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COST ENGINEERING
Short Handout for Exit Exam Preparation

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1. Fundamental Principles of Cost Engineering

1.1 Introduction

The broad array of cost engineering topics represents the intersection of the fields of project management, business management, and engineering. Cost Engineering recognizes and focuses on the relationships between the physical and cost dimensions of whatever is being "engineered." Cost Engineering is an area of engineering practice concerned with the application of scientific principles and techniques to problems of cost estimating, cost control, business planning and management science, profitability analysis, project management, and planning and scheduling. It is undertaken throughout the project life-cycle by trained professionals utilizing appropriate techniques, cost models, tools and databases in a rigorous way, and applying expert judgment with due regard to the specific circumstances of the activity and the information available. Cost Engineering shares common traits of the following

- ✓ combines both **science and art**
- ✓ **does not offer guarantees** of costs:
- ✓ can only be as accurate as **the information upon which it is based**
- ✓ **accuracy increases** as the design becomes more **precisely defined**
- ✓ requires standard computing **methodology and procedures**
- ✓ Provides the financial input required **to prepare a cash flow curve**

1.2 Cost Engineer

Cost Engineer is a qualified professional dedicated to Total Cost Management over the life cycle of a project, facility or manufacturing operation. A cost Engineer utilizes engineering principles and judgment to project, assess, and control costs and plan, schedule, and manage projects. A Cost Engineer determines how much money, resources, and time a project will require prior to its launch. They apply cost engineering and cost management principles, project management methodology and specialized technology to their projects.



Figure 1-0-1 required skills and knowledge to a Cost Engineer

1.3 Cost Engineering in construction projects

Project Cost is one of the three main challenges for the construction manager, where the success of a project is judged by meeting the criteria of cost with the budget, schedule on time, and quality as specified by the owner. Poor strategy, incorrect budget, or schedule forecasting can easily turn an expected profit into a loss. Therefore, effective estimating is one of the main factors of a construction project's success. Accordingly, cost estimate in the early stage plays a significant role in any construction project, allowing owners and planners to evaluate project feasibility and control costs effectively. Moreover, the cost of a building is significantly affected by decisions made in the early phase. While this influence decreases through all phases of a building project.

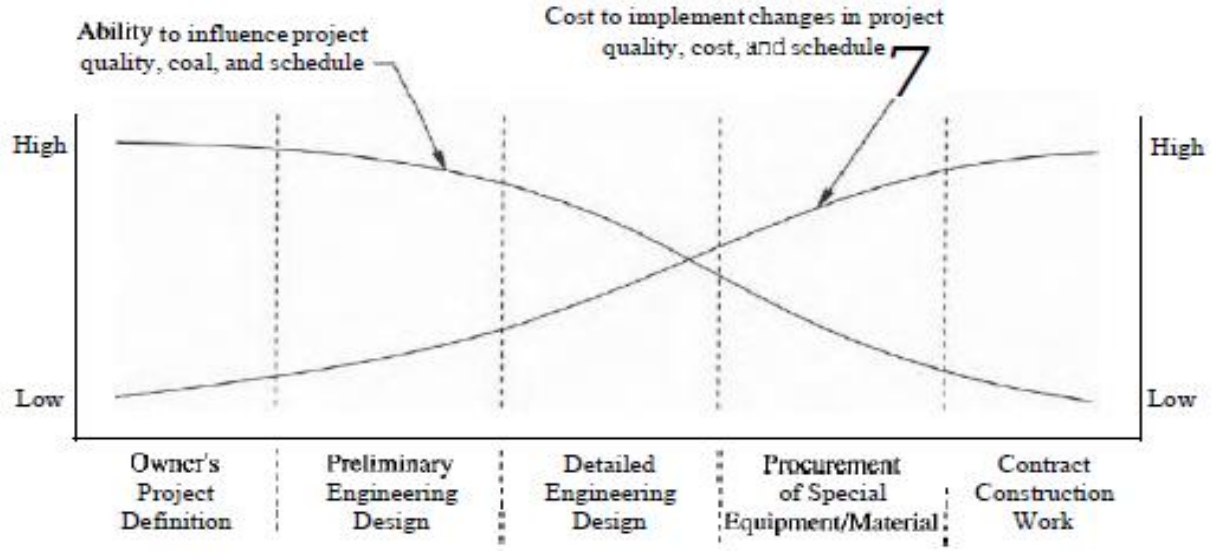


Figure 1-0-2 the ability to influence project vs cost of change implementation

1.4 Functions of Cost Engineering in Construction

From owners' perspective	From Designer and Engineers' perspective	From Contractors' perspective
✓ Ascertain the necessary amount required to complete the proposed work for his decision and arranging finance for the same ✓ to obtain administrative approval, allotment of fund and technical sanction. ✓ guide and facilitate the decision among two or three possible options ✓ Provides an assessment of capital cost for a specified piece of project ✓ help to classify and prioritize development projects with respect to an overall business plan ✓ to justify investments from cost-benefit analysis	✓ Helps to be aware of the cost implications for the design decisions they make while still in the design phase ✓ form the base core for negotiation between the signing parties in a contract agreement. ✓ required to invite tenders and prepare bills for payment.	✓ A key function for acquiring new contracts at right price hence providing gateway for long survival in the business ✓ for achieving a reasonable profit ✓ help them in making bid-price decisions when the available bid estimation time is insufficient ✓ Determine what resources to commit to the project with providing much of the basic information needed for preparing a schedule.

2. Cost and Risk Allocation in construction projects

2.1 Considerations in Costing

Cost estimating is critical in the development of the project because it informs the owner of costs, which in turn guide design decisions. Cost Engineers consider past projects while anticipating new factors. Some of these factors include: *Current technologies, Market demand and supply of material and labor,, Quantities of materials, Collective bargaining agreements of suppliers and buyers,, Level of quality and project size, Requirements for completion*. The accuracy of costing is directly affected by the ability of the Cost Engineer to properly analyze these basic issues:

I. **Project Size:** The principle of economy of scale is an important factor when addressing project size. Essentially as projects get bigger, they get more expensive but at a less rapid rate. This occurs because the larger the project, the more efficiently people and equipment can be used
II. **Project Quality;** Early in the project, the Cost Engineer must discuss expectations of quality with the users, the designers, and applicable government agencies. The Higher the quality of the project the higher the cost.
III. **Project Location:** The cost of constructing a facility in various project locations may be subjected to different conditions that might result deference in labor costs, the availability of materials and equipment, delivery logistics, local regulations, and climate conditions.
IV. **Project time:** examining past and current trends, the estimator can predict where Labor and material costs will be at the time of actual construction

2.2 Construction Contracts

While construction contracts serve as a means of pricing construction, they also structure the allocation of risk to the various parties involved. The owner has the sole power to decide what type of contract should be used for a specific facility to be constructed and to set forth the terms in a contractual agreement.

2.2.1 Lump Sum Contract/ Fixed Price Contracts

Lump sum contracts specify a total fixed price that will be paid for all construction work. In this type of agreement, owners agree to pay this fixed price and the contractor agrees to complete the project for this fixed price.

2.2.2 Unit Price Contract/ Admeasurements Contracts

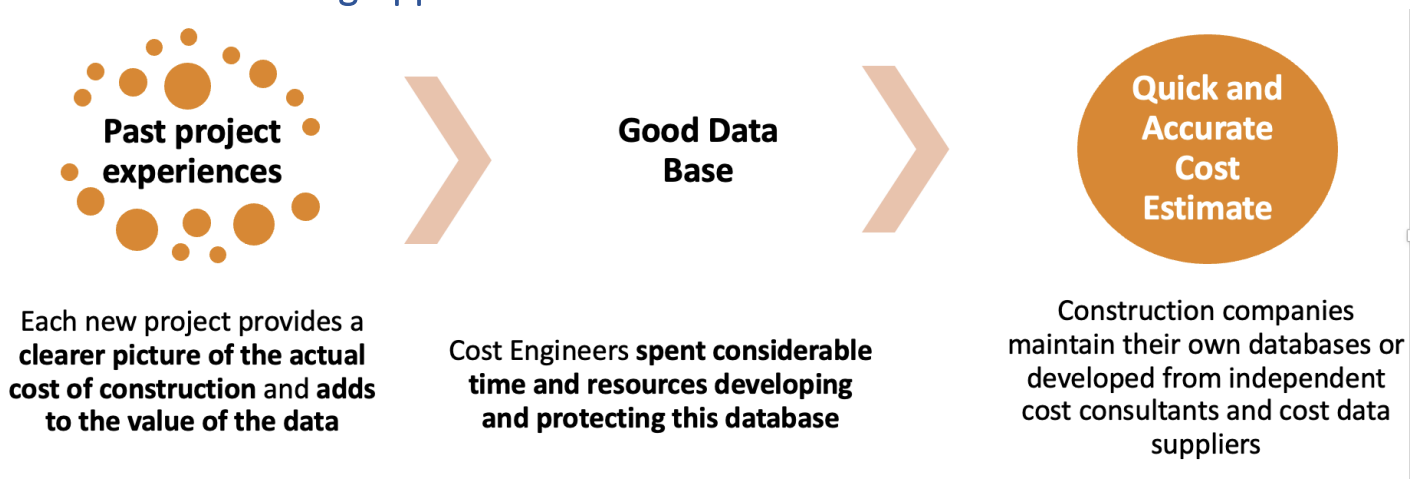
Unit price contracts involve the contractor determining a specific price for a certain task. After this, the owner must agree to pay that price for the number of units the contractor executed based on the actual measurement. This type of contract is commonly used on repetitive or public works projects.

2.2.3 Cost Plus (Cost Reimbursement) contracts

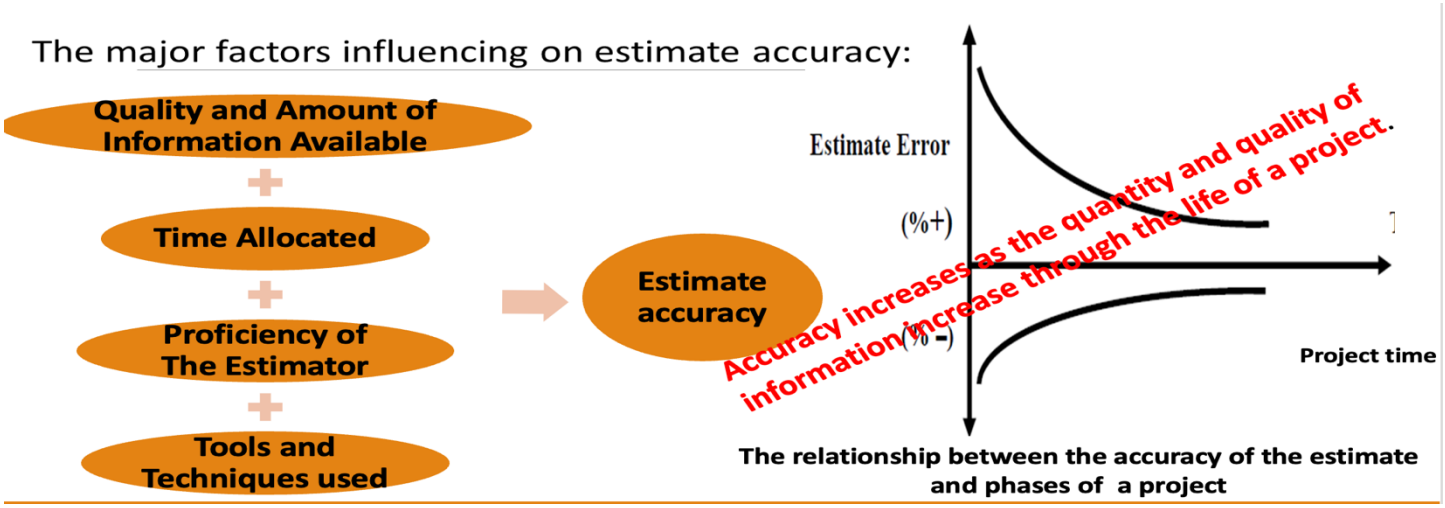
This type of contract is Suitable for use when the amount and type of work are not known. When the Client has little idea of the total cost, he will agree to pay the contractor the actual cost plus a negotiated reimbursement to cover overheads and profit. By using this type of contract, the contractor can start work without a clearly defined project scope, since all costs will be reimbursed and profit is guaranteed. There are different methods of reimbursement some of them are: Cost + percentage, Cost + fixed fee, Cost + variable percentage, Cost + fixed fee + profit-sharing clause.

Type	Advantages	Disadvantages
Lump Sum Contract	➢ Low risk for the owner. ➢ 'Fixed' construction cost. ➢ Minimize change orders. ➢ Owner supervision is reduced when compared to Time and Material Contract. ➢ The contractor will try to complete the project faster. ➢ Accepted widely as a contracting method. ➢ Bidding analysis and selection process is relatively easily. ➢ Contractor will maximize its production and performance. ➢ The contractors' cash flow is predictable and the owner can arrange the capital according to the payment plan	➢ It presents higher risk to contractor (ill productivity and mismanagement, inaccurate estimation of quantities of work can lead the project into loss. ➢ The project needs to be designed completely before the commencement of activities. ➢ Improper detail and specifications in the design can lead can lead to disputes ➢ Changes are difficult to quantify. ➢ Contractor will select its own means and methods. ➢ Higher contract prices that could cover unforeseen conditions.
Unit rate/ Admeasurement contracts	✓ Suitable for competitive bid (easy to compare tenderers) ✓ The client has an accurate estimate of total cost ✓ Easy for contract selection ✓ Early start is possible ✓ Possible to vary the amount of work during construction ✓ Flexibility: quantities and scope can be easily adjusted	➢ The actual final cost is not guaranteed to be equal to the estimated total cost at the beginning ➢ Staff needed to measure the finished quantities and report on the units not completed. ➢ A tender has no obvious place to put major temporary works costs hence detailed comparisons may be meaningless. ➢ Contractors raise prices on certain items and make corresponding reductions of the prices on other items, without changing the total amount of the bid
Cost + %	Profitable for the contractor	✓ No incentive to finish the job quickly ✓ Owners do not know the total cost ✓ Larger the Job costs, the higher the fee the client pays
Cost + fixed fee	Fee amount is fixed regardless of the price fluctuation provides incentive to complete the project quickly	Expensive materials and construction techniques maybe used to expedite the construction
Cost + fixed fee + profit-	✓ Rewards contractors who minimize cost ✓ Percentage of cost under GMP is considered profit and shared with the contractor ✓ Guaranteed Maximum Price (GMP) ✓ % of profit sharing is specified in contract	

3 Cost Estimating Approach

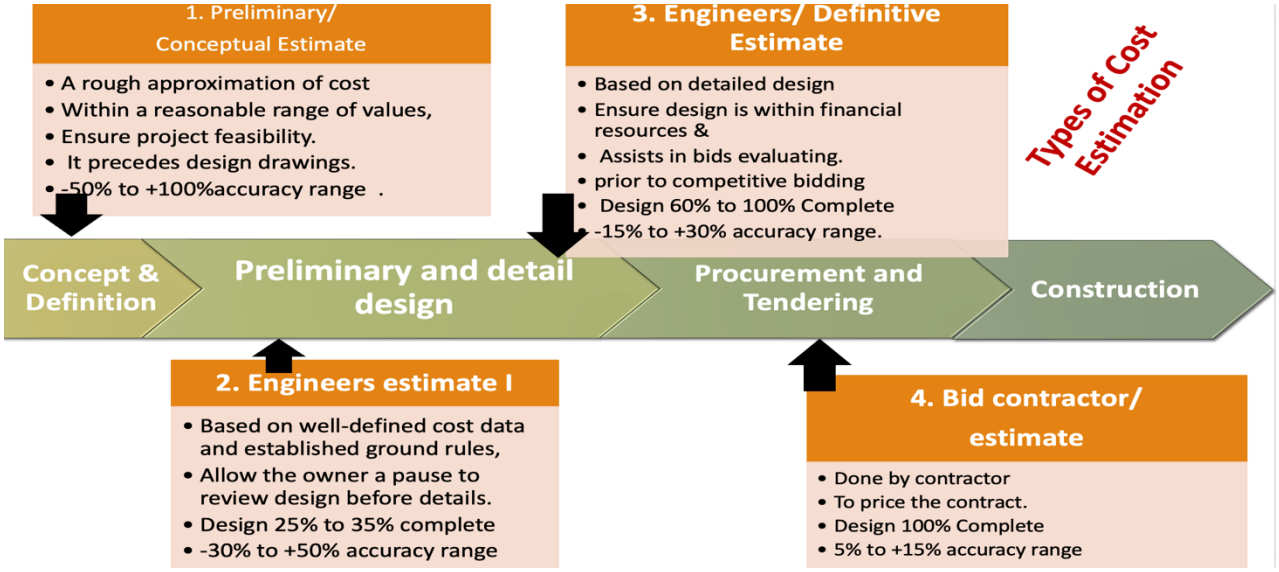


A good database of actual costs from past project experiences facilitate the preparation of a quick and accurate cost estimate. Cost Engineers spent considerable time and resources developing and protecting this database. Each new project provides a clearer picture of the actual cost of construction and adds to the value of the data.



3.2 Types of Cost Estimation

During the life cycle of a project are made different estimates which are used for the various functions of project management. The type of estimate is a classification that is used to describe one of several estimate functions. However, there are different types of estimates which vary according to several factors including the purpose of estimates, available quantity and quality of information, range of accuracy desired in the estimate, calculation techniques used to prepare the estimate, time allotted to produce the estimate, phase of project, and perspective of estimate preparer.



4 Cost estimating at Project Initiation and Feasibility study

For engineering and construction projects, accurate early cost estimates are extremely important to the sponsoring organization and the engineering team. For the sponsoring organization, early cost estimates are often a basis for business unit decisions, including asset development strategies, screening of potential projects, and committing resources for further project development. Inaccurate early estimates can lead to lost opportunities, wasted development effort, and lower-than-expected returns. Every project must be shown as economically feasible before it is approved by the owner's management. Economic feasibility is determined by an economic analysis for projects in the private sector or by a benefit/cost ratio for projects in the government sector. An economic analysis can be performed once an owner's estimate/ conceptual estimates have been prepared.

Estimating costs during project initiation by the owner, prior to any design, is difficult because only limited detailed information is known about the project. However, this cost estimate is important because it is used to set the maximum project budget that will be approved for design and construction. At this stage of project development, the only known information is the number of units or size of the project, such as number of square feet of building area, number of cars in a parking garage, etc. At some point in time an estimate must be frozen and converted to a project budget. Preparation of the owner's estimate requires knowledge and experience of the work required to complete the project. Cost information from professionals who are knowledgeable about design and construction is essential. Cost information for preparation of the owner's budget is usually derived from one of two sources: cost records from previous projects of similar type and size, or pricing manuals that are published annually by several organizations derived from previous projects

that have been completed at numerous geographic locations. In summary the following steps shall be taken when estimating construction projects at the conceptual phase using previously completed projects data

Step one: Identify the Purpose of the project
Step Two: Identify the Desired size/ area of the project
Step Three: identify the average cost per area
Step Four: Consider and adjust for the Quality of the desired project against the cost database
Step Five: compute Size Adjusting Factor
Step Six: location adjustment
Step Seven: Time adjusting factor, Compute the Year difference between the published data and planned construction time
Step Eight: Compute the Estimated project cost based on the above the identified factors

Size of the project X cost per unit X Factors (Quality x size x Location x Time)

5 Cost Estimating at Design and Engineering Stage

1. Preliminary Estimates	2. Detailed Estimates	3. Engineer's Estimates
✓ The level of detail in defining tasks is quite coarse.	✓ The level of detail could be fine	✓The level of detail can be very fine
✓ It is based on the Preliminary design of the facility at the state when the basic technologies for the design are known	✓It is made when the scope of work is clearly defined	✓ Estimate is based on the completed plans and specifications when they are ready for Construction bids
30% of design completed	60% of design completed	90% - 100% of design completed
✓The project is decomposed into major structural systems or production equipment items,	✓The detailed design is in progress so that the essential features of the facility are identifiable.	✓The project is decomposed into detailed items of various components as warranted by the available cost data. Examples of detailed items are slabs and beams in a floor panel, or the piping and connections for a heat exchanger.
✓ E.g. the entire floor of a building or a cooling system for a processing plant.	✓The project is decomposed into components of various major systems, i.e., a single floor panel for a building or a heat exchanger for a cooling system	✓The unit cost for each element in the bill of quantities must be assessed in order to compute the total construction cost. This concept is applicable to both design estimates and bid estimates, although different elements may be selected in the decomposition.
		✓ This concept is applicable to both design estimates and bid estimates, although different elements may be selected in the decomposition.
		✓In preparing these estimates, the design professional will include expected amounts for contractors' overhead and profits.

6 Cost Estimating at Tendering Stage

6.1 Basic Components of Construction bid prices

The task of the estimator is to evaluate the cost of the resources from the project and to build up a unit rate for each itemized work item. A fundamental principle is that unit rates should be prepared taking into account methods of construction and all circumstances which may affect the execution of work on the project. For the contractor, a bid estimate submitted to the owner either for competitive bidding or negotiation consists of a prediction of the cost of the physical resources and mark-up by management. Generally, construction price classified into construction costs and markups as lustrated on **Error! Reference source not found.**

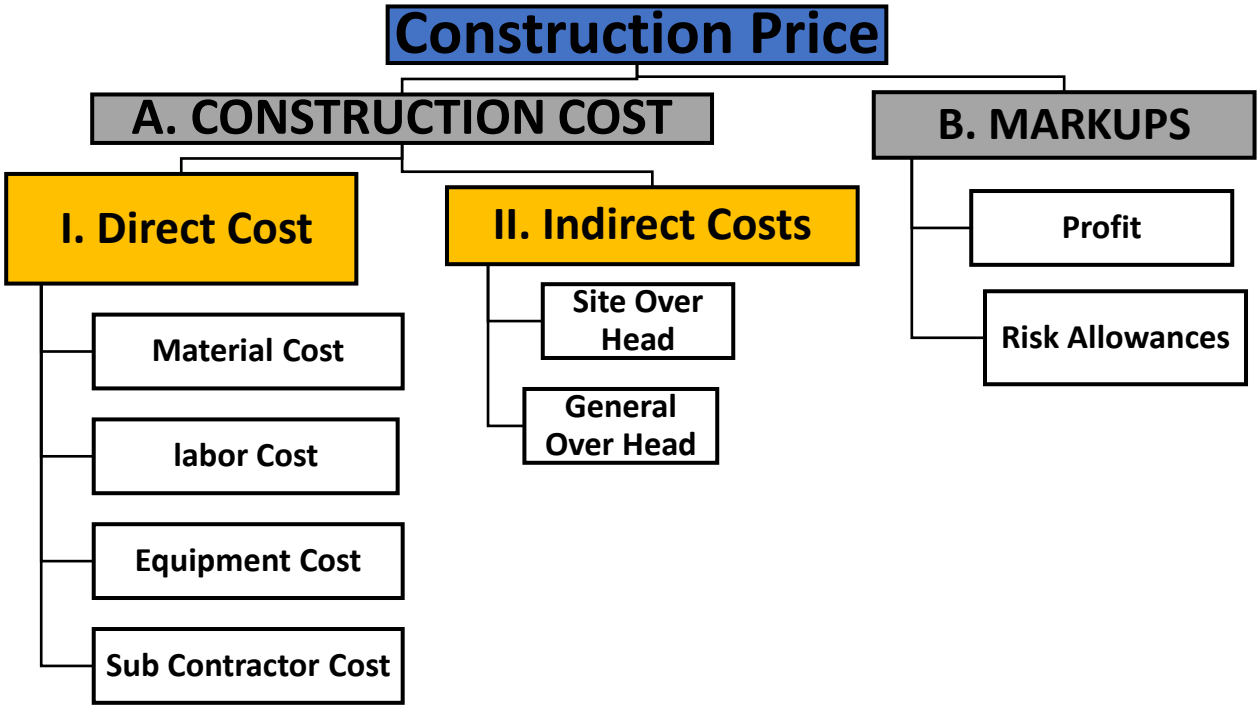


Figure 4-0-1 Components of Construction bid prices

A. Construction Cost

The principal components of a contractor's costs and expenses result from the use of labors, materials, equipment, and subcontractors. Additional overhead cost components include taxes, premiums on bonds and insurance, and interest on loans. The sum of a project's direct costs and its allocated indirect costs is termed the project cost.

I. **Direct costs:** The costs and expenses that are incurred for a specific activity are termed direct costs. These costs are estimates based on detailed analysis of contract activities, the site conditions, resources productivity data, and the method of construction being used for each

activity. A breakdown of direct costs includes labor costs, material costs, equipment costs, and subcontractor costs.

II. **Indirect costs / Overheads cost:** are construction costs of any kind that cannot be attributed to any specific item of work. The indirect costs always classified to: project (site) overhead; and General (head-office) overhead.

B. Markups

In construction industry, markup is defined as the amount added to the estimated direct and indirect costs to recover the desired profit and contingencies.

Each detail of the above-mentioned components of construction prices will be discussed in the subsequent sub topics along with their computation techniques for estimating bid price of any construction works.

1.3.1. Fundamental Approaches to Bid Estimation

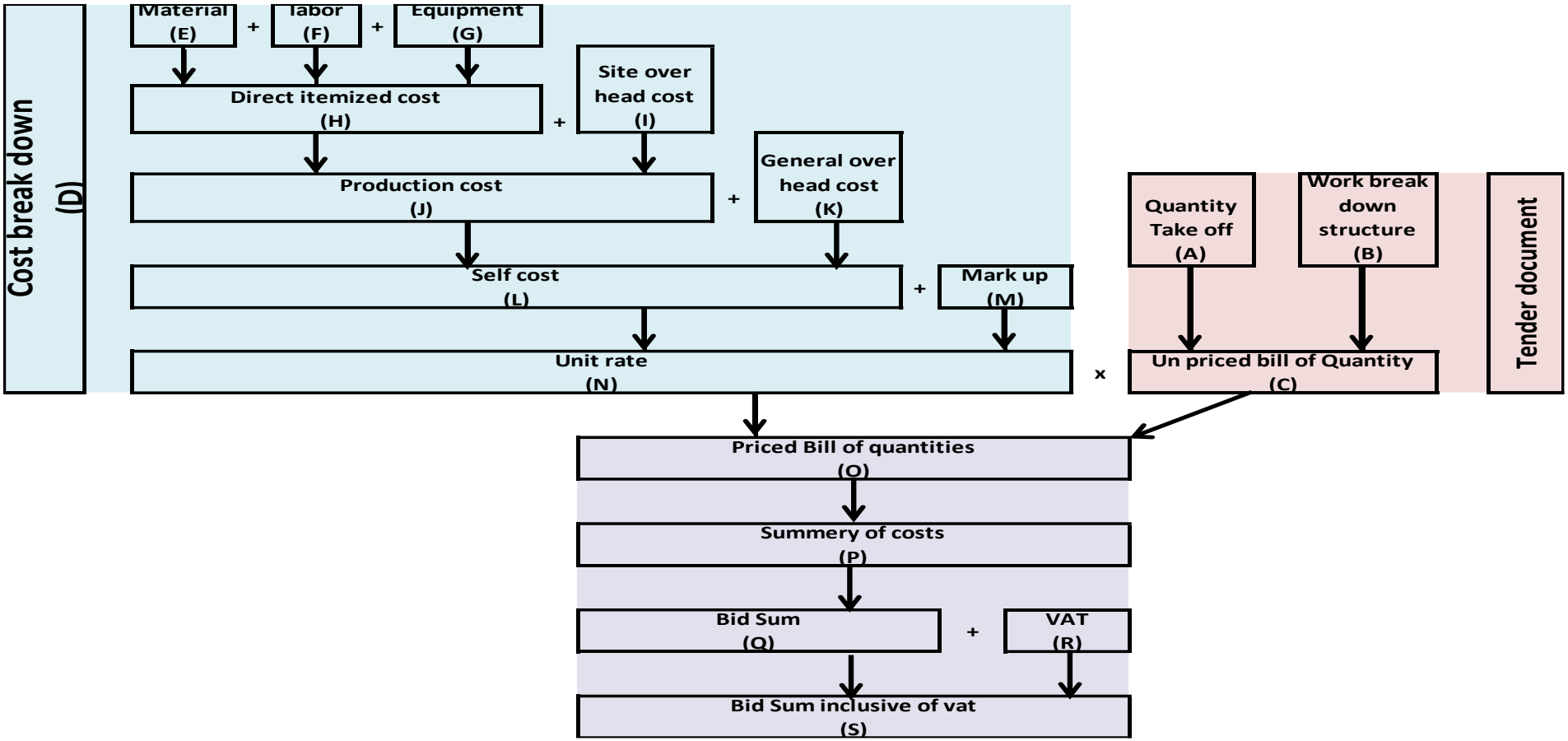
A quantity surveyor must have a thorough understanding of the construction drawings and the corresponding specifications in order to produce a good cost estimate for the project. Bid estimates are usually derived from a combination of the following approaches.

A. QUANTITY TAKEOFFS

The decomposition of a project into items of quantities that are measured (or *taken off*) from the engineer's plan will result in a procedure similar to that adopted for a detailed estimate or an engineer's estimate by the design professional. Quantity takes off or quantity survey is a tedious process in determining required construction quantities. A quantity surveyor must have a thorough understanding of the construction drawings and the corresponding specifications in order to produce a good cost estimate for the project.

B. WORK BREAKDOWN STRUCTURES (WBS)

A work breakdown structure (WBS) is a system of breaking down a project into manageable tasks, phases, deliverables or work packages (subdivision of effort). However, it is not a recipe for how a project should be constructed nor a schedule or an organization chart although it provides a basis from which a schedule or task list can be created. The benefit of a WBS is that it allows detailed thinking at the micro level without losing sight of the macro picture.

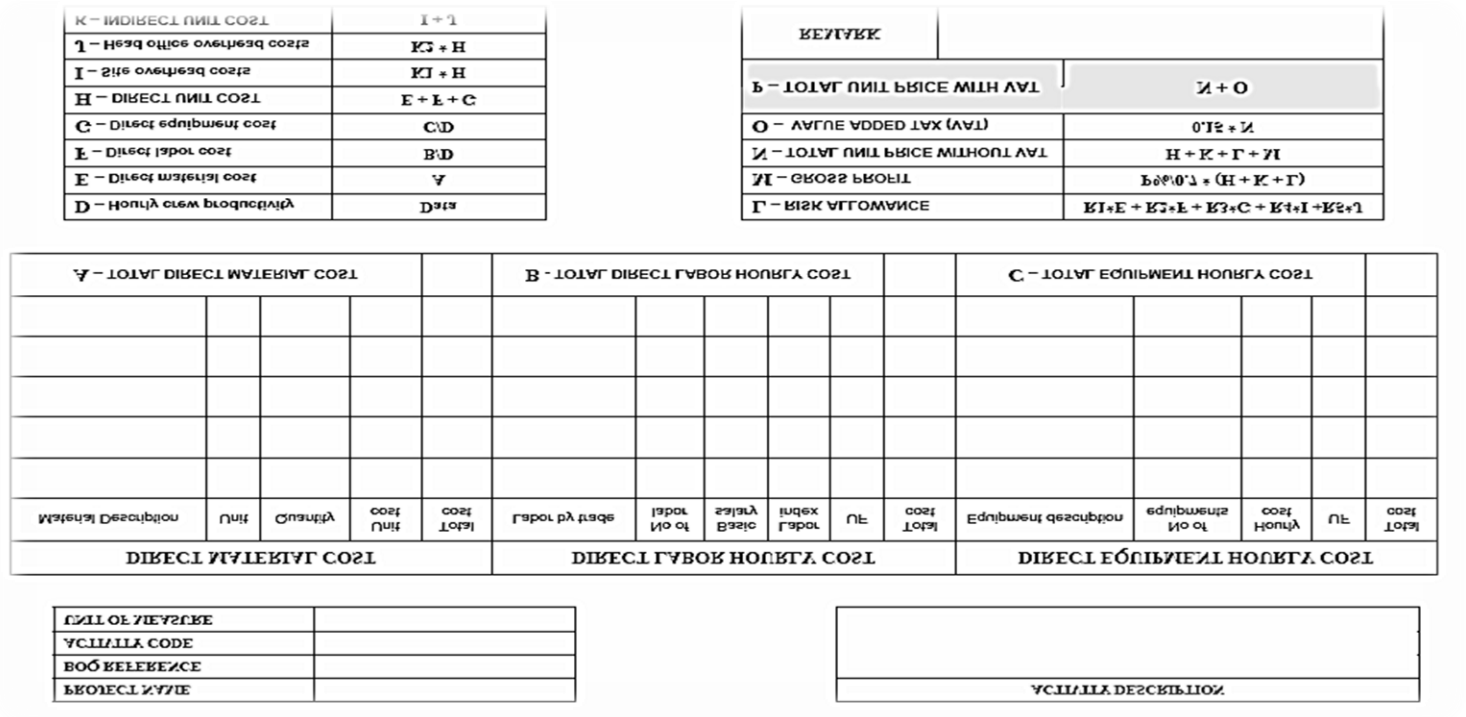


C. BILL OF QUANTITIES (BOQ)

The Bill of Quantities (BOQ) is defined as a list of brief descriptions and estimated quantities. The bill of quantities provides project specific measured quantities of the items of work identified by the drawings and specifications for a project. The quantities are defined as estimated because they are subject to admeasurement. The objective of preparing the Bill of Quantities is to assist estimators to produce an accurate tender efficiently and to assist the post contract administration to be carried out in an efficient and cost-effective manner. The term **un priced bill of quantity** refers to a bill of quantity where all the items such as work description and their quantities are filled except for the rate and amount of the work. It is bill of quantities without the prices filled out. The rate and Amount is left for contractors to fill out when they participate in the tender and submit their bid price for the competition.

D. COST BREAKDOWN

Cost breakdown is the systematic process of identifying the individual elements that comprise the total cost of a good, service or package. The cost breakdown structure can be developed based on the work breakdown structure (WBS) over the years, the construction cost breakdown has remained relatively stable, even though there have been changes in the survey methodology due to differences in the sales price breakdown. The construction cost breakdown sheet permits a contractor to generate a total estimate after breaking down the costs of materials, labor cost, equipment, etc. Cost break downs usually generate the unit price of a specific work item.



E. CONSTRUCTION MATERIAL COSTS

Material estimation for construction works or projects deals with calculation of quantities of various materials, required for construction. The cost of materials includes not only the direct cost of the material items, but additional items of cost to be considered are; transportation, sales taxes and freight costs, delivery, storage, sales and other taxes and losses. Cost of all material which will be part of the building. Therefore, the following information are required for computing the material unit price of itemized work item

Step one: identify the types of materials required for producing the specific work item

Step Two: calculate quantities of each material required for producing one unit of the spesfic work iterm from specification, mix design, company records or from other published data.

Step Three: account for wastage of the materials

Step four: from different market sources asses the unit price of the each materials

Step Five: Account for other additional costs , According to the market condition and the site condition identify quantity discounts and storage costs, transportation and loading unloading costs

Step six: Assess the current trend of each of the material prices and identify the annual escalation rate. To forecast the unit prices each material after n years the following formula is used $FV = PV(1+r)^n$ Where: FV is future price, PV is the present price, R is escalation rate, N is no of years from now

Step Seven: compute the cost of the materials for producing 1m3 of C-25 concrete work

- **Direct material cost = $\sum$ (Material quantity * Material unit cost)**

F. CONSTRUCTION DIRECT LABOR COSTS

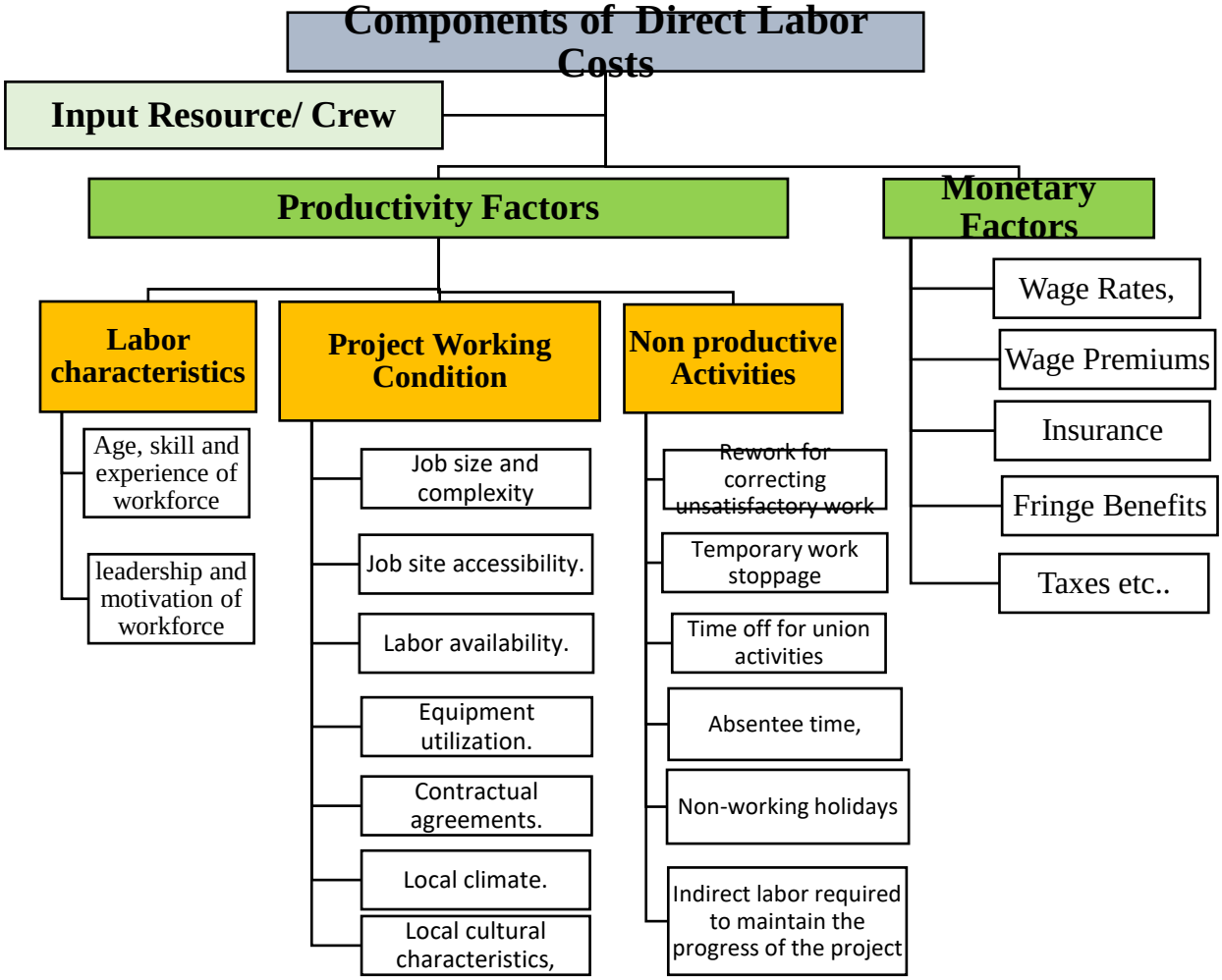


Figure 4-0-2 Components of Labor Costs

Summary of steps to be taken when computing labor cost for a specific work item

Step one: Form a crew of different trades that would ensue consistent flow of work and yield similar production rate as the equipment to be used to avoid unnecessary idle time and wastages costs

Step Two: identify the utilization of factor of each worker

Step Three: Estimate the productivity of a crew by considering different factors that would influence the production rate of the crew. one of the two approaches should be used

- ✓ If the work involve the use of equipment, the crew productivity depends on the output capacity of the equipment
- ✓ If the work is done by simple tools and craftsman use reliable historical recorded data and experience to estimate the productivity

Step Four: Assess the basic salaries of each workers in the crew

Step Five: identify the labor index to account for benefits, leaves, insurances, etc

Step Six: Calculate the indexed hourly wages of each workers

Step Seven: Calculate the hourly cost of the task using the following formula

$$Direct\ Labor\ hourly\ Cost = \sum_{i}^{n} No\ of\ labor\ x\ \ Utilization\ Factor\ x\ \ Indexed\ hourly\ wage$$

Step Eight: Calculate the labor cost per unit of the work item based on the hourly cost and productivity using the following formula

$$\textbf{Direct labor cost} = \frac{\boldsymbol{Direct\ labor\ hourly\ cost}}{\boldsymbol{Hourly\ crew\ productivity}}$$

G. CONSTRUCTION EQUIPMENT

Modern construction is characterized by the increasing efficiency of equipment to accomplish numerous construction activities. Equipment refers to all the machineries, tools, and apparatus necessary for the proper construction and acceptable completion of a project.

- ➢ **Type and number of equipment**
- ➢ **Capacity and equipment utilization factor (UF):** identify the equipment will be operating in full capacity and how much of its available time is devoted directly to a particular work item.

- **The equipment hourly cost:** Asses the rental prices of equipment to be used. In addition for more accurate estimation the escalation rate should salon be checked and adjusted.
- **Productivity:** The performance of equipment per hour for a unit amount of work should be identified. In case of the use of different equipment at once, careful consideration should take in computations of the governing production rate.

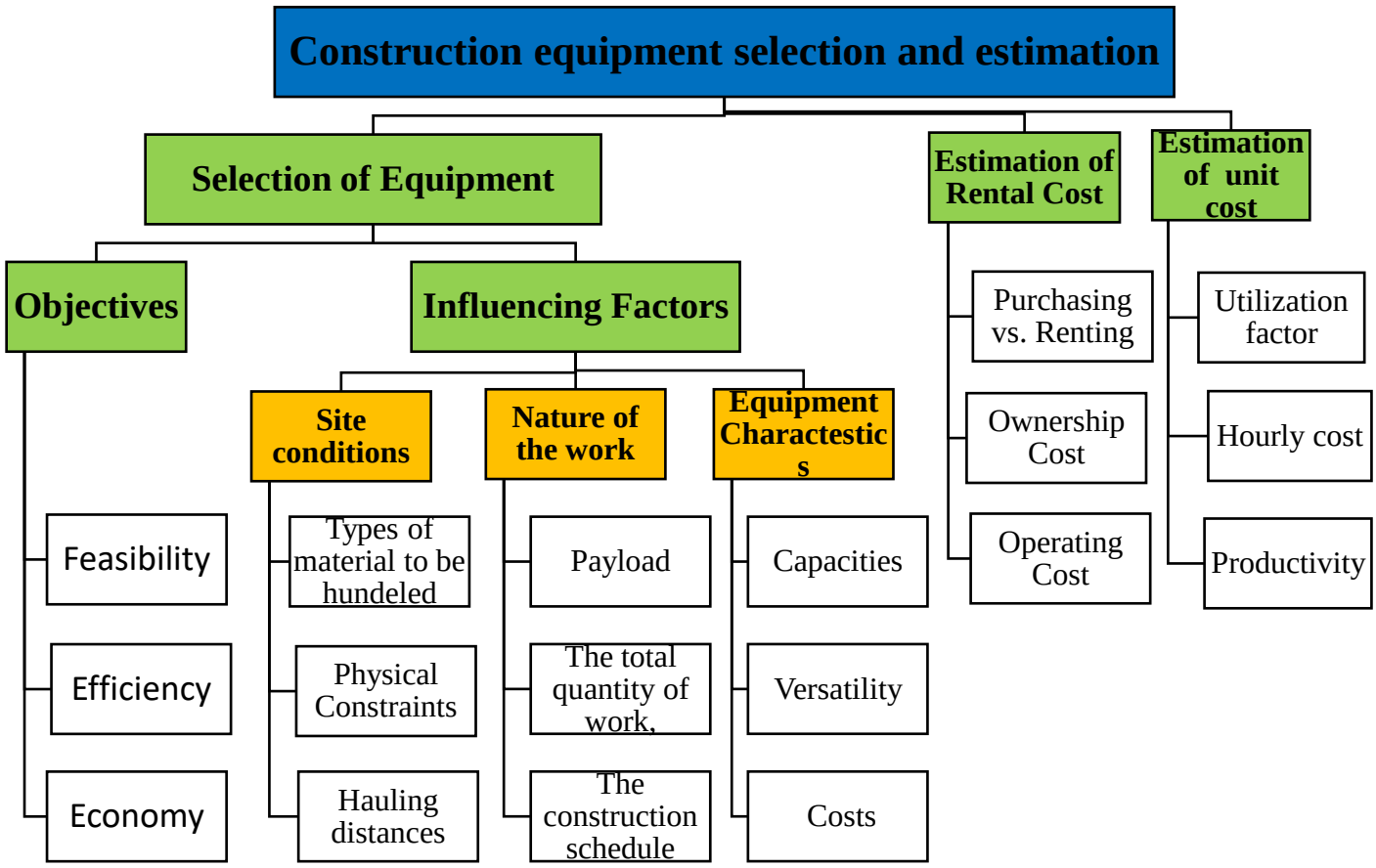


Figure4- 0-3Construction equipment selection and estimation process

After the above information are completed then the next step is computation of the direct equipment cost for a specified work item using the following equations

- **Direct equipment hourly cost = $\sum$ (No of equipment * Hourly cost * UF)**
- **Direct equipment cost = Direct equipment hourly cost / Hourly crew productivity**

H. DIRECT ITEMIZED COST

The cost of labor, material and equipment expended on the items that were measured in the quantity takeoffs is usually referred to as the direct costs of the work. The direct cost if each bid item represents the sum of its material, labor, equipment and subcontractor costs. The sum of bid items direct costs gives the estimated direct cost of the contract

.Direct itemized cost = Material cost + Direct Labor cost+ Direct Equipment cost

I. SITE OVERHEAD COST

Site overhead costs are all costs required to run the whole operation of a specific construction project at site level. These costs are not associated with specific activity in a project but rather shared proportionally by all activities within the project. The estimated total jobsite overhead costs will become the baseline budget for jobsite overhead expenditure control. These items might include *Site management costs, Mobilization and demobilization costs, Indirect labor costs, General use equipment, Jobsite production facilities, Protective aids, Office furniture and running expenses, Access roads* , Site *utilities, Transportation expenses,etc…* It is easier to express the site overhead costs as a percentage of the direct unit cost of an activity.

- **Let, K1 = Total site overhead costs / Total project direct costs**
  - **Site overhead costs = K1 * Direct unit cost**

J. PRODUCTION COST

Production cost is the cost needed to produce a specific work item on site which includes the direct itemized cost and the site management costs.

Production cost = Direct cost + Site overhead Cost

K. GENERAL OVERHEAD COST

General/ Head office overhead costs are all costs required to run the whole operation of the construction company, which usually administers different projects at a time. These costs are not usually associated with specific project but rather shared proportionally by all projects under the company.

- **Let, K2 = Annual head office overhead costs / Annual direct cost turnover**
  - **Head office overhead costs = K2 * Direct unit cost**

H. SELF COST

Self cost is of a work item is all the required expenses to produce that work item including the general over head costs. Which includes direct costs, site overhead costs and head office costs to do the work. It is computed as follows

Self-costs = Production cost +General overhead cost

= Direct cost + Site overhead costs + General overhead cost

L. MARKUPS

In the construction industry, markup is defined as "the amount added to the estimated direct cost and estimated Overhead costs to recover for risks for unforeseen circumstances and desired profit.. Hence, contractors need to decide on the markup percentage that makes the bid low enough to win and, at the same time, high enough to make reasonable profit and enough contingency for risks. Generally, contractors often have to maintain methods of assessing a specific contract markup.

Risk contingency = K3 x Direct cost Where: K3 is risk contingency factor

Profit = K4 x Direct cost. Where: K4 is profitability ratio

N. UNIT RATE

The unit price of a tender comprises the cost and the markup. The cost includes direct and indirect costs. The markup, on the other hand, includes profit margin, financial charges (cost of borrowing), and a risk allowance margin: ***Unit cost/rate = Self- costs + Markups***

= Direct cost + Indirect costs+ Markups

= Direct cost + (K1+K2+K3+K4) x Direct costs

O. PRICED BILL OF QUANTITIES

A bill of quantities consists of a complete list of all various items of works for a project, giving the item number and description of items with unit and quantity of work against each, thus enabling an estimated calculation of price of work.

Priced BOQ (Amount) = Unit rate x Quantity of a specific work

P. SUMMARY OF COSTS

After the amount of each work item is computed the next step is to summarize the cost of the work based on the work break down structure.

$$\sum(\textit{Quantity x Unit price with out VAT of each work item}$$

Q. BID SUM WITHOUT VAT

As shown on the above table the bid sum will be computed from summery page by summing up all the summery costs. After looking the bid sum, the contractor may decide to add discount in percentages if he thinks the bid sum is higher than anticipated and to ensure he stays in the competition. This discount rate is called rebate.

$$\sum(\boldsymbol{Summery\ of\ costs}) - \boldsymbol{Rebet}$$

R. VALUE ADDED TAX (VAT) and S. BID SUM INCLUSIVE OF VAT

A value-added tax (VAT) is a consumption tax placed on a product whenever value is added at each stage of the supply chain, from production to the point of sale.

VAT = Bid Sum Without Vat X 15%

Bid Sum Inclusive Of Vat = Bid Sum Without + VAT

7. Cost Estimation at Construction and contract Administration Stage

Effective project management requires planning, measuring, evaluating, forecasting, and controlling all aspects of a project: quality and quantity of work, costs, and schedules. Project tracking cannot be accomplished without a well-defined work plan, budget, and schedule. Earned value management is a project management technique that measures forward progress objectively. It has the unique ability to combine measurements of technical performance that means accomplishment of planned work and schedule performance. It measures schedule behind/ahead of schedule and cost performance under/over budget within a single integrated methodology. Earned value management provides an early warning of performance problems while there is time for corrective action. It views project progress in terms of cost as a function of time against a firm baseline set up at the start of the project. When the project is originally planned, it is divided into work breakdown structure and further sub-divided into work packages.

Definition of terms

- **Budgeted Cost of Work Scheduled (BCWS) or Planned Value (PV)** – The sum of budgets for all work packages scheduled to be accomplished within a given time period.
- **Budgeted Cost of Work Performed (BCWP) or Earned Value (EV)** – The sum of budgets for the work that has actually been completed to date.
- **Actual Cost of Work Performed (ACWP) or Actual Cost (AC)** – The actual cost incurred in accomplishing the work performed within a given time period. For equitable

comparison, ACWP is only recorded for the work performed to date against tasks for which a BCWP is also reported

- **Budget At Completion (BAC) –** The sum of all the budgets allocated to a project

I. Variances: these are deviations occurred from planned or budgeted values

- **Schedule Variance (SV) –**The difference between the work actually performed (BCWP) and the work scheduled (BCWS). **= Planned – Earned costs**
- **Cost Variance (CV) –** The difference between the planned cost of work performed (BCWP) and actual cost incurred for the work (ACWP). **= Earned – Actual cost**

II. Indexes

- **Cost Performance Index (CPI) –** The ratio of cost of work performed (BCWP) to actual cost (ACWP). CPI of 1.0 implies that the actual cost matches to the estimated cost. CPI greater than 1.0 indicates work is accomplished for less cost than what was planned or budgeted. CPI less than 1.0 indicates the project is facing cost overrun.

$$\text{CPI} = \frac{\text{BCWP}}{\text{ACWP}} \qquad \left(\text{Cost Performance Index} = \frac{\text{Earned}}{\text{Actual}}\right)$$

- **Schedule Performance Index (SPI)** – The ratio of work accomplished (BCWP) versus work planned (BCWS), for a specific time period. SPI indicates the rate at which the project is progressing**.**

$$\text{SPI} = \frac{\text{BCWP}}{\text{BCWS}} \qquad \left(\text{Schedule Performance Index} = \frac{\text{Earned}}{\text{Planned}}\right)$$

III. Forecasts:

Estimate at Completion (EAC) – It is a forecast of most likely total project costs based on project performance and risk quantification. At the start of the project BAC and EAC will be equal. EAC will vary from BAC only when actual costs (ACWP) vary from the planned costs (Earned cost) (BCWP). The Most common forecasting techniques are some variations of:

1. EAC = Actual to date plus a new estimate for all remaining work. This approach is most often used when past performance shows that the original estimating assumptions were fundamentally flawed, or they are no longer relevant to a change in conditions.

- **EAC = Actual cost + new Remain work estimate to complete the project**
- **EAC = AC + ETC**

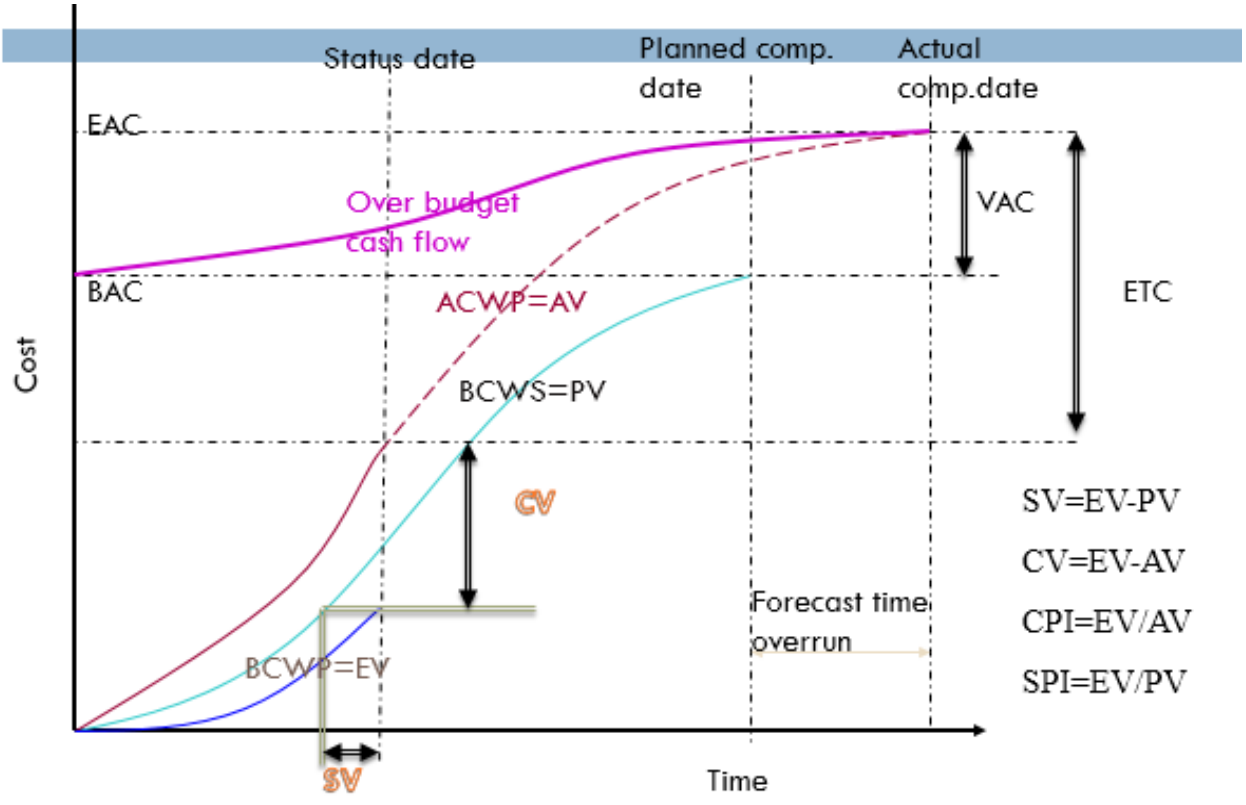
2. EAC = Actual to date plus remaining budget. This approach is most often used when current variances are seen as not typical and the project management team expectations are that similar variances will not occur in the future.

- **EAC = Actual cost + (Budget at completion – Earned cost)**
- **EAC = AC + (BAC – EV)**

3. EAC = Actual to date plus the remaining budget modified by a performance factor, often the cumulative cost performance index (CPI). This approach is most often used when current variances are seen as typical of future variances

Estimate To Complete (ETC) – the difference between Estimate At Completion (EAC) and the Actual Cost (AC). This is the estimated additional cost to complete the project from any given time.

Variance At Completion (VAC) – The difference between Budget At Completion and Estimate At Completion (EAC). This is the dollar value by which the project will be over or under budget.



8. Value Engineering

Value Engineering is a systematic and organized effort to identify the functions of a product, system or procedure and to attain that function with minimum cost without jeopardizing quality, aesthetics, appearance etc. It is an organized creative approach which has for its purpose the

efficient identification of unnecessary cost without scarifying reliability, performance or maintainability.

Value engineering studies may be performed by Consultants during design development as a contractor performed pre-construction services, or by the contractor during construction. The most effective time to conduct such studies is during design development. Some construction contracts contain a value engineering incentive provision that allows the contractor to share in the savings that results from approved value engineering change proposals. Value engineering change proposals submitted by the contractor are reviewed by the consultant and owner for acceptability. If approved, up to 50% of the savings in construction cost may go to the contractor. The percentage split between the owner and the contractor will be stated in the value engineering provision of the contract.

The value of a component or system can be defined as its function plus quality divided by its lifecycle cost.

$$\textbf{Value of a component} = \frac{\text{(Function + Quality)}}{\text{Life Cycle-Cost}} - \text{Worth benefit}$$

Life-Cycle Cost = Initial or Construction Cost + Operating Cost+ Maintenance Cost +

+ Depreciation Cost – any Salvage Value

Value Engineering seeks the highest value design components by improving utility I it same cost or maintains same function with less cost. In general Value engineering:

- ✓ Enhances value of money,
- ✓ Effects improvements in function, performance and quality,
- ✓ Enables people pin point areas that need attention and improvement,
- ✓ Provides a method of generating ideas and alternatives for possible solution to a problem,
- ✓ Provides a vehicle for dialogue,
- ✓ Documents the rationale for decisions,
- ✓ Improves the value of goods and services.