Cost Estimating

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Introduction

Accurately forecasting the cost of future projects is vital to the survival of any business or organization contemplating future construction. Cost estimators develop the cost information that business owners or managers, professional design team members, and construction contractors need to make budgetary and feasibility determinations. From an Owner's perspective the cost estimate may be used to determine the project scope or whether the project should proceed. The construction contractor's cost estimate will determine the construction bid or whether the company will bid on the construction contract.

There were about 198,000 cost estimators in 1994 according to the U.S. Department of Labor, Bureau of Labor Statistics, 2006-2007 Occupational Outlook Handbook, Cost Estimators, of which 58% work in the construction industry, 17% are employed in manufacturing industries, and the remaining 25% elsewhere. Most construction estimators have considerable experience gained through working in the building construction industry. This guide will be confined to cost estimating in the building construction industry.

Construction cost estimators can be contractually hired in many different ways. They may be employed by the owner's representative/project manager, employed by the construction manager, employed as a member of a professional design team, or separately hired by the owner. They estimate building costs through all the stages of design and the construction of the project. On large projects it is common for estimators to specialize in disciplines that parallel design discipline specialization.

It is very important to have the cost estimator involved right from the start of the project to ensure that the project budget reflects the decisions made by the rest of the project team throughout the integrated design process.

Description

A. Professional Behavior Expected of the Cost Estimator

- **Ethics:** The practice of construction estimating is a highly technical and professional discipline. It also involves abiding by certain standards of ethical conduct and moral judgment that go beyond the technical aspects of the discipline. Estimators are often the most familiar with the complete project. They must exercise sound moral and professional judgment at all times when preparing the project estimate. Estimators sometime receive pressure from other members of the construction team to make expedient short-term
decisions that can result in an unsound bid. Resistance to this type of pressure is a part of the estimator's job. Examples of expedient behavior litter the history of inaccurate construction estimating. Deficient estimates can also cause strife and litigation between members of the construction team. The American Society of Professional Estimators (ASPE) has stated the following ethical, moral and technical precepts as basic to the practice of estimating. See the ASPE Basic Canons.

- **Integrity**: Estimators are expected to use standards of confidentiality in a manner at least equal to that of other professional societies. The estimator shall keep in strictest confidence information received from outside sources. The practice, commonly called "bid peddling", is a breach of ethics and is condemned by the ASPE and that of other societies and construction organizations.

- **Judgment**: Judgment is a skill obtained by estimators through proper training and extensive experience. Estimators should always use sound judgment and common sense when preparing estimates. Proper use of judgment may mean the difference between profit and loss for the company or client.

- **Attitude**: Estimators should approach each estimate with a professional attitude and examine in thorough detail all areas of the work. They will set aside specific times each day for entry of estimate quantities and data without interruption. Total mental concentration is a basic requirement for preparing accurate cost estimates.

- **Thoroughness**: An estimator will allow enough time to research and become familiar with the background and details of the project and then promptly complete the quantity survey. They will review the various aspects of the project with the other disciplines involved. The estimator with the most thorough knowledge of a project best serves the owner and project team, and has the best competitive advantage when preparing a bid.

**B. Common Cost Estimator Practice Traits**

- **Awareness**: The estimator should firstly consider the project scope and the level of effort and resources needed to complete the task ahead; the organization's financial capability, staff, and plant capacity (if working as an estimator for a construction company) to complete the project.
  
  - Consider the time allotted for the construction of the project in coordination with the owner's schedule needs.
  - Examine the general and special conditions of the contract and determine the effect these requirements have on indirect costs.
  - Consider alternate methods of construction for the projects.
  - Review all sections of the drawings and division specifications to ascertain an accurate perspective of the total project scope, level of design discipline coordination, adequacy of details, and project constructability.
- Make other members of the project team aware of any problems with the project documents.
- Communicate and coordinate information to other project team members in a timely manner.

**Uniformity:** The estimator should develop a good system of estimating forms and procedures that exactly meet the requirements of the project, and that is understood and accessible by all team members. This system should provide the ability to define material, labor hour and equipment hour quantities required for the project. Material, labor, and equipment unit costs are then applied to the quantities as developed in the quantity survey. Apply amounts for overhead and profit, escalation, and contingency in the final summaries.

**Consistency:** Use methods for quantity surveys that are in logical order and consistent with industry standard classification systems such as the UniFormat™ or CSI MasterFormat™ systems. These methods also must meet the specific need of the company or client. Use of consistent methods allows several estimators to complete various parts of the quantity survey, or be continued later by another estimator. Consistency also aids the identification of cost increases and decreases in certain areas as the project progresses through the design stages. Combine these surveys into the final account summaries.

**Verification:** The method and logic employed in the quantity survey must be in a form, which can provide independent method of proof of the accuracy of any portion of the survey.

**Documentation:** Document all portions of the estimate in a logical, consistent, and legible manner. Estimators and other personnel may need to review the original estimate when the specific details are vague. The documentation must be clear and logical or it will be of little value to the reader. Such instances may occur in change order preparation, settlements of claims, and review of past estimates as preparation for new estimates on similar projects.

**Evaluation:** When the estimate involves the use of bids from subcontractors, check the bids for scope and responsiveness to the project. Investigate the past performance records of subcontractors submitting bids. Determine the level of competence and quality of performance.

**Labor Hours:** The detailed application of labor hours to a quantity is primary in governing the accuracy and sufficiency of an estimate. The accuracy of the project's schedule and work force requirements are dependent on the evaluation and definition of the hours. The combined costs for worker's compensation, unemployment insurance and social security taxes are significant factors in the project costs. The most accurate method for including these costs is to define labor hours and wage rates; then apply percentages to the labor costs.

**Value Engineering:** Structure the estimate to aid in researching and developing alternative methods that will result in cost optimization. These alternative methods can include different construction methodology, replacement materials, etc. Using the same level of detail in both the value engineering studies and the base estimate is extremely important. This provides a more precise comparison of costs for proposed alternate methods.
• **Final Summaries:** Provide methods for listing and calculating indirect costs. Project scope governs the costs of overhead items such as insurance, home office plant, and administrative personnel. Determine these costs in a manner consistent with quantity survey applications. Consider other work in progress, and/or owner occupancy of existing space that may have a bearing on projected overhead costs. Determine amounts for performance bonding, profits, escalation, and contingencies.

• **Analysis:**
  - Develop methods for analyzing completed estimates to ascertain if they are reasonable. When the estimate is beyond the normal range of costs for similar projects, research the detail causes for possible errors.
  - Develop methods of analysis of post-bid estimates to find the reasons for the lack of success in the bidding process.
  - Calculate the variation of the estimate from the low bid and low average bids.
  - Determine from an outside source if there were subcontract or material bids provided only to certain bidders.
  - Determine if bids were submitted by a representative number of contractors for the level of construction quality expected.
  - Determine if the low bidder may have made omissions in the estimate.
  - Properly document this information for future use and guidance.

• **Conversion:** Show estimating procedures that allow conversion of the estimate to field cost systems so management can monitor and control field activities. These procedures include methods of reporting field costs for problem areas. Make reports daily or weekly rather than at some point in time after the project is complete. Field cost reporting, when consistent with estimating procedures, enables estimators to apply the knowledge gained from these historical costs to future estimates, and help train field personnel in labor hour and cost reporting that provide the level of accuracy required.

• **Change Orders:** Apply the highest level of detail from information provided or available to the estimator. State quantities and costs for all material, labor, equipment, and subcontract items of work. Define amount for overhead, profit, taxes, and bond. Specific itemization of change order proposals is essential in allowing the client to determine acceptability. Upon approval, use the estimate detail as the definition of scope of the change order.

**C. Levels of Estimate**

As a project is proposed and then developed, the estimate preparation and information will change based on the needs of the Owner/Client/Designer. These changes will require estimates to be prepared at different levels during the design process with increasing degrees of information provided. It should also be noted that within each level of estimate preparation, not all portions of the design would be at the same level of completeness. For example, the architectural design may be at 80%
complete while the mechanical design is only 50% complete. This is common through the design process, but should always be noted in the estimate narrative.

In addition to construction costs, estimates for process or manufacturing areas require information related to the involved processes such as product line capacity, process layout, handling requirements, utility requirements, materials and storage required, service requirements, flow diagrams, and raw materials access.

The following descriptions constitute the different levels of an estimate. Estimates within each of these levels may be prepared multiple times during the design process as more information becomes available or changes are made to the scope. As the level of the estimate increases it will become more detailed as more information is provided; "unknowns" are eliminated; fewer assumptions are made; and the pricing of the quantities become more detailed. Contingencies for the aforementioned will be reduced as more design documentation is produced.

The levels of the construction cost estimate correspond to the typical phases of the building design and development process and are considered standards within the industry. These levels are as follows:

**LEVEL 1 - ORDER OF MAGNITUDE**

The purpose of the Level 1 estimate is to facilitate budgetary and feasibility determinations. It is prepared to develop a project budget and is based on historical information with adjustments made for specific project conditions. Estimates are based on costs per square foot, number of cars/rooms/seats, etc.

Project information required for estimates at this level usually might include a general functional description, schematic layout, geographic location, size expressed as building area, numbers of people, seats, cars, etc., and intended use.

**LEVEL 2 - CONCEPTUAL/SCHEMATIC DESIGN**

The purpose of the Level 2 estimate level is to provide a more comprehensive cost estimate to compare to the budgetary and feasibility determinations made at Level 1 and will be typically based on a better definition of the scope of work. An estimate at this level may be used to price various design schemes in order to see which scheme best fits the budget, or it may be used to price various design alternatives, or construction materials and methods for comparison. The goal at the end of schematic design is to have a design scheme, program, and estimate that can be contained within budget. This estimate is often prepared in the UniFormat™ estimating system rather than the MasterFormat™ system, which allows the design team to easily and quickly evaluate alternative building systems and assemblies in order to make informed alternatives analysis decisions to advance the design progress. The Level 2 estimate is based on the previous level of information available at Level 1, in addition to more developed schematic design criteria such as a detailed building program, schematic drawings,
sketches, renderings, diagrams, conceptual plans, elevations, sections and preliminary specifications. Information is typically supplemented with descriptions of soil and geotechnical conditions, utility requirements, foundation requirements, construction type/size determinations, and any other information that may have an impact on the estimated construction cost.

**LEVEL 3 - DESIGN DEVELOPMENT**

Estimates prepared at Level 3 are used to verify budget conformance as the scope and design are finalized and final materials are selected. Information required for this level typically includes not less than 25% complete drawings showing floor plans, elevations, sections, typical details, preliminary schedules (finishes, partitions, doors, and hardware etc.), engineering design criteria, system single line diagrams, equipment layouts, and outline specifications.

The Level 3 estimate provides a greater amount of accuracy, made possible by better defined and detailed design documentation. Estimates at this phase may be used for value engineering applications before the completion of specifications and design drawings.

**LEVEL 4 - CONSTRUCTION DOCUMENTS**

Level 4 estimates are used to confirm funding allocations, to again verify the construction cost as design is being completed, for assessment of potential value engineering opportunities before publication of the final project design documentation for bids, and to identify any possible "design creep" items, and their costs, caused by modifications during the completion of the construction documents. This final construction document cost estimate will be used to evaluate the subcontract pricing during the bid phase. Level 4 estimates are typically based on construction documents not less than 90% complete.

**LEVEL 5 - BID PHASE**

The purpose of this level estimate is to develop probable costs in the preparation and submittal of bids for contract with an Owner. In the traditional "design-bid-build" delivery system, this would be with 100% completed and coordinated documents. The Level 5 estimate will be used to evaluate subcontractor bids and change orders during the construction process.

In other delivery systems, becoming more widely used, such as design-build or guaranteed maximum price, the bid could actually be prepared at an earlier level, often Level 3 or Level 4. In such an instance estimates are prepared as previously described along with progressive estimates as the design is completed. It should be stressed that when preparing a bid at a prior estimate level, it is very important to include a complete and thorough "Scope of Estimate" statement that would state clearly such items assumptions, allowances, documents used for the estimate, and contingency amounts included.

For a discussion of [project delivery systems](#).
To explore the impact of various delivery systems on a specific project.

Various types of construction contracts include:

- Stipulated sum
- Lump sum unit price
- Cost plus a fee
- Design-build
- Bridging
- Cost plus a fee with a guaranteed maximum price (GMP)
- Turn Key

The transfer of the estimate information to the field cost control system provides management the opportunity to closely monitor and control construction costs as they occur. Computer estimating and cost control programs, whether industry-specific or general spreadsheet type, are especially valuable for rapid and efficient generation of both the estimate and actual construction cost information.

It should be noted that it is always good cost control practice to review and evaluate the final cost estimate vs. the actual bid. This exercise is not another level of estimate, but is a cost control mechanism and important data for estimating future projects.

D. Elements of a Cost Estimate

Quantity Takeoff: The foundation for a successful estimate relies upon reliable identification (takeoff) of the quantities of the various materials involved in the project.

Labor Hours: Labor hour amounts can be developed by crew analysis or applied on a unit man-hour basis. The use of a labor dollar per unit of work (ex: $15 per cubic yard for grade beams or $20 per cubic yard for walls) is only applicable when the cost history supports the data being used. The estimator must make allowance for the varying production capability that will occur based upon the complexity of a project.

Labor Rates: The labor rate is the cost per hour for the craftsmen on the project. To determine any craft rate, whether union or open shop, the estimator starts with the basic wages and fringe benefits.

To the wages and fringe benefits, the estimator must add payroll burdens. These are FICA (Social Security), FUI (Federal Unemployment Insurance), SUI (State Unemployment Insurance), WC (Worker Compensation) and others mandated by legislation and/or company operations. These burdens, plus the base wages and fringe benefits, determine the hourly cost of a craft classification (i.e., carpenter, pipefitter, etc.).
- The hourly rate can also involve a mixed crew where a mix of different crafts for a work crew for the performance of the work.

- Overtime or the lack of overtime is another consideration in determining the calculation of the hourly rates. A project that is scheduled for completion using a forty hour work week (Some areas may have a standard 35 hour week) will have a modest amount of overtime costs required in the estimate. A project that is scheduled for extended 50, 60 or even 70 hour work weeks will have a substantial amount included for overtime and loss of productivity.

**Material Prices:** Material prices, especially in today's current market, fluctuate up and down. The estimator must both understand and anticipate the frequency and extent of the price variations and the timing of the buying cycle. Material prices may be affected by:

- purchase at a peak or slack time of the year for the manufacturer
- material availability
- the size of the order
- the delivery timeframe requirement
- physical requirements for delivery, such as distance, road size, or site access
- payment terms and history on previous purchases
- sole-source items
- exchange rates (if the material will be imported into the U.S.)

**Equipment Costs:** Equipment rates depend on the project conditions to determine the correct size or capacity of equipment required to perform the work. When interfacing with other equipment, cycle times and equipment capacity control the costs on the project. Costs will also differ if the equipment is owned by the contractor as opposed to rented.

**Subcontractor Quotes:** A subcontractor quote, like the general estimate, contains labor, material, equipment, indirect costs, and profit. It is dependent upon having the quantities, labor hours, hourly rate, etc., prepared in a reliable manner just like any other part of an estimate. The amount of the subcontractor quote is also dependent upon the payment terms of the contract, and previous payment history between the subcontractor and general contractor. Bonding costs should also be considered.

**Indirect Costs:** Indirect costs consist of labor, material, and equipment items required to support the overall project.

- *For the owner:* design fees, permits, land acquisition costs, legal fees, administration costs, etc.
- *For the contractor and subcontractor:* mobilization, staffing, on-site job office, temporary construction, temporary heat/cooling, and temporary utilities, equipment, small tools and consumables, etc.
**Profit Amount:** Apply appropriate or contracted profit rate uniformly to all contractors and to original bid and change orders.

## Emerging Issues

**Computers and Building Information Models (BIM)**

Computers have played an increasingly larger role in cost estimation for complex calculations as the design and construction industry has become more computerized. For example, to undertake a parametric analysis (a process used to estimate project costs on a per unit basis, subject to the specific requirements of a project), cost estimators will often use a computer database containing information on costs and conditions of many other similar projects and geographic locations.

BIM is a simple concept—a master, intelligent data model, resulting in an as-built database that can be readily handed over to the building operator upon completion of commissioning. The BIM standard could someday integrate CAD data with product specifications, submittals, shop drawings, project records, as-built documentation and operations information, making printed O&M and Systems manuals virtually obsolete. The technology has moved forward, but the industry's ability to absorb these IT advances has yet to change. Clearly, if BIM offers a genuine solution to reduce errors and rework, while improving building operations, it will eventually change the way all project team members develop and share information over facility life-cycle phases.

**Sustainable Design and LEED® Certification**

The GSA LEED® Cost Study for the U.S. General Services Administration defines costs associated with the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) ratings. Two building types (new construction courthouses and Federal Building modernization) are modeled against two scenarios for each LEED® rating (Certification, Silver, Gold), identifying differential costs of construction, design, and documentation/submission requirements.

The newly issued GSA LEED® Applications Guide, a companion document to the GSA LEED® Cost Study, outlines an evaluation process in which the predicted first cost impacts of the individual LEED® prerequisites and credits (developed from the Cost Study) are used as a basis for structuring an overall LEED® project approach. The process also illustrates how LEED® criteria relate to existing GSA mandates, performance goals, and programmatic requirements.

Descriptions of LEED® cost impacts on private and non-federal public sector work may be found in various periodicals describing current projects. Coverage of sustainable and LEED® issues is becoming more frequent and is often the main focus of many periodical articles.

An article that discusses LEED® cost impacts and the participation of the cost estimator in the LEED® point evaluation process is The Cost of LEED Certification by Joseph Perryman (Design Cost Data
(DCD), November 15, 2005). Mr. Perryman is Chairman of the ASPE Sustainability Special Interest Group, and a member of the Association for Project Management, the USGBC, the Royal Institution of Chartered Surveyors, SAVE International, and the Association for the Advancement of Cost Engineering.

**Relevant Codes and Standards**

The American Society of Professional Estimators (ASPE) recognizes the Certified Professional Estimator (CPE) as an individual trained in the estimating practices within the construction industry. Private and/or public sector owners can ensure a certain level of professionalism and ethics by stipulating that the cost estimator be a member of the ASPE. There are no legislative codes or mandated standards applicable to the cost engineering or cost estimating profession.

**Major Resources**

**Publications**

- American Society of Professional Estimators:
  - Awards Guidelines
  - Estimating Today Newsletter—Back Issues Inside
  - Estimating Today Rate Card
  - Gek Study Guide—Order Online
  - Logosheet
  - Recommended Bidding Procedures
  - Standard Estimating Practice—Order Online
  - Building News International
  - GCCRG—General Construction Cost Review Guide
  - GSA Project Estimating Requirements
  - R.S. Means

**Professional Associations**

- American Society of Professional Estimators (ASPE)
- Association for the Advancement of Cost Engineering International (AACEI)
- International Cost Engineering Council
- Royal Institution of Chartered Surveyors (RICS)
- Society of Cost Estimating and Analysis (SCEA)

WBDG

DESIGN OBJECTIVES
Cost-Effective Branch

COST ESTIMATING SOFTWARE

- ProEst:
  - *ProEst Estimating - General Construction Version*, General Contractors, Residential Builders and any other contractor that performs general construction work
  - *ProEst Estimating - Electrical Construction Version*, Electrical Contractors including Residential, Commercial and VDV Contractors
  - *ProEst Estimating - Mechanical Construction Version*, Mechanical Contractors including Piping, Plumbing and HVAC
  - *ProEst Digitizer Takeoff*

- *RS Means Databases*, National pricing databases
- Computer Guidance Corporation, *Invitation to Bid*

- Quest Solutions:
  - *Quest Estimator*—Digitized takeoff for pricing out all types of cost items, and for printing out your final bid
  - *Quest Earthwork*—Cut-and-fill measuring software
  - *Quest Roadwork*—Cut and fill quantities for highway and roadway projects
  - *Quest Trenchwork*—Calculate cut and fill quantities for underground projects
  - *Quest Cross Sections*—Calculate cut and fill quantities in cross-section view
- Turtle Creek Software, *Goldenseal*, Estimating & Accounting
- Vertigraph, Inc., *BidPoint & BidScreen*, Estimating