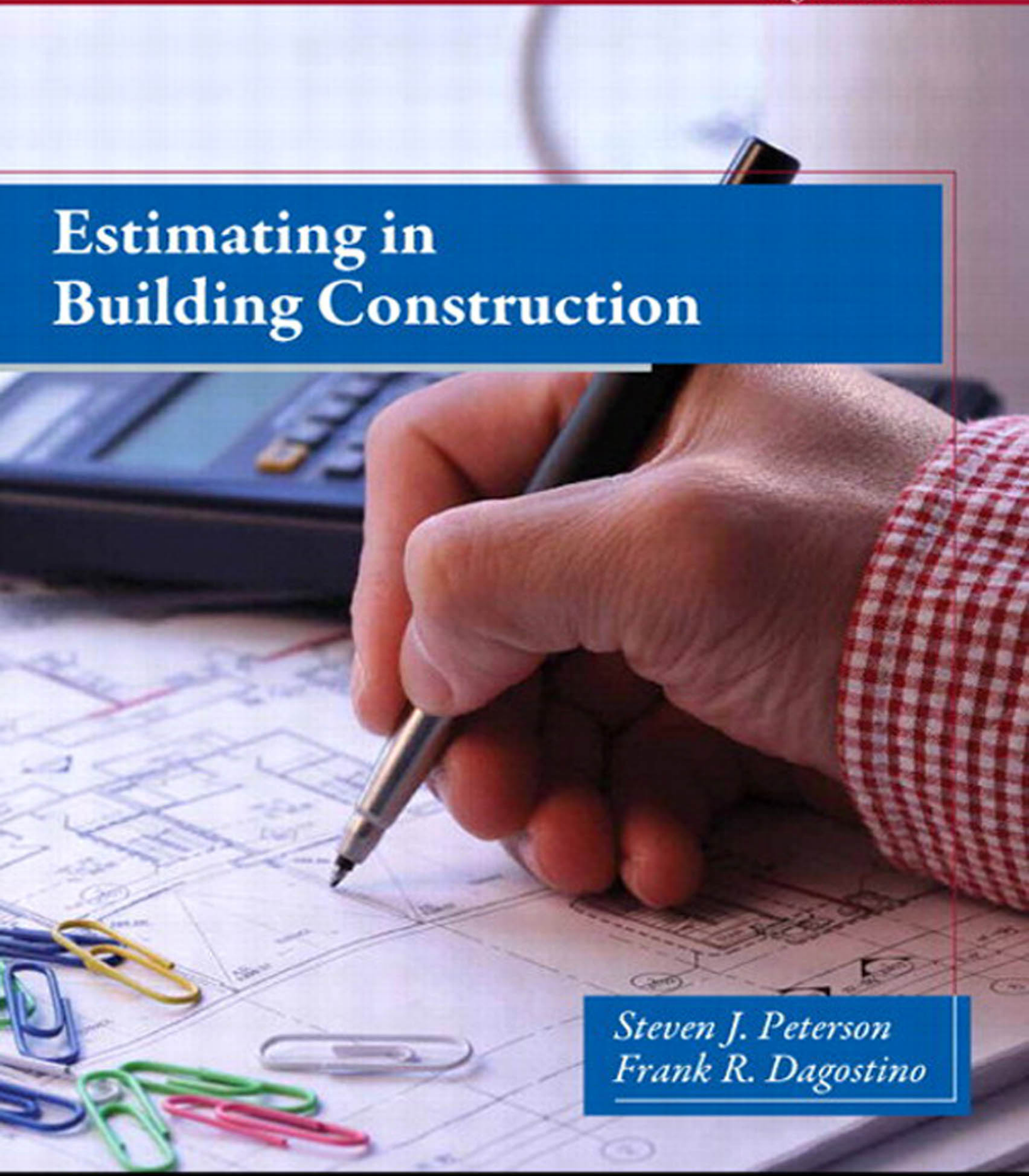
Eighth Edition

Estimating in Building Construction



Steven J. Peterson
Frank R. Dagostino

Estimating in Building Construction

EIGHTH EDITION

Steven J. Peterson
Weber State University

Frank R. Dagostino

PEARSON

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To my father for encouraging me to get an education and my mother for her loving support. SP

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PREFACE

The eighth edition continues to build on the strong foundation of the previous editions. The need for estimators to understand the theory behind quantification is critical and must be fully understood prior to performing any computerized estimating. This underlying premise has been one of the guiding principles that began with Mr. Dagostino and continues with the current author. This edition uses extensive examples and exercises to demonstrate the estimating methodology and the organization of the estimate. Estimating is an art that relies heavily on the judgment of the person performing the takeoff. A person's estimating skills can only be developed with practice; therefore, the reader is encouraged to work the example problems and apply the skills taught in this book. Since the estimate is used throughout the project, the assumptions and methodologies assumed must be documented and organized so that subsequent users will have access to this knowledge.

NEW TO THIS EDITION

The intent of this revision is to expand the estimating material covered by this book and to bring other material in line with current industry practices. The following is a list of key changes and additions that have been made to this edition:

- Over 200 problems have been added to the chapters.
- Chapter 4 has been rewritten to give the reader a better overview of the estimating process.
- A discussion of the use of building information modeling (BIM) in estimating has been added to Chapter 5. Estimating problems using a building information model for a wood-framed office building (included on the companion website) have been included in the problem sets of many of the chapters.
- A discussion of Fair Labor Standards Act and Davis-Bacon Act has been added to Chapter 7.
- Chapter 8 has been rewritten to provide a more thorough discussion of equipment costs.
- Chapter 17 has been rewritten to provide a more thorough discussion of estimating electrical.
- Chapter 18 has been rewritten to provide a more thorough discussion of estimating plumbing, including fire sprinklers.
- Chapter 19 has been rewritten to provide a more thorough discussion of estimating HVAC.
- Chapter 20 has been rewritten to provide a more thorough discussion of profit.
- A bid simulation has been added to the instructor resource materials. Student instructions for the bid simulation are found in Appendix H.All supplementary plans for the Appendices can be found at the Pearson Careers Resources for Students website (http://www.pearsonhighered.com/careersresources/) by searching for the book by title or going to Browse by Discipline and choosing Civil and Construction Technology.

I thank the following for their insightful reviews: Stuart Bernstein, University of Nebraska; Daniel Castro, Georgia Institute of Technology–Atlanta; Soon-Jae Lee, Texas State University; and Charles Parker, East Tennessee State University.

Steven Peterson

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CONTENTS

CHAPTER **ONE**

INTRODUCTION TO ESTIMATING

1–1 GENERAL INTRODUCTION

Building construction estimating is the determination of probable construction costs of any given project. Many items influence and contribute to the cost of a project; each item must be analyzed, quantified, and priced. Because the estimate is prepared before the actual construction, much study and thought must be put into the construction documents. The estimator who can visualize the project and accurately determine its cost will become one of the most important persons in any construction company.

For projects constructed with the design-bid-build (DBB) delivery system, it is necessary for contractors to submit a competitive cost estimate for the project. The competition in construction bidding is intense, with multiple firms vying for a single project. To stay in business, a contractor must be the lowest-qualified bidder on a certain number of projects, while maintaining an acceptable profit margin. This profit margin must provide the general contractor an acceptable rate of return and compensation for the risk associated with the project. Because the estimate is prepared from the working drawings and the project manual for a building, the ability of the estimator to visualize all of the different phases of the construction project becomes a prime ingredient in successful bidding.

The working drawings usually contain information relative to the design, location, dimensions, and construction of the project, while the project manual is a written supplement to the drawings and includes information pertaining to materials and workmanship, as well as information about the bidding process. The project manual is often mistakenly referred to as the specifications because it contains the technical specifications, but it contains much more. The working drawings and the project manual constitute the majority of the contract documents, define the scope of work, and *must* be considered together when preparing an estimate. The two complement each other, and they often overlap in the information they convey. The bid submitted must be based on the scope of work provided by the owner or the architect. The estimator is responsible for including everything contained in the drawings and the project manual in the submitted bid. Because of the complexity of the drawings and the project manual, coupled with the potential cost of an error, the estimator must read everything thoroughly and recheck all items. Initially, the plans and the project manual must be checked to ensure that they are complete. Then the estimator can begin the process of quantifying all of the materials presented. Every item included in the estimate must contain as much information as possible. The quantities determined for the estimate will ultimately be used to order and purchase the needed materials. The estimated quantities and their associated projected costs will become the basis of project controls in the field.

Estimating the ultimate cost of a project requires the integration of many variables. These variables fall into either direct field costs or indirect field costs. The indirect field costs are also referred to as general conditions or project overhead costs in building construction. The direct field costs are the material, labor, equipment, or subcontracted items that are permanently and physically integrated into the building. For example, the labor and materials for the foundation of the building would be a direct field cost. The indirect field costs are the costs for the items that are required to support the field construction efforts. For example, the project site office would be an indirect field cost. In addition, factors such as weather, transportation, soil conditions, labor strikes, material availability, and subcontractor availability need to be integrated into the estimate. Regardless of the variables involved, the estimator must strive to prepare as accurate an estimate as possible. Since subcontractors or specialty contractors may perform much of the work in the field, the estimator must be able to articulate the scope of work in order for these companies to furnish a price quote. The complexity of an estimate requires organization, the estimator's best judgment, complete specialty contractors' (subcontractors') bids, accurate quantity takeoffs, and accurate records of completed projects.

The design-build (DB) and construction-manager (CM) project delivery systems are gaining in popularity. In the design-build delivery system, the contractor acts as both the designer and the general contractor. In the construction-manager delivery system, the contractor and some of the key subcontractors are involved in the design process, providing expertise in construction methods and costs, as well as managing the construction process. Integrated project delivery (IPD), a relatively new delivery system, involves the owners, designers, contractor, and some of the key subcontractors in the design process. IPD differs from the CM delivery system in that the owners, designers, contractor, and key subcontractors share governance, risk, contingency, and the profit on the project. All of these delivery systems require the contractor to provide cost estimates for the proposed project throughout the design process.

At the conceptual stage of the project, the contractor prepares a cost estimate based on the project's concept. This is known as a conceptual estimate. When performing a conceptual estimate, typically, drawings are not available or they are very limited. What exists is often a vague verbal or written description of the project scope, which may be accompanied by a few sketches. When preparing this type of estimate, the contractor makes assumptions about virtually every aspect of the project. The conceptual estimate is used early in the design process to check to see if the owners' wants are in line with their budget and is often used as a starting point to begin contract negotiations.

During the design process, the contractor prepares and maintains a cost estimate based on the current, but incomplete, design. This is often referred to as a preliminary estimate. In addition, the contractor may prepare estimates that are used to select between building materials and to determine whether the cost to upgrade the materials is justified. What all these estimates have in common is that the design is incomplete. Once the design is complete, the contractor can prepare a detailed estimate for the project.

1–2 ESTIMATING METHODS

The required level of accuracy coupled with the amount of information about the project that is available will dictate the type of estimate that can be prepared. These estimating methods require different amounts of time to complete and produce different levels of accuracy for the estimate. The relationship between the time to complete the estimate and the accuracy of the estimate is shown in Figure 1.1. The different estimating methods are discussed below.

Detailed Estimate

The detailed estimate includes determination of the quantities and costs of everything that is required to complete the project. This includes materials, labor, equipment, insurance, bonds, and overhead, as well as an estimate of the profit. To perform this type of estimate, the contractor must have a complete set of contract documents. Each item of the project should be broken down into its parts and estimated. Each piece of work that is to be performed by the contractor has a distinct labor requirement that must be estimated. The items that are to be installed by others need to be defined and priced. Caution needs to be exercised to ensure that there is agreement between the contractor and the subcontractor as to what they are to do and whether they are only to install or both supply and install the items. In addition, there needs to be an agreement about who is providing support items such as cranes and scaffolding. The contractor is responsible for making sure that the scope of work is divided among the contractor and subcontractors so that there are no overlaps in the individual scope of works and that everything has been included in someone's scope of work.

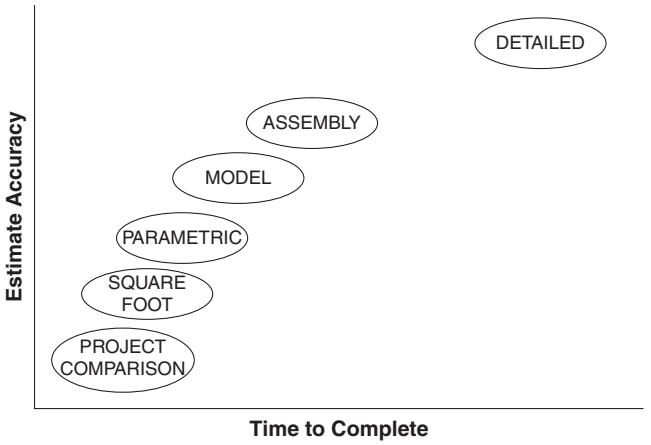

FIGURE 1.1. Estimating Time Versus Accuracy.

The detailed estimate must establish the estimated quantities and costs of the materials, the time required for and costs of labor, the equipment required and its cost, the items required for overhead and the cost of each item, and the percentage of profit desired, considering the investment, the time to complete, and the complexity of the project. The principles used to prepare the detailed estimates are covered in Chapters 4 and 6 through 20.

Assembly Estimating

In assembly estimating, rather than bidding each of the individual components of the project, the estimator bids the components in groups known as assemblies. The components of an assembly may be limited to a single trade or may be installed by many different trades. An example of a simple assembly would be a residential light switch, which includes a single-gang box, a single-pole switch, cover plate, two wire nuts, and an allowance of 20 feet of NM-B 12-gage wire. The entire assembly would be installed by an electrician. A residential electrical estimate could be prepared using assemblies for the switches, outlets, lights, power panels, and so forth rather than determining the individual components. An example of a complex assembly would be a metal-stud, gypsum-board partition wall, which would include bottom track, metal studs, top track, drywall, screws, tape, joint compound, insulation, primer, paint, and

other miscellaneous items needed to construct the wall. This assembly would be installed by multiple trades.

Many high-end estimating computer programs, such as WinEst and Timberline, allow the user to prepare detailed estimates by taking off assemblies. For the switch assembly, the estimator would take off the number of switch assemblies needed for the project, and the software would add one single-gang box, one single-pole, one cover plate, two wire nuts, and 20 feet of NM-B 12-gage wire to the detailed estimate for each switch assembly. This simplifies the estimating process and increases the productivity of the estimator.

Assembly estimating is also useful for conceptual and preliminary estimates. By using broad assemblies, an estimate can be prepared quickly for an entire building. For example, an estimate for a warehouse can be prepared by using assembles for the spot footings, the continuous footings, the foundation wall, the floor slab (slab, reinforcement, granular base, vapor barrier, and fine grading), the exterior wall, personnel doors, overhead doors, joist and deck roof structure (including supports), roof insulation, roofing, wall cap, skylights, bathrooms, fire sprinklers, heating, lighting, and power distribution. This type of estimate can be prepared in hours instead of spending days preparing a detail estimate. The trade-off is that this type of estimate has many broad assumptions and is less accurate. This type of assembly estimating is good for estimates prepared with limited drawings, to compare design approaches, and as a check of a detailed estimate. If the assembly price comes from previously completed projects, it is assumed that this project is identical to the completed projects. This assumption is clearly not valid in the construction of buildings. Weather conditions, building materials, and systems as well as design and construction team members change from project to project, all adding to the uniqueness of every project. Skill and judgment must be used while preparing this type of assembly estimate to ensure that proper adjustments are made by taking into account the varying conditions of each project. Companies such as R.S. Means publish annual guides (such as *Square Foot Costs*) that contain pricing for assemblies. Assembly estimating is discussed in Chapter 21.

Square-Foot Estimates

Square-foot estimates are prepared by multiplying the square footage of a building by a cost per square foot and then adjusting the price to compensate for differences in the building heights, length of the building perimeter, and other building components. In some cases, a unit other than square footage is used to measure the size of the building. For example, the size of a parking garage may be measured by the number of parking stalls in the garage. The information required to produce a square-foot estimate is much less than is needed to prepare a detailed estimate. For example, a preliminary set of design drawings (a single-line floor plan and key elevations) would have the dimensions that are necessary to prepare a square-foot estimate. Square-foot estimates are helpful to check whether the project, as designed, is within the owner's budget. Like an assembly estimate that uses broad assemblies, care must be exercised while preparing a square-foot estimate to ensure that the projects used to determine the cost per square foot are similar to the proposed project. Companies such as R.S. Means publish annual guides (such as *Square Foot Costs*) that contain a range of unit costs for a wide variety of building types. These guides provide a number of adjustments to compensate for varying building components, including the city where the project is located. Square-foot estimating is discussed in Chapter 21.

Parametric Estimates

Parametric estimates use equations that express the statistical relationship between building parameters and the cost of the building. The building parameters used in the equation may include the gross square footage, number of floors, length of perimeter, percentage of the building that is common space, and so forth. For an equation to be usable, the parameters used in the equation must be parameters that can be determined early in the design process; otherwise the equation is useless. Parametric estimates are similar to square-foot estimates; however, the equations used in parametric estimates are more complex and may use log functions, ratios of parameters, and multiplication of parameters. Parametric estimating is useful for preparing conceptual estimates based on assumptions of key building parameters or estimates based upon early designs. As with square-foot estimates and assembly estimates that use broad assemblies, care must be taken to ensure that the proposed project is similar to the projects from which the equation has been derived.

Model Estimating

Model estimating uses computer models to prepare an estimate based on a number of questions answered by the estimator. Model estimating is similar to assembly estimating, but it requires less input from the estimator. For example, an estimate may be prepared for a warehouse by answering the following questions:

- What is the length of the building?
- How many bays are along the length of the building?
- What is the width of the building?
- How many bays are along the width of the building?
- What is the wall height above the grade?
- What is the depth (from the grade) to the top of the footing?
- What is the floor thickness?
- Do you want wire mesh in the slab?
- How many roof hatches do you want?
- How many personnel doors do you want?
- How many and what size of overhead doors do you want?
- How many and what size of skylights do you want?
- Do you want fire sprinklers?
- What bathroom facilities do you want (separate male and female, unisex, or none)?

On the basis of the answers to these questions, the model prepares a preliminary estimate for the project. Logic is built into the model, such that the model selects the necessary components for the estimate based upon the answers to the questions. For example, the size of the spot footings in the center of the building that support the roof and their costs are selected based on the area of the roof the footings support, which is equal to the width of a bay multiplied by the length of a bay. The length and width of the bays are calculated from the first four questions. A simple model estimate (Warehouse.xls) for a warehouse is provided on the companion website. This model makes many assumptions as to the design of the warehouse, such as assuming the exterior wall is constructed of concrete masonry units (CMU). The model ignores the site and excavation cost, which needs to be added to the estimate from the model to get a complete estimate.

Estimating models may be complex and may prepare a detailed estimate for the entire project, or the models may be simple and prepare a preliminary estimate for part of a project. As with square-foot estimates, assembly estimates that use broad assemblies, and parametric estimates, care must be taken to make sure that the proposed project is similar to the projects from which the model was developed.

Project Comparison Estimates

Project comparison estimates are prepared by comparing the cost of a proposed project to a completed project. When preparing an estimate using this method, the estimator starts with the costs of a comparable project and then makes adjustments for differences in the project. For example, an estimate for the buildings in an apartment project may be prepared from a project built using the same plans during the previous year in a nearby city. In this example, the prices from the completed project need to be adjusted for inflation, changes in the availability and cost of labor, changes in the plans made to meet city codes, and so forth. In most cases, the site should be estimated using another method because of the many differences in site conditions. As with other estimating methods that do not prepare a detailed list of materials, care must be taken to ensure that the proposed project is similar to the completed project. The project comparison method is discussed in Chapter 21.

1–3 ESTIMATING OPPORTUNITIES

For anyone who is not aware of the many opportunities in the estimating field, this section will review some of the areas in which knowledge of estimating is necessary. Generally, knowledge of the procedures for estimating is required by almost everyone involved in or associated with the field of construction. From the estimator, who may be involved solely with the estimating of quantities of materials and the pricing of the project, to the carpenter, who must order the materials required to build the framing for a home, this knowledge is needed to do the best job possible at the most competitive cost. Others involved include the project designer, drafters, engineers, contractors, subcontractors, material suppliers, and material representatives. In the following sections, a few of the estimating opportunities are described.

Architectural Offices. The architectural office will require estimates at three design stages: preliminary (rough square foot or project comparison costs), cost evaluation during drawing preparation (usually more accurate square foot or assembly costs), and a final estimate (usually based on material and installation costs, to be as accurate as possible). For projects built using the design-build or construction-manager delivery systems, the preliminary estimate is often used during negotiation with the general contractor. Once the general contractor is hired, the general contractor's estimator will prepare the remaining estimates.

In large offices, the estimating may be done by an estimator hired primarily to do all the required estimating. In many offices, the estimating may be done by the chief drafter, head or lead architect, or perhaps someone else in the office who has developed the required estimating skills. There are also estimating services or consultants who perform estimates on a for-fee basis.

Engineering Offices. The engineering offices involved in the design of building construction projects include civil, structural, mechanical (plumbing, heating, air-conditioning), electrical, and soil analysis. All of these engineering design phases require preliminary estimates, estimates while the drawings are being prepared, and final estimates as the drawings are completed. They are prepared in the same way estimates are prepared by the architects.

General Contractors. For design-bid-build projects, the general contractor makes *detailed* estimates that are used to determine what the company will charge to do the required work.

The estimator will have to take off the quantities (amounts) of each material; determine the cost to furnish (buy and get to the site) and install each material in the project; assemble the bids (prices) of subcontractors; as well as determine all of the costs of insurance, permits, office staff, and the like. In smaller companies, one person may do the estimating, whereas in larger companies several people may work to negotiate a final price with an owner or to provide a competitive bid.

On projects built using the design-build or construction-manager delivery system, the contractor's scope of work involves providing assistance to the owners, beginning with the planning stage, and continuing through the actual construction of the project. Under these delivery systems, the estimators will also provide preliminary estimates and then update them periodically until a final price is set.

Estimating with Quantities Provided by the Designer. Estimating for projects with quantity surveys provided by the designer involves reviewing the specifications for the contract and material requirements, reviewing the drawings for the type of construction used, and assembling the materials used. The estimator will spend part of the time getting prices from subcontractors and material suppliers and the rest of the time deciding on how the work may be most economically accomplished.

Subcontractors. Subcontractors may be individuals, companies, or corporations hired by the general contractor to do a particular portion of the work on the project. Subcontractors are available for all the different types of work required to build any project and include excavation, concrete, masonry (block, brick, stone), interior partitions, drywall, acoustical ceilings, painting, erection of steel and precast concrete, windows, metal and glass curtain walls, roofing, flooring (resilient, ceramic and quarry tile, carpeting, wood, terrazzo), and interior wall finishes (wallpaper, wood paneling, and sprayed-on finishes). The list continues to include all materials, equipment, and finishes required.

The use of subcontractors to perform all of the work on the project is an acceptable model in building construction. The advantage of this model is that the general contractor can distribute the risk associated with the project to a number of different entities. In addition, the subcontractors and craft personnel perform the same type of work on a repetitive basis and are therefore quasi experts in their niche. However, the general contractor relinquishes a substantial amount of control over the project when this method is employed. The more that the contractor subcontracts out, the more the field operation becomes involved in coordination rather than direct supervision of craft personnel.

The subcontractor carefully checks the drawings and project manual and submits a price to the construction companies that will be bidding on the project.

The price given may be a unit or lump sum price. If a subcontractor's bid is presented as what he or she would charge per unit, then it is a *unit price* (such as per square foot, per block, per thousand brick, per cubic yard of concrete) bid. For example, the bid might be $5.25 per linear foot (lf) of concrete curbing. Even with unit price bids, the subcontractors need to perform a quantity takeoff in order to have an idea of what is involved in the project, at what stages they will be needed, how long it will take to complete their work, and how many workers and how much equipment will be required. The subcontractor needs the completed estimate to determine what the reasonable amount for overhead and profit is. Typically, as the quantity of work increases, the associated unit cost of jobsite overhead decreases. For example, the cost of mobilization for a 100 lf of curb is $1,000 or $10 per lf; if the quantity had been 1,000 lf, it would have been $1 per lf. The subcontractor would not know how much to add to the direct field cost unit price for overhead unless a quantity takeoff had been performed.

If the subcontractor submits a lump-sum bid, then he or she is proposing to install, or furnish and install, a portion of work: For example, the bid might state, "agrees to furnish and install all Type I concrete curbing for a sum of $12,785.00."

Each subcontractor will need someone (or several people) to check specifications, review the drawings, determine the quantities required, and put the proposal together. It may be a full-time estimating position or part of the duties assumed, perhaps in addition to purchasing materials, helping to schedule projects, working on required shop drawings, or marketing.

Material Suppliers. Suppliers submit price quotes to the contractors (and subcontractors) to supply the materials required for the construction of the project. Virtually every material used in the project will be estimated, and multiple price quotes will be sought. Estimators will have to check the specifications and drawings to be certain that the materials offered will meet all of the requirements of the contract and required delivery dates.

Manufacturers' Representatives. Manufacturers' representatives represent certain materials, product suppliers, or manufacturers. They spend part of their time visiting contractors, architects, engineers, subcontractors, owners, and developers to be certain that they are aware of the availability of the material, its uses, and approximate costs. In a sense they are salespeople, but their services and the expertise they develop in their product lines make good manufacturers' representatives welcome not as salespersons, but as needed sources of information concerning the materials and products they represent. Representatives may work for one company, or they may represent two or more.

Manufacturers' representatives will carefully check the specifications and drawings to be certain that their materials meet all requirements. If some aspect of the specifications or drawings tends to exclude their product, or if they feel there may be a mistake or misunderstanding in these documents, they may call the architects/engineers and discuss it with them. In addition, many times they will be involved in working up various cost analyses of what the materials' or products' installed cost will be and in devising new uses for the materials, alternate construction techniques, and even the development of new products.

Project Management. Project management companies specialize in providing professional assistance in planning the construction of a project and keeping accurate and updated information about the financial status of the project. Owners who are coordinating large projects often hire such companies. Among the various types of owners are private individuals, corporations, municipal government agencies (such as public works and engineering departments), and various public utility companies.

Both the firms involved in project management, as well as someone on the staff of the owner being represented, must be knowledgeable in estimating and scheduling projects.

Government. When a government agency is involved in any phase of construction, personnel with experience in construction and estimating are required. Included are local, state or province, and nationwide agencies, including those involved in highways, roads, sewage treatment, schools, courthouses, nursing homes, hospitals, and single and multifamily dwellings financed or qualifying for financing by the government.

Employees may be involved in preparing or assisting to prepare preliminary and final estimates; reviewing estimates from architects, engineers, and contractors; the design and drawing of the project; and preparation of the specifications.

Professional Quantity Surveyors. Professional quantity surveyors are for-hire firms or individuals who make unit quantity takeoffs of the materials required to build a project. They are available to provide this service to all who need it, including governmental agencies.

Freelance Estimators. Freelance estimators will do a material takeoff of a portion or entire project for whoever may want a job done. This estimator may work for the owner, architect, engineer, contractor, subcontractor, material supplier, or manufacturer. In some areas, the estimator will do a material takeoff of a project being competitively bid and then sell the quantity list to one or more contractors who intend to submit a bid on the project.

Many times a talented individual has a combined drafting and estimating business. Part of the drafting business may include preparing shop drawings (drawings that show sizes of materials and installation details) for subcontractors, material suppliers, and manufacturers' representatives.

Residential Construction. Estimators are also required for the contractors, material suppliers, manufacturers' representatives, and most of the subcontractors involved in residential construction. From the designer who plans the house and the drafter who draws the plans and elevations to the carpenters who put up the rough framing and the roofers who install the roofing material, knowledge of estimating is necessary.

The designer and drafter should plan and draw the house plans using standard material sizes when possible (or being aware of it when they are not using standard sizes). In addition, they will need to give preliminary and final estimates to the owner. Workers need to have a basic knowledge of estimating so they can be certain that adequate material has been ordered and will be delivered by the time it is needed.

Computer Software. The use of computers throughout the world of construction offers many different types of opportunities to the estimator. Job opportunities in all the areas mentioned earlier will be centered on the ability to understand, use, and manipulate computer software. The software available today integrates the construction drawings, estimating, bidding, purchasing, and management controls of the project. Some construction consultants specialize in building databases for computerized estimating systems and training estimators in the use of these systems.

1–4 THE ESTIMATOR

Most estimators begin their career doing quantity takeoff; as they develop experience and judgment, they develop into estimators. A list of the abilities most important to the success of an estimator follows, but it should be more than simply read through. Any weaknesses affect the estimator's ability to produce complete and accurate estimates. If individuals lack any of these abilities, they must (1) be able to admit it and (2) begin to acquire the abilities they lack. Those with construction experience, who are subsequently trained as estimators, are often most successful in this field.

To be able to do quantity takeoffs, the estimator must:

1. Be able to read and quantify plans.
2. Have knowledge of mathematics and a keen understanding of geometry. Most measurements and computations are made in linear feet, square feet, square yards, cubic feet, and cubic yards. The quantities are usually multiplied by a unit price to calculate material costs.
3. Have the patience and ability to do careful, thorough work.
4. Be computer literate and use computer takeoff programs such as On-Screen Takeoff or Paydirt.

To be an estimator, an individual needs to go a step further. He or she must:

1. Be able, from looking at the drawings, to visualize the project through its various phases of construction. In addition, an estimator must be able to foresee problems, such as the placement of equipment or material storage, and then develop a solution and determine its estimated cost.
2. Have enough construction experience to possess a good knowledge of job conditions, including methods of handling materials on the job, the most economical methods of construction, and labor productivity. With this experience, the estimator will be able to visualize the construction of the project and thus get the most accurate estimate on paper.
3. Have sufficient knowledge of labor operations and productivity to thus convert them into costs on a project. The estimator must understand how much work can be accomplished under given conditions by given crafts. Experience in construction and a study of projects that have been completed are required to develop this ability.
4. Be able to keep a database of information on costs of all kinds, including those of labor, material, project overhead, and equipment, as well as knowledge of the availability of all the required items.
5. Be computer literate and know how to manipulate and build various databases and use spreadsheet programs and other estimating software.

6. Be able to meet bid deadlines and still remain calm. Even in the rush of last-minute phone calls and the competitive feeling that seems to electrify the atmosphere just before the bids are due, estimators must "keep their cool."
7. Have good writing and presentation skills. With more bids being awarded to the best bid, rather than the lowest bid, being able to communicate what your company has to offer, what is included in the bid, and selling your services is very important. It is also important to communicate to the project superintendent what is included in the bid, how the estimator planned to construct the project, and any potential pitfalls.

People cannot be taught experience and judgment, but they can be taught an acceptable method of preparing an estimate, items to include in the estimate, calculations required, and how to make them. They can also be warned against possible errors and alerted to certain problems and dangers, but the practical experience and use of good judgment required cannot be taught and must be obtained over time.

How closely the estimated cost will agree with the actual cost depends, to a large extent, on the estimators' skill and judgment. Their skill enables them to use accurate estimating methods, while their judgment enables them to visualize the construction of the project throughout the stages of construction.

1–5 QUANTITY SURVEYING

In Canada and parts of Europe, and on most road construction projects in the United States, the estimated quantities of materials required on the project are determined by a professional quantity surveyor or engineer and provided to the interested bidders on the project. Figure 1.2 is an example of the quantities that would be provided by a quantity surveyor or engineer for the construction of a sewer line. This is often referred to as a unit price bid.

In this method of bidding, the contractors are all bidding based on the same quantities, and the estimator spends time developing the unit prices. For example, the bid may

Item No.	Description	Quantity
1	Mobilization (Insurance and Bond Included)	1 lump sum
2	12-inch Reinforce Concrete Pipe—Varying Depths	24 linear feet
3	18-inch Reinforce Concrete Pipe—Varying Depths	6,696 linear feet
4	24-inch Reinforce Concrete Pipe—Varying Depths	1,176 linear feet
5	36-inch Reinforce Concrete Pipe—Varying Depths	1,160 linear feet
6	42-inch Reinforce Concrete Pipe—Varying Depths	1,560 linear feet
7	54-inch Reinforce Concrete Pipe—Varying Depths	2,096 linear feet
8	Catch Basin 3 feet x 3.67 feet (depth < 6 feet)	58 each
9	Catch Basin 3 feet x 5.33 feet (depth < 6 feet)	1 each
10	Catch Basin 4 feet x 3.67 feet (depth < 6 feet)	4 each
11	Catch Basin 4.5 feet x 3.67 feet (depth < 6 feet)	2 each
12	Catch Basin 5.75 feet x 3.67 feet (depth < 6 feet)	12 each
13	Clean out 3 feet x 3.67 feet (depth < 6 feet)	7 each
14	Clean out 4 feet x 3.67 feet (depth < 6 feet)	5 each
15	Clean out 5.25 feet x 3.67 feet (depth < 6 feet)	1 each
16	Clean out 5.75 feet x 3.67 feet (depth < 6 feet)	1 each
17	Combo Box 4.5 feet x 3.67 feet (depth < 6 feet)	1 each
18	Post Construction Sewer Main Television	12,712 linear feet
19	18-inch Slip Under Railroad	1 lump sum
20	42-inch Slip Under Railroad	1 lump sum
21	End Section	1 lump sum
22	Tie to Existing Sewer	1 lump sum

FIGURE 1.2 Quantity Survey.

be $78.74 per lineal feet of 18-inch reinforced concrete pipe. Because all of the contractors are bidding on the same quantities, they will work on keeping the cost of purchasing and installing the materials as low as possible.

As the project is built, the actual number of units required is checked against the original number of units on which the estimates were made. For example, in Figure 1.2, the original quantity survey called for 6,696 linear feet (lf) of 18-inch reinforced concrete pipe. If 6,703 lf were actually installed, then the contractor would be paid for the additional 7 lf. If 6,690 lf were used, then the owner would pay only for the 6,690 lf installed and not the 6,696 lf in the original quantity survey. This type of adjustment is quite common. When errors do occur and there is a large difference between the original quantity survey and the actual number of units, an adjustment to the unit price is made. Small adjustments are usually made at the same unit rate as the contractor bid. Large errors may require that the unit price be renegotiated.

If the contractor is aware of potential discrepancies between the estimated quantities and those that will be required, the contractor may price his or her bid to take advantage of this situation. With a belief that the estimated quantities are low, the contractor may reduce his or her unit price to be the low bidder. If the assumption is true, the contractor has the potential to make the same profit by distributing the project overhead over a greater number of units.

1–6 TYPES OF BIDS

Basically, the two bidding procedures by which the contractor gets to build a project for owners are as follows:

1. Competitive bidding
2. Negotiated bidding

Competitive bidding involves each contractor submitting a lump-sum bid or a proposal in competition with other contractors to build the project. The project may be awarded based on the price or best value. When the project is awarded based on the price, the lowest lump-sum bidder is awarded the contract to build the project as long as the bid form and proper procedures have been followed and this bidder is able to attain the required bonds and insurance. When the project is awarded based upon the best value, the proposals from the contractors are rated based on specified criteria with each criterion given a certain percentage of the possible points. The criteria may include review of the capabilities of the assigned project team, the company's capabilities and its approach to the project (including schedule), proposed innovation, method of mitigating risk, and price. The price is often withheld from the reviewers until the other criteria have been evaluated to prevent the price from affecting the ratings of the other criteria. Most commonly, the bids must be delivered to the person or place specified by a time stated in the instruction to bidders.

The basic underlying difference between negotiated work and competitive bidding is that with negotiated work the parties arrive at a mutually agreed upon price, terms and conditions, and contractual relationship. This arrangement often entails negotiations back and forth on virtually all aspects of the project, such as materials used, sizes, finishes, and other items that affect the price of the project. Owners may negotiate with as many contractors as they wish. This type of bidding is often used when owners know which contractor they would like to build the project, in which case competitive bidding would waste time. The biggest disadvantage of this arrangement is that the contractor may not feel the need to work quite as hard to get the lowest possible prices as when a competitive bidding process is used.

1–7 CONTRACT DOCUMENTS

The bid submitted for any construction project is based on the contract documents. If an estimator is to prepare a complete and accurate estimate, he or she must become familiar with all of the documents. The documents are listed and briefly described in this section. Further explanations of the portions and how to bid them are contained in later chapters.

For design-bid-build projects, the contract documents consist of the *invitation to bid*, *instructions to bidders*, *bid form*, *owner–contractor agreement, general conditions of the contract, supplementary general conditions, technical specifications*, and the *working drawings*, including all *addenda* incorporated in the documents before their execution. All of these documents become part of the *contract*.

Invitation to Bid. The invitation to bid invites potential contractors to bid on the project and provides a brief summary of the project, including project scope and size, location, project's owner, and so on.

Instructions to Bidders. The instructions to bidders provides bidders with the procedures that must be followed to submit a complete bid and contains such information as the date, time, and place the bid is due, attendance at pre-bid meetings, and so on.

Bid Form. The bid form is a standard form that all contractors use to submit their bids.

Owner–Contractor Agreement. The owner–contractor agreement is the document that formalizes the construction contract, and it is the basic contract. It incorporates by reference all of the other documents and makes them part of the contract. It also states the contract sum and time allowed to construct the project.

General Conditions. The general conditions define the rights, responsibilities, and relations of all parties to the construction contract.

Supplementary General Conditions (Special Conditions). Because conditions vary by locality and project, the supplementary general conditions are used to amend or supplement portions of the general conditions.

Technical Specifications. The technical specifications are written instructions concerning project requirements that describe the quality of materials to be used and their performance. The technical specifications supplement the information on the working drawings.

Working Drawings. The actual plans (drawings, illustrations) from which the project is to be built are the working drawings. They contain the dimensions and locations of building elements and materials required, and delineate how they fit together.

Addenda. The addenda statement is a drawing or information that modifies the basic contract documents after they have been issued to the bidder, but prior to the taking of bids. They may provide clarification, correction, or changes in the other documents.

For projects built with the design-build and construction-manager delivery systems, the contract documents are more limited than for projects built with the design-bid-build delivery system because the contractor is involved in the design and selection of the specifications for the project. These documents can be as simple as an agreement with a conceptual description of the project.

1–8 BIDDING INFORMATION

There are several sources of information pertaining to the projects available for bidding. Public advertising (advertisement for bids) is required for many public contracts. The advertisement is generally placed in newspapers, trade magazines, and journals, and notices are posted in public places and on the Internet. Private owners often advertise in the same manner to attract a large cross section of bidders (Figure 1.3). Included in the advertisement is a description of the nature, extent, and location of the project; the owner; the availability of bidding documents; bond requirements; and the time, manner, and place that the bids will be received.

Reporting services, such as *Dodge Reports* and *Engineering News Record* (ENR), provide information about projects that are accepting bids or proposals. The *Dodge Reports* are issued for particular, defined localities throughout the country, and separate bulletins are included that announce new projects within the defined area and provide a constant updating on jobs previously reported. The updating may include a listing of bidders, low bidders, awards of contracts, or abandonment of projects. In short, the updates provide information that is of concern to the contractors.

Local contractor groups may provide reporting services similar to *Dodge Reports* and provide plan rooms where interested parties may review the drawings and project manual of current projects. While most general contractors will obtain several sets of contract documents for bidding, the various subcontractors and material suppliers make extensive use of such plan rooms.

1–9 AVAILABILITY OF CONTRACT DOCUMENTS

When paper copies of the plans and the project manual are used, there is usually a limit on the number of sets of contract documents a general contractor may obtain from the architect/engineer, and this limitation is generally found in the invitation to bid or instructions to bidders. Subcontractors, material suppliers, and manufacturers' representatives can usually obtain prints of individual drawings and specification sheets for a fee from the architect/engineer, but it should be noted that this fee is rarely refundable. The architect/engineer will require a deposit for each set of contract documents obtained by the prime contractors. The deposit, which acts as a guarantee for the safe return of the contract documents, usually ranges from $10 to over $200 per set and is usually refundable. It should be realized that the shorter the bidding period, the greater the number of sets that would be required. Also, a large complex job requires extra sets of contract documents to make an accurate bid.

To obtain the most competitive prices on a project, a substantial number of subcontractors and material suppliers must bid the job. To obtain the most thorough coverage, there should be no undue restrictions on the number of sets of contract documents available. If this situation occurs, it is best to call the architect/engineer and discuss the problem. For many projects, the owner makes drawings available in computer files, which can be printed or used in estimating software (such as On-screen Takeoff). This reduces the cost of reproducing the drawings and project manual, making it economical to distribute them to numerous contractors and subcontractors. Often electronic copies of the plans and the project manual can be downloaded via the Internet.

During the bidding period, the lead estimator needs to be certain that the contract documents are kept together. Never lend out portions of the documents. This practice will eliminate subcontractors' and material suppliers' complaints that they did not submit a complete proposal because they lacked part of the information required for a complete bid.

Some subcontractors and suppliers still prefer to work with paper copies of the plans. The general contractors often set aside space in their offices where the subcontractors' and material suppliers' estimators may work. In this manner, the contract documents never leave the contractor's office and are available to serve a large number of bidders who want to use the paper copies.

1–10 SOURCES OF ESTIMATING INFORMATION

For matters relevant to estimating and costs, the best source of information is your historical data. These figures allow for the pricing of the project to match how the company actually performs its construction. This information takes into account the talent and training of the craft personnel and the management abilities of the field staff personnel. In addition, it integrates the construction companies' practices and