SECTION NINETEEN
CONSTRUCTION COST ESTIMATING

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Black magic. Bean counting. Guess work. Guestimates. Ask a group of engineers to describe construction cost estimating and that is what you are likely to hear. Not that they regard cost estimating as unimportant. They realize it is essential to all projects. But from their point of view, it is a mysterious process.

There is nothing esoteric, however, about cost estimating. It is an engineering discipline like any other, with its own rules and techniques, and a knowledge of these can be very helpful to those in other disciplines. Such knowledge can, for example, help designers, contractors, and building owners to determine whether an estimate adequately reflects their intentions and to understand how a change in design or construction can affect the schedule or total cost of a project. This can lead to consideration of appropriate alternatives and development of better quality, lower-cost projects.

19.1 COMPOSITION OF PROJECT PRICE

The total price of a construction project is the sum of direct costs, contingency costs, and margin.

Direct costs are the labor, material, and equipment costs of project construction. For example, the direct cost of a foundation of a building includes the following:

Costs of formwork, reinforcing steel, and concrete

Cost of labor to build and later strip the formwork, and place and finish the concrete

Cost of equipment associated with foundation activities, such as a concrete mixer

Contingency costs are those that should be added to the costs initially calculated to take into account events, such as rain or snow, that are likely to occur during the course of the project and affect overall project cost. Although the effects and probability of occurrence of each contingency event cannot be accurately predicted, the total effect of all contingencies on project cost can be estimated with acceptable accuracy.

Margin (sometimes called markup) has three components: indirect, or distributable, costs; company-wide, or general and administrative, costs; and profit.

Indirect costs are project-specific costs that are not associated with a specific physical item. They include such items as the cost of project management, payroll preparation, receiving, accounts payable, waste disposal, and building permits.

Company-wide costs include the following: (1) Costs that are incurred during the course of a project but are not project related; for example, costs of some portions of company salaries and rentals. (2) Costs that are incurred before or after a project; for example, cost of proposal preparation and cost of outside auditing.

Profit is the amount of money that remains from the funds collected from the client after all costs have been paid.

19.2 ESTIMATING DIRECT COSTS

Methods for preparing an estimate of direct costs may be based on either or both of two approaches: industry, or facility, approach, and discipline, or trade, approach. For any project, the approach that may be selected depends on user preference and client requirements. If used properly, the two approaches should yield the same result.

Industry or Facility Approach. Industry in this case refers to the specific commercial or industrial use for which a project is intended. For example, a client who wishes to build a factory usually is more concerned with the application to which the factory will be put than with the details of its construction, such as bricks, mortar, joists, and rafters. The client is interested in the specific activities that will be carried out and the space that will be needed. When information about these activities has been obtained, the designers convert this information into a total building design, including work spaces, corridors, stairways, restrooms, and air-conditioning equipment. After this has been done, the estimator uses the design to prepare an estimate.

Discipline or Trade Approach. This takes the point of view of the contractor rather than the client. The job is broken into disciplines, or trades, of the workers who will perform the construction. The estimate is arrived at by summing the projected cost of each discipline, such as structural steel; concrete; electrical; heating, ventilating, and air conditioning (HVAC); and plumbing.

19.2.1 Types of Estimates

Typical types of estimates are as follows: feasibility, order of magnitude, preliminary, baseline, definitive, fixed price, and claims and changes. These do not represent rigid categories. There is some overlap from one type to another. All the types can be prepared with an industry or discipline approach, or sometimes a combination of them.

Feasibility Estimates. These give a rough approximation to the cost of the project and usually enable the building owner to determine whether to proceed with construction. The estimate is made before design starts and may not be based on a specific design for the project under consideration. For example, for a power plant, the estimate may involve only a determination of the energy density of the fuel; the altitude of the plant, which determines the amount of oxygen in the air and hence the efficiency of combustion; the number of megawatts to be produced; and the length of the transmission line to the grid. The feasibility estimate is inexpensive and can be made quickly. Not very accurate, it does not take into account creative solutions, new techniques, and unique costs. It can be prepared by the owner, the lender, or the designer.

Order-of-Magnitude Estimates. These are more detailed than feasibility estimates, because more information is available. For example, a site for the building may have been selected and a schematic design, including sketches of the proposed structure and a plot of its location on the site, may have been developed. Like the feasibility estimate, the order-of-magnitude estimate is inexpensive to prepare. Generally made by the designer, it is prepared after about 1% of the design has been completed.

Preliminary Estimates. These reflect the basic design parameters. For this purpose, a site plan and a schematic design are required. The schematic should show plans and elevations plus a few sections through the building. For buildings such as power plants and chemical refineries, it should also contain a process diagram, major equipment list, and an equipment arrangement diagram. Preliminary estimates can reflect solutions, identify unique construction conditions, and take into account construction alternatives. Usually, this type of estimate does not reveal design interferences.

Generally prepared by the designer, preliminary estimates are made after about 5 to 10% of the design has been completed. Several preliminary estimates may be made for a project as the design progresses.

Baseline Estimates. These are final preliminary estimates. For most buildings, requirements for preparation of an estimate include plans, elevations, and sections. For process plants, also necessary are complete flow diagrams, process and instrumentation diagrams (P&ID) in outline form, and a list of equipment selected and the location of the equipment. Subsequent changes in the estimate are measured with respect to the baseline estimate. Identifying all cost components, the estimate provides enough detail to permit price comparisons of material options and is sufficiently detailed to allow equipment quotations to be obtained.

The baseline estimate is generally prepared by the designer. It is made after about 10 to 50% of the design has been completed.

Definitive Estimates. From a definitive estimate, the client learns what the total project cost should be and the designer's overall intent. The estimate is based on plans, elevations, and sections; flow diagrams, P&IDs, and equipment and instrument lists (for process plants); design segments for each discipline; and outline specifications. It identifies all costs. It is sufficiently detailed to allow quotes to be obtained for materials, to order equipment, and to commit to material prices for approximate quantities.

This type of estimate is generally prepared by the designer and represents the end of the designer's responsibility for cost estimates. It is made after about 30 to 100% of the design has been completed.

Fixed-Price Estimates. Prepared by a general contractor, a fixed-price estimate, or bid, represents a firm commitment by the contractor to build the project. It is based on the contractor's interpretation of the design documents. It requires detailed drawings for each discipline, equipment lists, P&IDs, wiring diagrams, and specifications. A fixed-price estimate is highly accurate. It should be in sufficient detail to enable the contractor to obtain quotes from suppliers and to identify possible substitutes for specific items. It is made after 70 to 100% of the design has been completed.

Claims and Changes Estimates. These are prepared when a difference arises between actual construction and the project as specified in the original contract. This type of estimate should identify the changes clearly and concisely. It should specify, whenever possible, the additional costs that will be incurred and provide strong and compelling support for the price adjustments requested. Generally, the estimate is reviewed by all parties involved (designer, contractor, and building owner) as soon as the need for change is identified. Claims and change estimates can be prepared by any or all of the parties to the contract.

19.2.2 Estimating Techniques

There are three estimating techniques: parametric, unit price, and crew development. In general, the parametric technique is the least expensive, least time-consuming, and least accurate. The crew development technique is the most expensive, most time-consuming, and most accurate. Of the three techniques, the parametric requires the most experience and the unit-price technique, the least. During the course of a typical project, all three of these techniques may be used.

Parametric Technique. For every type of project, there are certain key parameters that correlate strongly with cost; for example, for power plants, altitude, and hence the amount of oxygen in the air, is such a parameter. The parametric technique takes such a correlation into account. It is usually employed for preparing feasibility or order-of-magnitude estimates. Sometimes, it is used for preparing preliminary or baseline estimates or small portions of definitive or fixed-price estimates. It is often used for checking high-level estimates, such as definitive, fixed price, and claims and changes, that have been developed by the unit-price or crew development technique.

The parametric technique derives data from proprietary tables that incorporate historical data, or standard tables, or experience. Historical tables are compilations of data from numerous projects of various types. There are historical tables, for example, for the amount of pipe needed to process a barrel of oil in a refinery, the volume of fuel storage necessary for a given size of airport, and the optimum air-conditioning system for a given building size. Proprietary tables are updated as required. Standard tables may be either historical or calculated and tend to be updated more frequently than historical tables.

The industry approach to development of a feasibility cost estimate for a warehouse using the parametric technique typically proceeds as follows: The client supplies a list of the items to be stored in the warehouse, sizes of the items, and the number of types of items. The client also indicates the turnover, or shelf life, of each item. Given the preceding information, the estimator calculates the amount of storage volume and circulation area and obtains the total costs of materials, labor, and equipment from historical tables.

The discipline approach to development of a feasibility or preliminary cost estimate for a warehouse using the parametric technique generally proceeds as follows: Given the spacing between roof supports and the ceiling heights that are specified in the design, the estimator looks up the cost per square foot of ceiling in standard tables. (Disciplines involved are structural steel and concrete work.) From the design, the estimator determines the height and area of the exterior and interior walls. From the weather conditions for the location, the insulating properties required for the exterior walls and roof are determined using standard tables. From the preceding information, the estimator calculates the costs of the walls and roofs using standard tables. (Disciplines involved are carpentry, masonry, and roofing.) Also, from the design, the estimator computes the exterior area and volume of the building, the amount of sunlight falling on the building, and the internal lighting levels required and determines the cost of the mechanical and electrical work. (Disciplines involved are mechanical and electrical.) Finally, the preceding costs are added to arrive at the cost of materials, labor, and equipment for the warehouse.

Unit-Price Technique. This relates directly to specific physical entities in the design—square feet of office area, cubic yards of concrete, number of fixtures in rest rooms. Unlike the parametric technique, which often involves information that is not in the drawings (for example, barrels of oil to be processed) and may not pertain to a specific design, the unit-price technique is tied directly to the contract documents. The estimator employs the quantities given in these documents to determine costs.

The unit-price technique is frequently used for preparation of cost estimates. It can be used for any level of estimate but does require that some design be performed. Data for the technique are obtained from commercially available handbooks of unit prices, which are usually updated at least once a year.

The industry approach to development of preliminary or higher-level cost estimates for a warehouse using the unit-price technique usually proceeds as follows:

The warehouse is divided into categories, for example, loading dock, storage facilities, aisles, restrooms, and offices. The special equipment required, such as cranes, crane rails, and docks, is listed. Then, the estimator looks up in a unit-price book the cost of each of the items specified above. For each category, the unit-price book gives the total cost of materials, labor, and equipment to construct an item. For instance, for a loading dock, the unit price would be specified as either the cost per linear foot or the cost per truck accommodated by the dock; for rest rooms, the unit price would be specified as the total cost of all the fixtures needed or as the total cost per square foot. Finally, the estimator sums the preceding costs to arrive at the total cost of the warehouse.

The discipline approach to development of a preliminary or higher-level cost estimate for a warehouse using the unit-price technique typically proceeds as follows:

From the design documents, the estimator determines the ground area the building occupies (the footprint of the building). The costs of grading and the building floor slab are obtained from a unit-price handbook. With information from the contract documents, the estimator calculates the amount and cost of the structural materials and finishes needed. The unit cost of illumination and air-conditioning are also obtained from a unit-price handbook. Finally, the estimator adds the preceding costs to arrive at the total costs.

Crew Development Technique. This is used to prepare the estimate based on the costs for the specific personnel and equipment that would be needed to complete each item during each phase of construction. The crew development technique differs from the unit-price technique, where the activity is priced without assignment of specific workers and equipment.

For a specific project, the size and mix of crew selected depend on project needs. If early completion is the key consideration, a large crew working multiple shifts and much overtime might be advisable. If access to a site is difficult, a small crew might be necessary. Size and mix of crew can also vary during the course of construction. For example, for a typical high-rise structure, construction may start with personnel and equipment that provides the lowest cost per unit of production. As work progresses and access to work areas grows more difficult, a smaller crew using more equipment may be used. In the final construction stages, when the investment in the building is large and interest costs are high, the contractor may employ a large crew working shifts and overtime to finish as soon as possible, thereby minimizing total project costs.

Estimators tend to use the crew development technique for high-level estimates, the definitive and above. Unlike the unit-price technique, the crew development technique is based on the way the facility actually will be erected. Consequently, it is the most accurate of the estimating techniques. Hence, it is the principal technique for fixed-price estimates; where accuracy is critical.

The crew development technique is based on data from production handbooks. These may be organized in accordance with the use of a facility or by building trades.

The industry approach to development of a definitive cost estimate for a warehouse using the crew development technique generally proceeds as follows:

From the contract documents, the estimator determines the volume and footprint of the warehouse and the uses to which each area would be put, for example, offices, rest rooms, and loading docks. Assuming that one crew will be used to build the shell of the building and other crews to construct the interior areas, the estimator obtains the unit rates of production from standard production handbooks. (The production handbooks for facilities change only with the introduction of new equipment or materials.) Next, for each item taken off the contract documents, the estimator determines the unit costs of materials, labor, and equipment. Then, each unit cost is multiplied by the corresponding quantity of the item to be used. Finally, the estimator adds the products to obtain the total cost of materials, labor, and equipment for the warehouse.

Estimators tend to use the industry approach with the crew development technique where labor costs are low or differences between costs of different crafts are slight.

The discipline approach to preparation of a definitive cost estimate for a warehouse using the crew development technique usually proceeds as follows: From the contract documents, the estimator determines the exact quantities of materials—for example, for piping, linear feet of pipe, number of the various types of fittings, and amount of insulation; for electrical work, the number of fixtures and devices and linear feet of conduit and wire. Assuming the size and composition of the crew by trade (personnel plus equipment), the estimator obtains from production handbooks, for each discipline, the productivity of the crew and the length of time required for installation of the materials. Then, for each item taken off the contract documents, the estimator determines the unit costs of materials, labor, and equipment. Next, each unit cost is multiplied by the corresponding quantity of the item to be used. Finally, the estimator adds the results to arrive at the total cost of materials, labor, and equipment for the warehouse.

Estimators tend to use the crew development technique and discipline approach where labor costs and differences between the costs of the different crafts are high.

19.3 ESTIMATING CONTINGENCY COSTS

These are the costs that must be added to the initially calculated costs to take into account events that are highly likely to occur some time during the course of a project and that will affect project cost (Art. 19.1). Although the effect and the probability of occurrence of each contingency event cannot be predicted, the total effect of all the contingencies on the project cost can be estimated with a high degree of accuracy. In this respect, contingency allowances are much like insurance. Contingency costs are usually expressed as a percentage of direct costs but they also may be expressed as a dollar amount.

These costs should not be considered a handy slush fund to compensate for inaccurate estimating. No matter how careful and expert the initial estimate, no matter how excellent the design, no matter how skilled the constructor, the unexpected is likely to occur and must be intelligently gaged in each estimate. If the contingency allowance is underestimated, all parties to the construction contract can suffer financial loss. If the contingency is overestimated, the contract may not be awarded or the client may not be able to finance the project.

Contingency should be evaluated for each estimate and will vary by project type, location, and level of estimate. A contingency cost as high as several hundred percent may be justified, for instance, for an experimental process plant, whereas the contingency cost for a prefabricated warehouse may be only 3 to 5%.

Owner's contingency covers the costs that the owner could incur during the course of a project. For example, if the project is delayed for any reason, there will be additional interest charges for the financing. If the city or state changes the building code during project execution, construction costs could increase. If an important commodity undergoes a sudden price increase, the overall cost of the project could be significantly impacted.

Designer's contingency covers the costs that the designer could incur during the course of a project, such as the cost of services that the designer renders and that were not originally anticipated and the additional construction costs due to changes in the design. Both types of contingency costs are illustrated in the following examples.

During the design phase, a designer finds that a portion of the structure being designed has an extremely congested area. This congestion requires changes in design of either the steel structure or the ventilation system. The steel might have to be reinforced or the ventilation might have to be redesigned. All additional design and construction costs will have to come out of the contingency funds.

As a second example, during the construction phase, the contractor learns that specified equipment has been discontinued by the manufacturer. A substitute will be needed, along with associated design modifications. Design and contingency costs needed for this modification will have to come out of contingency funds.

Contractor's contingency covers the costs that the contractor could incur during the course of a project. Suppose, for example, that rain occurs while excavation for the foundation is well under way. Water entrapped in the excavation must be pumped out and mud removed. Also, because of enlargement of the excavation, the amount of backfill required increases. The additional costs incurred must be covered by contingency funds.

Costs not normally covered by contingency allowances include: costs normally covered by insurance; substitution of better materials (should be covered by a change order); increases in project size or scope; and "acts of God," such as floods, tornadoes, and earthquakes.

19.4 ESTIMATING MARGIN (MARKUP)

Margin comprises three components: indirect costs, company-wide costs, and profit. These are defined in Art. 19.1.

19.4.1 Determining Indirect, or Distributable, Costs

The techniques used to calculate indirect costs (often called indirects) resemble those used to calculate direct costs (Art. 19.2).

Parametric Technique. The indirects calculated by this technique may be expressed in many ways, for example, as a percentage of the direct cost of a project, as a percentage of the labor cost, or as a function of the distance to the site and the volume of the construction materials that must be moved there. For a warehouse, for instance, the cost of indirects is often taken to be either one-third the labor cost or 15% of the total cost.

Unit-Price Technique. To determine indirects by the unit-price technique, the estimator proceeds as follows: The various project activities not associated with a specific physical item are determined. Examples of such activities are project management, payroll, cleanup, waste disposal, and provision of temporary structures. These activities are quantified in various ways: monthly rate, linear feet, cubic yards, and the like. For each of the activities, the estimator multiplies the unit price by the unit quantity to obtain activity cost. The total cost of indirects is the sum of the products.

Crew Development Technique. To determine the cost of the indirects by this technique, the estimator proceeds as follows: The various project activities not associated with a specific physical item are determined. Next, the estimator identifies the specific personnel needed (project manager, project engineer, payroll clerks) to perform these activities and determines their starting and ending dates and salaries. Then, the estimator computes total personnel costs. After that, the estimator identifies the specific facilities and services needed, the length of time they are required, and the cost of each and calculates the total cost of these facilities and services. The total cost of indirects is the sum of all the preceding costs.

19.4.2 Determining Company-Wide Costs and Profit

Company-wide costs and profit, sometimes called gross margin, are usually lumped together for calculation purposes. Gross margin is generally a function of market conditions. Specifically, it depends on locale, state of the industry and economy, and type of discipline involved, such as mechanical, electrical, or structural.

To calculate gross margin, the estimator normally consults standard handbooks that give gross margin as a percent of project cost for various geographic areas and industries. The estimator also obtains from periodicals the market price for specific work. Then, the information obtained from the various sources is combined.

As an example, consider the case of a general contractor preparing a bid for a project in a geographic region where the company has not had recent experience.

At the time that the estimate is prepared, the contractor knows the direct and indirect costs but not the gross margin. To estimate this item, the estimator selects from handbooks published annually the gross margin, percent of total cost, for projects of the type to be constructed and for the region in which the building site is located. Then, the estimator computes the dollar amount of the gross margin by multiplying the selected percentage by the previously calculated project cost and adds the product to that cost to obtain the total price for the project. To validate this result, the estimator examines reports of recent bids for similar projects and compares appropriate bids with the price obtained from the use of handbooks. Then, the estimator adjusts the gross margin accordingly.

19.5 SAMPLE ESTIMATE

As an example, the following illustrates preparation of an estimate for a trench excavation. The estimate can be regarded as a baseline type or higher type. The discipline approach and crew development technique is used.

The estimate begins with a study of information available for the project: From the design documents, the estimator takes off such information as trench depth, length, slopes, soil conditions, and type of terrain. Wages for the locality in which the trench is to be excavated are obtained from standard handbooks, local labor unions, and the U.S. Census Bureau. The wage figures influence determination of the level of mechanization to be used for the project.

Crew Operation Calculation Sheet. With the basic information on hand, the estimator can now prepare a crew operation calculation sheet (Fig. 19.1). This sheet indicates the work to be done, how it will be done, who will perform it, and duration of the tasks. (The crew operation calculation sheet is normally the first item developed in a cost estimate.)

Crew Worksheet. The items, quantities, and units for the first three columns of the crew worksheet (Table 19.1) are obtained from Fig. 19.1. Unit costs for materials and subcontractors for columns four and five are obtained by direct quotations from vendors and subcontractors or from standard price lists. The worker-hours listed in Table 19.1 are based on data in Fig. 19.1. The wages in Table 19.1 are part of the basic information.

To obtain equipment costs, the estimator either gets quotations from rental yards or performs equipment ownership and operating cost analyses (Table 19.2). These costs include labor and material costs for owning and maintaining the equipment. The equipment costs in Table 19.1 are assumed to be supplied by a subcontractor.

The total cost for one hour of production is calculated as the sum of the products of the quantities and the unit prices given in Table 19.1. The estimator obtains the unit cost for materials, labor, and equipment by dividing the cost for one hour of production by the length of the trench.

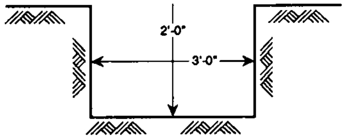
Estimate Worksheet. Table 19.3 gives the estimate for the total cost of the trench. The quantities and units for the trench are taken off the contract documents. The costs are derived from the crew worksheet (Table 19.1), to yield the total direct cost for the excavation. To the direct cost, the estimator adds contingency costs (for

Calculation Sheet

Originator *C. Mullin*	Date *6-1-00*	Calc. No. *1*	Rev. No. *0*
Project *Demonstration*	Job No. *12345-678*	Checked *GRP*	Date *12-1-00*
Subject *Trench Excavation*			Sheet No. *1 of 1*

Scope

- Excavate 3'-0" wide x 2'-0" deep trench in stable soil.
- Spoil excavated material.
- Backfill with clean fill.



Production Description: 100 lf/hr (23 yd³/hr)

- Excavation and backfill proceed at same rate.

Excavation

- Excavator digs trench.
- Front-end loader loads trucks (2 each).
- One laborer trims bottom and sides.
- One laborer works with loader.

Backfill

- Purchased clean fill is delivered from quarry.
- Front-end loader dumps fill in trench.
- Two laborers spread fill in trench.
- Two laborers with plate tamper compact fill.
- One water truck sprinkles water on fill.

Excavate and Backfill Crew

- Labor
  - Equipment operators - 3 each
  - Teamsters - 3 each
  - Laborers - 6 each
- Equipment
  - Excavator - 1 each
  - Front-end loaders - 2 each
  - Water truck - 1 each
  - Dump trucks - 2 each
  - Plate tamper - 1 each
- Material
  - Clean fill - 26 yd³/hr (including 15% swell)
- Subcontract
  - Dump fee - 29 yd³/hr (including 30% swell)

FIGURE 19.1 Crew operation calculation sheet for cost estimate.

rain, striking concealed utility lines, excavating in unexpected subgrade conditions), indirects (30% of labor cost), and company-wide costs and profit (10%). The sum is the total price of the project.

The estimator then makes two parametric checks to determine the reasonableness of the result:

1. *By trench volume.* The estimator compares the estimated price with that for similar projects with similar restrictions and requirements. A review of published bids for similar projects shows unit prices of $60 to $100 per cubic yard. This indicates that the estimated price of $73.65 is within that range.

TABLE 19.1 Crew Worksheet

JOB NO., TITLE & CLIENT: 12345-678 Demonstration – McGraw-Hill
DESCRIPTION: Crew Worksheet – Trenching
JOB LOCATION: San Francisco, CA

TAKEOFF: C. Mallin
PRICED: C. Mallin
CHECKED: RHK
APPROVED: GRP
DATE: 11/1/92
SHEET 1 OF 1

ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST		WORKER HOURS BECHTEL / S/C			TOTAL COST			
			MAT'L	S/C	UNIT	TOTAL	$/MH	MATERIAL	LABOR	SUB-CONT	TOTAL
1-hour production											
Material											
Select fill	26	yd³	25.00					650			650
Subcontract fee											
Dumping fee	29	yd³		10.00						290	290
Labor											
Equipment operators	2	hr			1	2	37.02		74		74
Teamsters	3	hr			1	3	32.71		98		98
Laborers	6	hr			1	6	29.12		175		175
Equipment											
Excavator	1	hr	14.76	7.06	0.1	0.1	S/C	15		7	22
Loaders	2	hr	9.72	4.34	0.1	0.2	S/C	19		9	28
Dump trucks	2	hr	19.22	11.17	0.3	0.6	S/C	38		22	60
Water truck	1	hr	12.16	12.40	0.2	0.2	S/C	12		12	24
Plate tamper	1	hr	1.02	0.62	0.2	0.0	S/C	1		1	2
Cost for 1 hour	100	ft	7.36	3.41	0.119	11.9	29.15	735	347	341	1423
CODE — Use for	1	ft	7.36	3.41	0.119		29.15				

TABLE 19.2 Equipment Ownership and Operating Cost Analysis Report

JOB NO : 12345-678
TITLE : DEMONSTRATION PROJECT
DATE : 11/21/92

RUN NO :
PAGE NO : 1

EQP COD	SUB COD	EQUIPMENT-DESCRIPTION	TIRE-DESCRIPTION	ACCESSORIES	WEIGHT-(TONS) U.S.	METRIC	---VOLUME---- CUFT	(M3)	CAPACITY	UNIT	FUEL $/GAL	ELECT POWER $/KWH	OIL $/GAL	GREASE $/LB	MECH WAGE $/HR	MACHINE ECON-LIFE YRS	HR/YR	TIRE LIFE (HR)
102A		demonstration 1		UNIVERSAL BLADE	45.77	41.60	2,720	77	370.00	HP	1.10	0.08	0.80	0.60	62.00	7	1885	0

OWNING COST			U.S. -- RATE --
LIST PRICE	$	390,000	
DISCOUNT (5%)	$	-19,500	
SALE TAX (7%)	$	25,935	
VALUE OF TIRES	$	0	
RESIDUE VALUE (20%) ...	$	-78,000	
	$	318,435	
OWNERSHIP COST ($/HR)	$	24.13	
INTEREST COSTS ($/HR)	$	11.10	11.50 % / YR
INSURANCE COSTS ($/HR)	$	0.96	1.00 % / YR
TOTAL HOURLY OWNING COST	$	36.19	
OPERATING COST			
REPAIR LABOR COST ($/OPERATING HR)			
UNDERCARRIAGE	$	24.80	0.400 MH/HR
REPAIR RESERVE	$	15.50	0.250 MH/HR
SPECIAL ITEMS	$	2.48	0.040 MH/HR
	$	42.78	
REPAIR SPARE PARTS COST ($/OPERATING HR)			
UNDERCARRIAGE	$	0.00	0.00 $/HR
REPAIR RESERVE	$	22.00	22.00 $/HR
SPECIAL ITEMS	$	0.00	0.00 $/HR
	$	22.00	
FUEL COST	$	19.80	18.00 GAL/HR
LUBE OILS	$	2.40	3.00 QT/HR
GREASE	$	1.20	2.00 LB/HR
FILTERS	$	0.15	0.15 $/HR
ELECT. POWER	$	0.00	0.00 KW/HR
SUBTOTAL FUEL,OIL,GREASE...	$	23.55	
DEPRECIATION OF TIRE	$	0.00	
TOTAL HOURLY OPERATING COST	$	88.33	
TOTAL OWNING & OPERATING COST....	$	124.52	

MONTHLY RATE FOR 1ST SHIFT ...... $ 7,240
MONTHLY RATE FOR TWO SHIFTS ..... $ 12,308

TABLE 19.3 Estimate Worksheet

LUMP-SUM BIDDING GROUP

JOB NO. 12345-678	PROJECT Demonstration	TAKEOFF C. Mallin	APPROVED GRP
TYPE OF ESTIMATE Demonstration	CLIENT McGraw Hill	PRICED C. Mallin	DATE 11/1/92
	JOB LOCATION San Francisco, CA	CHECKED RHK	SHEET 1 OF 1

ITEM AND DESCRIPTION	QUANTITY	UNIT	UNIT COST		WORKER HOURS BECHTEL / S/C			TOTAL COST			
			MAT'L	S/C	UNIT	TOTAL	$/MH	MATERIAL	LABOR	SUB-CONT	TOTAL
Trenching 2'-0" x 3'-0" deep (direct costs)	1,750	ft	7.36	3.41	0.119	208	29.15	12,877	6,071	5,969	24,917
Contingency	10	%				21		1,288	607	577	2,492
Subtotal						229		14,165	6,678	6,566	27,409
30% of labor for indirects	1	lot				30%			2,003		2,003
Subtotal								14,165	8,681	6,566	29,412
Company-wide costs and profit	15	%									4,412
Total	1,750	ft		19.33							33,824
Parametric checks											
#1 Check by trench volume	389	yd^3		73.65	OK						
#2 Clock time check @ 11.9 manhours/clock hour	19	hr	OK								
	2.4	days	OK								
CODE											

2. *By time clock.* The estimator verifies that the specific equipment and personnel can be made available by the contractor. This is done by consulting the contractor's work schedule for the equipment and personnel.

19.6 REVIEWING ESTIMATES

All estimates should be reviewed by all responsible parties at every stage. An estimate review should begin with a survey of the verbal description of the work, including all or most of the following: scope statement, assumptions, clarifications, qualifications, and exclusions.

As an example, the estimate is to be reviewed for a warehouse to be built in an urban area as part of a redevelopment project. The scope statement should specify the location, refer to design drawings and specifications, and list applicable building codes. The assumptions might include such data as the number of persons who will work in the warehouse. This is an indication of the number of restrooms and fixtures needed, which can be listed as a clarification. If the price quotes are valid for 90 days, this should be stated as a qualification. Handling and disposing of any existing hazardous material found on the site might be listed as an exclusion.

This warehouse description may be reasonably complete from the viewpoint of designer and contractor and may be accurately priced. But because of the assumption regarding the number of occupants, it may not be suitable from the viewpoint of the intended users. The exclusion regarding hazardous materials may result in unacceptable financial exposure for the client. Issues such as these need to be addressed. The client may decide that the prospective tenants, or users, may employ more persons than the number assumed. Hence, either the estimate will have to allocate more money for rest rooms or the client will have to give the tenants an allowance to enable them to build the rest rooms they desire. The client may also decide that an analysis of soil samples may be necessary before any construction is done to determine the extent of contamination, if any, and cost of cleanup.

Bearing these issues in mind, the parties should now review the quantitative part of the estimate. This review should comprise the following:

A summary of the key quantities involved; for example, floor area, tons of steel, cubic yards of concrete.

As a cross check, a list the key quantities—by discipline if the estimate has been prepared with the industry approach or by industry if the estimate has been prepared by the discipline approach.

A summary of the project, by industry or discipline.

At each step of the review, changes may be made, as required. After all parties agree to all parts of the estimate, it can be considered final. At this stage, the designer should be satisfied that enough money has been allocated to carry out the project. The client should have a clear idea as to what the project will entail and how much it will cost.

19.7 COMPUTER ESTIMATING

There are essentially three types of commercial computer products useful in preparation of cost estimates:

Utilities. These are programs that arrange information or do arithmetic; for example, spreadsheets and report generators databases. Most estimating programs fall into the utilities category.

Databases. These contain raw information, for example, prices of plumbing fixtures, that the estimator must analyze and choose from.

Expert Systems. These are programs that question the estimator, then use the answers to produce an estimate. (Expert systems are sometimes referred to as artificial intelligence systems.)

Some commercial packages may contain two or more of these.

Computer aided estimating has now specialized with software blurring these distinctions. This goes across the construction industry where you see competitors using the same software with certain information customized. One sees a single brand of software in use by contractors and another by designers and yet another by home builders. Contractors tend to use utilities that talk to their expert system for material control and fabrication. Designers use specialized expert systems for the specific work they performed (i.e., environmental remediation), and the home builder may have sales people using an expert system that was created in a utility with pricing from window and door vendors.

19.7.1 Utilities

These enhance, but do not replace, the expertise and knowledge of estimators. They enable estimators to extract and summarize needed information rapidly and accurately.

Utilities are broad based; they can be applied to almost any estimating type, approach, and technique. Use of some programs is easy to learn; for example, spreadsheets. Others are difficult; for example database report generators. In general, the more powerful a utility is, the more difficult it is to learn to use it.

19.7.2 Databases

Generally, databases are designed to be used with one specific utility and one specific approach, such as industry or discipline (Art. 19.2). Some are limited to a particular type of estimate and technique (Art. 19.2.2).

The estimator should always be aware that a database responds only to specific queries asked in a specific way and cannot interpolate. For instance, if a database has the prices of ½-in and 1-in bolts and the estimator requests the price of a ¾-in bolt, the computer will reply that the database contains no such price. At this stage, the estimator should devise the proper queries to solicit responses helpful in preparing the estimate.

19.7.3 Expert Systems

Generally, expert systems are even narrower in application than databases. Unlike databases, however, expert systems will respond to a query as long as the estimator operates within the limits of their area of expertise. They have several drawbacks: They do not take into account creative solutions or project-specific problems. They do not change with changing technology. And they tend to be very expensive. As a result, they are not widely used.