مدیریت مالی، حسابداری و هزینه در پروژه ها و سازمان‌های پروژه‌محور

بخش هفتم:

مدیریت هزینه: برآورد هزینه و قیمت پروژه

ارائه دهنده:

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(PhD, PMP, CMIT)

What you will learn?

- Purpose of this session
- Introduction to cost estimating
- Common types of estimates
- Other types of estimates
- Estimates during the life cycle of the project
- Types of costs
- Project time schedule
- Time-cost tradeoff
- Direct cost
- Indirect cost
- Bid price
- Computer-based estimating
- Cost models
- Project budget
- Key points

Common types of estimates – Assemblies (systems) estimate

- **An assemblies estimate** is **best used** as a **budgetary tool** in the **planning stages** of a project. **Accuracy is expected at -10% to +20%.**

- **Can** be used when **at least 25% to 30%** of **design completed**.

- **Unit price estimating**, because of the **time** and **detailed information required**, is **not suited** as a **budgetary** or **planning** tool.
  - A **faster** and **more cost-effective** method for the **planning phase** of a project is the **assemblies** or **systems estimate**.
  - This approach is a **logical**, **sequential** approach that reflects how a project is constructed.

Common types of estimates – Assemblies (systems) estimate

- **Unlike unit price estimates**, the **assemblies** method does **not** require **final design details**, **but** the **estimators** who use it must have **solid background knowledge** of **construction materials** and **methods**, **code requirements**, **design options**, and **budgetary restrictions**.

- The **assemblies estimate may** be used as a **substitute** for the **unit price estimate**.

- While the **assemblies approach** can be an **invaluable tool** in the **planning stages** of a project, it **should be supported** by **unit price estimating when greater accuracy** is required.

Common types of estimates – Assemblies (systems) estimate

- **Seven UNIFORMAT II elements organize building construction** into **major components** that can be used in **assemblies estimates**. These UNIFORMAT II elements are listed below.

  A-Substructure
  B-Shell
  C-Interiors
  D-Services
  E-Equipment & Furnishings
  F-Special Construction
  G-Building Site Work
  Z-General

- **Each element** is **further broken down** into **individual assemblies**.
- **Each individual assembly** incorporates **several different items** into a **system** that is **commonly used** in **building construction**.

Common types of estimates – Assemblies (systems) estimate

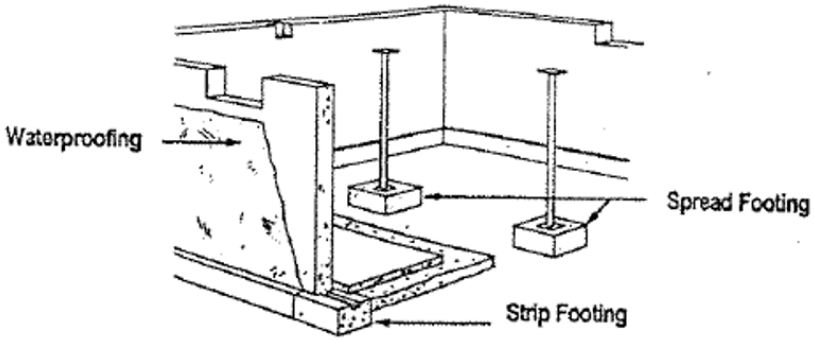
- **A great advantage** of the assemblies estimate is that the **owner** can then **anticipate accurate budgetary requirements** **before** **final details** and **dimensions** are established.
- **Not adjusted** for **time**, **location**, **design fees**, and **profit and overhead markup**

***RsMeans** publishes **"Assemblies Cost Data" updated annually**.*

Common types of estimates – Assemblies (systems) estimate

- Substructure
  - A
  - Level 1
- Foundation
  - A10
  - Level 2

FOUNDATIONS **A1.1** **Footings & Foundations**



1.1-120	Spread Footings	COST EACH		
		MAT.	INST.	TOTAL
7090	Spread footings, 3000 psi concrete, chute delivered			
7100	Load 25K, soil capacity 3 KSF, 3'-0" sq. x 12" deep	32	70.50	102.50
7150	Load 50K, soil capacity 3 KSF, 4'-6" sq. x 12" deep	66.50	123	189.50
7200	Load 50K, soil capacity 6 KSF, 3'-0" sq. x 12" deep	32	70.50	102.50
7250	Load 75K, soil capacity 3 KSF, 5'-6" sq. x 13" deep	104	174	278
7300	Load 75K, soil capacity 6 KSF, 4'-0" sq. x 12" deep	54	105	159
7350	Load 100K, soil capacity 3 KSF, 6'-0" sq. x 14" deep	131	207	338
7410	Load 100K, soil capacity 6 KSF, 4'-6" sq. x 15" deep	81	144	225
7450	Load 125K, soil capacity 3 KSF, 7'-0" sq. x 17" deep	206	298	504
7500	Load 125K, soil capacity 6 KSF, 5'-0" sq. x 16" deep	104	173	277
7550	Load 150K, soil capacity 3 KSF 7'-6" sq. x 18" deep	247	350	597
7610	Load 150K, soil capacity 6 KSF, 5'-6" sq. x 18" deep	138	218	356
7650	Load 200K, soil capacity 3 KSF, 8'-6" sq. x 20" deep	350	465	815
7700	Load 200K, soil capacity 6 KSF, 6'-0" sq. x 20" deep	179	269	448
7750	Load 300K, soil capacity 3 KSF, 10'-6" sq. x 25" deep	640	750	1,390
7810	Load 300K, soil capacity 6 KSF, 7'-6" sq. x 25" deep	335	455	790

Common types of estimates – Assemblies (systems) estimate

- Substructure
  - A
  - Level 1
- Foundation
  - A10
  - Level 2

ASSEMBLIES | **Example** | **Instructions**

Means Forms

ASSEMBLY NUMBER	DESCRIPTION	QTY	UNIT	TOTAL COST UNIT	TOTAL COST TOTAL	COST PER S.F.
1.0	Foundations					
1.1-120-7900	Corner Footings 8'-6" SQ. x 27"	4	Ea.	1060	4240	
-8010	Exterior 9'-6" SQ. x 30"	8	↓	1410	11280	
-8300	Interior 12" SQ.	3	↓	2550	7650	
1.1-140-2700	Strip 2' Wide x 1' Thick					
	320 L.F. [(4x8.5)+(8x9.5)] =	210	L.F.	22.80	4788	
1.1-210-7260	Foundation Wall 12' High, 1' Thick	↓	↓	134.50	28245	
1.1-292-2800	Foundation Waterproofing	↓	↓	11.00	2310	
1.9-100-3440	Building Excavation & Backfill	6,000	S.F.	3.77	22620	
-3500	(Interpolated: 12' Between					
-4620	8' and 16'; 6,000 Between					
-4680	4,000 and 10,000 S.F.)					
	Total				81133	1.50
2.0	Slab on Grade					
2.1-200-2240	4", non-industrial, reinf.	6,000	S.F.	2.85	17100	
	Total				17100	.32

Common types of estimates – Assemblies (systems) estimate

- These are compatible with old version of UniFormat

ESTIMATING FORM R17.1-300 **Systems Costs Summary**

Means Forms
PRELIMINARY
ESTIMATE (Cost Summary)

PROJECT		TOTAL AREA	SHEET NO
LOCATION		TOTAL VOLUME	ESTIMATE NO
ARCHITECT		COST PER S.F.	DATE
OWNER		COST PER C.F.	NO. OF STORIES
QUANTITIES BY:	PRICES BY:	EXTENSIONS BY:	CHECKED BY:

NO	DESCRIPTION	SUB TOTAL COST	COST/S.F.	%
1.0	Foundation			
2.0	Substructure			
3.0	Superstructure			
4.0	Exterior Closure			
5.0	Roofing			
6.0	Interior Construction			
7.0	Conveying			

Common types of estimates – Assemblies (systems) estimate

7.0	Conveying			
8.0	Mechanical System			
9.0	Electrical			
10.0	General Conditions (Breakdown)			
11.0	Special Construction			
12.0	Site Work			

Building Sub Total $

Sales Tax ____ % × Sub Total $ ____ /2 = $

General Conditions (%) ____ % × Sub Total $ ____ = ____

General Conditions $

Sub Total "A" $

Overhead ____ % × Sub Total "A" $ ____ = $

Sub Total "B" $

Profit ____ % × Sub Total "B" $ ____ = $

Sub Total "C" $

Location Factor ____ % × Sub Total "C" $ ____ =

Adjusted Building Cost $

Architects Fee ____ % × Adjusted Building Cost $ ____ = $

Contingency ____ % × Adjusted Building Cost $ ____ = $

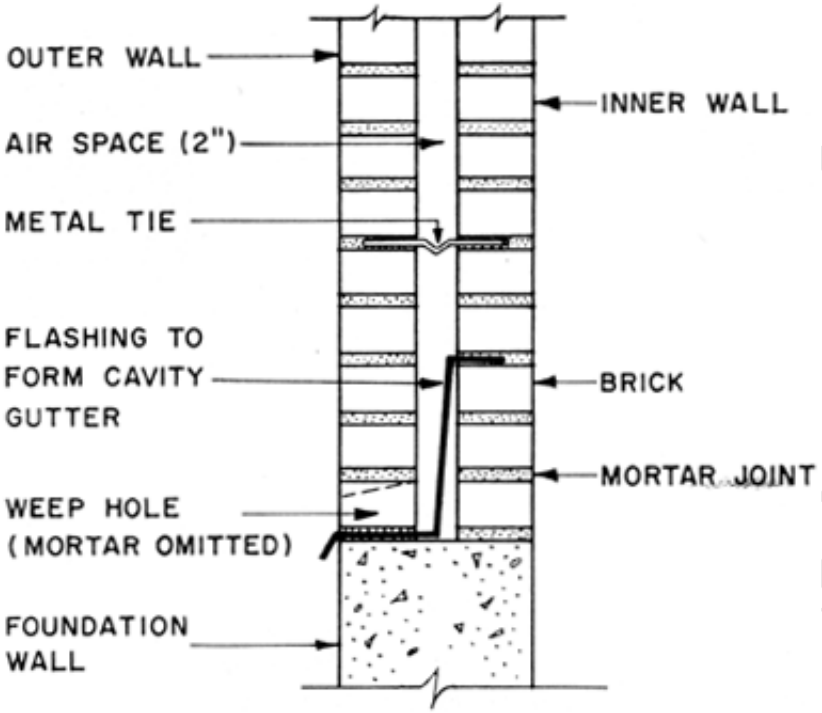
Total Cost

Square Foot Cost $ ____ / ____ S.F. = ____ $/S.F.

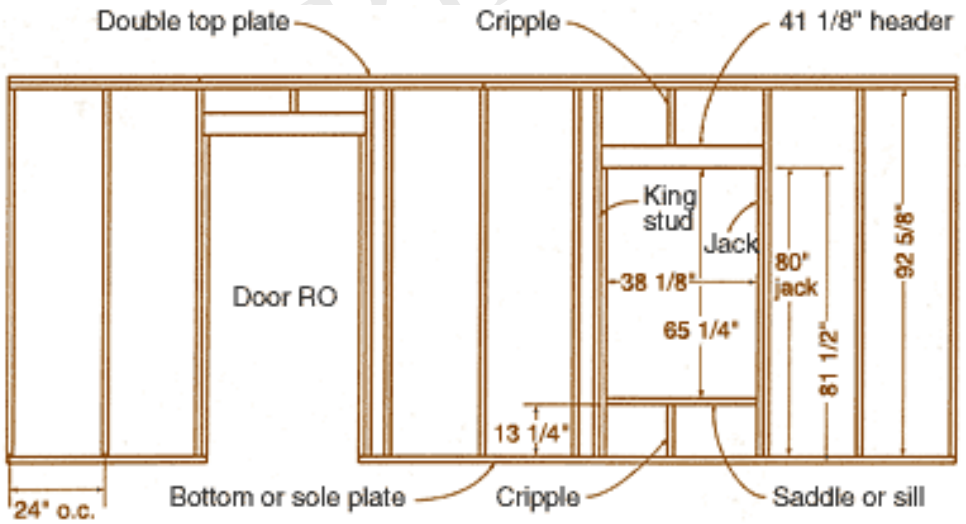
Cubic Foot Cost $ ____ / ____ C.F. = ____ $/C.F.

Common types of estimates – Assemblies (systems) estimate

- See File #4



Support of Cavity Wall



Stud Wall

Other types of estimates – Production function

- **In construction**, the **production function** may be expressed by the **relationship** between the **volume of construction** and a **factor of production** such as **labor**.

- A **production function** relates the **amount** or **volume** of **output** to the **various inputs** of **labor**, **material** and **equipment**.
  - For example, the **amount of output Q** may be derived as a **function of various input factors x1, x2, ..., xn** by means of **mathematical and/or statistical methods**.
  - The **relationship** between the **size** of a **building project** (expressed in **square feet**) to the **input labor** (expressed in **labor hours per square foot**) is an **example of a production function for construction**.

Allowances and contingency

1. ***Allowances*** may be referred to a **component of work**,

   whereas

2. ***Contingency*** may be referred to the total project cost or an **aggregated control account**.

❑ The **quantity of the allowance** depends on the phase of the **project and scope definition**.

- ❖ For **conceptual estimates**, a **higher allowance**
- ❖ For a **detailed design phase**, a **lower allowance.**

✓ Generally, **allowances** are based on **historical data** and **vary from organization to organization.**

✓ **Contingency** is based on **risk assessment**

Allowances and contingency

CONTINGENCY

- In **most construction budgets**, there is **an allowance** for **contingencies** or **unexpected costs** occurring **during construction**.
  - May be included **within each cost item or a single category**
- The **amount** of contingency may be **based** on **historical experience** and the **expected difficulty** of a **particular construction project**.
  - For example, one construction firm makes estimates of the **expected cost in five areas**:

- Design development changes,
- Schedule adjustments,
- General administration changes (such as wage rates),
- Differing site conditions for those expected, and
- Third party requirements imposed during construction, such as new permits.

Methods of Construction Estimating During Project Life Cycle

Estimates during the life cycle of the project

The Life Cycle of the Construction Project						© Ray Lemming	
TIMELINE	Start---->----->----->---->	----->----->----->---->	----->----->----->---->	----->----->----->---->	----->----->----->---->	----->----->----->---->	Finish
Phase	Decision to Build	Schematic Design	Preliminary Design	Final Design	Bid	Construction	Post Construction
Estimating	Wish Price	Parametric Est. (Square Foot Estimate)	Initial Line Item Est.	Final Line Item Est (Engineer's Estimate)	Contractor's Bid Est.	Change Order Est.	Forensic Est.
Contingency	50-100%	30-40%	20-30%	10%	0%	0% (Owner budgets contingency for Change Orders)	0%

Critical factors for profitable projects

Halpin

Within the project format, there are a number of issues that are critical to making a given job profitable:

- Tracking costs to date is one of the primary jobs of a successful project manager.
- On more sophisticated projects, finding the earned value to date is essential to avoiding cost overruns.
- Projection of profit to date, based on revenues and costs to date allows the PM to assess the profitability of the project.
- Actual costs must be compared to budgeted costs in order to determine whether the project is on the cost profile originally predicted.
- A viable cost control system must be developed to ensure the early detection and assessment of financial problems on the project.
- An effective cost control system must be able to detect and reflect both profitable and negative cost trends.
- A good cost control system can be the basis for accurate calculation of unit costs, which can be used for pricing future work.

Critical factors for profitable projects

In construction, the price and revenue from the project are effectively fixed at the time the bid is quoted and accepted. Therefore, decisions, regarding pricing and profit are agreed to by the client and the contractor prior to beginning construction.[1] Since the price and levels of expected revenues are, as a practical matter, fixed when the bid is accepted, construction project managers are primarily involved with management and control of costs. The quoted price cannot be changed or renegotiated unless major deviation from the conditions, as shown in the contract documents, can be established.

Once the bid price is accepted by the client, project managers are focused on cost control. The lower the cost, the greater the profit generated on a given project. Pricing is subject to very little variation. Therefore:

Project Profit = Bid Price as adjusted (Fixed) − Cost of Work (Variable)

[1] Certain contracts (Unit price, Cost plus, etc.) do provide for small adjustments based on field conditions and quantities installed.

Estimates for pre-design and design phases

- **Decision to build === "Order of magnitude" used for:**
  - Wish price, or
  - Screening estimate, or
  - Analogous estimate

  ✓ At the **very early stage** of the project, **before** the facility is **designed**

Estimates for pre-design and design phases

- **Schematic design === "SF foot estimate" used for:**
  - Parametric estimate, or
  - Preliminary estimate, or
  - Conceptual estimate

  - ✓ When the **conceptual design** of the facility **prepared**
  - ✓ When **basic technologies** for the design are **known**
  - ✓ **Requires** a **clear understanding** of **owner's requirements**

Estimates for pre-design and design phases

- **Preliminary design === "Unit price" or "Assemblies" used for:**
  - Initial line item estimate, or
  - Detailed estimate, or
  - Definitive estimate

    - ✓ When the **scope of work** is **clearly defined** and the **detailed design** is **in progress** so that the **essential features** of the facility are **identifiable**.
    - ✓ Begins with the **physical quantities** (**quantity take-off**)
    - ✓ **Detailed estimate** is often **used** as the **budget estimate**
      - ✓ Since it is **sufficient definitive** to reflect the **project scope** and is available long **before** the **engineer's estimate**

Estimates for pre-design and design phases

- **Final design === "Unit price" used for:**
  - Final line item estimate, or
  - Engineer's estimate

  ✓ Based on the **completed plans** and **specifications** when they are **ready** for the owner to **solicit bids** from **construction contractors.**

References of cost estimating and budgeting

For more information, please see the webinar that was held in Farvardin 1399

https://dralavipour.com/applied-tutorials/show/web12

- CMAA Cost Management Guideline
- AACE International Recommended Practice 18R-97
  - **RP 18R-97** – engineering, procurement, and construction for the process industries (**EPC projects**)
- AACE International Recommended Practice 56R-08
  - **RP 56R-08** – for the building and general construction industries
- ARCADIS Guideline for cost estimating and budgeting

Estimates for bidding, construction, and post-construction phases

- **Bidding === "Unit price" used for:**
  - Contractor's bid estimate

  - ✓ A **bid estimate** submitted to the **owner** either for **competitive bidding** or **negotiation**
  - ✓ **All field supervision** items and **profit and overhead markup** should be included
  - ✓ **GC** may ask **SC** to **bid** for special work.
  - ✓ The **plans** and **specs** provided by **owner** used to **estimate the cost**.

Estimates for bidding, construction, and post-construction phases

❑ Construction:

- ❖ Change order estimate
- ❖ Estimates for claims
- ❖ Control estimate

- ✓ **Bid estimate** used to calculate **change orders**
- ✓ For **contractor**, the **bid estimate** is used as **budget estimate** to **control cost, committed and non-committed costs** and **financing**
- ✓ For the **owner**, **detailed estimate** used to control **financing**

Estimates for bidding, construction, and post-construction phases

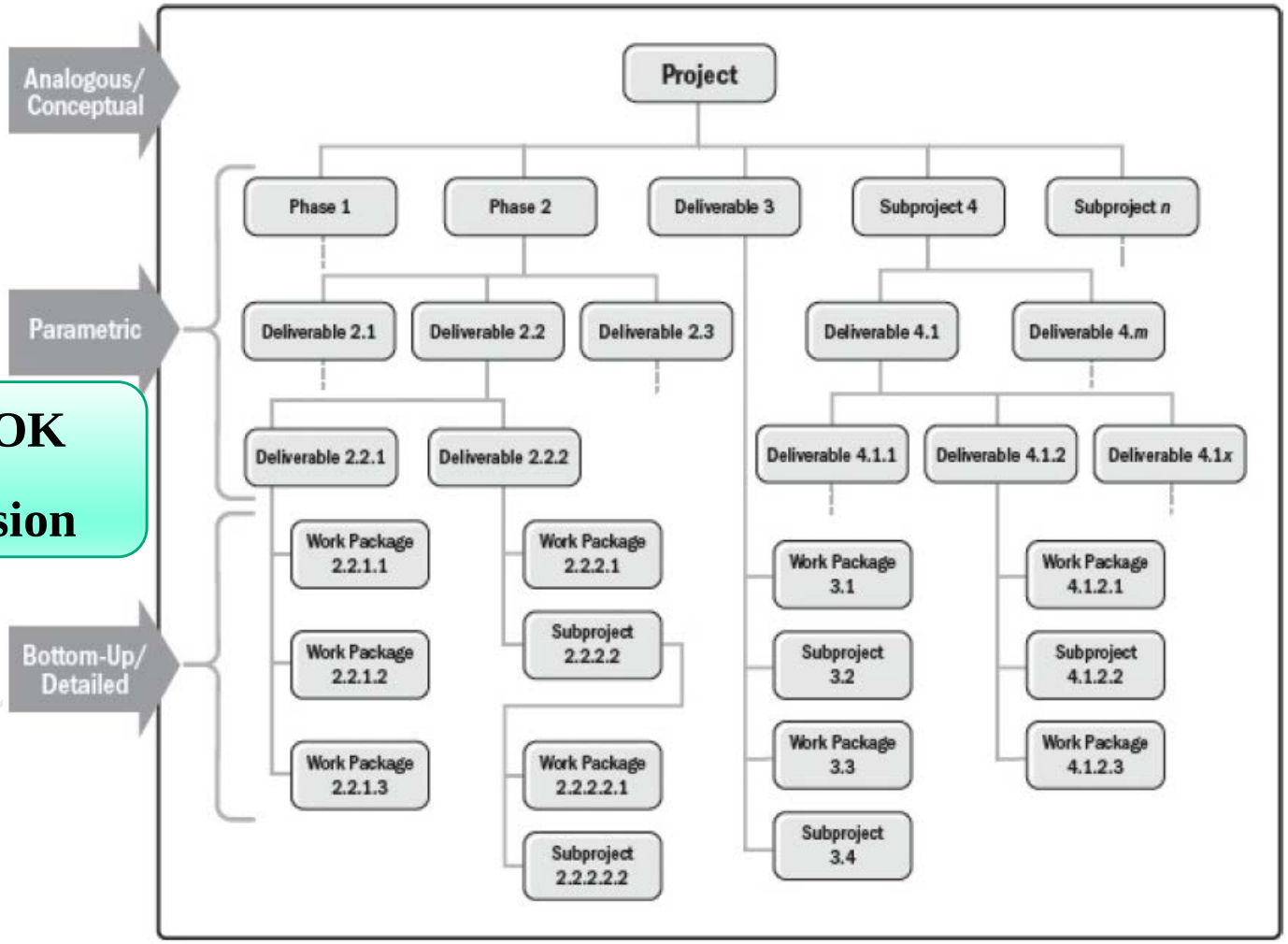
- **Post-construction:**
  - Forensic estimate

✓ A **process** of **identification**, **quantification**, and **pricing** of **each element** of **damages** that either a **contractor** or an **owner** might **assert** against the other party.

We will teach this in DELAY ANALYSIS COURSE

Estimates for bidding, construction, and post-construction phases

PMBOK Extension



Sample Construction Estimating Techniques Using WBS

Types of Construction Costs and Details of Estimating

Types of costs

Halpin

Contractor-incurred costs associated with the construction of a given facility relate to:

1. Direct cost consumed in the realization of a physical subelement of the project (e.g., labor and material costs involved in pouring a footer).
2. Production support costs incurred by project-level support resources or required by the contract (e.g., the superintendent's salary, site office costs, builder's risk insurance, etc.).
3. Costs associated with the operation and management of the company as a viable entity (i.e., *General and Administrative "G & A" costs*) such as the costs associated with preparation of payroll in the home office, preparation of the estimate, marketing, and salaries of company officers.

The production support costs are normally referred as *project indirect costs* or *field overhead*. G & A costs are also referred to as *home office* overhead. All of these charges must be recovered before income to the firm is generated.

Types of costs

- **Direct Cost**
  - Material (**fixed cost**)
  - Subcontractor (**fixed cost**)
  - Labor (**variable cost**)
  - Equipment (**variable cost**)
- **Indirect cost**
  - **General overhead** or **home-office overhead** or **company overhead**
    - ✓ **Fixed overhead cost**
  - **Project overhead** or **job overhead**
    - ✓ **Fixed or variable overhead cost**
      - o Cost of bonding (fixed)
      - o Mobilization (variable)

How are they related?

Types of costs

Len Holm

Revenue = Cost + Profit
Construction cost = Direct cost + Indirect cost
Direct cost = Labor + Material + Equipment + Subcontractors
Indirect cost = Jobsite general conditions + Home office general conditions

What factors affect on estimating?

Project time schedule

- **Project schedule** is needed for **estimate, why?**
  - **Project overhead** (travel, storage fees, testing and inspection, etc.)
  - **Time available** for **resources**
  - **Weather** to be anticipated. This offers a basis for decisions regarding:
    - Equipment and labor **productivity**,
    - **Cold weather** operations,
    - Need for **multiple shifts overtime**, and
    - Etc.

Since many of these costs of a project are a direct function of the amount of time required to complete the project, a reasonably accurate estimate should be made of the project duration.

It is indeed foolish to prepare an estimate without preparing a schedule

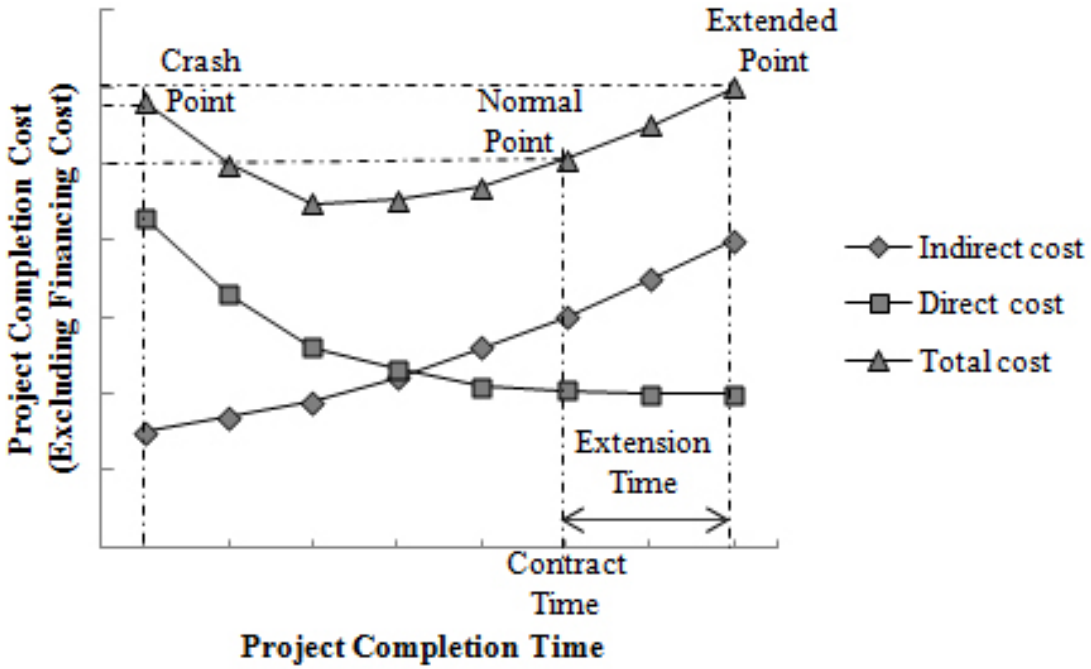
Project time schedule

- **How to do it?**

1. **Divide** the project into **major segments**
2. **Estimate** the **time** for each of these **segments**
3. Establish the **sequence**
4. The result is a **bar cart** that shows the **start** and **finish dates** for the overall project and the **approximate calendar times**.

For many **overhead items**, it is **essential** that an **accurate estimate** be made of the **project duration**. Thus, it is important that **some effort** be **expended** on **scheduling** a project **as the quantity estimate is performed**.

Time-cost tradeoff



How to start estimating?

Construction estimate

Halpin

Project cost control starts with the estimate prepared to support submittal of a bid for any given project. In order to bid on a job, an estimate of all direct, indirect, and home office overhead costs for the project is prepared. The line items and quantities required to complete the project are estimated ("taken off") from its plans and specifications. The total cost associated with each direct cost line item is the product of its quantity times its unit cost. Ideally, unit costs are based on data from past projects of a similar nature performed by the company.

What should be done next?

ACEMI

Construction estimate

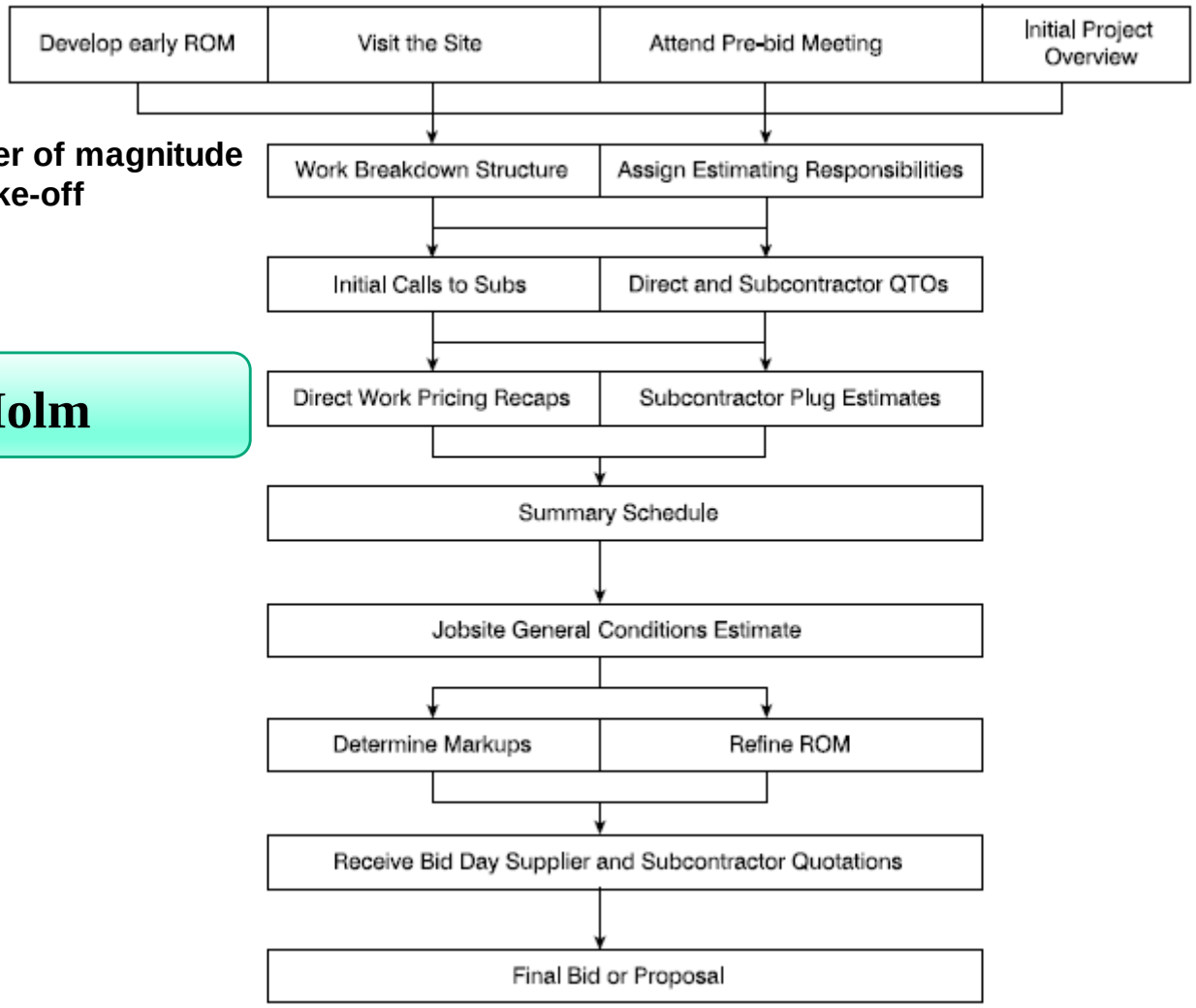
Halpin

The line items in the estimate can be referred to as estimating accounts. The costs developed during the estimating period form the basis of the project budget, which consists of cost accounts establishing target values and cost goals for the project.

When the estimate of costs is distributed across the life of the project by plotting cost amounts during each period of the project against time, the cost estimate is transformed into a time-scaled budget. The budget also reflects corrections and refinements made to the estimate following acceptance of the bid and prior to commencement of the work. There is normally a one-to-one relationship between the estimating accounts in the estimate and the cost accounts in the project budget. The costs developed during the estimating phase are transferred to the budget and represent target values against which field costs and performance can be measured.

What is the process of estimating?

Construction estimate – Estimating process



ROM = Rough order of magnitude
QTO = Quantity take-off

Len Holm

Why WBS is important?

Construction estimate – WBS importance

Len Holm

The work breakdown structure (WBS) for the project is an early outline of the significant work items that will have associated cost or schedule considerations. This includes scopes of work such as concrete walls, exterior paving, ceramic tile, electrical, etc. Before detailed take-offs and pricing are prepared, the estimator should develop this general picture of all of the work that will be included on the WBS. One of the first steps in the estimating process is to perform a brief document overview. The estimator should slowly leaf through the drawings and specifications and develop a good understanding of the type of project and the building systems that are included. The estimator should not start quantifying or pricing any work items until this overview is complete.

How to start with WBS?

Construction estimate – WBS importance

. This early WBS is not to be considered a final product, just a good first step. Cost codes are a theme throughout this study of accounting and financial management and the WBS is a good place for the estimator to start using them – even if only with two-digit Construction Specifications Institute (CSI) divisions or six-digit specification sections. The WBS will continue to evolve throughout the estimating, scheduling, and subcontract buyout processes. As the estimator dives deeper into the project, there will be several more detailed subsequent levels of the WBS.

Len Holm

Evergreen Construction Company
Work Breakdown Structure

Olympic Hotel and Resort

CSI	Description
2	Demolition
3	Concrete
4	Masonry
5	Structural Steel
6	Carpentry
7	Waterproofing
8	Doors and Windows:
	Windows:
	Storefront Windows
	Punch Windows
	Door Relites
	Un-framed Mirrors
	Doors, Frames, and Hardware:
	Door Frames:
	HM Door Frames
	Grout HM Frames
	Wood Door Frames
	Aluminum Door Frames
	Door Leafs:
	HM Door Leafs
	Solid Wood Leafs
	Hollow Wood Leafs
	Pocket Doors
	Plam Door Leafs
	Bi-fold Doors
	Door Hardware Sets
	Access Doors
9	Finishes
10	Specialties

Continued....

How about construction tasks?

Construction estimate – Tasks

Len Holm

Construction tasks which are to be self-performed will require a more intense quantity take-off and pricing effort. It is appropriate at this early work breakdown structure phase for the estimator to separate direct versus subcontracted scopes of work.

The work breakdown structure, if properly developed including sufficient detail and cost codes, can also function as a preliminary 'bill-of-materials' from which the superintendent and cost engineer can issue short-form purchase orders and place material orders.

So, what should be done next?

Construction estimate – Quantity take-off

After the work breakdown structure is developed, the estimator takes material quantities directly off the drawings. The estimator prepares quantity take-offs by conducting detailed measurements and counts of each item of work that the team selected to be self-performed.

Evergreen Construction Company
Quantity Take-off Sheet

Project:	Olympic Hotel, Job #422						Date:	03/25/2019
Owner/Loc:	NW Resorts, LLC						Estimator:	Chris Anderson
							Est #:	1
Div #:	05, Structural Steel							
Ref	Description	Qty (ea)	L (ft)	W (ft)	H (ft)	Total LF	#/LF	Total #
S2.1	Columns: 6 x 6 x 1/2" HSS	40			12.5	500	35.24	17,620
S2.4	Girders: W24 x 30	24	30			720	30	21,600
S2.4	Lintels: 6 x 6 x 1/2"<	48	30			1,440	19.6	28,224
	Total Members:	112	Ea					
	Total Weight							67,444
	Add 10% for Gussets and Plates							74,188
	= Tons @ 2000 #/Ton							37.1
								Tons
Notes:	Miscellaneous steel and metal decking are quantified on separate QTO sheets,							
	Anchor bolt QTO with foundations, Steel safety cable QTO with rough framing							

Len Holm

How to develop QTO of subcontracted work?

Construction estimate – Quantity take-off

Len Holm

Quantity take-off sheets for subcontracted work are prepared similarly, but by system or assembly and need not be as detailed as that of the general contractor's direct work. For example, the GC will take-off sheetrock walls, including metal studs and taping, by the square foot or linear foot of wall system, and not independently quantify sheets of drywall, metal studs, and taping mud. Order-of-magnitude (OM) estimates will be developed for subcontracted work to be replaced later when competitive quotes are provided by the subcontractors.

How to develop estimating and pricing for each cost types?

Direct cost – Material

- Include **every thing** that becomes a **part** of the **finished structure**.
- From a **variety of sources**, but the **usual procedure** is to purchase the materials from a **standard source.**
- **Sometimes** the **contractor produces** its **own materials**.
  - The **cost of production** should be calculated. For example, **aggregate** for **highway project**.
    - ✓ Costs of **drilling**, **shooting**, **crushing**, **screening**, and **stockpiling** should be considered in **material cost**.
- **Not unusual** for the **bidding documents** to provide that **certain materials** will be supplied by the **owner** to the **contractor at no charge.**
- **All other costs associated** with such materials, such as **handling**, **storage**, and **installation expense**, must be **included**.

Direct cost – Direct Labor costs

- From the **production rate** and **basic wage rates**.
- Do **not** include **indirect labor costs**.
- One of the **two largest areas** of **uncertainty**.
- **No single correct method:**
  - Labor production rates can be expressed in a **variety of ways**:
    1. **Man-hours** or **crew-hours** required to accomplish **a unit**

Example: Each 1 m3 concrete needs 2 man-hours === we have to perform 10 m3 === we pay $3 per hr to each man

========== 3 $/man-hr × 10 m3 × 2 man-hrs/m3 = $60

Direct cost – Direct Labor costs

2. **Number of units** of work **accomplished** per working **day** by:
   - A worker or
   - A crew or
   - Total man-hours or
   - Total crew-hours

Example: A worker accomplishes 5 m3 concrete each day === we pay $24 to each worker each day ===we need to perform 10 m3

========== $24 / day × (10 m3 / 5 m3 / day) = $48

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Direct cost – Direct Labor costs

- **Difficult** to determine **because** of **productivity rate**
  - May **obtain** productivity rate from:
    1. **Similar projects**, but should include factors.
    2. **Published sources**, but should include factors.
  - Differs from one **geographical location** to another, variable with **season**, etc.

- **To do the best job, must:**
  - Detailed quantity takeoff,
  - Job conditions
  - Construction methods
  - Comprehensive library of:
    1. **Costs**
    2. **Productivity rates**

Direct cost – Direct Labor costs

PMBOK Extension

Example of Direct Labor Hours

			A	B	C	C	E = A + B + C + D
Item Description	Quantity	Unit	Prefabrication Hours	Module Assembly Hours	Direct Field Hours	Subcontractor Field Hours	TOTAL Hours
Piling		EA					
Site Prep/ Earthworks		CM					
Concrete		CM					
Steel		MT					
Buildings		EA					
Equipment		EA					
Piping		LM					
Electrical		LM					
Instrumentation		EA					
Painting		SM					
Insulation		LM					
Scaffolding		Lot					
Freight/Module Shipping		Lot					
DIRECT FIELD HOURS TOTAL							

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Indirect Labor costs

- **Additional costs** to the basic **hourly rates** and are paid by the **employer.**
  - Employee benefits, insurance, taxes, etc.
- **Substantial in amount**, usually adding **25 to 50 percent** to **direct payroll costs.**
- **How to estimate? Two** different **approaches:**
  1. **Integrate** direct and indirect labor costs, however, **not recommended** because:
     - Accounting system
     - Cash flow model
  2. A **commonly used approach** is to add the proper **percentage** allowance
     - ✓ Either for the entire project or
     - ✓ For each major work category

Compute indirect labor cost at the same time that direct labor expense is obtained on the summary sheets

Direct cost – Equipment

- Like those of **labor**, are **difficult** to evaluate with any **exactness.** It is better to divide the estimate into **two categories**:

1. **Major items** such as **earth-moving machine** and **concrete plants** need **detailed studies**
   - For major equipment, **size**, **type**, and the necessary **units provided** to the **project** and **activities** (**number of hrs.** will be used) should be known.

2. **Minor items** such as **power tool** and **concrete vibrators** does **not need detailed studies**
   - **Allowance** can be used as a **small percentage** of the **total direct labor cost** for **small equipment** such as **hand tools**, **water hoses**, etc., and included on the **project overhead**

Direct cost – Equipment

- If the **equipment** is **purchased** for the **project** and **will be sold** at the **end**, the **difference** between the **purchase price** and the **estimated salvage value** is entered as **project overhead**.
- Both **cost of ownership** and **operating** should be considered.
  1. **Ownership expense** is **fixed** and **includes** depreciation, interest on investment, taxes, insurance and storage
  2. Equipment **operating costs include** fuel, oil, grease, filters, repairs and parts, tire replacement and repairs, and maintenance labor and supplies

Direct cost – Equipment

- **Some contractors** consider **labor associated with equipment** as a **labor expense**, **others** include as a **part of the equipment operating expense**.
  - **Recommended** to include equipment **operators' wages** as **labor cost** and not part of equipment expense.
    - ✓ It is **different** than **labor cost for repairs**.

Why?

Direct cost – Equipment expense

- **Similar** to the **direct labor cost**, but **equipment production rates** and **hourly equipment costs** should be considered.
  1. **Power shovels** and **tractor-scrapers** are examples of equipment for which the **costs** are **usually** expressed in terms of **hourly rates**.
  2. The costs of **some classes** are frequently expressed **per unit** of **product produced**.
     - ✓ **Portland cement concrete** mixing plants and **asphalt paving plants** are familiar instances of this expense.
- ❖ **Ownership, lease, or rental expense** is **combined** with **operating costs**

Direct cost – Equipment expense

3. If **support equipment** is involved, such as an **air compressor** or **light plant**, **production rates** do **not apply**, and therefore

   ownership and **operating costs** are instead expressed on a **weekly** or **monthly** basis.

   ❖ In this case we multiply **$/week** by number of **weeks** the equipment will be used.

4. **Move-in**, **erection, dismantling**, and **move-out expenses**, also called **mobilization** and **demobilization** costs, are **independent of equipment operating time** and **production**, therefore

   are **usually not included** in **equipment hourly rates**.

   ✓ They are **often included** as an item of **project overhead**.

Let's look at equipment cost and production rates.

Direct cost – Equipment cost

- The **standard method** of computing future equipment expense is through the **use of historical equipment cost records**
  - Equipment ledger

- **Manufacturers**, **equipment dealers**, and a **large assortment of publications** offer **data** for **ownership** and **operating** costs.

- For **estimating equipment costs an** excellent reference is:
  - **RENTAL RATE BLUE BOOK**, published by EquipmentWatch (online database available) – **File #5**
    - ✓ https://equipmentwatch.com/blue-book-cost-recovery/

Direct cost – Equipment production rates

- Are **influenced** by a host of **job conditions**.

Climate, altitude, weather, job location and conditions, operator skill, field supervision and other factors should be considered.

- Some **equipment production rates** must be computed using **specific job conditions** such as **haul distances**, **grades**, and **rolling resistance**.
- The **most reliable sources** are **production records**.
- There are **many published sources** of information concerning **average equipment production rates**.
- **Stopwatch "spot checks,"** made to ascertain the **productivity** of specific equipment items, **can be of value**.

Direct cost - Subcontractor

- **Proposal** is important

- Frequently, between **70 and 85 percent** of the dollar **value** of **building construction** is performed by **subcontractors**.

- Unfortunately, **many** of these **bids** may **not be submitted** to the **general contractor** **until late** in the bidding period, a factor that makes it **difficult** to **study and analyze** them.

- The submission of **written quotations** by subcontractors, with **sufficient time** to **allow** the **general contractor** to **analyze** the bids, is to be **preferred**.

Indirect cost – Project overhead

- Job or field overhead

- **How to estimate?**
  1. **Percentage of the total direct cost**
  - **Not recommended** because:
    - ✓ **Different projects** can and do have widely varying job overhead **requirements**.
  - Common values range from **5 to 15 percent**.

  2. **Detailed analysis**
  - The **only reliable way**
  - **List** and **price** each item on a **separate overhead sheet**. Examples:
    - Salaries (project manager, project engineer, field engineer, etc.)
    - Equipment costs (fax machines, automobiles, air compressors, etc.)
    - Reporting expenses (CPM schedules, progress reports, photography, etc.)
    - Testing and inspection (concrete, load, steel, etc.)
    - Communication costs (radios, telephone, mobile, etc.)
    - Supplies (stationary, drinking water, ice, file folders, etc.)
    - Other (travel, storage fees, data processing, etc.)

Indirect cost – Project overhead

Project Overhead Estimate

Job: Highway Bridge — Estimator: GAS

Overhead Item	Calculations	Amount	Totals
Project manager	$5,500 x 3.5 mo x 0.5 time =	$9,625.00	
Project superintendent	$5,000 x 3.5 mo =	$17,500.00	
Utilities			
Electricity	$225 / mo		
Telephone	$350 / mo		
Fax	$100 / mo		
	$675 / mo x 3.5 mo =	$2,362.50	
Utility installation charges	(job)	$1,520.00	
Facilities			
Job office	$350 / mo		
2 ea. tool sheds	$600 / mo		
Toilet	$125 / mo		
	$1,075 x 3.5 mo. =	$3,762.50	
Travel expense	$212 / wk x 15 wk =	$3,180.00	
Water tank & water service	$80 / wk x 15 wk =	$1,200.00	
Soil & concrete testing	$600 / mo x 3.5 mo =	$2,100.00	
Scaffolding	$480 / mo x 1 mo =	$480.00	
Trash removal	$190 / mo x 3.5 mo =	$665.00	
Tire repair	$100 / mo x 3.5 mo =	$350.00	
Photographs	$130 / mo x 3.5 mo =	$455.00	
Computer	$140 / mo x 3.5 mo =	$490.00	
	Subtotal of time-variable overhead expenses =		$43,690.00
Surveys	(job)	$1,600.00	
Project insurance	(job)	$1,164.00	
First aid	(job)	$220.00	
Sign	(job)	$570.00	
Reproductions	(job)	$400.00	
Fence	$2.00 / ft x 680 ft =	$1,360.00	
Move in	See calculations, Appendix A	$14,155.20	
Clean up	See calculations, Appendix A	$6,709.20	
	Subtotal of time-constant overhead expenses =		$26,178.40
	Total project overhead =		**$69,868.40**

I will add one important update here next year!
DON'T WORRY
Association members will have it

Indirect cost – Mobilization

- **Mobilization** cost includes those costs that are necessary for the **movement** and **communication** of **personnel**, movement of **equipment**, **supplies**, and **other facilities** required for work to **begin on the job site**.

- The **mobilization** cost is:
  - The percentage of (direct cost + project overhead cost) or
  - It is calculated in details

Indirect cost – General overhead

- **Home-office overhead** or **company overhead**
- The general overhead budget is a **plan of all expenditures** for the company that **cannot be billed to a project**.
- **Experience** has shown that **companies** that use **sound budgeting principles** to **manage** their **general overhead** are **more profitable** than companies that do not.
- These costs tend to be **constant over the duration** of a **project** since, for instance (e.g., **Rent of the office**)

Indirect cost – General overhead

- Just as a **project manager tracks** and **manages project costs**, the **general manager** needs to **track** and **manage** the **general overhead costs**.

- A **general overhead budget** is also needed to prepare the **company's annual cash flow projection**.

- Like a project budget, the **general overhead budget** should be **broken down** into a number of categories.
  - **Enough detail** to **track** and **manage** costs
  - Should **not** have **so much detail** to spend **a lot of time** (e.g., office labor costs)

Indirect cost – General overhead

- The categories included in a **general overhead budget** will **vary** from company to company. The following is a **list** that could be included in a general overhead budget:

- Advertising, bank fees, car and truck expenses, charitable contributions, computer and office furniture, depreciation (related to office), dues and memberships, employee wages and salaries, employee benefits, employee retirement, employee recruiting, employee training, employee taxes, insurance (vehicle insurance should be included in the car and truck expenses), interest expense, janitorial and cleaning, legal and professional services, meals and entertainment, office supplies, office purchases (office spaces), office rent, office utilities, postage and delivery, promotion (to promote the company, branding costs), publications and subscriptions, repairs and maintenance, taxes and licenses, telephone, travel, unallocated labor (on a project but are not billable to a project), unallocated materials (purchased for a project but are not billable to a project, inventory shrinkage due to theft or damage), miscellaneous.

- **If** these costs are **specific to a single project**, they should be **billed to the project rather than** to the **general overhead**.

Indirect cost – How to estimate general overhead?

- **Usually** ranges from **2 to 8 percent of a contractor's annual business volume**
- **How?**
  1. **Actual general overhead** calculated for the **current year**
  2. The **volume** of the work and **activities** determined for the **next year**
  3. **Costs** calculated for **each item**
     - **Historical costs** are used as the **best source**
     - When **multiple years** of data is available, **trend analysis** may be used to **project future costs**. **Trend analysis** involves:
       1. **Determining** the **annual inflation rate** and **changes** in the **market**
       2. **An initial cost** using **exponential regression**

Indirect cost – How to estimate general overhead?

- To accurately **project** and **control** costs, the **general overhead budget** must be estimated **line by line**.
  - By doing this, **managers** are **forced** to **look** at **each line item** and **estimate** how their **goals**, the **market conditions**, and **inflation** **affect** **each line item**.

- **Monthly budget** is much **more better** to **measure** the performance against and **more accurate** to **forecast** **company cash flow**.

Indirect cost – Sample of general overhead

12/14/04 Page 1

EXPENSE REPORT

From 12/1/03 to 11/30/04

Ck Num	Date	Payee	Account	Amount
5068	01/14/04	Gas Company	Office Utilities	137.18
5069	01/14/04	Power Company	Office Utilities	66.44
5079	02/13/04	Gas Company	Office Utilities	190.35
5080	02/13/04	Power Company	Office Utilities	66.05
5088	03/12/04	Gas Company	Office Utilities	162.82
5089	03/12/04	Power Company	Office Utilities	66.47
5099	04/09/04	Gas Company	Office Utilities	128.17
5101	04/09/04	Power Company	Office Utilities	53.18
5113	05/15/04	Power Company	Office Utilities	56.50
5115	05/15/04	Gas Company	Office Utilities	96.71
5123	06/09/04	Power Company	Office Utilities	48.54
5124	06/09/04	Gas Company	Office Utilities	55.40
5137	07/14/04	Power Company	Office Utilities	62.66
5138	07/14/04	Gas Company	Office Utilities	46.44
5147	08/06/04	Gas Company	Office Utilities	28.35
5148	08/06/04	Power Company	Office Utilities	69.02
5162	09/09/04	Power Company	Office Utilities	64.42
5163	09/09/04	Gas Company	Office Utilities	31.24
5179	10/16/04	Gas Company	Office Utilities	33.46
5182	10/16/04	Power Company	Office Utilities	57.39
5234	11/05/04	Gas Company	Office Utilities	39.48
5235	11/05/04	Power Company	Office Utilities	51.02
5244	12/10/04	Gas Company	Office Utilities	65.84
5248	12/10/04	Power Company	Office Utilities	68.46
			Total	1,745.59

Utility Costs for the Last 12 Months

Indirect cost – Sample of general overhead

Item	Annual Cash Flow From Operations												
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Revenues	768,000	712,000	785,000	769,000	560,000	545,000	500,000	391,000	342,000	460,000	492,000	516,000	6,840,000
Overhead:													
Advertising	7,680	7,120	7,850	7,690	5,600	5,450	5,000	3,910	3,420	4,600	4,920	5,160	68,400
Promotion	—	—	—	—	—	—	8,000	—	—	—	—	15,000	23,000
Car and Truck Expenses	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	1,100	13,200
Computer and Office Furniture	—	—	—	—	—	—	18,000	—	—	—	—	—	18,000
Employee Wages and Salaries	22,618	22,618	22,618	22,618	22,618	22,618	22,618	22,618	22,618	22,618	22,618	22,618	271,416
Employee Benefits	750	750	750	750	750	750	750	750	750	750	750	750	9,000
Employee Retirement	679	679	679	679	679	679	679	679	679	679	679	679	8,142
Employee Taxes	2,300	2,238	2,046	1,994	1,924	1,878	1,809	1,809	1,809	1,801	1,565	1,144	22,317
Insurance	4,366	4,086	4,451	4,371	3,326	3,251	3,026	2,481	2,236	2,826	2,986	3,106	40,514
Taxes & Licenses	100	—	—	—	—	—	—	—	—	—	—	—	100
Office Supplies	500	500	500	500	500	500	500	500	500	500	500	500	6,000
Office Rent	500	500	500	500	500	500	500	500	500	500	500	500	6,000
Office Utilities	350	350	250	250	250	350	350	350	250	250	350	350	3,700
Postage and Delivery	100	100	100	100	100	100	100	100	100	100	100	100	1,200
Janitorial and Cleaning	433	433	433	433	433	433	433	433	433	433	433	433	5,200
Telephone	440	440	440	440	440	440	440	440	440	440	440	440	5,280
Charitable Contributions	—	—	—	—	—	—	—	—	—	—	—	3,000	3,000
Dues and Memberships	—	—	—	1,500	—	—	—	—	—	—	—	—	1,500
Legal and Professional Services	1,000	—	—	3,000	—	—	1,000	—	—	1,000	—	—	6,000
Meals and Entertainment	867	867	867	867	867	867	867	867	867	867	867	867	10,400
Bank Fees	50	50	50	50	50	50	50	50	50	50	50	50	600
Miscellaneous	100	100	100	100	100	100	100	100	100	100	100	100	1,200
Total Overhead	43,933	41,931	42,734	46,942	39,237	39,066	65,321	36,686	35,851	38,614	37,958	55,897	524,170

General Overhead Budget

Indirect cost – How to allocate general overhead?

- The **allowance** for **general overhead** can be added as:
  1. **A fee** for the **total project duration** in a **separate line item** or
  2. **A fee** included in **each line item**
     - ✓ For alternatives 1 and 2, allocate the general overhead cost based on **project duration** or based on the **contract price**.
       - o Calculate **average of general overhead (total divided by 12 or 52 weeks)** and multiply that by the **duration of the project** calculated **in month** (or in **week**).
         - ➢ What if the duration of the project is **less than a year**?
         - ➢ What if we perform **two projects simultaneously**?

This method of allocation can be very approximate

Indirect cost – How to allocate general overhead?

3. A suitable **"markup" percentage** can be added:
    1. Contribution margin
    2. Break-even contribution margin ratio
    3. P & O Markup

✓ Markup % = (General overhead % + profit % + contingency %)

✓ We teach you how to **calculate this %**

Markup

- Used to **cover** the **general overhead** and **contingency** for the company and provide the company with a **profit**.
  - The profit and overhead markup should **not be used** to **cover** **project overhead costs**.
- **Regarding contingency** as a **separate component** of markup is a **matter of management philosophy.**
- **Many factors** must be considered in **deciding a markup** figure.
  - The **size of the project** and its **complexity**, its **location**, **provisions** of the **contract documents**, the **contractor's evaluation** of the **risks** and **difficulties inherent** in the work, **identity** of the **owner** and/or the **architect-engineer,** and **other intangibles** can have a bearing on how a contractor marks up a particular job.

Markup

- **Many contractors** use **different markup** figures for **different projects** or even **parts of a project**.
  - For example, **contractors** commonly
    - ✓ **Apply one markup rate** to **self-performed work items** and
    - ✓ **Smaller markup** to **work that subcontracted**
  - **Not all projects** should be **bid** at the **same profit and overhead markup**.

- A company should **set a minimum profit and overhead markup** and then **increase** the markup when **conditions warrant**.

Markup

- **Project price** is frequently determined by **looking** at **current market conditions**, such as:
  - The state of the **local economy**,
  - The power of **competing contractors**,
  - The **value** of **similar contracts awarded** in **recent months**, and
  - The **number** of **bidders** on the bid list.

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Cost of bonding

- A form of **financial protection** against **contractor default**
- **Different types** of bonds
- **Many contracts**, especially public contracts
- There is a **premium** charged for bonds and **varies** with the type of work.
  - The **cost of purchasing** contract **bonds** is the **premium**.
- What **factors** affect the **premium**?
  - Duration of the project,
  - Class of construction,
  - Applicable bond rates,
  - Risks involved in the project, and
  - Total contract amount

affects the premium.

Types of Contracts & Pricing the Contracts

Engineering contracts

CII-P6-1

In industrial construction it is common for engineering, procurement, and construction to be handled in parallel and with some overlap - these are called *Engineering-Procurement-Construction (E-P-C) projects* for purposes of this publication. The engineering portion of the project may be part of a turnkey arrangement administered within a single agency or it may be handled as a separate contract that must tie-in with the contracts of others.

It is possible, however, for engineering to precede completely both procurement and construction. An engineering contract in this case is referred to in this publication as *Engineering-Only (E-O)*. The E-P-C format is the more challenging of the two from a project controls viewpoint.

What is the nature of engineering work?

Engineering contracts – Nature of engineering work

CII-P6-1

In performing its work, the engineering group is generally organized around engineering disciplines (civil, architectural, structural, mechanical, electrical, etc.) or specialty services (model shop, procurement, environmental studies, economic studies, etc.). These production units of the organization have products such as drawings, specifications, models, manuals, studies, and procurements. Supporting them are such functions as word processing, computer services, accounting, personnel, and others.

How some owners maintain this?

Engineering contracts – Nature of engineering work

CII-P6-1

In performing its work, the engineering group is generally organized around engineering disciplines (civil, architectural, structural, mechanical, electrical, etc.) or specialty services (model shop, procurement, environmental studies, economic studies, etc.). These production units of the organization have products such as drawings, specifications, models, manuals, studies, and procurements. Supporting them are such functions as word processing, computer services, accounting, personnel, and others.

How some owners maintain this?

Engineering contracts – Nature of engineering work

CII-P6-1

Some owners maintain internal organizations for accomplishment of conceptual and/or detail engineering of their facilities. But much if not most of it is handled under contract with an engineering firm. Many contracts in the latter case are reimbursable, although fixed-price contracts are becoming more common, and there are reimbursable contracts with ceilings, targets, or incentives. The typical reimbursable contract is handled in this fashion:

Let's see how reimbursable contract is managed!

Engineering contracts – Managing reimbursable contract

CII-P6-1

- Professionals within the production units are identified as reimbursable. The client agrees to pay for each hour of work of those reimbursable individuals in an amount equal to the base hourly pay of each individual times a multiplier. This multiplier is in the range of 1.5-2.5.

- Other items are identified as "reimbursable directs." These are items such as travel, reproduction, computer services, and communications. In most cases, their costs are passed through to the client without markup.

- Items such as general management, accounting, personnel services, and secretarial services are "non-reimbursable directs and indirects," and are not charged directly to the client. These costs are accounted for within the multiplier noted above. That multiplier also accounts for profit (unless the project is cost-plus) and for personnel fringe benefit costs (burden) such as vacation, medical, FICA, and retirement.

How about fixed-price or other than the reimbursable contracts?

Engineering contracts – Fixed-price contract

CII-P6-1

If the contract form is fixed-price or other than the reimbursable described above, the engineering agency still must account fully for the direct costs, project level indirects, general overhead, and any contingency and profit in the pricing.

How about construction contracts?

Construction contracts

CII RS6-5

Construction can be accomplished under several basic contracting formats. These formats create different contractual relationships and reporting responsibilities, and thus affect the project controls function.

Single General or Prime Contractor (GC). Under this form, the contract for construction is between the owner and one contractor who has full responsibility for accomplishing the construction. The GC normally has the option to use any combination of direct-hire and subcontracting desired, although the owner may establish Minority Business Enterprise or Women Business Enterprise (MBE/WBE) goals or reserve the right to approve all subcontractors and major vendors. The contract can be either fixed-price (lump sum, unit price, or combination thereof) or reimbursable. Special features such as a guaranteed maximum cost and incentive features such as target cost or work-hours with shared savings/penalties, milestone bonus/penalties, or other performance bonuses also may be included. The GC will be responsible for establishing and operating the project controls system. Under both forms, the owner can be expected to require submission of a schedule for the project and there must be some agreed-upon mechanism established for progress payments. If fixed-price, the information provided the owner is normally limited to that needed to verify physical completion and schedule status.

Construction contracts

CII RS6-5

Multiple Primes. This format is quite common on large projects that are managed by a construction manager (CM), with the CM function being handled by the owner or some agency under contract to the owner. The project is divided into major components such as site preparation, foundations, structural steel, and major piping, and separate contracts are awarded for each component. The contracts may be between the owner and the contractors or between the CM and the contractors. The administration of these contracts is essentially the same as for the GC format except that the individual contractors report directly to the CM. Normally, the CM will establish the overall project controls system and require the individual contractors either to operate within that system, which is operated as a network, or to provide information to the CM's project control staff in specified formats.

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Construction contracts

CII RS6-5

Turnkey. This format refers to a project wherein total management of engineering, procurement, and construction is given to one firm by the owner. That firm may choose to handle all functions using its own resources or may subcontract portions of the total to the others. Some turnkey projects are totally reimbursable. Others have certain portions reimbursable, usually engineering and procurement, with construction negotiated on a fixed-price basis after engineering definition is complete enough to permit this. The turnkey contractor will establish and maintain a project controls operation that integrates all activities.

Construction contracts

CII RS6-5

Owner as General Contractor. Occasionally an owner will maintain a project management staff that directly manages company projects by using some combination of direct-hire and subcontracting. Included will be an owner-operated project controls system.

The CII publication, *Impact of Various Construction Contract Types and Clauses on Project Performance*, provides additional information on contracting formats.

Bid price

Len Holm

Pricing

There are several methods for pricing contracts used in the construction industry but four are the most prevalent and others are hybrids of these four. The choice of which to use on any particular project is made by the owner after analyzing the risk associated with the project and deciding how much of the risk to assume and how much to pass on to the contractor. Contractors want compensation for risk they assume and usually do so with increased fees or estimating contingencies. The most common pricing methods include:

- Lump sum (LS),
- Unit price,
- Cost plus fixed fee or cost plus percentage fee, and
- Cost-plus with a guaranteed maximum price (GMP).

Which one should be used?

Bid price

Len Holm

Lump sum, or stipulated sum, contracts are awarded on the basis of a single lump sum estimate for a specified scope of work. Unit-price contracts are utilized for heavy-civil projects when the exact quantities of work cannot be defined. The designer estimates the quantities of work, and the contractor submits unit prices for each work item. The actual installed quantities required are multiplied by the bid unit prices to determine the final contract price but only after project completion. Cost-plus contracts are used when the complete scope of work cannot be defined. All of the contractor's project-related costs are reimbursed by the owner, and a fee is paid to cover profit and contractor home office overhead. This is also known as a time and materials contract. A guaranteed-maximum-price contract is a cost-plus contract in which the contractor agrees not to exceed a specified cost.

Bid price

- **We review two of most common forms** of pricing that are **widely** used:
  1. Lump-sum
  2. Unit price

Bid price – Lump sum

- A **fixed price** is compiled, for which the **contractor agrees** to perform a prescribed package of work in **full accordance** with the **drawings and specifications**, **regardless** of
  - The **difficulties** and **troubles** that **may be experienced** in the course of construction activities and
  - **Even though** the **total cost** of the work may turn out to be **greater** than the **contract price.**

Bid price – Lump sum

- **Popular with owners** because the **total cost** of the project is **known in advance**. However, its use is limited, of necessity, to programs that can be:
  1. **Accurately** and **completely** described at the **time of bidding** or **negotiation**.
  2. **Nature of the work** and the **quantities** involved could be **well defined** at the **time of bidding** or **negotiation**.

- It **may** or **may not** include **quantities** but the quantities are **insignificant** because:
  - ✓ The contractor only **gives** the **fixed price** for **each item**.

Lump sum contracts are widely used for residential and building construction.

Bid price – Lump sum

❑ **How to calculate bid price in lump sum contract?**

1. **Line items** given by **A/E**
2. **Specifications** and **drawings** given by **A/E**
3. The **total quantity** of **each major work classification** given by **A/E**
   - ❖ **Lump-sum estimating** requires a **"quantity survey,"** or **"quantity takeoff."**
4. A ***SUMMARY SHEET*** for **each major work classification**.
   - ❖ Using these **work quantities** as a basis, the **contractor** computes the costs of the **materials**, **labor**, **equipment**, **subcontractors**, **overhead**, and **tax**.
5. ***RECAP SHEET*** by **adding up major work classification** in ***SUMMARY SHEET*** and **removing quantities**.
   - ❖ **Markup** and **contract bond** added and **lump-sum estimate** submitted **to the owner.**

Bid price – Lump sum

Summary Sheet

- Does **not contain** an **equipment cost column**, **although it could**.

- It is **common practice** on projects that are **bid lump-sum**, such as **buildings**, to **compute equipment costs** for the **entire project** on a **separate sheet**.

SUMMARY SHEET

Project Municipal Airport Terminal Building Work Items Concrete and Forms

Cost Account Number	Work Item	Unit	Total Quantity	Material Cost Each	Material Cost Total	Labor Cost Each	Labor Cost Total	Total Cost
240	CONCRETE							
.01	Footings	c.y.	1,040	$59.25	$61,620	$6.75	$7,020	$68,640
.05	Grade beams	c.y.	920	$63.75	$58,650	$9.45	$8,694	$67,344
.07	Slab	c.y.	2,772	$59.25	$164,241	$9.00	$24,948	$189,189
.08	Beams	c.y.	508	$63.75	$32,385	$9.45	$4,801	$37,186
.09	Bond beams	c.y.	62	$63.75	$3,953	$13.50	$837	$4,790
.11	Columns	c.y.	102	$63.75	$6,503	$13.05	$1,331	$7,834
.12	Walls	c.y.	466	$63.75	$29,708	$10.13	$4,718	$34,426
.16	Stairs	c.y.	317	$63.75	$20,209	$11.70	$3,709	$23,918
.19	Sidewalks	c.y.	320	$59.25	$18,960	$9.00	$2,880	$21,840
.20	Expansion joint	l.f.	41,060	$0.38	$15,398	$0.23	$9,239	$24,636
.40	Screeds	s.f.	148,000	-	-	$0.18	$26,640	$26,640
.50	Float finish	s.f.	22,000	-	-	$0.23	$4,950	$4,950
.51	Trowel finsih	s.f.	128,000	-	-	$0.38	$48,000	$48,000
.52	Stair finsih	l.f.	2,060	-	-	$1.58	$3,245	$3,245
.60	Rubbing	s.f.	2,530	$0.09	$228	$0.83	$2,087	$2,315
.91	Curing	s.f.	180,000	$0.06	$10,800	$0.05	$8,100	$18,900
					$422,652		$161,198	$583,851
	Indirect Labor Cost					39%	$62,867	$62,867
	Total Concrete				$422,652		$224,065	$646,718
260	FORMS							
.01	Footings	s.f.	1,220	$1.05	$1,281	$1.50	$1,830	$3,111
.05	Grade beams	s.f.	4,840	$1.20	$5,808	$1.50	$7,260	$13,068
.08	Beams	s.f.	1,965	$1.32	$2,594	$1.62	$3,183	$5,777
.11	Columns	s.f.	1,642	$1.62	$1,786	$2.99	$3,267	$5,053
.12	Walls	s.f.	3,240	$1.32	$2,852	$1.50	$4,860	$7,712
.17	Risers	l.f	910	$1.02	$928	$1.92	$1,747	$2,675
.45	Chamfer	l.f.	510	$0.12	$61	$0.12	$61	$122
.60	Oil, ties, nails	s.f.	13,443	$0.09	$1,210	-	-	$1,210
.63	Anchor slot	l.f.	2,800	$0.45	$1,260	$0.09	$252	$1,512
					$17,780		$22,461	$40,241
	Indirect Labor Cost					43%	$6,908	$6,908
	Total Forms				$17,780		$29,369	$47,149

Bid price – Lump sum

Recap Sheet

- The **costs associated** with work are **posted** from the **summary sheets** and entered in the **Material** and **Labor columns**.
- Subcontract
- Equipment costs
- Project overhead costs
- Changes, markup, bond, tax

RECAP SHEET

Project Municipal Airport Terminal Building

Work Item	Material	Labor	Subcontract	Total
1 Clearing and grubbing	$1,725	$12,930	-	$14,655
2 Excavation and fill	$21,090	$23,670	-	$44,760
3 Concrete	$ 422,652	$224,065	-	$646,718
4 Forms	$17,780	$29,369	-	$47,149
5 Masonry	-	-	$633,000	$633,000
6 Carpentry	$28,680	$20,460	-	$49,140
7 Millwork	$ 81,090	$30,317	-	$111,407
8 Steel and misc. iron	$377,835	$110,010	-	$487,845
9 Kitchen equipment	-	-	$89,972	$89,972
10 Insulation	-	-	$33,420	$33,420
11 Caulk and weatherstrip	-	-	$7,470	$7,470
12 Lath, plaster, and stucco	-	-	$255,300	$255,300
13 Ceramic tile	-	-	$29,000	$29,000
14 Roofing and sheet metal	-	-	$274,155	$274,155
15 Resilient flooring	-	-	$33,936	$33,936
16 Acoustical tile	-	-	$42,029	$42,029
17 Painting	-	-	$125,010	$125,010
18 Glass and glazing	-	-	$93,479	$93,479
19 Terrazzo	-	-	$126,162	$126,162
20 Miscellaneous metals	$91,842	$16,973	-	$108,815
21 Finish hardware	$65,400	$6,645	-	$72,045
22 Plumbing, heating, and A/C	-	-	$813,180	$813,180
23 Electrical	-	-	$508,107	$508,107
24 Clean glass	-	-	$4,200	$4,200
25 Paving, curb and gutter	-	-	$119,330	$119,330
26 Construction equipment	$84,239	-	-	$84,239
27 Job overhead	$59,325	$132,407	-	$191,732
	$1,251,658	$606,845	$3,187,748	$5,046,250
			Changes	($143,178)
				$4,903,072
			Markup, 8%	$392,246
				$5,295,318
			Bond	$49,317
				$5,344,635
			Sales tax	$160,339
				$5,504,974

Bid price – Unit price

- It is the **most accurate** and **detailed** of the **four estimate types**, and therefore takes the **most time to complete**.

- **Detailed plans** and **specifications** **must** be **available** to the **unit price estimator.**

- **Unit-price estimates** can be compiled **when** **quantities of work items** **may** not be precisely determined **but** the **nature** of the work is **well defined**.

- These **quantity estimates** are those of the **architect-engineer** and are **not guaranteed** to be **accurate**.

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Bid price – Unit price

- The **total sum of money paid** to the **contractor for each work** item **remains** an **indeterminable factor** until **completion of the project**, because **payment** is made to the **contractor based on units** of work **actually done** and **measured in the field**.

- The **owner** does **not know** the **exact ultimate cost** of the project **until completion**.

- **Unit-price contracts** offer the **advantages** of **open completion** on projects involving **quantities of work** that **cannot be accurately forecast** at the **time of bidding** or **negotiation**.

Bid price – Unit price

- With the **work quantities** obtained from the **takeoff**, the **contractor** uses the **cost summary** to obtain the **total direct costs** of the bid item.
  - The **summary sheets** for unit-price projects customarily serve for the computation and recording of **material**, **labor**, **equipment**, and **subcontract costs**.
- It should be noted that a **cost account number** identifies **each work classification** entered on the **summary**. These are the **company's standard cost account numbers** that are basic to its **cost management system**.
  - **Each estimate** is **broken down** in accordance with the **established cost accounts**.
- Most **project specification** manuals **divide all unit price** estimating information into the **MasterFormat divisions**.

Bid price – Unit price

Quantity	LineNumber	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Ext. Mat. O&P	Ext. Labor O&P	Ex Equip. O&I
295426	023154240200	Excavating, bulk bank measure, 1 C.Y. capacity = 75 C.Y./hour, backhoe, hydraulic, crawler mounted, excluding truck loading	B12A	800	0.02	B.C.Y.	$ -	$ 1.07	$ 1.05	$ 2.12	$ -	$ 316,105.82	$ 310,197.30	$ 626,303.12	$ -	$ 475,635.86	$ 342,694.

Bid price – Unit price

تاریخ :

(مبالغ به ریال) صفحه : ۹ / ۱۳۵۵

شرح ردیف :	پرکردن و کوبیدن جای ریشه با خاک مناسب در صورتی که محیط تنه درخت در سطح زمین بیش از ۶۰ تا ۹۰سانتی متر باشد.
کد ردیف	۱۱۰۱۰۱۱۴
واحد	اصله

رسته : ساختمان و ساختمان صنعتی
رشته : ابنیه
فصل : عملیات تخریب

ردیف	کد عامل	نیروی انسانی	واحد	ضریب عامل	مقدار	بهای واحد عامل	بهای کل
۱	۱۳۰۴۰۹۰۱	متصدی غلطکهای دستی	نفر – ساعت	۱	۱٫۳۶۲۰۰۰۰۰۰		
۲	۱۴۰۱۰۱۰۱	سرکارگر	نفر – ساعت	۱	۰٫۰۱۳۸۰۰۰۰۰۰		
۳	۱۴۰۱۰۱۰۲	کارگر ساده	نفر – ساعت	۱	۰٫۱۳۷۳۰۰۰۰۰۰		
		درصد به قیمت ردیف				جمع	

ردیف	کد عامل	ماشین آلات و ابزار	واحد	ضریب عامل	مقدار	بهای واحد عامل	بهای کل
۱	۲۳۰۲۰۲۰۴	کامیون کمپرسی به ظرفیت حدود ۱۰ تن با راننده	دستگاه – ساعت	۱	۰٫۱۲۶۷۰۰۰۰۰۰		
۲	۲۵۰۱۰۶۰۲	بولدوزر به قدرت حدود ۱۵۰ اسب بخار باراننده	دستگاه – ساعت	۱	۰٫۰۲۸۰۰۰۰۰۰۰		
۳	۲۵۰۱۰۶۰۳	بولدوزر به قدرت حدود ۲۰۰ اسب بخار باراننده	دستگاه – ساعت	۱	۰٫۰۱۴۲۰۰۰۰۰۰		
۴	۲۵۰۱۰۸۰۲	لودرچرخ لاستیکی به قدرت حدود۱۵۰ اسب بخار باراننده	دستگاه – ساعت	۱	۰٫۰۴۴۸۰۰۰۰۰۰		
۵	۲۵۰۳۰۱۰۱	کمپکتورصفحه ای	دستگاه – ساعت	۱	۱٫۳۶۲۰۰۰۰۰۰۰		
۶	۲۸۰۷۰۱۰۱	بیل	عدد	۱	۰٫۰۰۴۵۰۰۰۰۰۰		
		درصد به قیمت ردیف				جمع	

ردیف	کد عامل	مصالح	واحد	ضریب عامل	مقدار	بهای واحد عامل	بهای کل
۱	۳۱۰۱۰۱۰۱	آب لوله کشی شهری	مترمکعب	۱	۰٫۱۷۶۰۰۰۰۰۰۰		
۲	۳۱۰۱۰۳۰۱	آب چاه وقنات	مترمکعب	۱	۰٫۰۸۸۰۰۰۰۰۰۰		
		درصد به قیمت ردیف				جمع	

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Bid price – Unit price

- Summary sheet

SUMMARY SHEET

Project Holloman Taxiways and Aprons Bid Item No. 5 Concrete Pavement, 9 inch

Cost Account Number	Work Item	Quantity	Unit	Material		Labor		Equipment		Subcontract
				Unit Cost	Total	Unit Cost	Total	Unit Cost	Total	
250.03	Concrete, production	23,625	c.y.	$30.90	$730,013	$22.91	$541,131	$5.16	$121,905	-
254.01	Concrete, hauling	23,625	c.y.	-	-	$0.45	$10,631	$0.53	$12,403	-
258.02	Concrete, lay-down	90,000	s.y.	-	-	$1.59	$143,100	$0.74	$66,150	-
270.08	Reinforcing	50	ton	$825.00	$41,250	$525.00	$26,250	-	-	
248.20	Grooves	105,000	l.f.	$0.06	$6,300	$0.05	$4,725	$0.02	$1,575	-
240.95	Curing	90,000	s.y.	$0.15	$13,500	$0.06	$5,400	$0.008	$675	-
			Totals		$791,063		$731,237		$202,708	-
							Labor Indirect Cost, 37%		$270,558	
							Labor Cost		$1,001,795	

Bid price – Unit price

- Recap sheet

RECAP SHEET

Project: Holloman Taxiways and Aprons Bid Date: August 9, 20-- Estimator: GAS

Item No.	Bid Item	Unit	Estimated Quantity	Labor Cost	Equipment Cost	Material Cost	Subcontract Cost	Direct Cost	Bid Unit	Bid Total
1	Clearing	l.s.	job	$5,139	$11,097	-	-	$16,236	$20,125.76	$20,126
2	Demolition	l.s.	job	$5,726	$7,383	-	-	$13,109	$16,248.98	$16,249
3	Excavation	c.y.	127,000	$75,636	$175,194	-	-	$250,830	$2.45	$310,923
4	Base course	ton	79,500	$352,670	$651,995	$159,479	-	$1,164,143	$18.15	$1,443,043
5	Concrete pavement, 9 in.	s.y.	90,000	$1,001,795	$202,708	$791,063	-	$1,995,565	$27.49	$2,473,655
6	Concrete pavement, 11 in.	s.y.	115,400	$1,572,819	$318,252	$1,241,967	-	$3,133,038	$33.65	$3,883,639
7	Asphalt concrete surface	ton	150	$1,035	$1,304	$2,208	-	$4,547	$37.57	$5,636
8	Concrete pipe, 12 in.	l.f.	1,000	$5,183	$5,439	$15,477	-	$26,099	$32.35	$32,351
9	Concrete pipe, 36 in.	l.f.	300	$2,937	$3,756	$6,809	-	$13,502	$55.79	$16,736
10	Inlet	ea.	2	$111	$164	$801	-	$1,076	$666.58	$1,333
11	Fiber duct, 4-way	l.f.	600	$3,278	$10,367	$5,126	-	$18,770	$38.78	$23,266
12	Fiber duct, 8-way	l.f.	1,200	$9,035	$20,576	$16,095	-	$45,705	$47.21	$56,655
13	Electrical manhole	ea.	6	-	-	-	$9,315	$9,315	$1,924.44	$11,547
14	Underground cable	l.f.	34,000	-	-	-	$255,957	$255,957	$9.33	$317,278
15	Taxiway lights	ea.	120	-	-	-	$45,710	$45,710	$472.17	$56,660
16	Apron lights	ea.	70	-	-	-	$26,313	$26,313	$465.96	$32,617
17	Taxiway marking	l.s.	job	$3,560	$675	$4,683	-	$8,918	$11,053.92	$11,054
18	Fence	l.f.	26,000	$28,506	$7,977	$129,477	-	$165,960	$7.91	$205,720
			Totals	$3,067,427	$1,416,885	$2,373,183	$337,295	$7,194,789		$8,918,488
						Job overhead		$272,091		
								$7,466,880		
						Markup, 15%		$1,120,032		
								$8,586,912		
						Bond		$71,815		
								$8,658,727		
						Sales tax		$259,762		
						Total Project Bid		$8,918,488		

Factor = $\frac{\$8,918,488}{\$7,194,789} = 1.240$ 1.2395

Bid price – Combination of lump-sum and unit price

- There are instances in which projects are bid as a **combination** of **lump-sum** and **unit prices**.
  - An example of this is a **powerhouse**, built under a **single contract**, the **foundation** of which was bid on the basis of **unit prices** and the **structure** itself was bid **lump-sum.**
  - **Another instance** is when the **proposal form** of a building being **bid lump-sum asks** for **certain unit prices** as well.
    - ✓ This **may be done** when **some changes** to the work during the construction phase **appear likely** and **bid prices** are **requested** on a **unit basis** for the **possible later addition** or **deletion of work items**.

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Computer-based estimating

- Using **database** and **entered price** and **productivity information**, the computer produces a **total estimated cost** of the project including **overhead**, **markup**, **bond**, etc.

- There are **basically two kinds** of cost estimating systems:
  1. A server-based system,
  2. A stand-alone system

- It must be recognized that a **computer cannot** replace the **human experience**, **skill**, and **judgement** so necessary to the **estimating process**.
  - The computer **assists** but does **not replace** the estimator.

How To Prepare Cost Model?

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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