the case when designing the subsurface and site topographical portions of the project. Since the designer's ability to look below the surface of the site is limited, he relies on approximations that indicate the general nature of the soil and rock conditions below grade. His "eyes" in establishing the design environment are the reports from subsurface investigations. These reports indicate the strata of soil and rock below the site based on a series of bore holes. These holes are generally located on a grid and attempt to establish the profile of soil and rock. The ability of the below-grade area to support weight may be established by a grid of test piles. The money available for this design activity (i.e., subsurface investigation) varies, and an inadequate set of bore logs or test piles may lead to an erroneous picture of subsurface characteristics. The engineer uses the information provided by the subsurface investigation to design the foundation of the facility. If the investigation is not extensive enough, the design can be inadequate.

The information provided from the subsurface investigation is also the contractor's basis for making the estimate of the excavation and foundation work to be accomplished. Again, if the investigation does not adequately represent the site conditions, the contractor's estimate will be affected. The topographic survey of the site is also a basis for estimate and, if in error, will impact the estimate and price quoted by the contractor. If the contractor feels the work conditions as reflected in the original investigation made available to him for bidding purposes are not representative of the conditions "as found," he can claim a changed condition. For instance, based on the boring logs, a reasonable estimate may indicate 2000 cu yd of soil excavation and 500 cu yd of rock. After work commences, the site may be found to contain 1500 cu yd of rock and only 1000 cu yd of soil. This, obviously, substantially affects the price of excavation and would be the basis for claiming a changed condition.

In some cases, a condition may not be detected during design, and the assumption is that it does not exist. For instance, an underground river or flow of water may go undetected. This condition requires dewatering and a major temporary-construction structure to coffer the site and to construct the foundation. If this condition could not reasonably have been foreseen by the contractor, there would be no allowance for it in his bid. The failure of the bid documents to reflect this situation would cause the contractor to claim a changed condition.

If the owner accepts the changed condition, the extended scope of work represented will be included in the contract as a change order. If the owner does not accept the changed condition claim, the validity of the claim must be established by litigation or arbitration.

3.7 VALUE ENGINEERING

Value Engineering (VE) was developed during World War II in the United States. It began as a search for alternative product components due to a shortage of critical items during the war. Innovation was required. It was discovered that a process of "function analysis" produced low-cost products without impacting functional characteristics or reducing quality. This initiative showed that innovation can yield products which cost less but maintain the expected levels of performance. In this case, "necessity was the mother of invention."

In the early 1960s, this concept of value was introduced in the construction industry through directives from the Navy and Army Corps of Engineers relating to facility procurement. Other major government agencies (e.g., Public Building Service) joined this movement by introducing incentive clauses in facility procurement (construction) contracts which provided rewards to contractors for value proposals which led to reduced construction costs while maintaining the functionality of the completed facility. These clauses are structured generally as follows:

> *The Contractor is encouraged to develop, prepare, and submit value engineering change proposals (VECP's) voluntarily. The Contractor shall share in any net acquisition savings realized from accepted VECP's, in accordance with the incentive sharing rates specified in the contract.*

In Army Corps of Engineers contracts, the VE incentive clause allows the construction contactor to share 50% or more of the net savings in firm fixed-price contracts. For example, if a contractor is constructing bridge towers supported (in the original design) by drilled pile foundations, and the contractor can re-design the foundations as spread mat footers with a savings of $400,000, a portion of the savings (usually 50%) is distributed to the contractor. The construction contractor must prepare a value engineering change proposal (VECP) which will be reviewed and then accepted or rejected by the owner. A potential reward to the contractor (in this case) of $200,000 is available if the proposal is accepted.

The VECP procedure allows the owner to harvest new and innovative ideas from the construction contractor. This overcomes, to some degree, the factors which obstruct the transfer of information from the contractor to the designer in classical Design-Bid-Build (DBB) contracts. In such contracts, information flow is impeded by the "friendly enemy" attitude, which is often characteristic of the relationship between the design professional and the contractor in competitively bid contracts. Also, due to the sequence of design and construction in the DBB format, contractors seldom have input to the design process.

Construction contractors are typically more knowledgeable about field conditions and construction methods than design engineers. The construction methods used to realize a given design in the field have a great impact on cost. Contractors are in a better position to know what materials are easiest to install and which designs are most constructable. This knowledge can greatly influence cost. The VECP process allows this expertise to be transferred to the owner yielding a cost saving.

The idea behind value engineering is the improvement of design by encouraging the contractor to make suggestions during construction. This is in contrast to the implementation of VE during the design phase which involves the designer or design professional in a systematic program of "value analysis." If at any point following selection, the contractor feels that a proposal to improve cost effectiveness of the design as transmitted at the time of bidding is appropriate, there is a monetary incentive to submit such a proposal. Again, if the contactor makes a suggestions that cuts the cost of the air-conditioning system by $60,000 and an equal sharing VE clause is in the contract, $30,000 is received for this VECP if accepted by the owner. The guiding principle in making the suggestion is that the cost is reduced while the functionality is maintained or improved.

VE can also be implemented during the design phase of project development. This aspect of VE uses various procedures such as brainstorming, prioritization, research, matrix analysis , and scoring systems to evaluate design alternatives. Criteria Evaluation can be used to assess multiple factors such as aesthetics, performance, safety, etc. A weighted analysis is used to do the final analysis. In the weighting process, a criteria matrix such as that shown in Figure 3.2 is used. All criteria to be considered are listed

Weighted Evaluation

Project: **Date:** ___________

❑ Architectural ❑ Structural ❑ Mechanical ❑ Others **Sheet No.:** ___________

Criteria

Criteria Scoring Matrix

How Important:

4 - Major Preference
3 - Above Average Preference
2 - Average Preference
1 - Slight Preference
- Letter / Letter
No Preference
Each Scored One Point

A. *Cost (LCC)*
B. *Aesthethic*
C. *Space*
D. *Performance*
E. *Safety*
F.
G.

A - 2 | A - 2 | A - 1 | A / E
B / C | D - 1 | E-1
D - 1 | E-2
E - 1

Analysis Matrix

Alternatives

	G	F	E	D	C	B	A	Total
Raw Score			5	2	1	1	6	
Weight of Importance (0 - 10)			9	4	2	2	10	
1. *Original Solution*			27 / 3	12 / 3	4 / 2	4 / 2	40 / 4	87
2. *Alternative No. 1*			27 / 3	8 / 2	8 / 4	6 / 3	50 / 5	99*
3. *Alternative No. 2*			36 / 4	20 / 5	10 / 5	10 / 5	10 / 1	86
4.								
5.								

* Selected based on weighted evaluation

5 -Excellent 4 -Very Good 3 -Good 2 -Fair 1 -Poor

Figure 3.2 Criteria Evaluation Matrix.

and compared. In comparing two criteria, preference for one over the other is scored as follows:

1 = slight preference	3 = above average preference
2 = average preference	4 = major preference

In Figure 3.2, five criteria are listed as A through E. In the triangular portion of the matrix Cost (A) is compared with Aesthetic (B). Cost has an "average preference" so A-2 is placed in the diamond linking these two criteria. B and C are compared, since they are equally preferred (no preference) B/C is entered in the diamond linking these two criteria. Now the A-2 diamond is compared to the B/C diamond and the preference of A-2 prevails and is noted in the diamond linking these two composite preferences (A to B and B to C). This process is continued until all criteria have been compared. The right most diamond shows that the most preferred criteria are A and E. They are effectively equally preferred.

In the lower part of the matrix however, E is given a raw score of 5 while A receives a slightly higher score of 6. These raw scores are converted to Weights of Importance as shown. Two alternatives are compared with the original design solution. Each of the factors (A to E) are given a score between 1 (poor) and 5 (excellent). These scores are multiplied by the Weight of Importance. For the original solution, factor E receives a score of 3 times 9 or 27. The original solution score is 27 + 12 + 4 + 4 + 40 or 87. This compares with scores for Alternative 1 and 2 of 99 and 86 respectively. Based on this weighted analysis, Alternative 1 would be selected.

This structured approach to evaluating alternatives during design helps to formalize consideration of various alternatives. A more comprehensive discussion of this topic is beyond the scope of this section. A basic reference on the use of VE is provided by Dell'Isola (Dell'Isola 1997).

Government agencies have led the way in the in the use of value engineering incentive clauses in construction contracts. This allows the owner (i.e., the government) to enhance the flow of cost saving information between the designer and the contractor during the construction phase. Success in the use of VECP clauses by public agencies has led to wide spread implementation of such incentive clauses in construction contracts used by private owners.

3.8 SUSPENSION, DELAY, OR INTERRUPTION

The standard general conditions utilized for many government contracts provide that:

> *The Contracting officer may order the Contractor in writing to suspend, delay, or interrupt all or any part of the work for such period of time as he may determine to be appropriate for the convenience of the government.*

Interrupting or suspending work for an extended period of time may be costly to the contractor, since he must go through a demobilization-remobilization cycle and may confront inflated labor and materials at the time of restarting. In such cases, within the provisions of the contract, the owner (i.e., the government) is required to pay an adjustment for "unreasonable" suspensions as follows:

> *An adjustment shall be made for any increase in cost of performance of this contract (excluding profit) necessarily caused by such unreasonable suspension, delay, or interruption and the contract modified in writing accordingly.*

The amount of this adjustment is often contested by the contractor and can lead to lengthy litigation. Normally, the owner will attempt to avoid interruptions. Difficulties in obtaining continuing funding, however, are a common cause for these suspensions.

3.9 LIQUIDATED DAMAGES

Projects vary in their purpose and function. Some projects are built to exploit a developing commercial opportunity (e.g., a fertilizer plant in Singapore) while others are government funded for the good and safety of the public (e.g., roads, bridges, etc.). In any case, the purpose and function of a project are often based on the completion of the project by a certain point in time. To this end, a project duration is specified in the contract document. This duration is tied to the date the project is needed for occupancy and utilization. If the project is not completed on this date, the owner may incur certain damages due to the nonavailability of the facility.

For instance, assume an entrepreneur is building a shopping center. The project is to be complete for occupancy by 1 October. The projected monthly rental value of the project is $30,000. If all space is rented for occupancy on 1 October and the contractor fails to complete the project until 15 October, the space cannot be occupied and half a month's rental has been lost. The entrepreneur has been "damaged" in the amount of $15,000 and could sue the contractor for the amount of the damage. Contracts provide a more immediate means of recourse in liquidating or recovering the damage. The special conditions allow the owner under the contractual relationship to charge the contractor for damages for each day the contractor overruns the date of completion. The amount of the liquidated damage to be paid per day is given in the special or supplementary conditions of the contract. The clause SC-2 of the Special Conditions in Figure 2.10 is typical of the language used, and reads:

> ***Liquidated Damages*** *In case of failure on the part of the Contractor to complete the work within the time fixed in the contract or any extensions thereof, the Contractor shall pay the owner as liquidated damages the sum of $3000 for each calendar day of delay until the work is completed or accepted.*

The amount of the liquidated damage to be recovered per day is not arbitrary and must be a just reflection of the actual damage incurred. The owner who is damaged must be able, if challenged, to establish the basis of the figure used. In the rental example given, the basis of the liquidated damage might be as follows:

$$\begin{aligned} \text{Rental loss: } \$30,000 \text{ rent/month} \div 30 \text{ days} &= \$1000/\text{day} \\ \text{Cost of administration and supervision of contract:} &= \underline{\$\ \ 200/\text{day}} \\ &\ \$1200/\text{day} \end{aligned}$$

If a project overruns, the owner not only incurs costs due to lost revenues but also must maintain a staff to control and supervise the contract. This is the $200 cost for supervision. The point is that an owner cannot specify an arbitrarily high figure such as $20,000 per day to scare the contractor into completion without a justification. The courts have ruled that such unsupported high charges are in fact not the liquidation of a damage but instead a penalty charge. The legal precedent established is that if the owner desires to specify a penalty for overrun (rather than liquidated damages), he must offer a bonus in the same amount for every day the contractor brings the project in early. That is, if the contractor completes the project three days late he must pay a penalty of $60,000 (based on the figure above). On the other hand, if the contractor completes the project three days early, he would be entitled to a bonus of $60,000. This has discouraged the use of such penalty-bonus clauses except in unusual situations.

Establishing the level of liquidated damages for government projects is difficult, and in most cases the amount of damage is limited to the cost of maintaining a resident staff and main office liaison personnel on the project beyond the original date of completion. In a claims court, it is difficult to establish the social loss in dollars of, for instance, the failure to complete a bridge or large dam by the specified completion date.

3.10 PROGRESS PAYMENTS AND RETAINAGE

During the construction period, the contractor is reimbursed on a periodic basis. Normally, at the end of each month, the owner's representative (e.g., project or resident engineer) and the contractor make an estimate of the work performed during the month, and the owner agrees to pay a progress payment to cover the contractor's expenditures and fee or markup for the portion of the work performed. The method of making progress payments is implemented in language as follows:

> *At least ten days before the date for each progress payment established in the Owner Contractor Agreement, the Contractor shall submit to the owner's representative an itemized Application for Payment, notarized if required, supported by such data substantiating the Contractor's right to payment as the Owner may require, and reflecting retainage, if any, as provided elsewhere in the Contract Documents.*

Retainage is considered in greater detail in Chapter 9 in discussing cash flow. The owner typically retains or holds back a portion of the monies due the contractor as an incentive for the contractor to properly complete the project. The philosophy of retainage is that if the project is nearing completion and the contractor has received virtually all of the bid price, he will not be motivated to do the small closing-out tasks that inevitably are required to complete the project. By withholding or escrowing a certain portion of the monies due the contractor as retainage, the owner has a "carrot," which can be used at the end of a project. He can say essentially, "Until you have completed the project to my satisfaction, I will not release the retainage." Retainage amounts are fairly substantial, and therefore, the contractor has a strong incentive to complete small finish items at the end of the project.

The amount of retainage is stated in the contract documents (e.g., general conditions) in the following fashion:

> *In making progress payments, there shall be retained 10 percent of the estimated amount until final completion and acceptance of the work.*

Various retainage formulas can be used, based on the owner's experience and policy. If work is progressing satisfactorily at the 50% completion point, the owner may decide to drop the retainage requirement as follows:

> *If the owner's representative (architect/engineer) at any time after 50 percent of the work has been completed finds that satisfactory progress is being made, he may authorize any of the remaining progress payments to be made in full.*

If a project has been awarded at a price of \$1,500,000 and 10% retainage is withheld throughout the first half of the job, the retained amount is \$75,000. This is a formidable incentive and motivates the contractor to complete the details of the job in a timely fashion.

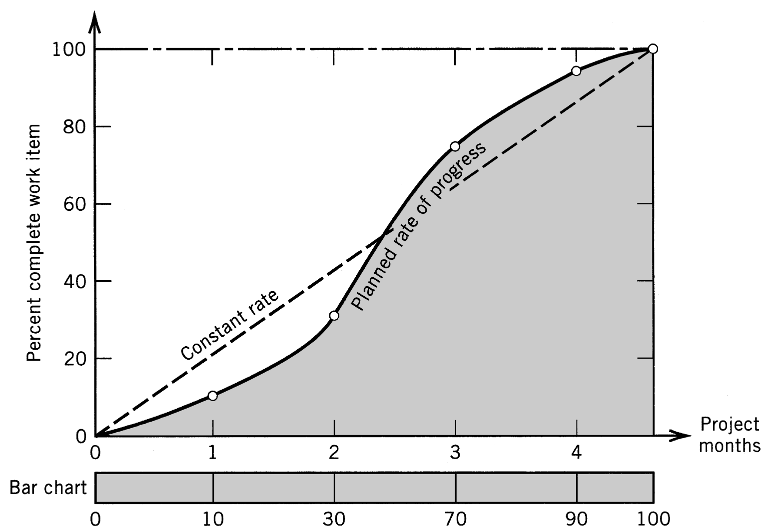
3.11 PROGRESS REPORTING

Contracts require the prime contractor to submit a schedule of activity and periodically update the schedule reflecting actual progress. This requirement is normally stated in the general conditions as follows:

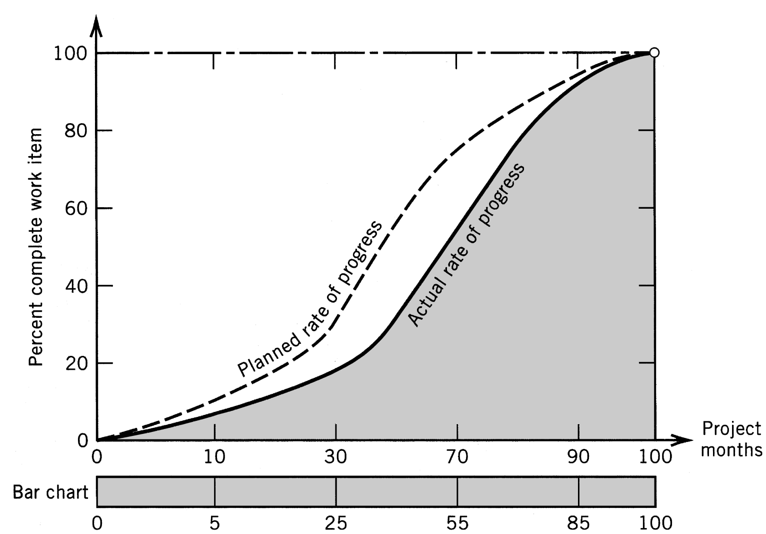
> ***Progress Charts*** *The contractor shall within 5 days or within such time as determined by the owner's representative, after the date of commencement of work, prepare and submit to the owner's representative for approval a practicable schedule, showing the order in which the contractor proposes to carry on the work, the date on which he will start the several salient features (including procurement of materials, plant, and equipment) and the contemplated dates for completing the same. The schedule shall be in the form of a progress chart of suitable scale to indicate appropriately the percentage of work scheduled for completion at*

any time. The contractor shall revise the schedule as necessary to keep it current, shall enter on the chart the actual progress at the end of each week or at such intervals as directed by the owner's representative, and shall immediately deliver to the owner's representative three copies thereof. If the contractor fails to submit a progress schedule within the time herein prescribed, the owner's representative may withhold approval of progress payment estimates until such time as the contractor submits the required progress schedule.

This provision is fairly broad and could well be interpreted to require only grossly defined S-curves or bar charts. These bar charts may be based either on activities or percentage completion of the various work categories such as concrete, structural, electrical, and mechanical work. These reports are used at the time of developing the monthly progress payments and to ensure the contractor is making satisfactory progress. Figures 3.3 and



(*a*)



(*b*)

Figure 3.3 Bar chart planning and control models: (*a*) planned rate of progress and (*b*) actual rate of progress.

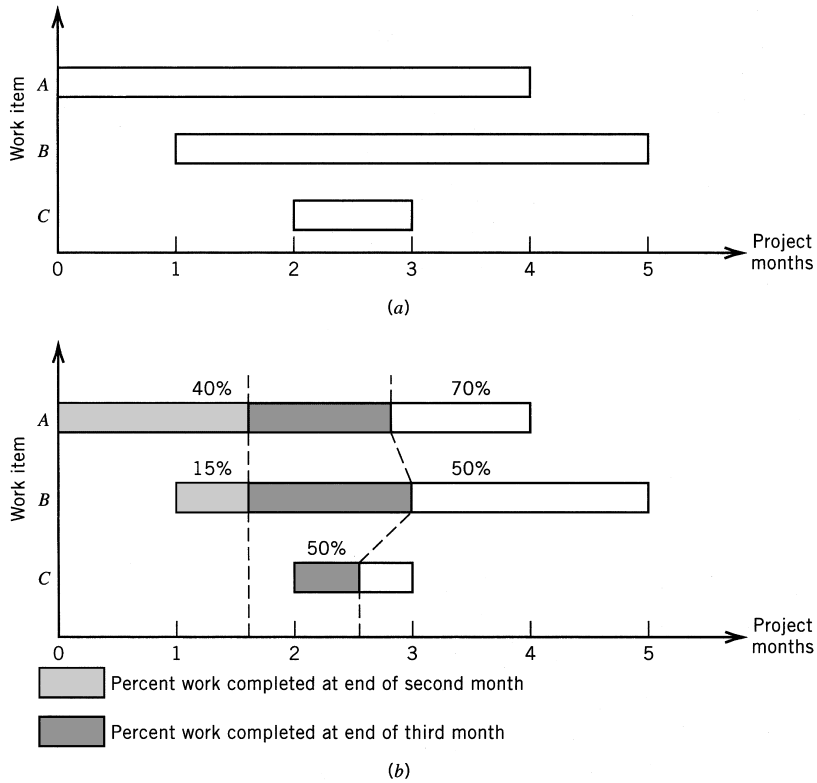


Figure 3.4 Bar chart project models: (*a*) bar chart schedule (plan focus) and (*b*) bar chart updating (control focus).

3.4 indicate sample reporting methods involving bar charts for work activities and S-curves of overall percentages complete.

Network methods provide greater detail and have the advantage during planning and scheduling of being oriented to individual activities and their logical sequence. From the owner's viewpoint they allow a more precise review of logic and progress during construction and acceptance periods. If the contractor is behind schedule on critical activities, a simple bar chart or S-curve will not highlight this. The network approach provides greater early warning of the impact of delays on total project completion.

3.12 ACCEPTANCE AND FINAL PAYMENT

Final acceptance of the project is important to all parties concerned. As noted above, it is particularly important to the contractor, since final acceptance means the release of retainage. Final acceptance of the project is implemented by a joint inspection on the part of the owner's representative and the contractor. The owner's representative notes deficiencies that should be corrected, and the contractor makes note of the deficiencies. These are generally detail items, and the list generated by the joint inspection is called the deficiency, or punch, list. It becomes the basis for accepting the work as final and releasing final payment (to include retainage) to the contractor. A similar procedure is utilized between the prime contractor and the subcontractors. When the subcontractor's work is complete, representatives of the prime and subcontractor "walk the job" and compile the deficiencies list for final acceptance of

May 20, 2XXX
Punch List Items Acme Plastering Co.
Barfield-400 Project

Larger Building
1. Caulking required between stucco and brick on the lower level.
2. Streaks and cracking on stucco must be remedied.

Smaller Building
1. Very noticeable line of stucco in rear of building.
2. Streaks and cracking on stucco must be repaired.
3. Exterior bridge entrances: patch stucco must be made uniform.
4. Areas of excess spalling must be corrected.

Figure 3.5 Typical punch list.

subcontract work. An example of a punch list between prime contractor and subcontractor is shown in Figure 3.5.

3.13 SUMMARY

This chapter has presented an overview of the cycle of activity that moves a project from the bid award stage through construction to acceptance by the owner or client. It is necessarily brief but provides a general frame of reference indicating how the contractor receives the project and some of the contractual considerations he must be aware of during construction. The competitively bid type of contract and the bid sequence particular to this contractual format have been used as the basis for presentation. Other forms of contract will be discussed in Chapter 4. However, the basic chronology of events is the same. Having established this general mapping of the construction process, the following chapters develop the details of the contractor's role in the construction team.

REVIEW QUESTIONS AND EXERCISES

3.1 What is the difference between liquidated damages and a penalty for late completion of the contract?

3.2 What is the purpose of retainage?

3.3 During what period can a contractor withdraw the bid without penalty?

3.4 As a contractor you have built a 100-unit apartment complex that rents for $450 per unit a month. For late completion you were assessed $2000 per day. Would you call the assessment liquidated damages or a penalty? If the contract had included a bonus of $500 per day for early completion, would you expect to gain any assessment from court action? Why?

3.5 Describe the procedures to be followed for the receiving and opening of bids. If possible attend a bid opening and determine the number of bids that were submitted. For several unsuccessful bids determine the dollar amounts by which they exceeded the winning bid. Then calculate (relative to the winning bid) the percentages by which they exceed the winning bid. What do these figures tell about the strength of the current estimating and market environments? How much did the winning bidder "leave on the table"?

3.6 Scan a typical stipulated sum contract and identify those clauses that either prescribe, modify, or are related to time considerations. Then develop a time strip map (similar to Fig. 3.1) for the contract that locates the times (or time zones) for which each of the clauses are relevant. Which clauses rigorously fix time constraints for the contract and which are dependent on acts of God or the owner for relevance?

3.7 Describe the procedure to be followed by the contractor who wishes to claim a time extension. What sort of documentation do you think is necessary to either refute or defend a time extension claim due to unusual weather? What sort of records do local contractors keep of weather conditions?

3.8 Must a contractor accept and perform all the work involved in each contract change order? Is there a limit to the number or magnitude of change orders that can be applied to a contract? When can a contractor refuse to accept a change order?

3.9 List the common causes of changed conditions in a building contract. What typical contract clauses bear on the problems caused by changed conditions? Suppose separate contracts are let for the building foundations and all remaining work. If you are the second contractor and you find that the foundations are incorrectly located, either in plan or elevation, would you be able to claim a changed condition?

3.10 Prepare a punch list of deficiencies or repairs that you consider necessary for your room, garage, or classroom. Can any of these items be related back to the original acceptance of the facility?

3.11 How would you go about either documenting a claim for a contractor's progress payment or its verification by the contract administrator for a typical building project in your locality?

Chapter 4

Construction Contracts

Web-based Contracts

The Need

Web-based contracting provides an environment supporting scheduling, controlling, regulating, analyzing, and auditing the procurement and delivery of materials and services for construction in an electronic format. By enabling online competitive bidding and improving the record-keeping associated with the purchasing process, buyers will be able to quickly and easily compare product offerings from different manufacturers, as well as solicit pricing and availability. This will put buyers in a position to make optimal price- and time-of-delivery decisions.

The Technology

A number of companies are developing network-based contracting services. These networks are adopting such solutions to improve their subcontract bidding process. With this system, construction companies can easily submit bid documents and specifications to solicit competitive bids for subcontracted work. They will be able to route RFQs/RFPs to approved contractors, or search for matching contractors according to attributes such as CSI (Construction Specifications Institute) classification, geographic location, specialty, minority status, licensing, and bonding. Eligible contractors and suppliers are notified of pending project bids and may then respond electronically. Their responses are automatically organized into bid summary spreadsheets for review and award. Buyers can anticipate an immediate return on investment from reduced costs associated with the processing of purchase orders, more competitive prices, and overall supply-chain efficiencies. Sellers will find new opportunities to increase sales by expanding their customer base and effectively communicating their product line and pricing. These online services help construction companies manage their complex supply chains, while enabling the project owner to make trade-off decisions about construction costs versus lifetime operational costs.

4.1 CONTRACT ENVIRONMENT

Construction is a product oriented activity that has many dimensions. One of these dimensions is the business side of construction. The business world is structured by contractual relationships, and the business aspects of construction require the establishment of legally binding relationships with a wide range of parties. The central role played by contracts is reflected by the fact that construction firms are referred to as “contractors.” In addition to the contractual relationship with the owner/client, construction managers supervise contracts with subcontractors, specialty firms such as scheduling services, labor unions, as well as equipment and materials vendors. Insurance and bonds as well as the documents establishing the legal structure of a company have the elements of contractual requirements. In this chapter, we investigate the major contractual forms used to establish contracts for the construction of projects.

An agreement between two or more parties to do something for a consideration establishes the basis for a contract. "A contract is a promise or a set of promises for the breach of which the law recognizes duty. This amounts to saying that a contract is a legally enforceable promise" (Jackson, 1973). The courts are often called upon to determine:

1. Who are the parties to a contract?
2. What are their promises?
3. Other aspects of the contractual agreement.

A whole body of law has grown up around the many facets of contractual relationships. Because these issues remain constant for most construction situations, contract language in the construction industry has been normalized over many years and a variety of standard contract forms have developed.

4.2 PROCESS OF PURCHASING CONSTRUCTION

Construction contracts structure the way in which construction is "purchased." It is interesting to compare the construction purchasing system with the way in which we would buy a new lawn mower or a set of living room furniture. Consumers who need to purchase something go to a store, look at the range of product choices, and then pay a single supplier (the store owner) for the item of interest. If, for instance, we need a refrigerator, we go to an appliance store, inspect the various models, check prices, select one for purchase, pay for it, and the store owner sends it to our house or apartment within the next few days.

Two major aspects of this process contrast with the way in which we "buy" construction.

1. We have the finished product available for our inspection, and we can decide whether it meets our requirements. That is, the manufactured product is available for our inspection prior to purchase.
2. Since the final product is available, we purchase it from a single individual or source.

In construction the facility is purchased before it is "manufactured" based on a set of drawings and work descriptors. Also the end item requires the purchaser to coordinate many entities to include designer(s), contractor(s), specialty subcontractors, and vendors. It is as if to buy a refrigerator we must develop a drawing of the refrigerator, purchase the materials required, and then coordinate 10 different entities who build it for us. Typically, none of the entities building the end item will warrant the proper operation of the refrigerator. They will only warrant the work that they provide.

In the building of the Brooklyn Bridge referred to in Chapter 1, Washington Roebling ordered a gigantic wooden box (e.g., a caisson) that was built by a local shipyard. The shipyard required payment in advance and would only warrant that the box was built according to plans that Roebling provided. They would not guarantee that it would perform adequately as a caisson because they did not know what a caisson was or how it was to be used.

Ideally, we would like to go to a single source and purchase the construction project as a finished unit. In construction this is seldom possible. Traditional contract formats address this problem by focusing on the purchase of the design from a single entity (e.g., the design professional) and the construction of the facility by a general contractor who purchases the needed materials and services and coordinates the work of all the entities building the facility. As has been noted, even this three-party purchasing relationship (e.g., owner, designer, and constructor) can lead to an adversarial relationship between the parties.

Owners would, in general, like to work with a single source and be able to purchase the facility as-built (e.g., fully constructed and ready for occupancy). That single source would warrant the operation of the facility and act as a single point of contact to reconcile all problems with the product. This approach is used in single-family housing to a large extent. The home builder builds a house on a speculative basis without a buyer on hand. The house is presented to the public as a finished product, and the contractor is a single point of contact for purchase and warranty.

Tunnels, bridges, and most large construction projects are not first built and then presented to the public for purchase. These are not built "on spec" (i.e., on a speculative basis) simply because the risk of building a "white elephant" that cannot be sold is too great. For this reason, the ability to present a finished product to a prospective buyer of construction is not feasible for most construction projects (one exception being single-family housing).

Project delivery systems have been developed to provide the construction buyer (i.e., the client) with a single point of contact or source of purchase. These contract formats have gained popularity over the past 20 years and are still evolving. The two major varieties of contract formats designed to provide the client with the construction equivalent of "one-stop shopping" are (1) design-build contracts and (2) construction management contracts. Before discussing these more recent developments in construction contracting, it is important to understand the contract types that have been used most widely over the past 50 years.

4.3 MAJOR CONSTRUCTION CONTRACT TYPES

The most widely used format of contract is the competitively bid contract. For a number of reasons, almost all contracts that involve public funds are awarded using competitively bid contracts. A competitively bid contract is used since it yields a low and competitive price that ensures taxpayers that their monies are being equitably and cost-effectively disbursed. The basic sequence of events associated with this type of contract has been described in Chapters 2 and 3. The two main categories of competitively bid contracts are (1) the lump, or stipulated, sum contract and (2) the unit-price contract. The names of both of these contract formats refer to the method in which the price for the work is quoted.

The second most widely used contract format is the negotiated contract. This form of contract is also referred to as a *cost-plus* contract although this refers to the method of payment rather than the nature of the selection process. The contractor is reimbursed for the cost of doing the work plus a fee. In this type of contract, the contractor risk is greatly reduced since the requirement of completing the work at a fixed price is not present. The owner has the flexibility to select the contractor based on considerations other than lowest price quotation. The method of selection involves the identification of a group of qualified contractors who are invited to prepare proposals based on the project documentation available. The proposals present the credentials of the firm and an approximate estimate of cost based on the project data available. The estimate includes not only the "bricks-and-mortar" direct costs but also estimates of the cost of supervision by the contractor's personnel and the level of fee requested. The proposal is often presented in a semiformal interview framework in which the contractor meets with the client and his/her representatives. Selection of the contractor is based on the preferences of the owner and the strengths and weaknesses of the contractor's proposal. This format is not well suited to public projects since favoritism can play a major part in determining which contractor is selected.

4.4 COMPETITIVELY BID CONTRACTS

The mechanism by which competitively bid contracts are advertised and awarded has been described in Chapters 2 and 3. Essentially, the owner invites a quote for the work to be performed based on complete plans and specifications. The award of contract is generally made to the lowest *responsible* bidder. The word responsible is very important since the contractor submitting the lowest bid may not, in fact, be competent to carry out the work. Once bids have been opened and read publicly (at the time and place announced in the notice to bidders), an "apparent" low bidder is announced. The owner then immediately reviews the qualifications of the bidders in ascending order from lowest to highest. If the lowest bidder can be considered responsible based on his or her capability for carrying out the work, then further review is unnecessary.

The factors that affect whether a contractor can be considered responsible are the same as those used in considering a contractor for prequalification:

1. Technical competence and experience
2. Current financial position based on the firm's balance sheet and income statement
3. Bonding capacity
4. Current amount of work under way
5. Past history of claims litigation
6. Defaults on previous contracts

Because of shortcomings in any of these areas, a contractor can be considered a risk and, therefore, not responsible. Owners normally verify the bidder's financial status by consulting the Dun and Bradstreet *Credit Reports* (Building Construction Division) or similar credit reporting system to verify the financial picture presented in the bid documents.

Generally, the advantages that derive from the use of competitively bid contracts are twofold. First, because of the competitive nature of the award, selection of the low bidder ensures that the lowest responsible price is obtained. This is only theoretically true, however, since change orders and modifications to the contract tend to offset or negate this advantage and increase the contract price. Some contractors, upon finding a set of poorly defined plans and specifications will purposely bid low (i.e., zero or negative profit) knowing that many change orders will be necessary and will yield a handsome profit. That is, they will bid low to get the award and then negotiate high prices on the many change orders that are issued.

The major advantage, which is essential for public work, is that all bidders are treated equally and there are no favorites. This is very important since in the public sector political influence and other pressures could bias the selection of the contractor. Presently, public design contracts are not awarded by competitive bidding. The practice of negotiating design contracts is traditional and supported by engineering professional societies (e.g., the American Society of Civil Engineers and the National Society of Professional Engineers). Nevertheless, it has been challenged by the U.S. Department of Justice.

The competitive method of awarding construction contracts has several inherent disadvantages. First, the plans and specifications must be totally complete prior to bid advertisement. This leads to a sequentiality of design followed by construction and breaks down feedback from the field regarding the appropriateness of the design. Also, it tends to extend the total design-build time frame since the shortening of time available by designing and constructing in parallel is not possible. In many cases, the owner wants to commence construction as quickly as possible to achieve an early completion and avoid the escalating prices of labor and materials. The requirement that all design must be complete before construction commences preempts any opportunity for commencing construction while design is still under way.

4.5 STIPULATED-SUM CONTRACTS

A lump-sum, or stipulated-sum, contract is one in which the contractor quotes one price, which covers all work and services required by the contract plans and specifications. In this format, the owner goes to a set of firms with a complete set of plans and specifications and asks for a single quoted price for the entire job. This is like a client going to a marine company with the plans for a sailboat or catamaran and requesting a price. The price quoted by the boat builder is the total cost of building the vessel and is a lump-sum price. Thus the lump sum must include not only the contractor's direct costs for labor, machines, and so forth but also all indirect costs such as field and front office supervision, secretarial support, and equipment maintenance and support costs. It must also include profit.

In stipulated-sum contracts the price quoted is a guaranteed price for the work specified in the plans and supporting documents. This is helpful for the owner since he knows the exact amount of money that must be budgeted for the project, barring any contingencies or change of contractual documents (i.e., change orders).

In addition, the contractor receives monthly progress payments based on the estimated percent of the total job that has been completed. In other contract forms, precise field measurement of the quantity of work placed (e.g., cubic yards of concrete, etc.) must be made continuously since the contractor is paid based on the units placed rather than on the percent of job completed. Since the percent of the total contract completed is an estimate, the accuracy of the field measurements of quantities placed need only be accurate enough to establish the estimated percent of the project completed. This means that the number and quality of field teams performing field quantity measurements for the owner can be reduced. The total payout by the owner cannot exceed the fixed or stipulated price for the total job. Therefore, rough field measurements and observations, together with some "Kentucky windage," are sufficient support for establishing the amount of progress payment to be awarded.

In addition to the disadvantage already noted (i.e., the requirement to have detailed plans and specifications complete before bidding and construction can begin), the difficulties involved in changing design or modifying the contract based on changed conditions are an important disadvantage. The flexibility of this contract form is very limited. Any deviation from the original plans and specifications to accommodate a change must be handled as a change order (see Section 3.5). This leads to the potential for litigation and considerable wrangling over the cost of contract changes and heightens the adversary relationship between owner and contractor.

The stipulated-sum form of contract is used primarily in building construction where detailed plans and specifications requiring little or no modification can be developed. Contracts with large quantities of earthwork or subsurface work are not normally handled on a lump-sum basis since such contracts must be flexible enough to handle the imponderables of working below grade. Public contracts for buildings and housing are typical candidates for lump-sum competitively bid contracts.

4.6 UNIT-PRICE CONTRACTS

In contrast to the lump-sum, or fixed-price, type of contract, the unit-price contract allows some flexibility in meeting variations in the amount and quantity of work encountered during construction. In this type of contract, the project is broken down into work items that can be characterized by units such as cubic yards, linear and square feet, and piece numbers (e.g., 16 window frames). The contractor quotes the price by units rather than as a single total contract price. For instance, he quotes a price per cubic yard for concrete, machine excavation, square foot of masonry wall, and so forth. The contract proposal contains a list of all work items to be defined for payment. Items 1 to 4 in Section 1 of Figure 2.9 provide a typical listing for unit-price quotation. This section is reprinted for reference:

Item number	Quantity	Unit	Description	Unit price	Total amount
1	550	cubic yard (cu yd)	Rock excavation (for structures and pipes only)	$________	$________
2	50	linear foot (lin ft)	8-in. C.I. force main	$________	$________
3	20	cubic yard (cu yd)	Trench excavation for pipes	$________	$________
4	200	square yard (sq yd)	Paving	$________	$________

Four items of unit-price work are listed. A guide quantity is given for each work item. The estimated amount of rock excavation, for example, is 550 cu yd. Based on this quantity of work, the contractor quotes a unit price. The total price is computed by multiplying the unit price by the guide quantity. The low bidder is determined by summing the total amount for each of the work items to obtain a grand total. The bidder with the lowest grand total is considered the low bidder. In true unit-price contracts, the entire contract is divided into unit-price work items. Those items that are not easily expressed in units such as cubic yards are expressed in the unit column as "one job."

Unit-price quotations are based on the guide quantity specified. If a small quantity is specified, the price will normally be higher to offset mobilization and demobilization costs. Larger quantities allow *economies of scale*, which reduce the price per unit. That is, if 100 sq ft of masonry brick wall is to be installed, the cost per square foot would normally be higher than the cost for 5000 sq ft. Mobilization and demobilization costs are spread over only 100 units in the first case, whereas in the second case these costs are distributed over 5000 units, reducing the individual unit cost.

Most unit-price contracts provide for a price renegotiation in the event that the actual field quantity placed deviates significantly from the guide quantity specified. If the deviation exceeds 10%, the unit price is normally renegotiated. If the field quantity is over 10% greater than the specified guide quantity, the owner or the owner's representative will request a price reduction based on economies possible due to the larger placement quantity. If the field quantity underruns the guide quantity by more than 10%, the contractor will usually ask to increase the unit price. He will argue that he must recover his mobilization, demobilization, and overhead costs since the original quote was based on the guide quantity. That is, there are fewer units across which to recover these costs and, therefore, the unit price must be adjusted upward.

In developing the unit-price quotation, the contractor must include not only direct costs for the unit but also indirect costs such as field and office overheads as well as a provision for profit.

In unit-price contracts, the progress payments for the contractor are based on precise measurement of the field quantities placed. Therefore, the owner should have a good indication of the total cost of the project based on the grand total price submitted. However, deviations between field-measured quantities and the guide quantities will lead to deviations in overall job price. Therefore, one disadvantage of the unit price contract form is that the owner does not have a precise final price for the work until the project is complete. In other words, allowances in the budget for deviations must be made. In addition, the precision of field measurement of quantities is much more critical than with the lump-sum contract. The measured field quantities must be exact since they are, in fact, the payment quantities. Therefore, the owner's quantity measurement teams must be more careful and precise

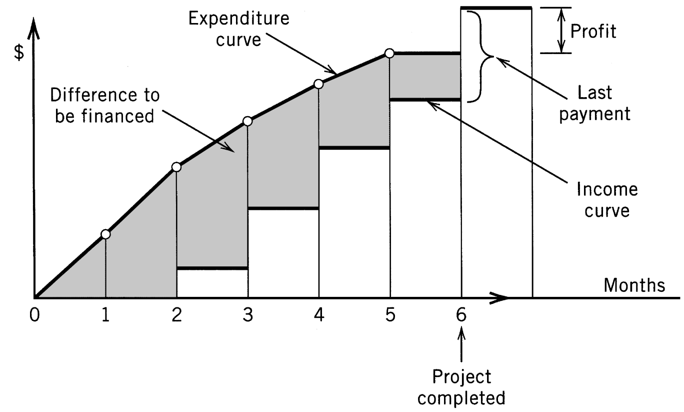


Figure 4.1 Project expense/income curves.

in their assessments since their quantity determinations establish the actual cost of the project.

Unit-price contracts can also be manipulated using the technique called unbalancing the bid. The relationship between the contractor's expenditures and income across the life of a typical project is shown schematically in Figure 4.1. Because of delays in payment and retainage as described in Section 3.10, the income curve lags behind the expenditure curve and leads the contractor to borrow money to finance the difference. The nature and amount of this financing is discussed in detail in Chapter 9.

The shaded area in Figure 4.1 gives an approximate indication of the amount of overdraft the contractor must support at the bank pending reimbursement from the client. In order to reduce this financing as much as possible, the contractor would like to move the income curve as far to the left as possible.

One way to achieve this is to unbalance the bid. Essentially, for those items that occur early in the construction, inflated unit prices are quoted. For example, hand excavation that in fact costs $50 per cubic yard will be quoted at $75 per cubic yard. Foundation piles that cost $40 per linear foot will be quoted at $60 per linear foot. Since these items are overpriced, in order to remain competitive, the contractor must reduce the quoted prices for latter bid items. "Close-out" items such as landscaping and paving will be quoted at lower-than-cost prices. This has the effect of moving reimbursement for the work forward in the project construction period. It unbalances the cost of the bid items leading to front-end loading.

The amount of overdraft financing is reduced, as shown by the income and expense profiles in Figure 4.2. Owners using the unit-price contract format are usually sensitive to this practice by bidders. If the level of unbalancing the quotations for early project bid items versus later ones is too blatant, the owner may ask the contractor to justify his price or even reject the bid.

Some contracts obviate the need to unbalance the bid by allowing the contractor to quote a "mobilization" bid item. This essentially allows the bidder to request front money from the owner. The mobilization item moves the income curve to the left of the expense curve (see Fig. 4.3). The contractor in the normal situation (Fig. 4.1) will bid the cost (e.g., interest paid) of financing the income/expense difference into his prices. Therefore, the owner ultimately pays the cost of financing the delay in payments of income. If the owner's borrowing (i.e., interest) rate at the bank is better than that of the contractor, money can be saved by providing a mobilization item, thereby offsetting the contractor's charge for interim financing. Large owners, for instance, are often able to borrow at the prime rate (e.g., 8 or 9%), while contractors must pay several percent above the prime rate (e.g., 11

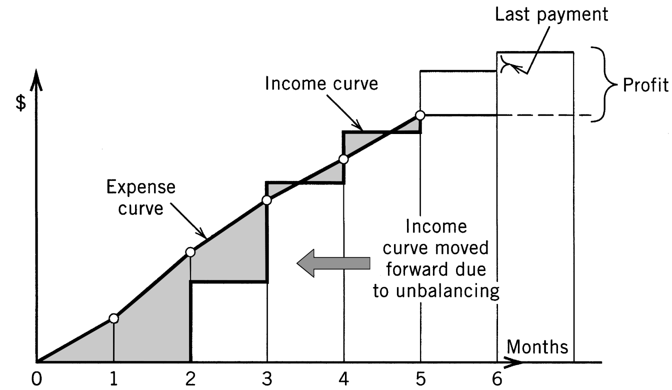


Figure 4.2 Unbalanced bid income profile.

or 12%). By providing a mobilization item, the owner essentially assumes the overdraft financing at his rate, rather than having the contractor charge for financing at the higher rate.

In addition to the flexibility in accommodating the variation in field quantities, the unit-price contract has the added advantage to the contractor that quantity estimates developed as part of the bidding process need only verify the guide quantities given in the bid item list (i.e., schedule). Therefore, the precision of the quantity takeoff developed for the contractor's estimate prior to construction need not be as exact as that developed for a fixed-price (lump-sum) contract. The leeway for quantity deviation about the specified guide quantities also normally reduces the number of change orders due to the automatic allowance for deviation.

Because of its flexibility, the unit-price contract is almost always used on heavy and highway construction contracts where earthwork and foundation work predominate. Industrial rehab work can also be contracted using the unit-price contract format with bid item list for price quotation. Major industrial facilities are typically bid using the negotiated contract format.

4.7 NEGOTIATED CONTRACTS

An owner can enter into contract with a constructor by negotiating the price and method of reimbursement. A number of formats of contract can be concluded based on negotiation between owner and contractors. It is possible, for example, to enter into a fixed-price or unit-price contract after a period of negotiation. In some cases, public owners will negotiate with the three low bidders on prices, materials, and schedule.

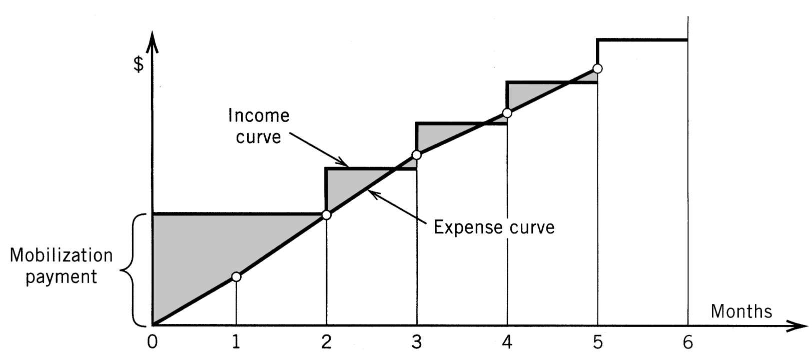


Figure 4.3 Income profile with mobilization payment.

The concept of negotiation pertains primarily to the method by which the contractor is selected. It implies flexibility on the part of the owner to select the contractor on a basis other than low bid. Therefore, a contractor competing for award of contract in the negotiated format cannot expect to be selected solely on the basis of low bid. This affects the bid cycle and the completeness of plans and specifications that must be available at the time of contractor selection. The owner invites selected contractors to review the project documentation available at the time of negotiation. This documentation may be total and complete design documentation as in the case of competitively bid contracts or only concept-level documentation. Based on the documentation provided, the contractor is invited to present his qualifications to perform the work and to indicate his projected costs and fee for completing the work. Since the level of the design documentation can vary from total detail to preliminary concept drawings, the accuracy of the cost projections will also vary. Within this presentation format, the owner evaluates the experience, reputation, facilities, staff available, charge rates, and fee structures of the various bidders participating. Based on this evaluation, the field is reduced to two or three contractors, and negotiations are opened regarding actual contract form and methods of reimbursement.

Since in most cases, the design documentation is not complete at the time of negotiation, the most common form of contract concluded is the COST + FEE. In this type of contract, the contractor is reimbursed for expenses incurred in the construction of the contracted facility. The contract describes in detail the nature of the expenses that are reimbursable. Normally, all direct expenses for labor, equipment, and materials as well as overhead charges required to properly manage the job are reimbursable. In addition, the contractor receives a fee for his expertise and the use of his plant in support of the job. The fee is essentially a profit or markup in addition to the cost reimbursement. The level and amount of fee in addition to the charge schedule to be used in reimbursement of the direct costs are major items of discussion during negotiation. Various formulas are used for calculating the fee and strongly influence the profitability of the job from the contractor's standpoint.

As in the case of competitively bid contracts, the contractor does the financing of the project and is reimbursed by periodic (e.g., monthly) progress payments. Both parties to the contract must agree to and clearly define the items that are reimbursable. Agreement regarding the accounting procedures to be used is essential. Areas of cost that are particularly sensitive and must be clearly established are those relating to home office overhead charges.[1] If the owner is not careful, he may be surprised to find out he has agreed to pay for the contractor's new computer network. Other activities that must be clearly defined for purposes of reimbursement are those pertaining to award and control of subcontracts as well as the charges for equipment used on the project.

Four types of fee structure are common. They lead to the following cost-plus types of reimbursement schemes:

1. Cost + percent of cost
2. Cost + fixed fee
3. Cost + fixed fee + profit-sharing clause
4. Cost + sliding fee

The oldest form of fee structure is the *percent of cost* form. This form is very lucrative for the contractor but is subject to abuse. There is little incentive to be efficient and economical in the construction of the project. Just to the contrary, the larger the cost of the job, the higher the amount of fee that is paid by the owner. If the cost of the job is $40 million and the fee is 2%, then the contractor's fee is $800,000. If the costs increase to $42 million the

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[1] Overhead charges pertain to costs that cannot be linked to a specific work item such as concrete placement but are required for proper supervision and control of the project.

contractor's fee increases by $40,000. Abuse of this form of contract has been referred to as the 'killing of the goose that laid the golden egg.' Therefore this form of reimbursement is seldom used.

In order to offset this flaw in the percent-cost approach, the fixed-fee formula was developed. In this case, a fixed amount of fee is paid regardless of the fluctuation of the reimbursable cost component. This is usually established as a percent of an originally estimated total cost figure. This form is commonly used on large multiyear industrial plant projects. If the projected cost of the plant is $500 million, a fixed fee of 1% of that figure is specified and does not change due to variation from the original estimated cost. Therefore, the contractor's fee is fixed at $5 million. This form gives the contractor an incentive to get the job done as quickly as possible in order to recover his fee over the shortest time frame. Because of the desire to move the job as quickly as possible, however, the contractor may tend to use expensive reimbursable materials and methods to expedite completion of the project.

The fixed-fee plus profit-sharing formula provides a reward to the contractor who controls costs, keeping them at a minimum. In this formula it is common to specify a target price for the total contract. If the contractor brings the job in under the target, the savings are divided or shared between owner and contractor. A common sharing formula provides that the contractor shares by getting 25% of this underrun of the target. If, for instance, the target is $15 million and the contractor completes the job for $14.5 million, he receives a bonus of $125,000. The projection of this underrun of the target and the percent bonus to be awarded the contractor are used by some construction firms as a measure of the job's profitability. If the contractor exceeds the target, there is no profit to be shared.

In some cases, the target value is used to define a guaranteed maximum price (GMP). This is a price that the contractor guarantees will not be exceeded. In this situation, any overrun of the GMP must be absorbed by the contractor. The GMP may be defined as the target plus some fraction of the target value. In the example above, if the target is $15 million, a GMP of $16 million might be specified.

In this form, a good estimate of the target is necessary. Therefore, the plans and concept drawings and specifications must be sufficiently detailed to allow determination of a reasonable target. The incentive to save money below the target provides an additional positive factor to the contractor. The owner tends to be more ready to compromise regarding acceptance of the project as complete if the job is under target. Additional work on punch list costs the contractor 25 cents, but it costs the owner 75 cents. The quibbling that is often present at the time the punch list is developed is greatly reduced to the contractor's advantage.

A variation of the profit-sharing approach is the *sliding fee*, which not only provides a bonus for underrun but also penalizes the contractor for overrunning the target value. The amount of the fee increases as the contractor falls below the target and decreases as he overruns the target value. One formula for calculating the contractor's fee based on a sliding scale is

$$\text{Fee} = R(2T - A)$$

where T = target price
R = base percent value
A = actual cost of the construction

Negotiated contracts are most commonly used in the private sector, where the owner wants to exercise a selection criterion other than low price alone. The negotiated contract is used only in special situations in the public sector since it is open to abuse in cases where favoritism is a factor. Private owners are also partial to the negotiated format of contracting because it allows the use of phased construction (see Fig. 4.4) in which design

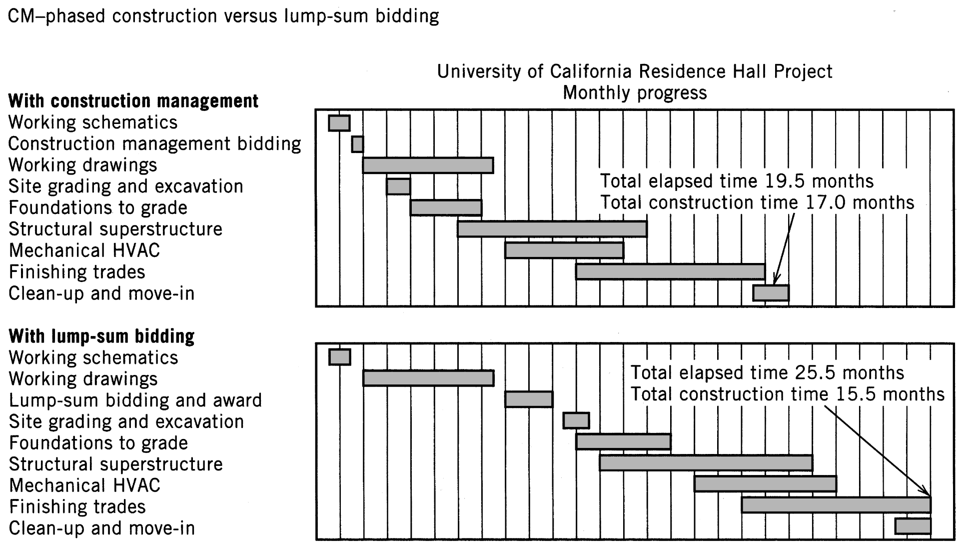


Figure 4.4 Traditional versus phased construction.

and construction proceed simultaneously. This allows compression of the classical "design first-then construct or design-bid-build" sequence. Since time is literally money, every day saved in occupying the facility or putting it into operation represents a potentially large dollar saving. The cost of interest alone on the construction financing of a large hotel complex can run as high as $50,000 a day. Financial costs generated by delays on complex industrial facilities are estimated at between $250,000 and $500,000 a day. Quite obviously, any compression of the design-build sequence is extremely important.

Large and complex projects have durations of anywhere from to 2 to 3 up to 10 years. For such cases, cost-plus contracts are the only feasible way to proceed. Contractors will not bid fixed prices for projects that continue over many years. It is impossible to forecast the price fluctuations in labor, material, equipment, and fuel costs. Therefore, negotiated cost-plus-fee contracts are used almost exclusively for such complex long-duration projects.

4.8 PROJECT DELIVERY METHODS

In ancient times, great structures were constructed by "master builders" who developed the project concept, designed the appearance and technical details of the finished building or monument, and mobilized the resources needed to realize the final structure. This classical approach was used to build the pyramids, the great castles and churches of the Middle Ages, and the civil engineering infrastructure of the industrial revolution. Master builders designed and constructed facilities acting as a single point of contact for the client.

Over the past 100 years, the processes of designing and building were gradually separated. Design and construction were viewed as separate endeavors. A design professional prepared the project plans, and a separate firm was contracted to perform the actual construction of a facility. This separation of activities also led to a sequencing of activities in which design was completed before construction commenced. This became the "traditional" sequence and is now referred to as Design-Bid-Build or DBB. This contracting procedure has been the basis for our discussions in Chapters 2 and 3. In contrast, master builders conducted design and construction simultaneously.

Over the past 30 years, a number of new concepts for project delivery have been developed to compress the time required to realize a constructed facility. It has been recognized that the DBB method of project delivery, with its sequential emphasis, leads to longer-than-necessary project time frames. It is advantageous from a time perspective to have design and construction proceed simultaneously. This has led to a reconsideration of the master builder concept and a discussion of what is meant by "Project Delivery Systems or Methods."

The topic of project delivery methods addresses "the organization or the development of the a framework relating the organizations required to complete or deliver a project and the establishment of the formal (i.e., contractual) and the informal relationships between these organizations." In the DBB approach, for instance, the owner holds a contract with the designer or A/E for the development of the plans and specifications and a separate contract with the construction contractor for the building of the facility. In other delivery systems, the owner contracts with a single group or entity for both the design and construction of a facility. Another accepted definition is as follows:

"A project delivery method is the comprehensive process of assigning the contractual responsibilities for designing and constructing a project. (AGC, 2004)."

Based on guidance given by the Associated General Contractors (AGC), the concept of project delivery addresses two critical issues:

1. Is the responsibility to the owner/client for project design and construction tied to a single entity (e.g., a performing group) or multiple entities? In other words, does the owner deal with a single entity or multiple entities when pursuing design and construction of a project?
2. Is the criteria for award based on lowest cost or on other criteria?

In the framework of this discussion, competitively bid contracts require multiple entities and the contract award is based on lowest quotation or cost to the owner. Negotiated contracts also involve multiple entities (e.g., architects, design professionals, construction contractors, etc.) and may be based on lowest cost, although, in certain cases other considerations take precedence over cost (e.g., expertise, previous performance, ability to react quickly, etc.). Two relatively new contract formats have been introduced which focus on simplifying the project delivery process. Low cost is not as central to these formats as in the competitive or negotiated types of contracts. The emphasis is on optimizing parameters other than cost (e.g., quality, time of completion, meeting market needs, safety, etc.). Design Build (DB) and Construction Management (CM) contracts differ from the traditional DBB format in terms of how they address the two critical issues of project delivery methods stated above. They also facilitate the use of "phased construction" or "fast-tracking" based on design and construction occurring in parallel (i.e., at the same time) in contrast to the sequential nature of the DBB approach.

4.9 DESIGN-BUILD CONTRACTS

As noted in Section 4.2, it is advantageous from the client's point of view to have a single contractor provide the entire project as a single contract package. In the 1970s, large firms began to offer both design and construction services in order to provide the client with a single source for project delivery. This approach of providing both design and construction services can be viewed as a natural evolutionary step beyond the negotiated contract and is often referred to as ***integrated*** design build. It has been common practice in industrial construction to use the design-build approach for complex projects that have tight time requirements. In such cases, it is advantageous for the client to have a single firm providing both design and construction services.

This system has the advantage that differences or disputes between the design team or group and the construction force are matters internal to a single company. This eliminates the development of an adversary relationship between two or more firms involved in realizing the project (i.e., it eliminates disputes between designer and constructor). Normally, the management of the design-build contractor is motivated to reconcile disputes or differences between design and construction in an expeditious and efficient manner. If such problems are not addressed, they can lead to loss of profit and potential dismissal of the contractor for poor performance.

Coordination between design and construction is also enhanced by having both functions within the same firm. This system improves the communication between designers and the field construction force and assists in designing a facility that is not only functional but is also efficient to construct. The firm is driven by the profit motive to optimize the design both for the functional life-cycle use of the building as well as to design for construction thus enhancing the efficiency of the construction process. This can be compared to the manufacturing design of the refrigerator referred to in Section 4.2. If a firm manufactures a refrigerator, it designs the appliance to be efficient for use in the home. It also designs the item so that it can be assembled in the most cost-efficient and timely manner so as to reduce production costs.

Design-build contracts also have the advantage that design and construction can be done concurrently. That means that work can be started in the field before a complete design is available. This allows for "phased construction," or a "fast track" approach as described above and a compression of the schedule since design must not be totally complete prior to commencement of construction. This compression of schedule is illustrated in Figure 4.4 in which design and construction proceed simultaneously.

During the 1970s this type of contract was used mainly on large and complex projects (e.g., petrochemical plants, industrial complexes, power plants, etc.) to improve the flow of information between the design team and the construction people in the field. Usually, only firms with large design and construction capabilities were able to provide design-build services. Projects built with a single design-build contractor were often referred to as "turn key" projects since the owner dealt with only one contractor and that contractor was charged with the completion of the facility so that the project was ready to be placed in operation at the "turn of a key." That is, this owner signed a single contract and said "Call me when you have the project complete and you want me to turn the key to start it up."

4.10 DESIGN-BUILD IN A CONSORTIUM FORMAT

In the past decade, the use of design-build contracts has become more common in the building construction sector. A number of firms have marketed this project delivery approach to private entrepreneurs (e.g., owners building hotels, apartment and office structures, etc.) in the building sector as a way to receive the best product in the most timely way at the best price. Since most building contractors do not have an in-house design capability, lead contractors typically form a team or consortium of designers and specialty contractors who work together to meet the needs of the client. The owner/client contracts with the consortium as a single group providing the total project package (e.g., design, construction, procurement, etc.).

Each member of the consortium is at risk and is motivated to work with other members to minimize delays and disputes. In effect, a group of designers and constructors form a consortium to build a project based on conceptual documentation provided by the owner. They agree to work together to achieve the project and, therefore, implicitly agree to avoid developing an adversarial relationship between one another.

The attraction of this consortium-based approach is the fact that the owner/client is given a stipulated-sum price for the project after 30 to 40% of the design of the project is completed. Barring major changes to the project, the consortium locks in the final price at the end of the preliminary design phase. This is very attractive to the owner since financing for the overall project can be lined up based on a definitive cost figure developed early in the design development process. This reduces the need for contingency funds and is attractive to the lender since the cost and, therefore, the amount of the borrowing is locked in.

The members of the consortium are motivated to be innovative and avoid disputes since failure to achieve the stipulated price quoted at the end of preliminary design will result in a loss to all of the members of the consortium. Again, the adversarial relationship typical of designer and constructors is largely eliminated since bickering and lack of cooperation among members of the team can lead to significant losses. Incentive to avoid disputes and to develop innovative solutions to field problems is inherent in this type of contract.

This consortium-based design–build contract has gained such wide acceptance in the private building construction community that it is now being used by the federal government on selected building projects. A number of large Internal Revenue Service (IRS) facilities have been built using design-build contracts. In its application in the private sector, stiff competition among a number of consortia for the same project has not been the normal case. In most cases, the owner/entrepreneur has worked with one or two lead contractors who form a design–build team to meet the customized requirements of the client. Competition among competing consortia in the private building construction sector has not been a major issue.

With the advent of the use of this method in the public sector, competition has been a major factor. Selection of the winning consortium is based on competitive review of proposals from each consortium. In this format, the nonselectcd consortia incur substantial losses based on the cost of organizing and developing a competitive proposal.

4.11 CONSTRUCTION MANAGEMENT (CM) CONTRACTS

The Construction Management format became popular in the 1970s as a method which provided a single point of coordination to owners. In this format, a single firm or entity called the Construction Manager (CM) is retained to coordinate all activities from concept design through acceptance of the facility. This firm represents the owner in all construction management activities. The CM coordinates the selection of all design and construction entities (firms) and supervises and controls the pre-design, design, pre-construction, and construction activities related to the project on behalf of the owner. In effect, the CM acts as the "agent" of the owner. For this reason, this contract format is often called agency construction management (CMa). In this type of contract, construction management is defined as "a group of management activities related to a construction program, carried out during the pre-design, design, and construction phases, that contributes to the control of time and cost in the construction of a new facility." The construction management firm's position in the classical relationship linking owner, contractor, and architect engineer is as shown in Figure 4.5.

One item of importance with the CMa approach is that although the construction manager works on behalf of the owner in managing and coordinating all aspects of the project, all contracts between design and construction firms involved in realizing the project are signed by the owner. Therefore, the CM is not "at risk." The CM is a coordinator and is responsible only to provide management services that are consistent with the norms of the industry established for other firms performing construction manager services.

In this coordination function, the CMa firm acts as a traffic cop monitoring and controlling the flows of information among all parties active on the project. The CM establishes the procedures for award of all contracts to architect/engineers, principal vendors, and the so-called trade or specialty contractors. Once contractual relationships are established, the CM controls not only the prime or major contractor but all subcontractors as well as major vendors and off-site fabricators. Major and minor contractors on the site are referred

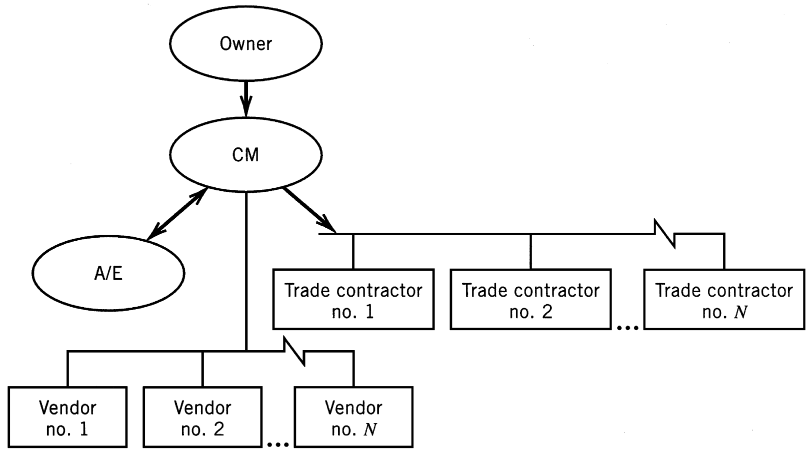


Figure 4.5 Construction management relationships to other principal parties on the project.

to as trade or specialty contractors. In this control or management function, the CM firm utilizes the project schedule as a road map or flight plan to keep things moving forward in a timely and cost-effective manner. The major functions carried out by the CM firm vary depending on whether the project is in the (1) predesign, (2) design, or (3) construction phase.

Agency construction management contracts are particularly attractive for organizations that periodically build complex structures (e.g., hospital authorities, municipalities, transit authorities, etc.) but do not desire to maintain a full-time construction staff to supervise projects on a recurring basis. In such cases an owner can retain a CMa firm to plan, develop, and coordinate the activities of one or more design professionals, trade contractors, vendors, and other interested parties such as licensing and control bodies.

4.12 CONSTRUCTION MANAGEMENT AT-RISK

Agency CMs are coordinators working on behalf of the client and are not contractually liable for the successful completion of the work. In addition, problems arising out of decisions made as a part of their oversight of the project often lead to legal issues which are difficult to resolve. For instance, if the CMa implements safety procedures on behalf of the owner which are found to be faulty and lead to unsafe construction operations, the owner, not the CMa, is normally viewed as liable for legal suites or claims arising out of these procedures. Therefore, the client, through lack of experience in dealing with construction problems and protocols, may be put at risk by poor decisions made by the CMa while supervising and controlling the project.

To close this loop hole, a version of the CM contract format has become popular in which the construction manager not only coordinates the project, but also assumes responsibility for the construction phase of the work. In the CM at-Risk contract, the CM assumes the same risk that a construction contractor in the DBB format would assume for the successful completion of the project. In this situation, the CM-at Risk signs all contracts related to the construction phase of the work. The design and other pre-constructions contracts and responsibilities are signed by or remain with the owner. Prior to the commencement of construction, the CM at-Risk provides services similar to those provided by a CMa firm. The CM at-Risk contract is similar to the DBB format in that design and construction are separate contracts. It differs from the DBB format, however, in that the selection criteria are based on issues other than lowest total construction cost.

Table 4.1 Project Delivery Method (PDM)

	Contract Type	Single or Multiple Contracts to Owners	Selection Criteria	Phased Construction
DBB	Competitively Bid	Multiple-Design Contract & Construction Contract	Low Construction Cost	No
	Negotiated	Multiple Design & Construction	Low Cost or Other	Possible
DB	DB	Single Contract with DB Firm	Usually not Low Cost—Based on Performance	Yes
CM	CMa	Contracts held by Owner—CM, Design, Construction, and Vendors	Based on Performance Expectations	Yes
	CM at Risk	Same as CMa above except CM and Construction Contracts are Combined	Based on Performance Expectations	Yes

4.13 COMPARING PROJECT DELIVERY METHODS

From the project delivery perspective, competitively bid contracts are required to be design-bid-build (DBB) contracts. Negotiated contracts can be viewed as DBB contracts although it is not unusual for design and construction to proceed in parallel (i.e., simultaneously) in a given situation. In other words, it is possible to use "phased construction" when working with negotiated construction contracts. A constructor involved in construction of a hotel building on a cost reimbursable basis can begin construction of the site excavation and sub-basements while the roof-top restaurant is still being designed. For both competitively bid and negotiated contracts, the owner holds separate contracts with the designer or design group and with the construction contractor.

In the Design Bid (DB) format, the owner enters into contract with a single entity—the Design Builder. The basis of selection of the Design Build firm or consortium is normally on the basis of considerations other than least cost. Fast tracking or phased construction is typical of DB contracts.

In both forms of the CM format, the owner holds multiple contracts. In the case of the *Agency Construction Management* format, the owner signs a management contract with the CMa, but holds contracts directly with the design and construction firms involved. Selection of the Agency CM firm is based on issues other than total construction cost (e.g., quality, schedule performance, etc.) Fast track construction is usual when using this format.

The CM at-Risk format requires separate contracts for the design team and the CM at-Risk firm (similar to the DBB format). Low total construction cost is not the basis for selection of the Construction Manager at-Risk. Fast track construction is possible when using this format. The major types of Project Delivery Methods are summarized in Table 4.1.

REVIEW QUESTIONS AND EXERCISES

4.1 Name and briefly describe each of the two basic types of competitively bid construction contracts. Which type would be most likely used for building the piers to support a large suspension bridge? Why?

4.2 If you were asked to perform an excavation contract competitively with limited boring data, what type of contract would you want and why?

4.3 Name three ways the construction contract can be terminated.

4.4 Name two types of negotiated contracts and describe the method of payment and incentive concept.

4.5 What is meant by unbalancing a bid? What type of contract is implied? Give an example of how a bid is unbalanced.

4.6 Why is cost plus a percentage of cost type of contract not used to a great extent?

4.7 Under what circumstances is a cost-plus contract favorable to both owner and contractor?

4.8 Valid contracts require an offer, an acceptance, and a consideration. Identify these elements in the following cases:

- **a.** The purchase of an item at the store
- **b.** The hiring of labor
- **c.** A paid bus ride
- **d.** A construction contract
- **e.** The position of staff member in a firm

4.9 Suppose you are a small local building contractor responsible for the construction of the small gas station in Appendix I. List the specialty items that you would subcontract.

4.10 Visit a local building site and ascertain the number and type of subcontracts that are involved. How many subcontracts do you think may be needed for a downtown high-rise building? Why would there be more subcontractors in a building job as opposed to a heavy construction job?

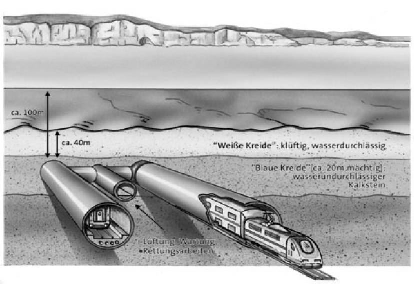
4.11 From the point of view of the owner's contract administrator, each different type of contract places different demands on supervision. List the significant differences that would impact the complement (number) of field personnel required to monitor the contract.

4.12 Visit a local contractor and determine the proportion of contracts that are negotiated against those that are competitively bid awards. Is this percentage likely to change significantly with small building contractors? Is there a difference between building contractors and heavy construction contractors?

Chapter 5

Legal Structure

Hoover Dam (http://www.usbr.gov)



Channel Tunnel

Joint Venturing

The Need

Larger and complex projects often exceed the capability of a single firm or contractor to do the work. In such cases, a team or group of contractors will combine their resources to bid and execute the work. A famous example of this situation is the construction of the Hoover Dam during the 1930s, in which a group of six of the largest contractors in the U.S. banded together to build this project. The approach of a group of firms or professionals establishing a team to complete a project is referred to as "a joint venture." Joint ventures are also referred to as consortia (e.g., a single team or group is a consortium).

There are many reasons why firms will decide to legally combine for a specific period of time to pursue a given project. A given project may be so large that the financial resources of a number of companies are required to bond the project. For instance, the construction of an addition to the McCormick Exhibition Center in Chicago was so large that bonding companies were not prepared to provide performance and payment bonds to a single company. Being prudent, the bonding companies wanted to spread their risk.

This was also a consideration in the financial structure for the construction of the Channel Tunnel which led to the establishment of a large consortium of companies (both French and English) who allied for the specific purpose of construction the "Chunnel." From a financial, political and technical perspective, it would not have been possible for one company to build this epic project.

The Approach

A joint venture is a business relationship undertaken by two or more companies to form a legal entity for the purpose of performing a specific work item or, in the case of construction, a given project. A team of firms may be involved in both the design and construction of a project or only (as in the Hoover Dam) the construction phase of a project. In any case, the owner contracts with the joint venture.

Therefore, the joint venture must be legally established in a rigorous fashion so that the contract required is binding. A major benefit to the owner/client when working with a joint venture is that the owner deals with single entity as opposed to a number of different companies. From a management point of view, the owner has a single point of contact or a single contractor made up of many sub-entities.