COST ESTIMATING PRINCIPLES

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ABSTRACT: Estimates of materials, time, and costs provide information to some construction decisions in a similar way that financial accounting information provides to others. Financial statements are required to comply with generally accepted accounting principles, described in accounting literature to ensure information is accurate and useful to decisions. This paper suggests general estimating principles that similarly guide good estimating practice. An estimate must be an accurate reflection of reality. An estimate should show only the level of detail that is relevant to decisions. Completeness requires that it include all items yet add nothing extra. Documentation must be in a form that can be understood, checked, verified, and corrected. Attention must be given to the distinction between direct and indirect costs and between variable and fixed costs. Contingency covers possible or unforeseen occurrences. Both the expected value of possible identified events and the expectation that events will occur that cannot be identified in advance.

INTRODUCTION

To estimate is to produce a statement of the approximate quantity of material, time, or cost to perform construction. This statement of quantity is called an estimate, and its purpose is to provide information to construction decisions. Typical decisions include procurement and pricing of construction, establishing contractual amounts for payment and controlling actual quantities by project management.

Estimates provide a similar level of information to some decisions as financial accounting information provides to others. Financial statements are required to comply with generally accepted accounting principles (GAAP), described in accounting literature, to ensure that the information they provide is accurate and useful to decisions. Estimating literature does not provide similar generally accepted estimating principles against which estimating practices can be judged. This paper suggests general estimating principles that guide good estimating practice.

GENERALLY ACCEPTED ACCOUNTING PRINCIPLES

Cost estimating shares some similarities with financial accounting. Both provide financial information that is needed in important decisions by a firm's management, as well as financial information to decisions outside the firm. Both also require standard practices that can be repeated from project to project or period to period. Selecting estimating and accounting methods is as much an art as a science, to meet practical situations of reality.

Financial accounting practice must conform to "generally accepted accounting principles," which is generic for a large group of standards, conventions, concepts, guidelines, and assumptions that guide but do not dictate accountants' decisions. Financial data can be represented in a variety of ways and still comply with GAAP. There is no one general set of

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GAAP, as demonstrated by the fact that different accounting textbooks have different lists of GAAP items. However, the different lists and descriptions do not conflict, in that they describe the same basic approach to financial accounting.

Estimating does not have a similar literature on generally accepted estimating principles (GAEP), though there is considerable literature on estimating practice. Estimating literature's primary focus is on estimating formats, procedures, and processes for particular applications. It gives little attention to establishing a fundamental base or foundation to estimating decisions, so that the formats, procedures, and processes will provide estimates that are accurate and useful for decisions. This leaves a particular void in teaching estimating, whether in academia or in practice. Engineers in estimating need to understand its fundamentals in the same manner that engineers in design need to understand design fundamentals.

GAAP used in accounting does not fill this void. Though accounting and estimating have strong similarities, they are basically different. Accounting is fundamentally historical, describing financial position and activity over the past, depending primarily upon objective evidence. There is some application of GAAP to estimating; however, some accounting principles have no application to construction estimating and others conflict directly with good estimating practice.

I have attempted to fill this void by describing general principles that I believe are generally applicable to estimating construction costs. The basic criteria under which I created the list is that of accuracy and usefulness for the normal range of business decisions for which estimates are used. These include conceptual and preliminary cost estimates during design, estimates of direct construction costs as a basis for competitive bidding, estimates of cost to complete a project as a basis for percentage of completion accounting for project gross income, estimates to establish budgets against which to control construction costs, and estimates of cost as a basis for analyzing contract changes.

GENERAL ESTIMATING PRINCIPLES

Reality

Anyone can come up with a set of numbers. A challenge to the estimator is to produce an estimate that is an accurate reflection of reality. This is first a question of professional experience and judgment, and second a matter of relevant historical data. To estimate at a detailed level one must mentally construct a project, selecting materials, methods, equipment, and crews to fit the design. The estimator then uses the best information available to estimate the costs of performing the required work using the selected resources. This information may be cost or crew time data from past work. It may be calculations based on detailed analysis of the construction process. It may be the estimator's best guess of cost and time. Usually it is a combination of these.

It is particularly important that the estimator not select information simply for its convenience or its appearance of objectivity. All too often an estimator will use numbers that are handy or from a source that would seem to release the estimator from personal responsibility. They may be cost data from past projects or published in estimating guides. The use of such data without knowledge of its similarity to the work at hand produces an inaccurate estimate, because it is not based upon the realities of the current project.

Level of Detail

Estimating takes time, which is expensive, and one should spend it only on detail that is relevant to decisions. Relevancy is based on two criteria: (1) If a particular level of uncertainty is acceptable in making a decision, the level of detail that provides this level of uncertainty is acceptable; and (2) the effect of the level of detail on accuracy of the estimate should be reasonably uniform for all components of the estimate.

At the conceptual stage of design, the owner is trying to decide whether to continue with facility procurement and the designer is working with the owner to establish the scope and general characteristics of the facility. An order of magnitude estimate is sufficient for decisions, particularly if it is sensitive to changes in scope.

When design is completed, it is important that contract prices be based on adequate estimating detail. Yet even here one should avoid needless detail. Detailed estimates will include procurement, fabrication, and installation of materials and equipment, but fasteners such as nails and screws and lengths of welds are not individually counted.

Completeness

Another challenge is to include all items that will be in the facility yet to add nothing extra. The estimator must have the vision to see beyond the obvious components and their primary costs of construction, primarily in preparing cost estimates prior to completion of design. In estimating industrial work, the major items of process equipment are obvious early in the design period. Estimates must include not only costs of procuring equipment but also the cost of its installation and the cost of piping, wiring, controls, and structure to support it. In addition to the cost of performing construction, there are major costs of providing administrative and physical infrastructure for the construction process, such as permits, insurance, financing, security, transportation, accounting, purchasing, utilities, warehousing, and shops. Onto this can be added costs of delays and changes that will have occurred before the project has been completed.

There may seem to be a conflict between the principles of completeness and level of detail, but there is none. By level of detail, an engineer describes detail only at the level appropriate to decisions; but by completeness, the engineer ensures that all costs are included. Therefore, the proper level of detail for a conceptual estimate may be a list of only the major items of equipment. Yet, at that level of detail, the cost of each item must include all construction costs. Similarly, level of detail precludes individual counting of builders' hardware or small tool items. However, their cost must still be included in the estimate in order that it be complete.

Documentation

An estimate is a permanent document that serves as a basis for business decisions. It must be in a form that can be understood, checked, verified, and corrected. This requires that the source of each number be readily apparent not only to the person who prepares the estimate but also to others who follow. Conditions that were assumed must be identified. Methods of construction. equipment spreads, and crews that were selected in the estimating process must be stated, if they are not obvious. The estimate should be organized to be followed easily. It should be in a form that can be easily duplicated by photocopy or computer, and it should be subject to the same level of document control as other permanent documents, such as contracts, proposals, and

purchase orders. One should not be embarrassed to have it appear as evidence in settling disputes.

On the other hand, an estimate is a working document. It is a private document, meant only for the parties who are using it for decisions. It may be prepared in a hurry to meet a deadline. with adjustments up to the last minute based on information that is not available earlier. It is usually not meant to be a finished financial statement nor meant for formal presentation. A well-engineered estimate is expected to include side notes, erasures, crossed-out items, and jotted-in corrections. This produces a well-documented, readable working document that can be easily updated to produce accurate realistic estimates of costs. This is strongly preferred to a rigid, presentation format that is not suited to estimating processes.

Direct and Indirect Costs

A direct cost of an activity is physically traceable to the activity in an economic manner. A direct cost is one not counted if the activity is not performed. Indirect costs are business costs other than direct costs of construction activities; they are not physically traceable and are counted even if the activity is not performed. Indirect costs are also known as overhead.

Construction costs are classified as materials, labor, and equipment. Direct materials for concrete walls include ready-mix concrete delivered to the site and placed in the forms, reinforcing steel fabricated off site and tied and placed in the forms, and plywood and form ties from which the forms are constructed. Direct labor includes carpenters who fabricate and erect the forms; reinforcing ironworkers who place the steel; and laborers who place concrete, strip forms, and patch the concrete surface. A concrete pump and elephant trunk brought onto the site to place concrete is a direct equipment cost, and its operator is direct labor.

Indirect costs consist of: (1) Large costs that would have occurred even if an activity had not been performed; and (2) small costs that would be direct except that assigning them to activities is not economical. The job-site superintendent and tower crane are examples of the former. The superintendent supervises the concrete activity, and the crane (and operator) lift reinforcing steel and form panels. Both are used for the concrete-wall activity; however, both are still needed even if no walls are constructed or if the quantity of walls changes. Their costs cannot be traced directly to the concrete-wall activity, and they are considered indirect costs of concrete walls and a part of project overhead. Nails to construct forms, wire to tie the reinforcing steel, and a portable power saw are examples of small costs that are not economical to trace to concrete walls. Nails, tie wire, and small tools are therefore considered project overhead. They are included in the estimate as a percentage of direct cost (percentage of lumber cost, for example) or as a cost per unit of output (cost per board foot of lumber or square foot of contact area) rather than as an individually counted direct cost.

There are two levels of overheads or indirects. Project overhead is all costs that are economically traceable to a project but that would not have occurred had the project not been performed. The superintendent’s salary and the tower-crane rental are indirect costs of the concrete process and other construction activities. However, if the project were not performed, there would be no supervision or crane rental costs. They are therefore project overhead costs, which are direct costs of the project.

The second level of overhead consists of the costs of running the construction business that are not economically traceable to its projects. These are called general overhead, general office

overhead, or general and administrative (G and A) costs. The estimating department is necessary in obtaining work, but only a few of the many projects estimated result in contracts. Its expenses are therefore not traceable to its projects, even those few it wins. General office and warehouse rental, insurance, and maintenance are necessary but are not direct costs of projects. The purchasing and accounting departments serve the different projects of the company, but: (1) It is not economical to trace their costs to the projects; and (2) obtaining a project does not directly impact purchasing and accounting department costs. All of these costs are included in general office overhead.

The direct/indirect cost concept is hierarchical. The roofing subcontract amount is a direct project cost to the prime contractor. The subcontract includes the roofing contractor's estimated direct and indirect costs and profit. Therefore, they are part of the prime contractor's direct project costs. Similarly, the prime contractor's bid is the sum of: (1) Its estimated direct activity costs; (2) its project overhead; and (3) its general office overhead and profit. These become part of the owner's direct project cost. The owner will have additional direct project cost for architect/engineer and its own direct expenses for supervision, furnishing, startup, etc. Thus one party's indirect costs and markups become another party's direct cost. In fact, if the owner were building a production plant, all the project's direct costs and indirect costs are transmitted to customers as their direct costs of purchasing products manufactured at the plant.

Variable and Fixed Costs

Costs can be classified by whether they change as the volume produced changes. Volume or quantity of construction activity is measured in many ways, such as linear feet (linear meters), square feet (square meters), or cubic yards (cubic meters) produced, hours worked, units installed, and months rented. If a cost changes in proportion to a change in volume or quantity, it is variable. If a cost remains unchanged in total despite wide fluctuations in volume or quantity, it is fixed. Most activities are a mixture of variable and fixed costs. An example is a job-site shop to fabricate spools of pipe, which consists of four welding bays, two cutting bays, a storage area, and an overhead crane. The cost of setting up the shop is a fixed cost of fabrication, because once it is set up, its cost will not change if half as much or twice as much pipe is fabricated as was expected. However, the hours of wages paid to pipefitters depends on the number of spools fabricated, as does the length of rental of welding machines, the fee of the weld inspector, and quantity of pipe. These are all variable costs of pipe fabrication.

Most of general and administrative costs, such as main office rent, insurance, taxes, and depreciation; salaries of main office personnel; and ownership costs of equipment; can be considered fixed for a given time period. They are often called period costs, because they occur or expire with time. Though considered fixed over a given time period, they may change considerably from one period of time to another as the level of business changes or as equipment or real estate is bought or sold. Many project overhead costs are fixed, particularly costs of installing job-site services. Examples of fixed costs for a broad range of project quantities produced are installation of electric and phone service to the job site and installation of shops, hoist, parking, and warehouse facilities. Project insurance and building permit are variable costs because they vary directly with cost of construction. Project supervision, security, and rental for crane and job-site offices are project period costs. They vary with length of project and are therefore considered variable costs.

The difference between variable and fixed costs is particularly important in determining relevant costs for changes in contract quantities. The two common types of competition are lump sum bids that give the owner fixed prices and unit price bids that give the owner sets of variable costs. However, neither accurately represents a contractor's costs, which are a mixture of variable and fixed costs. Each type of contract allows adjustment for the differences between the contract representation and the real cost picture. Though the lump sum contract contains no variable costs, its general conditions allow an owner to adjust quantities by change orders and make provision for changes in contract sum to recognize changes in quantities. Unit price contracts are designed to be more easily adjusted. But because the unit prices represent a mixture of fixed and variable costs, a change in quantity affects contract amount by more than the variable cost. Large quantity changes can cause major inequities for contractor or owner, and unit price contracts usually contain clauses allowing renegotiation of unit prices if there are major changes in quantities.

Contingency

An estimate is a prediction—an approximation—that provides information for decisions and is a surrogate or substitute for actual measurement that is not economical or possible. It is considered accurate if it is sufficiently close to actual performance that decisions based on the estimate are the same as decisions based on actual performance, were actual performance available.

Though the guiding concept of an estimator is accuracy, by its nature an estimate is uncertain. An estimator must live with uncertainty, though it is not his friend. In fact an estimator must not only live with uncertainty, but he must estimate and control uncertainty, because the uncertainty contained in an estimate is as important information as the estimated value itself.

A contingency is a possible or unforeseen occurrence. In estimating, the word *contingency* is used for two types of estimates. The first is the expected value of a possible identified event. For example, if there is a 20% chance a contractor may require two dozers instead of one, it may include a cost of 20% (or more) of the cost of the second dozer as a contingency. The second type of contingency is the possible cost of unforeseen events: events that cannot be identified because the engineer does not know what can happen. This second type is a true contingency and the one that needs close attention, because it is a margin for error.

The most worrisome thing in engineering (and probably in every profession) is the occurrence of the unanticipated. The possibility of unanticipated events flies in the face of the knowledge that is the cornerstone of professional practice and control. The unanticipated may be of such a magnitude and consequence that it overwhelms ones carefully considered decisions and actions, and it controls the outcome. The worst of it, however, is not to know when one does not know, not to know when to expect error, and not to provide for the occurrence of expected error.

An estimator is strongly interested in accuracy, which demands knowledge of what will occur. Contingency represents an unknown, which seems to conflict with accurate estimating. However, when an estimator expects events to occur that cannot be identified in advance, accuracy demands they be represented in a cost estimate. An example is a project that is being planned in an area in which the estimators have little experience. They know from past projects in areas in which they had little knowledge that construction difficulties occurred that they could not identify in advance. And these unidentified events added an average of 20% to the cost of events

and activities that they had identified. They therefore add 20% to their estimated costs, because not to do so would not accurately reflect their best estimate of final cost.

CONCLUSION

These estimating principles may be considered generally acceptable cost estimating principles to the extent that most engineers would generally accept them as a base for good estimating practice. Others are welcome to state their own view of acceptable principles and practices, because it is through such discourse that general principles and good practice are defined and become accepted by the profession.