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سلايدات

تحليل كلفة

د.محمد المشاقبة

Construction Cost Analysis & Estimating – 110401543

Introduction

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- Prerequisite: Construction Project Management –110401346
- Class Hours
  - 11:30 am – 12:30 pm: Sunday, Tuesday, and Thursday
- Course Website: Microsoft Teams
- Textbook: Peurifoy, R.L., and Oberlender, G.D. (2002). Estimating Construction Costs, 5^{th} edition, McGraw-Hill, New York

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- Course Topics
  - Introduction to construction cost estimating
  - Rough cost estimating
  - Detailed cost estimating
  - Labor cost
  - Equipment cost
  - Material cost
  - Subcontractors
  - Indirect cost
  - Profit
  - Risk cost
  - Cash flow

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- Grading
  - First exam 30%
    - Date: Tuesday, 4/4. 11:30 – 12:30 pm
  - Second exam 30%
    - Date: Thursday, 4/5. 11:30 – 12:30 pm
  - Final exam 40%

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- Construction estimating: the process of calculating the costs of the various items entering into the construction work
- The estimate is an approximation of the actual costs with reasonable accuracy
- Accuracy is a function of skill and judgment of the estimator
- Skill means the use of a good estimating method
- Judgment is based on the experiences of the estimator and the ability to visualize work

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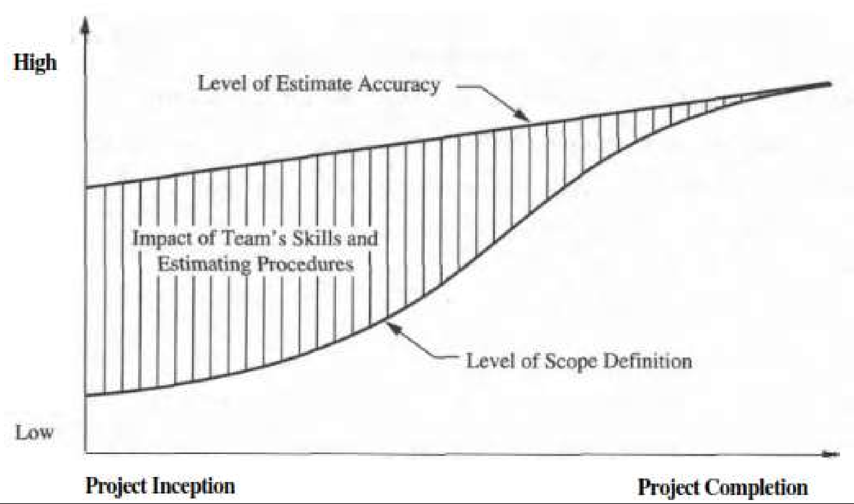
- When the level of scope definition is low. You must rely on the experience and skills of the project team to produce accurate early estimates



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- Because the estimate is prepared before the actual construction, much study and thought must be put into the construction documents
- The estimator who can visualize the project and accurately determine its cost will become one of the most important persons in any construction company

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- The competition in construction bidding is intense, with multiple firms competing for a single project
- To stay in business, a contractor must be the lowest-qualified bidder on a certain number of projects – depending on project delivery system – while maintaining an acceptable profit margin
- This profit margin must provide the general contractor an acceptable rate of return and compensation for the risk associated with the project

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- Estimating the ultimate cost of a project requires the integration of many variables
- These variables fall into either direct field costs or indirect field costs
- The indirect field costs are also referred to as general conditions or project overhead costs in building construction
- The direct field costs are the material, labor, equipment, or subcontracted items that are permanently and physically integrated into the building

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- For example, the labor and materials for the foundation of the building would be a direct field cost
- The indirect field costs are the cost for the items that are required to support the field construction efforts
- For example, the project site office would be a general conditions cost

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- Factors such as weather, transportation, soil conditions, labor strikes, material availability, and subcontractor availability need to be integrated into the estimate
- Regardless of the variables involved, the estimator must strive to prepare an accurate estimate as possible
- Since subcontractors or specialty contractors may perform much of the work in the field, the estimator must be able to articulate the scope of work in order for these companies to furnish a price quote

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- The required level of accuracy coupled with the amount of information about the project that is available will dictate the type of estimate that can be prepared
- Different types of estimates are developed at different phases of the project with the expectation that future estimates will be close to (equal to or less) initial estimates

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- Rough estimates are used to obtain an approximate cost in a short time
- Not as accurate as the detailed estimate and usually developed during early planning phase of the project
- Compare the costs of similar structures erected at other times and places

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- Detailed cost estimates require that the contractor has a complete set of contract documents
- Each item of the project should be broken down into its parts and estimated
- Each piece of work that is to be performed by the contractor has a distinct labor requirement that must be estimated
- The items that are to be installed by others need to be defined and priced

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- Caution needs to be exercised to ensure that there is agreement between the contractor and the specialty contractor as to
  - What they are to do
  - Whether they are to install or supply and install the items
- There needs to be an agreement about who is providing support items such as cranes and scaffolding

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- The detailed estimate must establish
  - Estimated quantities and costs of the materials
  - Time required for and costs of labor
  - Equipment required and its cost
  - Items required for overhead and the cost of each item
  - Percentage of profit desired (considering the investment, the time to complete, and the complexity of the project)

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- Contractor’s estimate
  - A carefully-prepared estimate by the contractor, used for
    - Determining the bid price of a project
    - Controlling the progress on the construction site
- Architect’s/engineer’s estimate
  - Made by the architect or engineer, used for
    - Checking the contractor’s bid
    - Financing the work
    - Evaluating feasibility of the project and/or design alternatives

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Cost Estimate Classification System

- Each enterprise may have its own project and estimating processes and terminology, and may classify estimates in particular ways
- No industry standards have been established for defining estimates
- Several organizations developed generic and generally-acceptable classification systems that can be used as a basis to compare against

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- If an organization has not yet formally documented its own estimate classification system, then these guidelines may provide an acceptable starting point
- Association for the Advancement of Cost Engineering (AACE) International

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Generic Cost Estimate Classification Matrix - (AACE) International

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical +/- range relative to best index of 1 [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Screening or Feasibility	Stochastic or Judgment	4 to 20	1
Class 4	1% to 15%	Concept Study or Feasibility	Primarily Stochastic	3 to 12	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Mixed, but Primarily Stochastic	2 to 6	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Primarily Deterministic	1 to 3	5 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Deterministic	1	10 to 100

Notes: [a] If the range index value of "1" represents +10/-5%, then an index value of 10 represents +100/-50%.
[b] If the cost index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%.

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- Level of Project Definition
  - This characteristic is based upon percent complete of project definition
  - The level of project definition defines maturity or the extent and types of input information available to the estimating process

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- Level of Project Definition
  - Such inputs include
    - Project scope definition
    - Specifications
    - Project plans
    - Drawings
    - Calculations
    - Learnings from past projects

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- End Usage
  - The various classes (or phases) of cost estimates prepared for a project typically have different end uses or purposes
  - As the level of project definition increases, the end usage of an estimate typically progresses from
    - Strategic evaluation and feasibility studies
    - Funding authorization and budgets
    - Project control purposes

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- Estimating Methodology
  - Estimating methodologies fall into two broad categories: stochastic and deterministic
  - In stochastic methods, the variables used in the cost estimating algorithms are generally something other than a direct measure of the units of the item being estimated
  - Stochastic methods often involve simple or complex modeling based on statistical relationships between costs and programmatic and/or technical parameters

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- Estimating Methodology
  - The cost estimating relationships used in stochastic methods often are somewhat subject to conjecture
  - With deterministic methods, the variables are a definitive measure of the item being estimated
  - Deterministic methods tend to be straightforward counts or measures of units of items multiplied by known unit costs or factors

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- Estimating Methodology
  - A deterministic methodology is not subject to significant conjecture
  - As the level of project definition increases, the estimating methodology tends to progress from stochastic to deterministic methods

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- Expected Accuracy Range
  - Estimate accuracy range is an indication of the degree to which the final cost outcome for a given project will vary from the estimated cost
  - Accuracy is traditionally expressed as a +/- percentage range around the point estimate
  - As the level of project definition increases, the expected accuracy of the estimate tends to improve, as indicated by a tighter +/- range

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- Effort to Prepare Estimate
  - The level of effort needed to prepare a given estimate is an indication of the cost, time, and resources required
  - The cost measure of that effort is typically expressed as a percentage of total project costs for a given project size
  - As the level of project definition increases, the amount of effort to prepare an estimate increases, as does its cost relative to the total project cost

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Project Delivery, Contracts, and Pricing

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Project Delivery Methods

- Project delivery methods addresses
  - The establishment of the contractual relationships between the organizations required to deliver a project
  - Does the owner deal with a single entity or multiple entities when pursuing design and construction of a project?
  - Is the award of contract based on lowest cost or on other criteria?

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- Design bid build (DBB)
  - Traditional
  - Design completed before start of the construction
  - The owner holds a contract with the designer or architect/engineer (A/E) for the development of the plans and specifications
  - The owner holds a separate contract with the construction contractor for the building of the facility
  - Competitive bidding
  - Longer project timeframe than other methods

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- Design build (DB)
  - Single source for project delivery
  - One firm offer both design and construction services to the owner
  - Common practice in industrial construction for complex projects that have tight time requirements
  - Coordination between design and construction is enhanced by having both functions within the same firm

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- Design build (DB)
  - Facilitate the use of ‘‘phased construction’’ or ‘‘fast-tracking’’
    - Design and construction occurring in parallel (at the same time)
    - Work can be started in the field before a complete design is available

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- Turnkey
  - Projects built with a single DB contractor
  - The owner deals with only one contractor and that contractor is charged with the completion of the facility so that the project is ready to be placed in operation with the ‘‘turn of a key’’
  - Less owner involvement compared to DB over schedule and budget

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- Consortium based DB
  - Many contractors do not have an in-house design capability
  - Contractors form a team or consortium of designers and specialty contractors who work together to meet the needs of the owner
  - The owner contracts with the consortium as a single group providing the total project package (e.g., design, construction, procurement, etc.)

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- Construction management (CM)
  - Agency CM
  - One firm coordinates all construction activities from concept design through acceptance of the facility
  - The firm represents the owner in all construction management activities

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- Construction management (CM) at risk
  - The CM firm not only coordinates the project but also assumes responsibility for the construction phase of the work
  - The CM firm assumes the same risk that a construction contractor in the DBB format would assume for the successful completion of the project

Public-private partnership (PPP/P3)

- Examples
  - Build operate transfer (BOT)
  - Build own operate transfer (BOOT)
  - Build own operate (BOO)

Construction Contracts and Pricing Mechanisms

- Competitively bid contract
  - Most widely used format of contract
  - Almost all contracts that involve public funds are awarded using competitively bid contracts
  - The owner invites a quote for the work to be performed based on complete plans and specifications
  - The award of contract is generally made to the lowest qualified bidder

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- Lump-sum (stipulated-sum/fixed price) contract
  - The contractor quotes one price, which covers all work and services required by the contract plans and specifications
  - The owner goes to a set of firms with a complete set of plans and specifications and asks for a single quoted price for the entire job
  - Contracts with large quantities of earthwork or subsurface work are not normally handled on a lump-sum basis since such contracts must be flexible enough to handle the difficult to estimate quantities of work below grade

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- Unit-price contract
  - Allows some flexibility in meeting variations in the amount and quantity of work encountered during construction
  - The project is broken down into work items that can be characterized by units such as cubic yards
  - The contractor quotes the price by units rather than as a single total contract price (price per cubic yard)

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- Negotiated contract (cost-plus)
  - An owner can enter into contract with a constructor by negotiating the price and method of reimbursement
  - A number of formats of contract can be concluded based on negotiation between owner and contractors
  - It is possible, for example, to enter into a fixed-price or unit-price contract after a period of negotiation
  - Some public owners will negotiate with the three low bidders on prices, materials, and schedule

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- Negotiated contract (cost-plus)
  - The owner invites selected contractors to review the project documentation available at the time of negotiation
  - This documentation may be total and complete design documentation as in the case of competitively bid contracts or only concept-level documentation
  - Since in most cases, the design documentation is not complete at the time of negotiation, the most common form of contract concluded is the cost + fee

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- Negotiated contract (cost-plus)
  - Types of fee structure
    - Cost + percent of cost
      - The larger the cost of the job, the higher the amount of fee that is paid by the owner
    - Cost + fixed fee
      - A fixed amount of fee is paid regardless of the fluctuation of the reimbursable cost component

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- Negotiated contract (cost-plus)
  - Types of fee structure
    - Cost + fixed fee+ profit-sharing clause
      - Provides a reward to the contractor who controls costs, keeping them at a minimum
      - Specify a target price for the total contract. If the contractor brings the cost under the target, the savings are shared between owner and contractor
      - In some cases, the target value is used to define a guaranteed maximum price (GMP)
        - This is a price that the contractor guarantees will not be exceeded. Any overrun of the GMP must be absorbed by the contractor

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- Negotiated contract (cost-plus)
  - Types of fee structure
    - Cost + sliding fee
      - Provides a bonus for underrun but also penalizes the contractor for overrunning the target value
      - The amount of the fee increases as the contractor falls below the target and decreases as the contractor overruns the target value

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Comparing Project Delivery Methods/Contracts

- Competitively bid contracts are required to be design bid build (DBB) contracts
- Negotiated contracts can be viewed as DBB contracts although it is possible to use ‘‘phased construction’’ when working with negotiated construction contracts
  - A constructor involved in construction of a hotel building on a cost reimbursable basis can begin construction of the site excavation and substructure while the roof-top restaurant is still being designed

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- For both competitively bid and negotiated contracts, the owner holds separate contracts with the designer or design group and with the construction contractor
- In the design build (DB) format, the owner enters into contract with a single entity (the design builder)
- The basis of selection of the DB firm or consortium is normally on the basis of considerations other than least cost
- Fast-tracking or phased construction is typical of DB contracts

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- In the CM format, the owner holds multiple contracts
- In the case of the agency construction management format, the owner signs a management contract with the CM, but holds contracts directly with the design and construction firms involved
- Selection of the Agency CM firm is based on issues other than total construction cost (e.g., quality, schedule performance)
- Fast-track construction is usual when using this format

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- The CM at-risk format requires separate contracts for the design team and the CM at-risk firm (similar to the DBB format)
- Low total construction cost is not the basis for selection of the CM at-risk
- Fast-track construction is possible when using this format

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	Contract Type	Single or Multiple Contracts to Owners	Selection Criteria	Phased Construction
DBB	Competitively Bid	Multiple-Design Contract & Construction Contract	Low Construction Cost	No
	Negotiated	Multiple Design & Construction	Low Cost or Other	Possible
DB	DB	Single Contract with DB Firm	Usually not Low Cost—Based on Performance	Yes
CM	CM	Contracts held by Owner—CM, Design, Construction, and Vendors	Based on Performance Expectations	Yes
	CM at Risk	Same as CM.. above except CM and Construction Contracts are Combined	Based on Performance Expectations	Yes

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Rough Cost Estimating

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Rough Cost Estimating

- Rough estimates are used to obtain an approximate cost in a short time
- Usually developed during early planning phase of the project
- When preparing an estimate using this method, the estimator starts with the costs of a comparable project and then makes adjustments (if necessary) for differences in the project

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Example

- Last year your construction company built a 6,500 m^2 warehouse for $6,500,000
- The owner wants to build another warehouse of similar size; this time they want to add 100 m^2 of office space
- Prepare a rough estimate for the new warehouse if the office space will cost $100,000 and costs have risen 5 percent during the last year

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- Last year your construction company built a 6,500 m^2 warehouse for $6,500,000
- The owner wants to build another warehouse of similar size; this time they want to add 100 m^2 of office space
- Prepare a rough estimate for the new warehouse if the office space will cost $100,000 and costs have risen 5 percent during the last year
- Cost = $6,500,000 x 1.05 + $100,000 = $6,925,000

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- When comparing two projects, the estimator needs to consider the following
  - The size should be within 10 percent for the projects being compared
  - As the size of the building increases, the cost per unit area decreases. Conversely, as the size decreases, the cost per unit area increases. This is due to economies of scale
  - Height between floors. Increasing the height between floors increases the envelope cost without increasing the area of the building

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- When comparing two projects, the estimator needs to consider the following
  - Length of perimeter. Two buildings, a long skinny one and a square one, will have very different perimeters and envelope costs for the same area
  - Project location (Labor availability, materials availability, and government regulations vary by location)
  - When the project was built. Inflation in labor, materials, and fuel costs; weather (summer versus winter)

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- When comparing two projects, the estimator needs to consider the following
  - Type of structure: Concrete, steel, etc
  - Level of finishes. Quality of materials and workmanship
  - Utilization of the space. Some spaces cost more than others do. Bathrooms and kitchens cost more per unit area than bedrooms
  - Soil conditions

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Unit Area Estimating

- Prepared by multiplying the area of a building (m^2, SF) by the cost per unit area and then by adjusting the price to compensate for differences in the design
- The cost per unit area may be determined by dividing the cost by the size of the building

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Example

- Last year your construction company built a 10,000 m^2, 5-story parking garage for $4,980,564
- The parking garage included one elevator, which cost $105,100, and its costs are included in the $4,980,564
- Prepare a rough cost estimate for a 9,500 m^2, 5-story parking garage with two elevators
- Assume that costs have risen 4 percent during the last year

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Cost ($\$/m^2$) = ($4,980,564 - $105,100) / 10,000 m^2

= $487.55/$m^2$

New garage cost (without adjustment) =

($487.55/$m^2$ x 9,500 m^2) + ($105,100 x 2) = $4,841,925

Adjust for inflation: $4,841,925 x 1.04 =$5,035,602

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- The rules of measurement
  - The building area of a major building structure is the sum of the areas of the several floors of the building, including basements measured from outside face to outside face of exterior walls or from the center line of common walls separating buildings
  - No deduction in floor area shall be made for openings such as stairs, elevators, duct shafts, escalators, and other vertical elements

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- The rules of measurement
  - Covered floor areas open to the atmosphere such as covered walkways, open roofed-over areas that are paved, exterior balconies, and similar spaces shall be included at one-half their building area

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- The rules of measurement
  - Slabs and floors that are not covered by roof or ceiling shall not be included
  - Sloping or stepped floors shall be measured flat on a horizontal plane

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- The rules of measurement
  - Building area does not include exterior unroofed terraces, steps, chimneys, roof overhangs

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- The rules of measurement
  - The outside of the exterior wall is defined as the outside perimeter line of exterior wall facing at each floor level

    No deduction is taken for setbacks at windows, glazing, or increase added for protruding features such as columns

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- Costs developed from unit area estimating are affected by
  - Ceiling height
  - Shape of the building (square buildings cost less per unit area than rectangular buildings because of the smaller amount of outside walls)
  - Spacing of columns (variations in floor systems, variations in loads on structural elements, large openings in floors)

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- Units other than m^2 and SF may be used
- For example, a parking garage may be measured by the number of parking stalls

  Estimated cost = cost per parking stall x number of parking stalls
- Other units: number of hospital beds, seats, students, production units, etc
- Cost adjustments may be applied if necessary

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- How to determine the unit cost
  - Company records (previous projects)
  - Published annual guides (such as RSMeans Square Foot Costs and ENR Magazine) that contain a range of unit costs for a wide variety of building types

    These guides provide a number of adjustments to compensate for varying building components, including the city where the project is located

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- The weighted unit cost is an estimate that considers previous similar projects and emphasizes average, minimum, and maximum incurred costs

$$\text{Weighted unit cost} = (A + 4B + C) / 6$$

A = minimum unit cost of previous projects

B = average unit cost of previous projects

C = maximum unit cost of previous projects

- This estimate is used based on the available information. Adjustments could be applied to increase accuracy

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Example

- Using the weighted unit cost method determine the cost of a proposed 80-bed hospital project. Use the following unit cost per hospital bed for previously constructed hospital projects

Project Number	Cost ($/bed)
1	$93,120
2	$110,380
3	$90,951
4	$143,702
5	$121,334
6	$127,238
7	$136,117

- Using the weighted unit cost method determine the cost of a proposed 80-bed hospital project. Use the following unit cost per hospital bed for previously constructed hospital projects

Weighted unit cost per bed =

($90,951 + 4($117,548.86) + $143,702)/ 6

= $117,474.74/ bed

Proposed hospital cost =

$ 117,474.74 x 80 =$9,397,979.2

Project Number	Cost ($/bed)
1	$93,120
2	$110,380
3	$90,951
4	$143,702
5	$121,334
6	$127,238
7	$136,117

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REGIONAL BUILDING COST COMPARISON

Building cost (US$/sqm)	UAE (Dubai)		KSA (Riyadh)		Qatar (Doha)		Bahrain (Manama)		Oman (Muscat)	
Typology	Low	High	Low	High	Low	High	Low	High	Low	High
Residential										
Low rise	1,000	1,550	800	1,350	1,300	1,600	800	1,350	850	1,000
Medium rise	1,050	1,550	1,250	1,500	1,600	1,850	1,050	1,600	1,050	1,300
High rise	1,550	2,400	1,650	2,050	1,900	2,150	1,450	2,000	N/A	N/A
Commercial										
Low-rise office (shell & core)	1,100	1,400	700	1,250	1,300	1,600	1,050	1,450	650	750
Mid-rise office (shell & core)	1,250	1,550	1,250	1,650	1,600	1,950	1,200	1,600	700	1,000
High-rise office (shell & core)	1,400	2,100	1,650	2,200	1,900	2,300	1,450	2,050	N/A	N/A
Fit-out — basic	1,000	1,550	700	950	1,300	1,800	650	950	400	500
Fit-out — medium	1,550	1,950	950	1,250	1,700	2,200	950	1,200	650	750
Fit-out — high	1,950	2,500	1,250	1,650	2,000	2,750	1,200	1,600	N/A	N/A
Retail										
Community	1,300	1,550	700	950	1,200	1,450	1,050	1,350	1,100	1,200
Regional mall	1,350	1,650	1,100	1,500	1,300	1,750	1,200	1,600	N/A	N/A
Super regional mall	1,500	1,900	1,250	1,800	1,300	1,900	1,450	1,850	1,100	1,250

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Retail										
Community	1,300	1,550	700	950	1,200	1,450	1,050	1,350	1,100	1,200
Regional mall	1,350	1,650	1,100	1,500	1,300	1,750	1,200	1,600	N/A	N/A
Super regional mall	1,500	1,900	1,250	1,800	1,300	1,900	1,450	1,850	1,100	1,250
Industrial										
Light duty factory	750	950	800	1,100	900	1,050	800	1,050	700	950
Heavy duty factory	900	1,100	1,100	1,200	1,050	1,300	950	1,200	900	1,200
Light industrial unit	650	750	700	800	750	900	650	950	N/A	N/A
Data center — Tier 3 (based on AED/kW(IT))	19,650	22,450	18,700	21,450	21,150	24,100	N/A	N/A	N/A	N/A
Hotel										
Budget	1,800	2,250	1,350	1,650	2,500	2,650	1,550	1,800	N/A	N/A
Mid market	2,250	2,800	1,650	2,200	2,700	3,650	1,650	2,250	2,300	2,950
Up market	3,350	3,800	2,600	3,000	3,700	4,400	2,100	2,650	2,650	3,100
Resort	3,200	3,900	3,000	3,550	4,100	4,950	2,500	3,350	N/A	N/A
Car parks										
Multi storey	550	650	600	750	800	950	450	650	300	300
Basement	800	950	800	950	900	1,050	650	1,000	650	700
Other										
Schools - primary, secondary academy	1,350	1,700	800	1,350	1,600	2,200	1,400	1,800	950	1,550
Healthcare - district hospital	2,200	3,200	1,950	2,750	2,350	2,950	2,500	3,050	2,150	2,750
Exchange rate to 1 US$	AED	3.67	SAR	3.75	QAR	3.64	BHD	0.37	OMR	0.38

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Department of Statistics, Jordan – 2017

جدول 9.2. 1 أبنية القطاع الخاص المنجزة كلياً حسب المحافظة،2017

Table 9.2.1 Buildings of Private Sector that are Completely Constructed by Governorate, 2017

Governorate	عدد الوحدات السكنية المنجزة No. of Completed Dwellings	متوسط تكلفة المتر المربع (دينار) Average Cost M^2 (JD)	الكلفة الإجمالية (بالألف دينار) Total Cost (000 JD)	متوسط مساحة المبنى (متر مربع) Average Building Area (M^2)	المساحة الإجمالية للأبنية (بالألف متر مربع) Total Buildings Area (000 M^2)	عدد الأبنية المنجزة (سكني وغير سكني) No. of Completed Buildings (Res. & Non Res.)	المحافظة
Amman	14616	190	706,398	1310	3713	2835	العاصمة
Balqa	1570	168	51,056	627	304	485	البلقاء
Zarqa	2528	165	71,901	586	437	746	الزرقاء
Madaba	415	168	12,104	649	72	111	مأدبا
Irbid	2313	221	101,421	436	459	1053	اربد
Mafraq	237	230	8,290	199	36	181	المفرق
Jarash	49	237	1,895	222	8	36	جرش
Ajloun	9	164	164	143	1	7	عجلون
Karak	551	184	17,995	334	98	293	الكرك
Tafiela	41	213	1,492	184	7	38	الطفيلة
Ma'an	224	137	5,202	247	38	154	معان
Aqaba	724	132	17,667	601	134	223	العقبة
Total	**23277**	**188**	**995,586**	**861**	**5304**	**6162**	**المجموع**

Source: Department of Statistics\ Complementary Survey 2017

المصدر: دائرة الإحصاءات العامة/ المسح التكميلي 2017

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- Pricing manuals provide costs per unit for various types of projects
- Low, average, and high cost per square foot based on the level of quality

	Secondary schools			Hospitals		
Component	Low $/SF	Median $/SF	High $/SF	Low $/SF	Median $/SF	High $/SF
Foundation	1.35	1.85	2.70	4.35	4.80	6.65
Floors on grade	3.65	4.40	6.00	0.30	0.40	0.60
Superstructure	10.95	12.30	17.25	17.05	18.55	25.50
Roofing	1.70	2.05	2.45	3.25	3.70	5.20
Exterior walls	3.75	5.55	8.00	16.00	18.55	25.10
Partitions	5.90	6.55	8.50	7.20	11.00	24.70
Wall finishes	3.05	3.40	5.15	6.75	7.95	11.10
Floor finishes	3.10	3.95	5.25	2.60	2.75	4.00
Ceiling finishes	3.20	3.65	4.65	2.15	2.20	3.55
Conveying systems	0.00	0.00	0.00	12.95	13.00	19.55
Specialties	1.70	1.90	2.60	3.10	3.25	4.60
Fixed equipment	2.85	3.35	6.00	5.20	5.25	7.65
Heat/vent/air cond.	9.05	10.45	14.45	21.65	25.50	36.05
Plumbing	5.05	6.00	9.20	9.10	10.65	16.45
Electrical	10.25	12.00	16.50	13.45	17.50	24.40
Total $/SF	$69.55	$77.40	$108.70	$125.10	$145.05	$215.10

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COMMERCIAL/INDUSTRIAL/ INSTITUTIONAL | **M.690** | **Warehouse**

Costs per square foot of floor area

Exterior Wall	S.F. Area	10000	15000	20000	25000	30000	35000	40000	50000	60000
	L.F. Perimeter	410	500	600	640	700	766	833	966	1000
Tiltup Concrete Panels	Steel Frame	98.05	89.30	85.25	81.30	79.15	77.60	76.55	75.00	73.00
Brick with Block Back-up	Bearing Walls	114.60	102.05	96.35	90.25	86.95	84.75	83.10	80.85	77.55
Concrete Block	Steel Frame	96.50	88.00	84.05	80.25	78.15	76.70	75.65	74.20	72.20
	Bearing Walls	93.75	85.10	81.10	77.25	75.10	73.65	72.55	71.05	69.10
Galvanized Steel Siding	Steel Frame	102.10	93.25	89.10	85.05	82.85	81.35	80.20	78.70	76.65
Metal Sandwich Panels	Steel Frame	104.30	94.35	89.70	85.10	82.55	80.80	79.55	77.85	75.40
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.35	4.25	3.25	2.60	2.10	1.90	1.55	1.30	1.00
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	.75	.60	.55	.45	.40	.40	.35	.40	.25
***For Basement**, add $23.55 per square foot of basement area*										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $30.13 to $120.30 per S.F.

Common additives

Description	Unit	$ Cost
Dock Leveler, 10 ton cap.		
6' x 8'	Each	6225
7' x 8'	Each	6225
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	265
Nickel cadmium	Each	770
Fence, Chain link, 6' high		
9 ga. wire	L.F.	20
6 ga. wire	L.F.	29
Gate	Each	293
Flagpoles, Complete		
Aluminum, 20' high	Each	1375
40' high	Each	3125
70' high	Each	9725
Fiberglass, 23' high	Each	1675
39'-5" high	Each	3225
59' high	Each	8025
Paving, Bituminous		
Wearing course plus base course	S.Y.	7.85
Sidewalks, Concrete 4" thick	S.F.	3.96

Description	Unit	$ Cost
Sound System		
Amplifier, 250 watts	Each	2125
Speaker, ceiling or wall	Each	174
Trumpet	Each	335
Yard Lighting, 20' aluminum pole with 400 watt high pressure sodium fixture.	Each	2600

Square Foot Costs with RSMeans data

Model costs calculated for a 1 story building with 24' story height and 30,000 square feet of floor area

Warehouse

				Unit	Unit Cost	Cost Per S.F.	% Of Sub-Total
A. SUBSTRUCTURE							
1010	Standard Foundations	Poured concrete; strip and spread footings		S.F. Ground	1.22	1.22	25.3%
1030	Slab on Grade	5" reinforced concrete with vapor barrier and granular base		S.F. Slab	10.73	10.73	
2010	Basement Excavation	Site preparation for slab and trench for foundation wall and footing		S.F. Ground	.14	.14	
2020	Basement Walls	4' foundation wall		L.F. Wall	69	2.10	
B. SHELL							
	B10 Superstructure						
1010	Floor Construction	Mezzanine: open web steel joists, slab form, concrete beams, columns	*10% of area*	S.F. Floor	18.00	1.80	13.8%
1020	Roof Construction	Metal deck, open web steel joists, beams, columns		S.F. Roof	5.95	5.95	
	B20 Exterior Enclosure						
2010	Exterior Walls	Concrete block	*95% of wall*	S.F. Wall	10.00	5.32	11.1%
2020	Exterior Windows	N/A		—	—	—	
2030	Exterior Doors	Steel overhead, hollow metal	*5% of wall*	Each	2436	.89	
	B30 Roofing						
3010	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation		S.F. Roof	4.55	4.55	8.7%
3020	Roof Openings	Roof hatches and skylight		S.F. Roof	.35	.35	
C. INTERIORS							
1010	Partitions	Concrete block (office and washrooms)	*100 S.F. Floor/L.F. Partition*	S.F. Partition	7.63	.61	10.0%
1020	Interior Doors	Single leaf hollow metal	*5000 S.F. Floor/Door*	Each	815	.17	
1030	Fittings	N/A		—	—	—	
2010	Stair Construction	Steel gate with rails		Flight	10,950	.73	
3010	Wall Finishes	Paint		S.F. Surface	11.63	1.86	
3020	Floor Finishes	90% hardener, 10% vinyl composition tile		S.F. Floor	1.76	1.76	
3030	Ceiling Finishes	Suspended mineral tile on zee channels in office area	*10% of area*	S.F. Ceiling	4.71	.47	
D. SERVICES							
	D10 Conveying						
1010	Elevators & Lifts	N/A		—	—	—	0.0%
1020	Escalators & Moving Walks	N/A		—	—	—	
	D20 Plumbing						
2010	Plumbing Fixtures	Toilet and service fixtures, supply and drainage	*1 Fixture/2500 S.F. Floor*	Each	2300	.92	4.3%
2020	Domestic Water Distribution	Gas fired water heater		S.F. Floor	.21	.21	
2040	Rain Water Drainage	Roof drains		S.F. Roof	1.28	1.28	
	D30 HVAC						
3010	Energy Supply	Oil fired hot water, unit heaters	*90% of area*	S.F. Floor	4.07	4.07	8.7%
3020	Heat Generating Systems	N/A		—	—	—	
3030	Cooling Generating Systems	N/A		—	—	—	
3050	Terminal & Package Units	Single zone unit gas, heating, electric cooling	*10% of area*	S.F. Floor	.81	.81	
3090	Other HVAC Sys. & Equipment	N/A		—	—	—	
	D40 Fire Protection						
4010	Sprinklers	Sprinklers, ordinary hazard		S.F. Floor	2.73	2.73	4.9%
4020	Standpipes	N/A		—	—	—	
	D50 Electrical						
5010	Electrical Service/Distribution	200 ampere service, panel board and feeders		S.F. Floor	.43	.43	9.1%
5020	Lighting & Branch Wiring	Fluorescent fixtures, receptacles, switches, A.C. and misc. power		S.F. Floor	4.30	4.30	
5030	Communications & Security	Alarm systems		S.F. Floor	.38	.38	
5090	Other Electrical Systems	N/A		—	—	—	
E. EQUIPMENT & FURNISHINGS							
1010	Commercial Equipment	N/A		—	—	—	4.2%
1020	Institutional Equipment	N/A		—	—	—	
1030	Vehicular Equipment	Dock boards, dock levelers		S.F. Floor	2.37	2.37	
1090	Other Equipment	N/A		—	—	—	
F. SPECIAL CONSTRUCTION							
1020	Integrated Construction	N/A		—	—	—	0.0%
1040	Special Facilities	N/A		—	—	—	
G. BUILDING SITEWORK	**N/A**						
					Sub-Total	56.15	**100%**
	CONTRACTOR FEES (General Requirements: 10%, Overhead: 5%, Profit: 10%)				25%	14.04	
	ARCHITECT FEES				7%	4.91	
					Total Building Cost	75.10	

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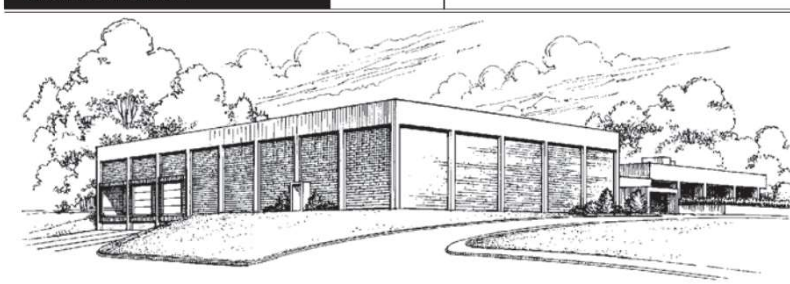
COMMERCIAL/INDUSTRIAL/ INSTITUTIONAL | **M.690** | **Warehouse**

Square Foot Costs with RSMeans data



Costs per square foot of floor area

Exterior Wall	S.F. Area	10000	15000	20000	25000	30000	35000	40000	50000	60000
	L.F. Perimeter	410	500	600	640	700	766	833	966	1000
Tiltup Concrete Panels	Steel Frame	98.05	89.30	85.25	81.30	79.15	77.60	76.55	75.00	73.00
Brick with Block Back-up	Bearing Walls	114.60	102.05	96.35	90.25	86.95	84.75	83.10	80.85	77.55
Concrete Block	Steel Frame	96.50	88.00	84.05	80.25	78.15	76.70	75.65	74.20	72.20
	Bearing Walls	93.75	85.10	81.10	77.25	75.10	73.65	72.55	71.05	69.10
Galvanized Steel Siding	Steel Frame	102.10	93.25	89.10	85.05	82.85	81.35	80.20	78.70	76.65
Metal Sandwich Panels	Steel Frame	104.30	94.35	89.70	85.10	82.55	80.80	79.55	77.85	75.40
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.35	4.25	3.25	2.60	2.10	1.90	1.55	1.30	1.00
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	.75	.60	.55	.45	.40	.40	.35	.40	.25
***For Basement**, add $23.55 per square foot of basement area*										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $30.13 to $120.30 per S.F.

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Costs per square foot of floor area

Exterior Wall	S.F. Area	10000	15000	20000	25000	30000	35000	40000	50000	60000
	L.F. Perimeter	410	500	600	640	700	766	833	966	1000
Tiltup Concrete Panels	Steel Frame	98.05	89.30	85.25	81.30	79.15	77.60	76.55	75.00	73.00
Brick with Block Back-up	Bearing Walls	114.60	102.05	96.35	90.25	86.95	84.75	83.10	80.85	77.55
Concrete Block	Steel Frame	96.50	88.00	84.05	80.25	78.15	76.70	75.65	74.20	72.20
	Bearing Walls	93.75	85.10	81.10	77.25	**75.10**	73.65	72.55	71.05	69.10
Galvanized Steel Siding	Steel Frame	102.10	93.25	89.10	85.05	82.85	81.35	80.20	78.70	76.65
Metal Sandwich Panels	Steel Frame	104.30	94.35	89.70	85.10	82.55	80.80	79.55	77.85	75.40
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.35	4.25	3.25	2.60	2.10	1.90	1.55	1.30	1.00
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	.75	.60	.55	.45	.40	.40	.35	.40	.25
***For Basement**, add $ 23.55 per square foot of basement area*										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $ 30.13 to $ 120.30 per S.F.

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Common additives

Description	Unit	$ Cost
Dock Leveler, 10 ton cap.		
6' x 8'	Each	6225
7' x 8'	Each	6225
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	265
Nickel cadmium	Each	770
Fence, Chain link, 6' high		
9 ga. wire	L.F.	20
6 ga. wire	L.F.	29
Gate	Each	293
Flagpoles, Complete		
Aluminum, 20' high	Each	1375
40' high	Each	3125
70' high	Each	9725
Fiberglass, 23' high	Each	1675
39'-5" high	Each	3225
59' high	Each	8025
Paving, Bituminous		
Wearing course plus base course	S.Y.	7.85
Sidewalks, Concrete 4" thick	S.F.	3.96

Description	Unit	$ Cost
Sound System		
Amplifier, 250 watts	Each	2125
Speaker, ceiling or wall	Each	174
Trumpet	Each	335
Yard Lighting, 20' aluminum pole with 400 watt high pressure sodium fixture.	Each	2600

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Model costs calculated for a 1 story building with 24′ story height and 30,000 square feet of floor area

Warehouse

				Unit	Unit Cost	Cost Per S.F.	% Of Sub-Total
A. SUBSTRUCTURE							
1010	Standard Foundations	Poured concrete; strip and spread footings		S.F. Ground	1.22	1.22	25.3%
1030	Slab on Grade	5″ reinforced concrete with vapor barrier and granular base		S.F. Slab	10.73	10.73	
2010	Basement Excavation	Site preparation for slab and trench for foundation wall and footing		S.F. Ground	.14	.14	
2020	Basement Walls	4′ foundation wall		L.F. Wall	69	2.10	
B. SHELL							
	B10 Superstructure						
1010	Floor Construction	Mezzanine: open web steel joists, slab form, concrete beams, columns	*10% of area*	S.F. Floor	18.00	1.80	13.8%
1020	Roof Construction	Metal deck, open web steel joists, beams, columns		S.F. Roof	5.95	5.95	
	B20 Exterior Enclosure						
2010	Exterior Walls	Concrete block	*95% of wall*	S.F. Wall	10.00	5.32	11.1%
2020	Exterior Windows	N/A		—	—	—	
2030	Exterior Doors	Steel overhead, hollow metal	*5% of wall*	Each	2436	.89	
	B30 Roofing						
3010	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation		S.F. Roof	4.55	4.55	8.7%
3020	Roof Openings	Roof hatches and skylight		S.F. Roof	.35	.35	
C. INTERIORS							
1010	Partitions	Concrete block (office and washrooms)	*100 S.F. Floor/L.F. Partition*	S.F. Partition	7.63	.61	10.0%
1020	Interior Doors	Single leaf hollow metal	*5000 S.F. Floor/Door*	Each	815	.17	
1030	Fittings	N/A		—	—	—	
2010	Stair Construction	Steel gate with rails		Flight	10,950	.73	
3010	Wall Finishes	Paint		S.F. Surface	11.63	1.86	
3020	Floor Finishes	90% hardener, 10% vinyl composition tile		S.F. Floor	1.76	1.76	
3030	Ceiling Finishes	Suspended mineral tile on zee channels in office area	*10% of area*	S.F. Ceiling	4.71	.47	
D. SERVICES							
	D10 Conveying						
1010	Elevators & Lifts	N/A		—	—	—	0.0%
1020	Escalators & Moving Walks	N/A		—	—	—	
	D20 Plumbing						
2010	Plumbing Fixtures	Toilet and service fixtures, supply and drainage	*1 Fixture/2500 S.F. Floor*	Each	2300	.92	4.3%
2020	Domestic Water Distribution	Gas fired water heater		S.F. Floor	.21	.21	
2040	Rain Water Drainage	Roof drains		S.F. Roof	1.28	1.28	
	D30 HVAC						
3010	Energy Supply	Oil fired hot water, unit heaters	*90% of area*	S.F. Floor	4.07	4.07	8.7%
3020	Heat Generating Systems	N/A		—	—	—	
3030	Cooling Generating Systems	N/A		—	—	—	
3050	Terminal & Package Units	Single zone unit gas, heating, electric cooling	*10% of area*	S.F. Floor	.81	.81	
3090	Other HVAC Sys. & Equipment	N/A		—	—	—	
	D40 Fire Protection						
4010	Sprinklers	Sprinklers, ordinary hazard		S.F. Floor	2.73	2.73	4.9%
4020	Standpipes	N/A		—	—	—	
	D50 Electrical						
5010	Electrical Service/Distribution	200 ampere service, panel board and feeders		S.F. Floor	.43	.43	9.1%
5020	Lighting & Branch Wiring	Fluorescent fixtures, receptacles, switches, A.C. and misc. power		S.F. Floor	4.30	4.30	
5030	Communications & Security	Alarm systems		S.F. Floor	.38	.38	
5090	Other Electrical Systems	N/A		—	—	—	
E. EQUIPMENT & FURNISHINGS							
1010	Commercial Equipment	N/A		—	—	—	4.2%
1020	Institutional Equipment	N/A		—	—	—	
1030	Vehicular Equipment	Dock boards, dock levelers		S.F. Floor	2.37	2.37	
1090	Other Equipment	N/A		—	—	—	
F. SPECIAL CONSTRUCTION							
1020	Integrated Construction	N/A		—	—	—	0.0%
1040	Special Facilities	N/A		—	—	—	
G. BUILDING SITEWORK		**N/A**					
				Sub-Total		56.15	**100%**
		CONTRACTOR FEES (General Requirements: 10%, Overhead: 5%, Profit: 10%)			25%	14.04	
		ARCHITECT FEES			7%	4.91	
				Total Building Cost		**75.10**	

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Model costs calculated for a 1 story building with 24′ story height and 30,000 square feet of floor area

Warehouse

				Unit	Unit Cost	Cost Per S.F.	% Of Sub-Total
A. SUBSTRUCTURE							
1010	Standard Foundations	Poured concrete; strip and spread footings		S.F. Ground	1.22	1.22	25.3%
1030	Slab on Grade	5″ reinforced concrete with vapor barrier and granular base		S.F. Slab	10.73	10.73	
2010	Basement Excavation	Site preparation for slab and trench for foundation wall and footing		S.F. Ground	.14	.14	
2020	Basement Walls	4′ foundation wall		L.F. Wall	69	2.10	
B. SHELL							
	B10 Superstructure						
1010	Floor Construction	Mezzanine: open web steel joists, slab form, concrete beams, columns	*10% of area*	S.F. Floor	18.00	1.80	13.8%
1020	Roof Construction	Metal deck, open web steel joists, beams, columns		S.F. Roof	5.95	5.95	
	B20 Exterior Enclosure						
2010	Exterior Walls	Concrete block	*95% of wall*	S.F. Wall	10.00	5.32	11.1%
2020	Exterior Windows	N/A		—	—	—	
2030	Exterior Doors	Steel overhead, hollow metal	*5% of wall*	Each	2436	.89	
	B30 Roofing						
3010	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation		S.F. Roof	4.55	4.55	8.7%
3020	Roof Openings	Roof hatches and skylight		S.F. Roof	.35	.35	
C. INTERIORS							
1010	Partitions	Concrete block (office and washrooms)	*100 S.F. Floor/L.F. Partition*	S.F. Partition	7.63	.61	10.0%
1020	Interior Doors	Single leaf hollow metal	*5000 S.F. Floor/Door*	Each	815	.17	
1030	Fittings	N/A		—	—	—	
2010	Stair Construction	Steel gate with rails		Flight	10,950	.73	
3010	Wall Finishes	Paint		S.F. Surface	11.63	1.86	
3020	Floor Finishes	90% hardener, 10% vinyl composition tile		S.F. Floor	1.76	1.76	
3030	Ceiling Finishes	Suspended mineral tile on zee channels in office area	*10% of area*	S.F. Ceiling	4.71	.47	

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D. SERVICES							
	D10 Conveying						
1010	Elevators & Lifts	N/A		–	–	–	0.0%
1020	Escalators & Moving Walks	N/A		–	–	–	
	D20 Plumbing						
2010	Plumbing Fixtures	Toilet and service fixtures, supply and drainage	*1 Fixture/2500 S.F. Floor*	Each	2300	.92	4.3%
2020	Domestic Water Distribution	Gas fired water heater		S.F. Floor	.21	.21	
2040	Rain Water Drainage	Roof drains		S.F. Roof	1.28	1.28	
	D30 HVAC						
3010	Energy Supply	Oil fired hot water, unit heaters	*90% of area*	S.F. Floor	4.07	4.07	8.7%
3020	Heat Generating Systems	N/A		–	–	–	
3030	Cooling Generating Systems	N/A		–	–	–	
3050	Terminal & Package Units	Single zone unit gas, heating, electric cooling	*10% of area*	S.F. Floor	.81	.81	
3090	Other HVAC Sys. & Equipment	N/A		–	–	–	
	D40 Fire Protection						
4010	Sprinklers	Sprinklers, ordinary hazard		S.F. Floor	2.73	2.73	4.9%
4020	Standpipes	N/A		–	–	–	
	D50 Electrical						
5010	Electrical Service/Distribution	200 ampere service, panel board and feeders		S.F. Floor	.43	.43	9.1%
5020	Lighting & Branch Wiring	Fluorescent fixtures, receptacles, switches, A.C. and misc. power		S.F. Floor	4.30	4.30	
5030	Communications & Security	Alarm systems		S.F. Floor	.38	.38	
5090	Other Electrical Systems	N/A		–	–	–	
E. EQUIPMENT & FURNISHINGS							
1010	Commercial Equipment	N/A		–	–	–	4.2%
1020	Institutional Equipment	N/A		–	–	–	
1030	Vehicular Equipment	Dock boards, dock levelers		S.F. Floor	2.37	2.37	
1090	Other Equipment	N/A		–	–	–	
F. SPECIAL CONSTRUCTION							
1020	Integrated Construction	N/A		–	–	–	0.0%
1040	Special Facilities	N/A		–	–	–	
G. BUILDING SITEWORK		**N/A**					
					Sub-Total	56.15	**100%**
	CONTRACTOR FEES (General Requirements: 10%, Overhead: 5%, Profit: 10%)				25%	14.04	
	ARCHITECT FEES				7%	4.91	
					Total Building Cost	**75.10**	

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- First, find the correct page for the type of construction to be estimated
- Adjust for area: The base cost per square foot for a 33,000 SF warehouse with a concrete block exterior that uses the exterior walls as bearing walls

Cost = \$74.23 / SF

- Adjust for perimeter: For a 30,000 SF warehouse, if the perimeter is 680' then the difference in the perimeters would be 0.2 hundred feet

Cost = 75.1 – (2.1 x 0.2) = \$74.68 / SF

- Adjust for story height: For a 30,000 SF warehouse, if the story height is 25'

Cost = 75.1 + 0.4 = \$75.5 / SF

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Example

- Determine the cost for a 250’ by 120’, tilt-up concrete warehouse
- The warehouse is 30’ high and has a steel frame
- Basement area = 8,500 SF
- Include four 7’ x 8’ dock levelers in the costs

- Area = 250’ x 120’ = 30,000 SF
- Perimeter = 2 x 250 + 2 x 120 = 740’

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- Area = 250’ x 120’ = 30,000 SF
- Perimeter = 2 x 250 + 2 x 120 = 740’

- Add for perimeter: 0.4 x 2.1 = $0.84
- Add for story height: $2.4
- Base cost = $79.15 + $0.84 + $2.4 = $82.39/SF

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Costs per square foot of floor area

Exterior Wall	S.F. Area	10000	15000	20000	25000	30000	35000	40000	50000	60000
	L.F. Perimeter	410	500	600	640	700	766	833	966	1000
Tiltup Concrete Panels	Steel Frame	98.05	89.30	85.25	81.30	79.15	77.60	76.55	75.00	73.00
Brick with Block Back-up	Bearing Walls	114.60	102.05	96.35	90.25	86.95	84.75	83.10	80.85	77.55
Concrete Block	Steel Frame	96.50	88.00	84.05	80.25	78.15	76.70	75.65	74.20	72.20
	Bearing Walls	93.75	85.10	81.10	77.25	**75.10**	73.65	72.55	71.05	69.10
Galvanized Steel Siding	Steel Frame	102.10	93.25	89.10	85.05	82.85	81.35	80.20	78.70	76.65
Metal Sandwich Panels	Steel Frame	104.30	94.35	89.70	85.10	82.55	80.80	79.55	77.85	75.40
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.35	4.25	3.25	2.60	2.10	1.90	1.55	1.30	1.00
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	.75	.60	.55	.45	.40	.40	.35	.40	.25
***For Basement**, add $23.55 per square foot of basement area*										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $30.13 to $120.30 per S.F.

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Model costs calculated for a 1 story building with 24′ story height and 30,000 square feet of floor area

Warehouse

				Unit	Unit Cost	Cost Per S.F.	% Of Sub-Total
A. SUBSTRUCTURE							
1010	Standard Foundations	Poured concrete; strip and spread footings		S.F. Ground	1.22	1.22	25.3%
1030	Slab on Grade	5" reinforced concrete with vapor barrier and granular base		S.F. Slab	10.73	10.73	
2010	Basement Excavation	Site preparation for slab and trench for foundation wall and footing		S.F. Ground	.14	.14	
2020	Basement Walls	4′ foundation wall		L.F. Wall	69	2.10	
B. SHELL							
	B10 Superstructure						
1010	Floor Construction	Mezzanine: open web steel joists, slab form, concrete beams, columns	*10% of area*	S.F. Floor	18.00	1.80	13.8%
1020	Roof Construction	Metal deck, open web steel joists, beams, columns		S.F. Roof	5.95	5.95	
	B20 Exterior Enclosure						
2010	Exterior Walls	Concrete block	*95% of wall*	S.F. Wall	10.00	5.32	11.1%
2020	Exterior Windows	N/A		—	—	—	
2030	Exterior Doors	Steel overhead, hollow metal	*5% of wall*	Each	2436	.89	
	B30 Roofing						
3010	Roof Coverings	Built-up tar and gravel with flashing; perlite/EPS composite insulation		S.F. Roof	4.55	4.55	8.7%
3020	Roof Openings	Roof hatches and skylight		S.F. Roof	.35	.35	
C. INTERIORS							
1010	Partitions	Concrete block (office and washrooms)	*100 S.F. Floor/L.F. Partition*	S.F. Partition	7.63	.61	10.0%
1020	Interior Doors	Single leaf hollow metal	*5000 S.F. Floor/Door*	Each	815	.17	
1030	Fittings	N/A		—	—	—	
2010	Stair Construction	Steel gate with rails		Flight	10,950	.73	
3010	Wall Finishes	Paint		S.F. Surface	11.63	1.86	
3020	Floor Finishes	90% hardener, 10% vinyl composition tile		S.F. Floor	1.76	1.76	
3030	Ceiling Finishes	Suspended mineral tile on zee channels in office area	*10% of area*	S.F. Ceiling	4.71	.47	

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Common additives

Description	Unit	$ Cost
Dock Leveler, 10 ton cap.		
6' x 8'	Each	6225
7' x 8'	Each	6225
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	265
Nickel cadmium	Each	770
Fence, Chain link, 6' high		
9 ga. wire	L.F.	20
6 ga. wire	L.F.	29
Gate	Each	293
Flagpoles, Complete		
Aluminum, 20' high	Each	1375
40' high	Each	3125
70' high	Each	9725
Fiberglass, 23' high	Each	1675
39'-5" high	Each	3225
59' high	Each	8025
Paving, Bituminous		
Wearing course plus base course	S.Y.	7.85
Sidewalks, Concrete 4" thick	S.F.	3.96

Description	Unit	$ Cost
Sound System		
Amplifier, 250 watts	Each	2125
Speaker, ceiling or wall	Each	174
Trumpet	Each	335
Yard Lighting, 20' aluminum pole with 400 watt high pressure sodium fixture.	Each	2600

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- Basement addition: 8,500 SF x $23.55/SF = $200,175
- Dock levelers cost = 4 x $6,225 = $24,900
- Total cost = ($82.39/SF x 30,000 SF) + $24,900 + $200,175
  = $2,696,775

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Adjustment for Location

- Local Labor rates, availability and rates of local material and equipment are impacted by construction location
- Cost in location/city A = national average cost x location A factor/index
- Location A cost = location B cost x $\frac{\text{location A factor}}{\text{location B factor}}$
- For example, if the construction cost of a project completed at city A is \$3,000,000 (city A index = 1.05). The construction cost for a similar project proposed in city B (index =1.1) = \$3,000,000 x (1.1/1.05) = \$3,142,857.14

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Construction Cost Analysis & Estimating – 110401543

Work Breakdown Structure

Dr. Mohammad Almashaqbeh
Department of Civil Engineering
Hashemite University

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Work Breakdown Structure (WBS)

- Detailed estimate: Each item of the project should be broken down into its parts and estimated
- These parts are often referred to as work packages
- The summation of the work packages can be shown in a hierarchical format called a work breakdown structure (WBS)
- WBS is the progressive hierarchical breakdown of the project into smaller pieces to the lowest practical level to which cost is applied

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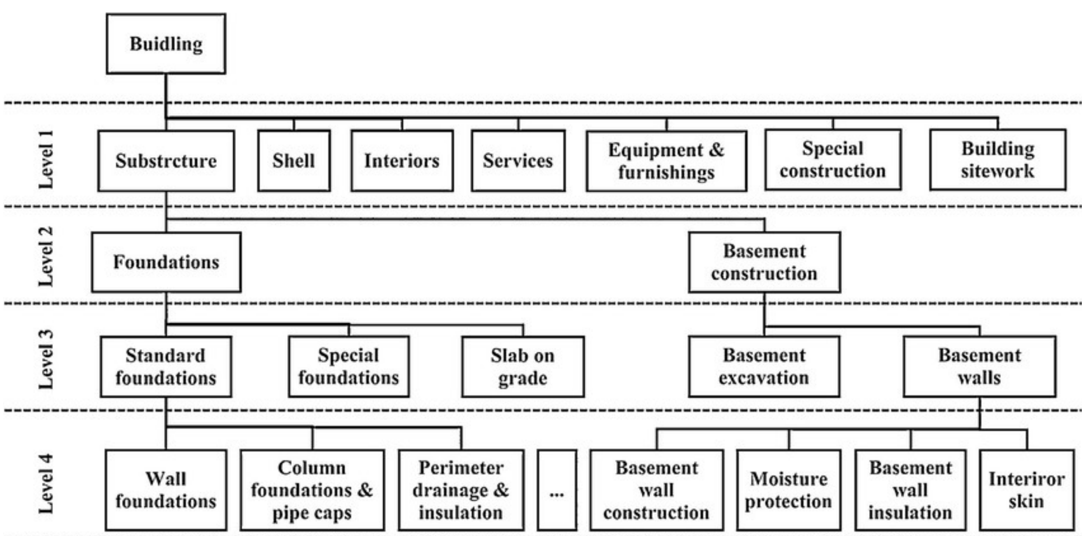

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- The WBS provides the framework for organizing the tasks to complete an entire project
- In a typical building the WBS would contain such systems as
  - The site work
  - Structure
  - Mechanical, electrical, and plumbing (MEP)
  - Interior finishes
  - Roofing system

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- In establishing the WBS, the following guidelines need to be considered
  - Work packages must be clearly distinguishable from other work packages
  - Each work package must have a unique starting and ending date
  - Each work package should have its own unique budget
  - Work packages should be small enough that precise measurement of work progress is possible

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- The WBS divides and subdivides a project into different components, whether by area, phase, function, or other descriptive means
- The development of the WBS should be from the top down and not from the bottom up
- The WBS will be used to provide further definition to the tasks to be performed
- For example, it will serve as the basis for determining the task durations and to estimate the costs

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- Assume that a WBS is prepared for a simple project consisting of constructing a whiteboard fence
- The WBS might be represented with the following major categories
  - Survey work
  - Build fence
  - Cleanup

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- A breakdown of the major categories in the WBS shows the tasks to be performed in each category
- Survey work
  - Establish legal boundary
  - Lay out fence line
  - Mark post locations

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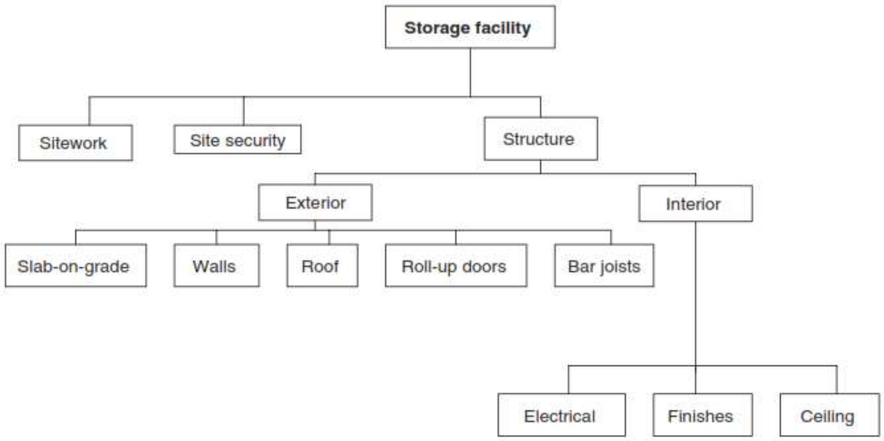
- Build fence
  - Dig post holes
  - Plumb and set posts
  - Attach boards to posts
  - Paint fence
- Cleanup
  - Touch up paint
  - Smooth out area along fence line

100

• WBS of a relatively small and simple construction project



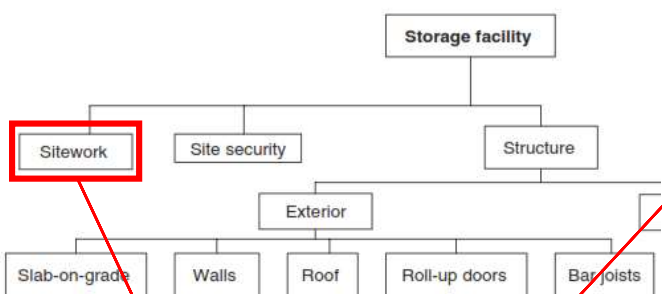
101

• The systems identified in the WBS might be as follows
• Site work
  • Drainage
  • Grading
  • Paving
  • Landscaping
• Site security
  • Fencing
  • Security lights

102

- Structure
  - Exterior
    - Slab-on-grade
    - Concrete masonry unit (CMU) walls
    - Bar joists
    - Roofing
    - Roll-up doors
  - Interior
    - Interior finish
    - Electrical
    - Ceiling

103



- Site work
  - Drainage
  - Grading
  - Paving
  - Landscaping

Activity Data Sheet

Project: ***Storage Facility***

Activity: *Grading* Activity Code: *S103*

Responsibility: *GT&B Grading Specialists – Subcontractor*

Scope of Work:

Reference: *Site Plan Sheets 1, 2, and 3*

Description:

- *Properly obtain a finish grade for the site as shown on the plans and detailed in the Specifications*
- *Properly dispose of all waste created during the performance of the work*
- *Maintain full compliance with the OSHA regulations while on the site*
- *Responsible for all equipment needed to properly execute the work*

Work Plan and Assumptions:

There will be no site encumbrances that will impede work during the days that the grading work is scheduled to be performed.

Duration Calculations:

Two Operators needed—two eight-hour days
Two Laborers needed—two eight-hour days

Total: *64 labor hours needed*

Reference:

Cost Calculations:

Labor:
Two operators at $47.00 per hour for 32 hours = $1,504
Two laborers at $34.00 per hour for 32 hours = $1,088

Equipment:
One front-end loader at $85.00 per hour for 16 hours = $1,360
One motor grader at $70.00 per hour for 16 hours = $1,120

Materials:
None

Total Cost: *$5,072*

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- Task durations can be computed through the use of the WBS

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One motor grader at $70.00 per hour for 16 hours = $1,120

Materials:
None

Total Cost: *$5,072*

105

- The estimate can be prepared from the WBS

Activity Data Sheet

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Activity: *Grading* Activity Code: *S103*

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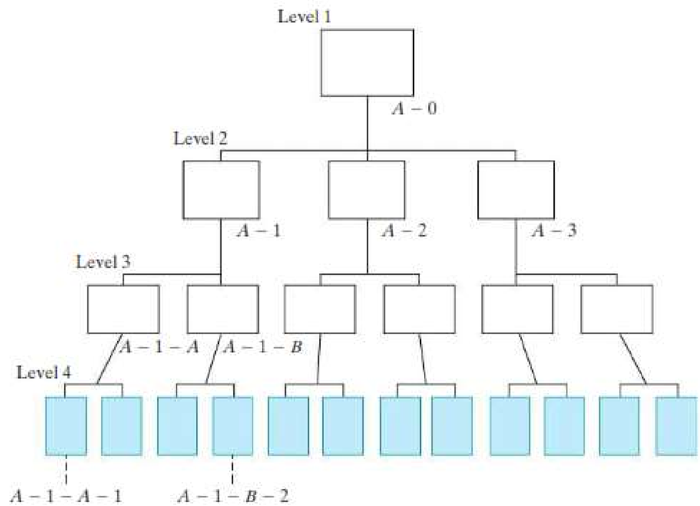
One motor grader at $70.00 per hour for 16 hours = $1,120

Materials:
None

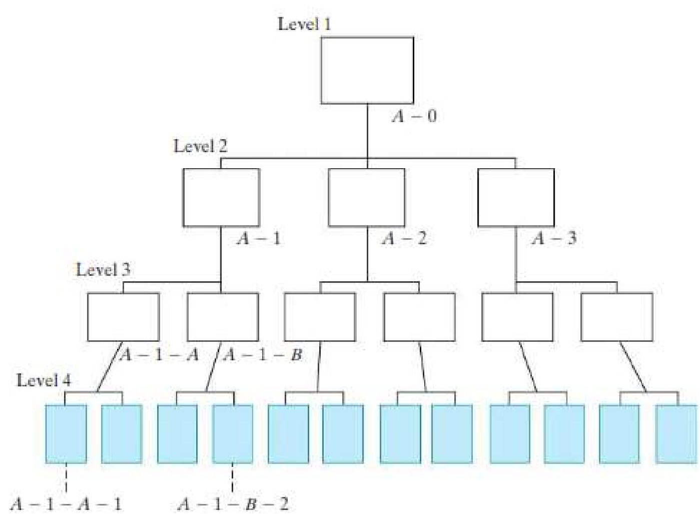
Total Cost: *$5,072*

106

- A four-level WBS
- It is developed from the top (project level) down in successive levels of detail
- The project is divided into its major work elements (Level 2)



- These major elements are then divided to develop Level 3
- This process is continued until the desired detail in definition and description of the project is achieved



- You have been appointed by your company to manage a project involving construction of a small commercial building with two floors of 15,000 gross square feet each
- The ground floor is planned for small retail shops, and the second floor is planned for offices
- Develop the first three levels of a representative WBS adequate for all project efforts from the time the decision was made to proceed with the design and construction of the building until initial occupancy is completed

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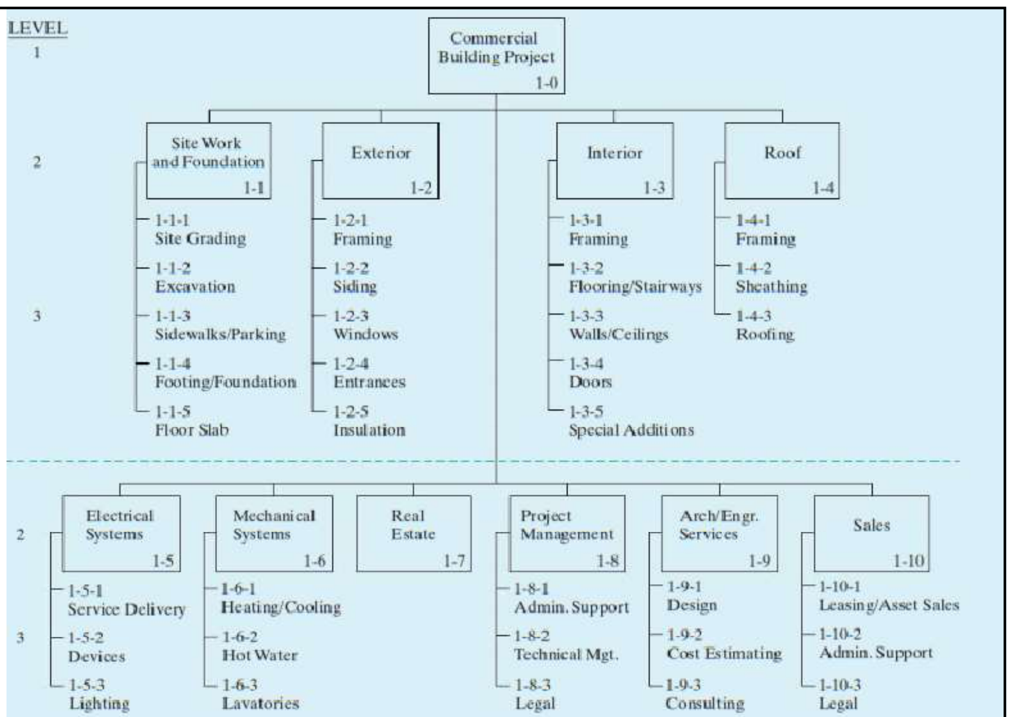
There would be variations in the WBSs developed by each individual



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- Example of electric power construction bid summary using the WBS organization of work

Group-level report

No.	Group	Material	Labor and equipment	Subcontract	Total
1100	Switch station	$1,257,295.00	$ 323,521.00	$3,548,343.00	$ 5,128,167.00
2100	Transmission line **A**	3,381,625.00	1,260,837.00	0.00	4,641,462.00
2300	Transmission line **B**	1,744,395.00	0.00	614,740.00	2,358,135.00
3100	Substation at spring creek	572,874.00	116,403.00	1,860,355.00	2,549,632.00
4200	Distribution line **A**	403,297.00	54,273.00	215,040.00	672,610.00
4400	Distribution line B	227,599.00	98,675.00	102,387.00	427,661.00
4500	Distribution line **C**	398,463.00	21,498.00	113,547.00	532,508.00
		$7,985,548.00	$1,872,215.00	$6,453,412.00	$16,311,175.00

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- Example of electric power construction bid summary using the WBS organization of work

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- Example of electric power construction bid summary using the WBS organization of work

DIVISION-LEVEL REPORT FOR TRANSMISSION LINE A

Cost item	Description	Material	Labor	Equipment	Total
2100	TRANSMISSION LINE A				
2210	Fabrication of steel towers	$ 692,775.00	$ 0.00	$ 0.00	$ 692,775.00
2370	Tower foundations	83,262.00	62,126.00	71,210.00	216,598.00
2570	Erection of steel towers	0.00	144,141.00	382,998.00	527,139.00
2620	Insulators and conductors	2,605,588.00	183,163.00	274,744.00	3,063,495.00
2650	Shield wire installation	0.00	78,164.00	63,291.00	141,455.00
	Total for 2100	$3,381,625.00	$467,594.00	$792,243.00	$4,641,462.00

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- Example of electric power construction bid summary using the WBS organization of work

DIVISION-LEVEL REPORT FOR TRANSMISSION LINE A

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2650	Shield wire installation	0.00	78,164.00	63,291.00	141,455.00
	Total for 2100	$3,381,625.00	$467,594.00	$792,243.00	$4,641,462.00

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- Example of electric power construction bid summary using the WBS organization of work

COMPONENT-LEVEL REPORT FOR TOWER FOUNDATIONS

Cost Item	Description	Quantity	Material	Labor	Equipment	Total
2370	TOWER FOUNDATIONS					
2372	Drilling foundations	4,196 lin ft	$ 0.00	$25,428.00	$44,897.00	$ 70,325.00
2374	Reinforcing steel	37.5 tons	28,951.00	22,050.00	15,376.00	66,377.00
2376	Foundation concrete	870 yd^3	53,306.00	13,831.00	10,143.00	77,280.00
2378	Stub angles	3,142 lb	1,005.00	817.00	794.00	2,616.00
Total for 2370			$83,262.00	$62,126.00	$71,210.00	$216,598.00

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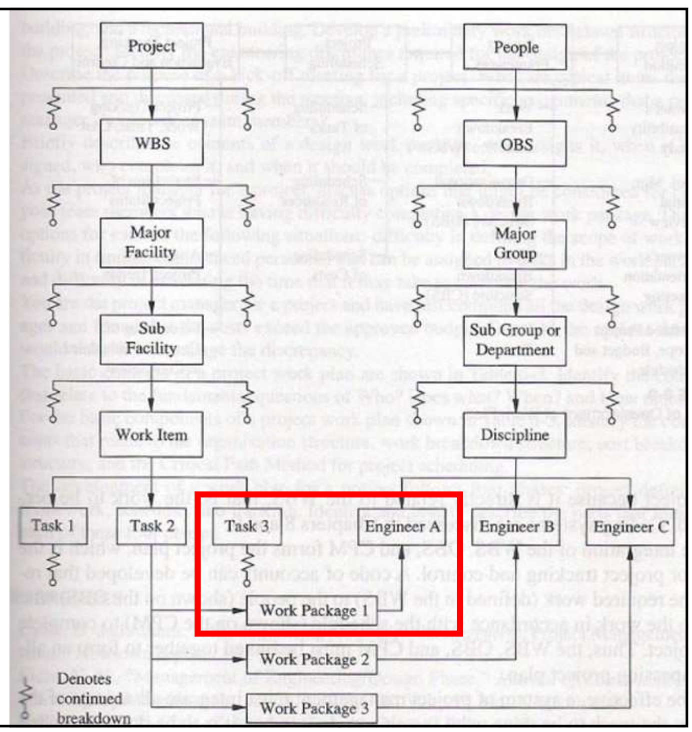
- Organizational breakdown structure (OBS)
- Used for management of people



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- CSI MasterFormat

DIVISION 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS

00 00 00	PROCUREMENT AND CONTRACTING REQUIREMENTS
00 10 00	SOLICITATION
00 20 00	INSTRUCTIONS FOR PROCUREMENT
00 30 00	AVAILABLE INFORMATION
00 40 00	PROCUREMENT FORMS AND SUPPLEMENTS
00 50 00	CONTRACTING FORMS AND SUPPLEMENTS
00 60 00	PROJECT FORMS
00 70 00	CONDITIONS OF THE CONTRACT
00 90 00	REVISIONS, CLARIFICATIONS, AND MODIFICATIONS

DIVISION 01 – GENERAL REQUIREMENTS

01 00 00	GENERAL REQUIREMENTS
01 10 00	SUMMARY
01 20 00	PRICE AND PAYMENT PROCEDURES
01 30 00	ADMINISTRATIVE REQUIREMENTS
01 40 00	QUALITY REQUIREMENTS
01 50 00	TEMPORARY FACILITIES AND CONTROLS
01 60 00	PRODUCT REQUIREMENTS
01 70 00	EXECUTION AND CLOSEOUT REQUIREMENTS
01 80 00	PERFORMANCE REQUIREMENTS
01 90 00	LIFE CYCLE ACTIVITIES

DIVISION 02 – EXISTING CONDITIONS

02 00 00	EXISTING CONDITIONS
02 20 00	ASSESSMENT
02 30 00	SUBSURFACE INVESTIGATIO
02 40 00	DEMOLITION AND STRUCTURE MOVING
02 50 00	SITE REMEDIATION
02 60 00	CONTAMINATED SITE MATERIAL REMOVAL
02 70 00	WATER REMEDIATION
02 80 00	FACILITY REMEDIATION

DIVISION 03 – CONCRETE

03 00 00	CONCRETE
03 10 00	CONCRETE FORMING AND ACCESSORIES
03 30 00	CAST-IN-PLACE CONCRETE
03 40 00	PRECAST CONCRETE
03 50 00	CAST DECKS AND UNDERLAYMENT
03 60 00	GROUTING
03 70 00	MASS CONCRETE
03 80 00	CONCRETE CUTTING AND BORING

DIVISION 04 – MASONRY

04 00 00	MASONRY
04 20 00	UNIT MASONRY
04 40 00	STONE ASSEMBLIES
04 50 00	REFRACTORY MASONRY
04 60 00	CORROSION-RESISTANT MASONRY
04 70 00	MANUFACTURED MASONRY

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DIVISION 02 – EXISTING CONDITIONS

02 00 00	EXISTING CONDITIONS
02 20 00	ASSESSMENT
02 30 00	SUBSURFACE INVESTIGATION
02 40 00	DEMOLITION AND STRUCTURE MOVING
02 50 00	SITE REMEDIATION
02 60 00	CONTAMINATED SITE MATERIAL REMOVAL
02 70 00	WATER REMEDIATION
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DIVISION 04 – MASONRY

04 00 00	MASONRY
04 20 00	UNIT MASONRY
04 40 00	STONE ASSEMBLIES
04 50 00	REFRACTORY MASONRY
04 60 00	CORROSION-RESISTANT MASONRY
04 70 00	MANUFACTURED MASONRY

03 00 00 Concrete

03 01 00 Maintenance of Concrete

03 01 10	Maintenance of Concrete Forming and Accessories
03 01 20	Maintenance of Concrete Reinforcing
03 01 23	Maintenance of Stressing Tendons
03 01 30	Maintenance of Cast-in-Place Concrete
03 01 30.51	Cleaning of Cast-in-Place Concrete
03 01 30.61	Resurfacing of Cast-in-Place Concrete
03 01 30.71	Rehabilitation of Cast-in-Place Concrete
03 01 30.72	Strengthening of Cast-in-Place Concrete
03 01 40	Maintenance of Precast Concrete
03 01 40.51	Cleaning of Precast Concrete
03 01 40.61	Resurfacing of Precast Concrete
03 01 40.71	Rehabilitation of Precast Concrete
03 01 40.72	Strengthening of Precast Concrete
03 01 50	Maintenance of Cast Decks and Underlayment
03 01 50.51	Cleaning Cast Decks and Underlayment
03 01 50.61	Resurfacing of Cast Decks and Underlayment
03 01 50.71	Rehabilitation of Cast Decks and Underlayment
03 01 50.72	Strengthening of Cast Decks and Underlayment
03 01 60	Maintenance of Grouting
03 01 70	Maintenance of Mass Concrete
03 01 80	Maintenance of Concrete Cutting and Boring

03 10 00 Concrete Forming and Accessories

03 11 00 Concrete Forming

03 11 13	Structural Cast-in-Place Concrete Forming
03 11 13.13	Concrete Slip Forming
03 11 13.16	Concrete Shoring
03 11 13.19	Falsework
03 11 16	Architectural Cast-in Place Concrete Forming
03 11 16.13	Concrete Form Liners

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- Example of building construction project bid summary using the CSI organization of work

Item	Division	Material	Labor	Subcontract	Total
1	General requirement	$ 16,435.00	$ 36,355.00	$ 4,882.00	$ 57.672.00
2	Site-work	15,070.00	20,123.00	146,186.00	181,389.00
3	Concrete	97,176.00	51,524.00	0.00	148,700.00
4	Masonry	0.00	0.00	212,724.00	212,724.00
5	Metals	212,724.00	59,321.00	0.00	272,045.00
6	Woods and plastics	38,753.00	10,496.00	4,908.00	54,157.00
7	Thermal and moisture	0.00	0.00	138,072.00	138,072.00
8	Doors and windows	36,821.00	32,115.00	0.00	68,936.00
9	Finishes	172,587.00	187,922.00	0.00	360,509.00
10	Specialties	15,748.00	11,104.00	9,525.00	36,377.00
11	Equipment	0.00	0.00	45,729.00	45,729.00
12	Furnishings	0.00	0.00	0.00	0.00
13	Special construction	0.00	0.00	0.00	0.00
14	Conveying systems	0.00	0.00	0.00	0.00
15	Mechanical	0.00	0.00	641,673.00	641,673.00
16	Electrical	0.00	0.00	354,661.00	354,661.00
	Total direct costs	$605,314.00	$408,960.00	$1,558,360.00	$2,572,644.00
	Material tax (5%)	30,266.00			2,602,910.00
	Labor tax (18%)		73,613.00		2,676,523.00
	Contingency (2%)			53,530.00	2,730,053.00
	Bonds/Insurance			34,091.00	2,764,144.00
	Profit (10%)			276,414.00	3,040,558.00
				Bid price =	$3,040,558.00

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- Example of building construction project bid summary using the CSI organization of work

Item	Division	Material	Labor	Subcontract	Total
1	General requirement	$ 16,435.00	$ 36,355.00	$ 4,882.00	$ 57.672.00
2	Site-work	15,070.00	20,123.00	146,186.00	181,389.00
3	Concrete	97,176.00	51,524.00	0.00	148,700.00
4	Masonry	0.00	0.00	212,724.00	212,724.00
5	Metals	212,724.00	59,321.00	0.00	272,045.00
6	Woods and plastics	38,753.00	10,496.00	4,908.00	54,157.00
7	Thermal and moisture	0.00	0.00	138,072.00	138,072.00
8	Doors and windows	36,821.00	32,115.00	0.00	68,936.00
9	Finishes	172,587.00	187,922.00	0.00	360,509.00
10	Specialties	15,748.00	11,104.00	9,525.00	36,377.00
11	Equipment	0.00	0.00	45,729.00	45,729.00
12	Furnishings	0.00	0.00	0.00	0.00
13	Special construction	0.00	0.00	0.00	0.00
14	Conveying systems	0.00	0.00	0.00	0.00
15	Mechanical	0.00	0.00	641,673.00	641,673.00
16	Electrical	0.00	0.00	354,661.00	354,661.00
	Total direct costs	$605,314.00	$408,960.00	$1,558,360.00	$2,572,644.00
	Material tax (5%)	30,266.00			2,602,910.00
	Labor tax (18%)		73,613.00		2,676,523.00
	Contingency (2%)			53,530.00	2,730,053.00
	Bonds/Insurance			34,091.00	2,764,144.00
	Profit (10%)			276,414.00	3,040,558.00
				Bid price =	$3,040,558.00

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• Division 2 Estimate for Site-work

Cost code	Description	Quantity	Material	Labor	Subcontract	Total
2110	Clearing	L.S.	$0.00	$0.00	$3,694.00	$3,694.00
2220	Excavation	8,800 yd^3	0.00	11,880.00	9,416.00	21,296.00
2250	Compaction	950 yd^3	0.00	2,223.00	722.00	2,945.00
2294	Handwork	500 yd^2	0.00	1,750.00	0.00	1,750.00
2281	Termite control	L.S.	0.00	0.00	3,475.00	3,475.00
2372	Drilled piers	1,632 lin ft	14,580.00	2,800.00	14,525.00	31,904.00
2411	Foundation drains	14 ea.	490.00	1,470.00	0.00	1,960.00
2480	Landscape	L.S.	0.00	0.00	8,722.00	8,722.00
2515	Paving	4,850 yd^2	0.00	0.00	105,633.00	105,633.00
			$\boxed{\$15,070.00}$	$\boxed{\$20,123.00}$	$\boxed{\$146,186.00}$	$\boxed{\$181,389.00}$

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Construction Cost Analysis & Estimating – 110401543

Detailed Cost Estimating

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- The detailed estimate includes determination of the quantities and costs of everything that is required to complete the project
- This includes materials, labor, equipment, insurance, bonds, overhead, and profit
- To perform this type of estimate, the contractor must have a complete set of contract documents
- Each item of the project should be broken down into its parts and estimated

123

- Each piece of work that is to be performed by the contractor has a distinct labor requirement that must be estimated
- The items that are to be installed by others need to be defined and priced
- Caution needs to be exercised to ensure that there is agreement between the contractor and the specialty contractor as to what they are to do and whether they are to install or supply and install the items

124

- In addition, there needs to be an agreement about who is providing support items such as cranes and scaffolding
- The contractor is responsible for
  - Making sure that the scope of work is divided among the contractor and subcontractors
  - There are no overlaps in the individual scope of works and that everything has been included in someone's scope of work

125

- The detailed estimate must establish
  - Estimated quantities and costs of the materials
  - Time required for and costs of labor
  - Equipment required and its cost
  - Items required for overhead and the cost of each item
  - Percentage of profit desired, considering the investment, the time to complete, and the complexity of the project

126

- A well-organized estimate improves the probability of getting the work, facilitating the actual work in the field, and completing the work within budget
- The organization required includes
  - A plan for completing the estimate and maintaining complete and up-to date files
  - A complete breakdown of costs for the project, both of work done by company forces (in-house) and of work done by subcontractors

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- All data generated during the development of the estimate must be filed in an orderly manner
- The estimating costs are often stored in spreadsheets, databases, or estimating software packages
- The estimator's work must be kept organized to the extent that in an unforeseen circumstance someone else might step in, complete the estimate, and submit a proposal on the project

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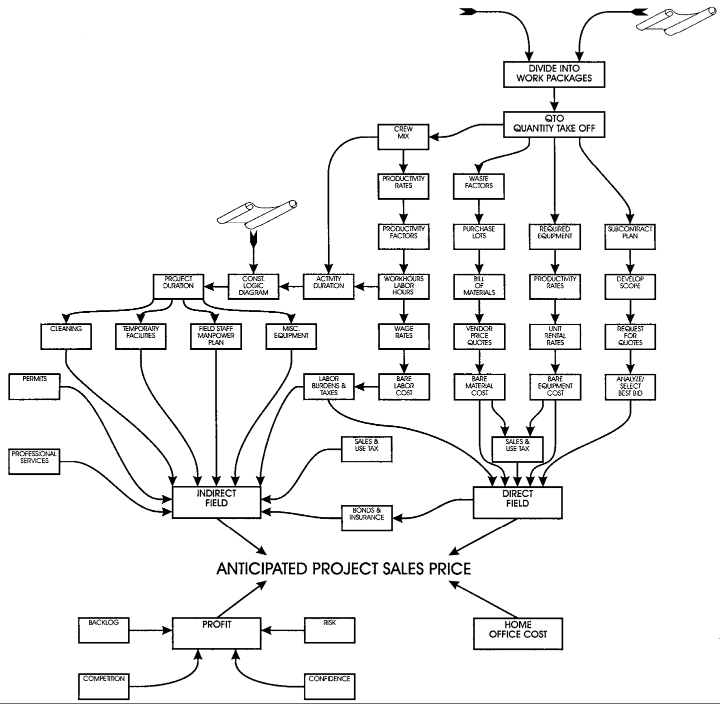
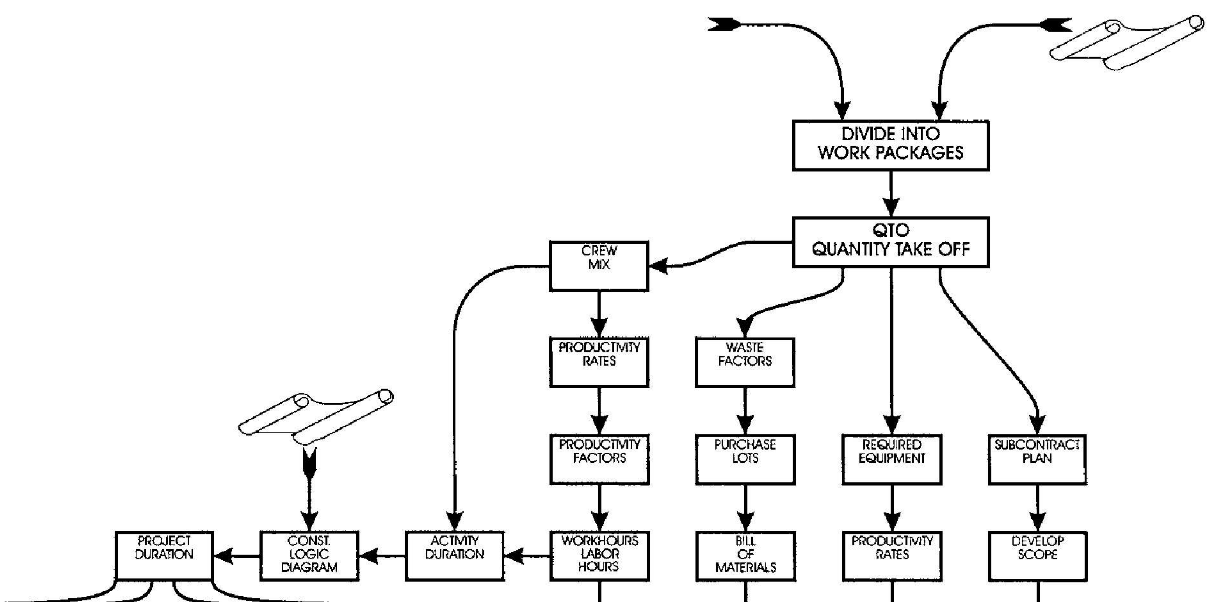
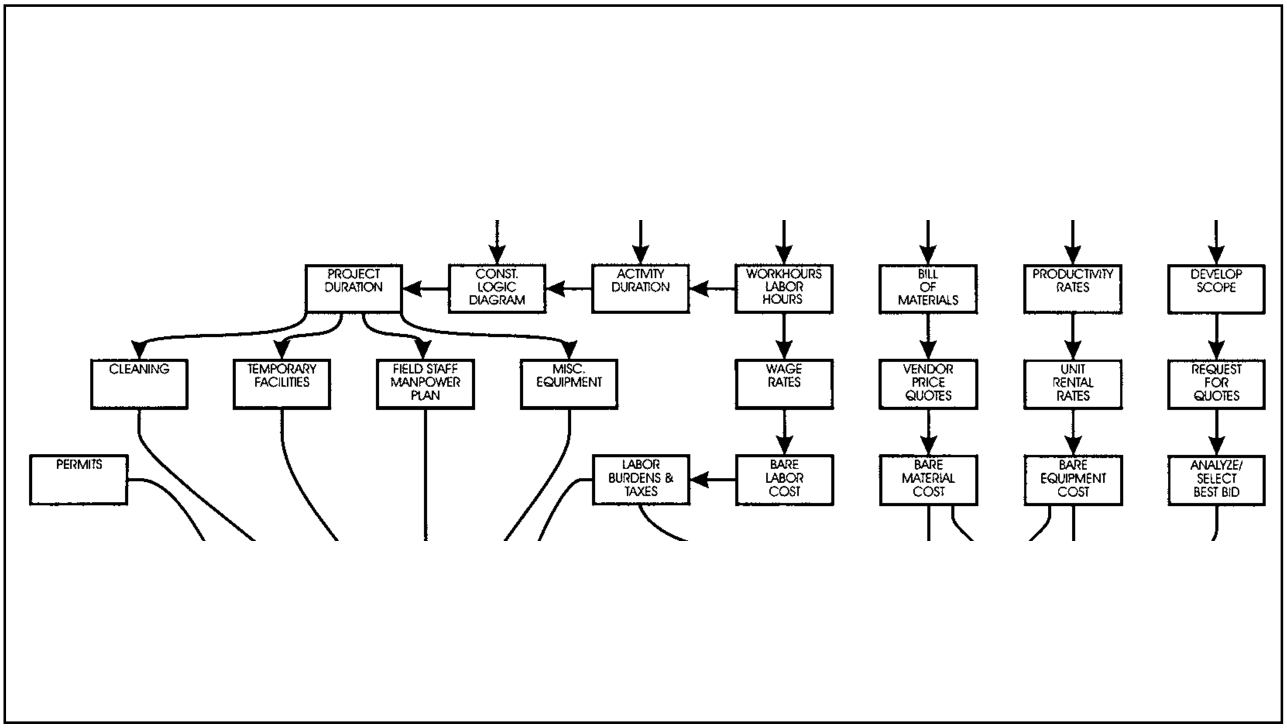
- Required steps to complete an estimate



129

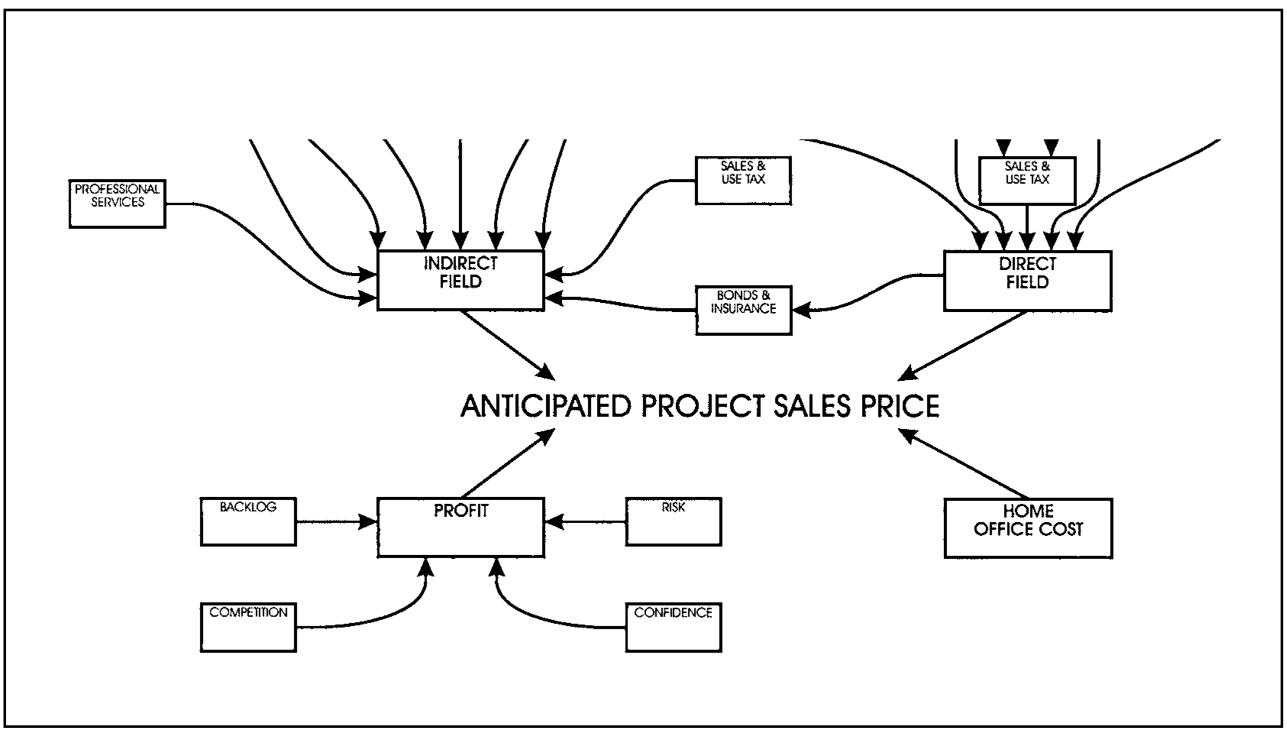


130



PROJECT DURATION
CONST. LOGIC DIAGRAM
ACTIVITY DURATION
WORKHOURS LABOR HOURS
BILL OF MATERIALS
PRODUCTIVITY RATES
DEVELOP SCOPE
CLEANING
TEMPORARY FACILITIES
FIELD STAFF MANPOWER PLAN
MISC. EQUIPMENT
WAGE RATES
VENDOR PRICE QUOTES
UNIT RENTAL RATES
REQUEST FOR QUOTES
PERMITS
LABOR BURDENS & TAXES
BARE LABOR COST
BARE MATERIAL COST
BARE EQUIPMENT COST
ANALYZE/ SELECT BEST BID

131



PROFESSIONAL SERVICES
SALES & USE TAX
SALES & USE TAX
INDIRECT FIELD
DIRECT FIELD
BONDS & INSURANCE
ANTICIPATED PROJECT SALES PRICE
BACKLOG
PROFIT
RISK
HOME OFFICE COST
COMPETITION
CONFIDENCE

132

- A helpful tool when preparing an estimate is a bar chart schedule that details when the activities comprising the estimate will be completed
- In addition, the persons who are responsible for those activities should be listed on the schedule
- The bars and milestones will be darkened as the activities are completed

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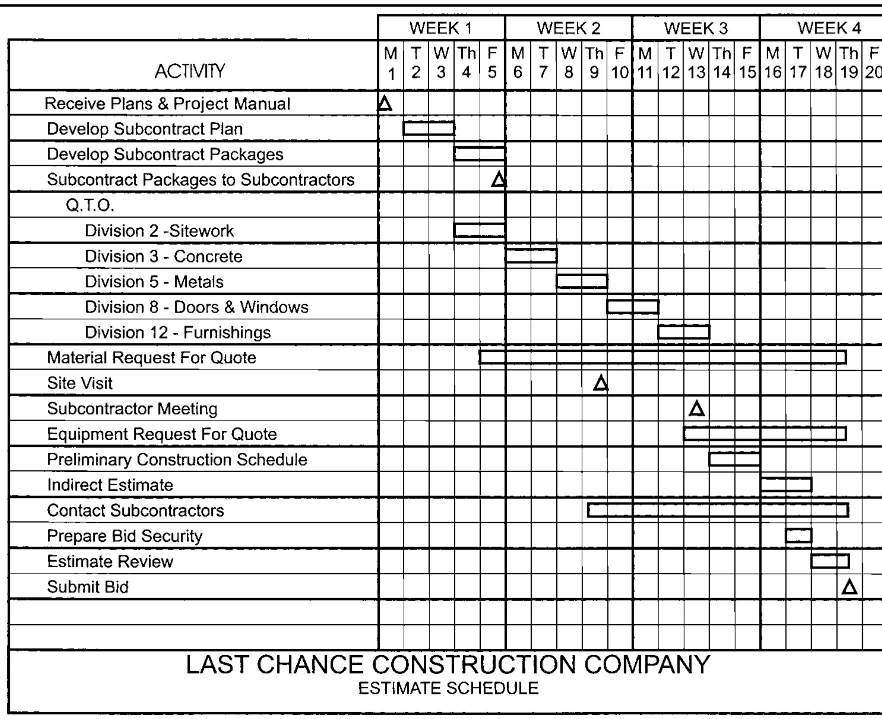

134

- A notebook should be kept for each estimate prepared
- The notebook should be broken down into several areas
  - Workup sheets
  - Summary sheets
  - Errors and omissions sheets
  - Proposals received from subcontractors
  - Proposals received from material suppliers and manufacturers' representatives
  - Notes pertaining to the project

135

- A listing of all calls made to the architect/engineer should be kept together, specifying who called, who was contacted at the architect/engineer's office, the date of the call, and what was discussed
- Every page of the estimate should be numbered and initialed by the person who prepared that portion of the estimate
- When construction begins and the estimate is used to purchase materials, if there are questions concerning a specific item, the estimator can be found and asked to clarify any questions

136

- It is impossible for a contractor to submit a proposal for every project that goes out to bid
- Through personal contact and the reporting services, the contractor finds out
  - What projects are out for bid
  - Which projects to submit a proposal

137

- Many factors must be considered
  - Type of construction involved compared with the type of construction the contractor is usually involved in
  - Location of the project
  - Size of the project in terms of total cost and in relation to bonding capacity
  - Architect/engineer
  - Amount of work currently under construction
  - Equipment available
  - Availability of qualified personnel to run the project

138

- There are also certain projects for which a contractor is not allowed to submit a proposal
- The owners may accept proposals only from contractors who are invited to bid
- Other projects may have certain conditions pertaining to work experience or years in business that must be met

139

- Once the contractor has decided to bid on a particular project, arrangements need to be made to pick up the contract document
- The estimator should proceed with the estimate in a manner that will achieve the greatest accuracy and completeness possible

140

Steps in working up a detailed estimate

- Carefully check the drawings and the project manual to be sure that you have everything, including all addenda
- Not all architectural and engineering offices number their drawings in the same manner
- Typically, the front of the project manual or the drawings contains a list of all the drawings included in the set
- Check all sources to ensure that you have received all of the drawings
- If there are any discrepancies, check with the architect/engineer and complete your set

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SHEET INDEX

Sheet List	
Sheet Number	Sheet Name
C0	COVER SHEET
C1	SITE PLAN
D1	DEMO PLANS
D2	DEMO ELEVATIONS
A1	BASEMENT & MAIN LEVEL FLOOR PLANS
A2	UPPER LEVEL & ROOF PLANS
A3	ELEVATIONS
A4	ELEVATIONS
A5	BUILDING SECTIONS
E1	ELECTRICAL PLAN
E2	ELECTRICAL PLAN
S1	FOUNDATION PLAN & MAIN LEVEL FRAMING
S2	UPPER LEVEL FRAMING & ROOF FRAMING PLAN
S3	STRUCTURAL DETAILS
S4	STRUCTURAL DETAILS
G1	GARAGE PLAN
G2	GARAGE ELEVATIONS and SECTIONS

142

- Examine the size and shape of the project
- What are the principal materials?
- Pay particular attention to the elevations
- At this step, it is important that the estimator understands the project
- Make a note of exterior finish materials, the amount of glass required, special room layouts, and any unusual features

143

- Review the structural drawings
- Note what types of structural systems are being used and what types of construction equipment will be required
- Once again, if the structural system is unusual, the estimator should make a note to spend extra time on this area

144

- Review the mechanical drawings
- Pay particular attention to how they will affect the general construction, underground work requirements, outlet requirements, and other items of this sort
- Even under separate contracts, the mechanical portions must be checked

145

- The submitted bid is based on the drawings and the project manual
- You are responsible for everything contained in the project manual as well as what is covered on the drawings
- Visit the site after making a preliminary examination of the drawings and the project manual
- The visit should be made by the estimator or by other experienced persons, including members of the proposed project execution team

146

- Call a meeting with the people who would most likely hold the key supervisory positions if you are the successful bidder
- Be sure to allow these people time before the meeting to become familiar with the project
- During this meeting, the project should be discussed in terms of the construction methods that could be followed, the most desirable equipment to use, the time schedules to be followed, and the personnel needed on the project

147

- Check carefully through the general conditions and supplementary general conditions
- Make a list of all items contained in the project manual that will affect the cost of the project
- Send a copy of all insurance requirements for the project to your insurance company and all bonding requirements for the project to your bonding company

148

- The estimator may now begin the takeoff of the quantities required
- Each item must be accounted for, and the estimate itself must be as thorough and complete as possible
- The items should be listed in the same manner and with the same units of measure in which the work will be constructed on the job

149

- Whenever possible, the estimate should follow the general setup of the specifications
- This work is done on a workup sheet
- As each item is estimated, the type of equipment to be used for each phase should be listed
- The list will vary depending on the equipment owned and what is available for rent. Prices on equipment to be purchased or rented must be included

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ESTIMATE WORK SHEET

REINFORCING STEEL

Project: Little Office Building
Location Littleville, Tx
Architect U.R. Architects
Items Foundation Concrete

Estimate No. 1234
Sheet No. 1 of 1
Date 11/11/20XX
By LHF **Checked** JBC

Cost Code	Description	Dimensions L	W	Space			Count	Bar Size	Linear Feet	Pounds / Foot				Quantity	Unit
		ft	ft	/ ft											
	Continuous Footings														
	Perimeter - Long Bars	336	3.167	2			8	5	2688	1.043				2,804	Pounds
	Perimeter - Short Bars	2.83	336	2			673	5	1904.59	1.043				1,986	Pounds
	Interior - Long Bars	76	3	2			7	5	532	1.043				555	Pounds
	Interior - Short Bars	2.67	76	2			153	5	408.51	1.043				426	Pounds
	Dowels														
	Perimeter	4	336	1			337	5	1348	1.043				1,406	Pounds
	Interior	4	76	1			77	5	308	1.043				321	Pounds
	Foundation Walls														
	Perimeter - Long Bars	336	4	2			9	5	3024	1.043				3,154	Pounds
	Perimeter - Short Bars	3.67	336	2			673	5	2469.91	1.043				2,576	Pounds
	Interior - Long Bars	76	8	2			17	5	1292	1.043				1,348	Pounds
	Interior - Short Bars	8	76	2			153	5	1224	1.043				1,277	Pounds
					Count										
	Spread Footings	2.67	2.67	2	3		42	5	112.14	1.043				117	Pounds
	Dowels	4			3		12	5	48	1.043				50	Pounds
	Column Piers - Vertical Bars	3.67			3		12	5	44.04	1.043				46	Pounds
	Column Piers - Stirrups	3.33	4	1	3		15	3	49.95	0.376				19	Pounds
	Drilled Piers														
	Vertical Bars	20			3		18	5	360	1.043				375	Pounds
	Horizontal Bars	3.67	20	1.5	3		93	3	341.31	0.376				128	Pounds
	Grade Beams - Long Bars	69					6	5	414	1.043				432	Pounds
	Grade Beams - Stirrups	3.67	69	1			70	3	256.9	0.376				97	Pounds

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- At the time the estimator is preparing the quantity takeoff on workup sheets, the following tasks can also be ongoing
  - Notify subcontractors, material suppliers, and manufacturers' representatives that the company is preparing a proposal for the project and ask them if they intend to submit bids on the project
  - Begin to make a list of all items of overhead that must be included in the project. This will speed up the future pricing of these items

152

- The information on the workup sheet is carried over to the summary sheet
- Common errors
  - Misplaced decimal point
  - Errors in addition, subtraction, multiplication, and division
  - Omission of items such as materials, labor, equipment, or overhead
  - Errors in estimating the length of time required to complete the project
  - Errors in estimating construction waste

153

- Common errors
  - Errors in estimating quantities of materials
  - Errors in transferring numbers from one sheet to another
  - Adding a line to a spreadsheet and not checking to make sure that the new line is included in the total
  - Errors in setting up formulas, items, assemblies, markups, and so forth in estimating software
  - Using typical productivity rates and costs from estimating software without adjusting them for individual project conditions

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ESTIMATE SUMMARY SHEET

Project	Little Office Building	Estimate No.	1234
Location	Littleville, TX	Sheet No.	1 of 1
Architect	U.R. Architect, Inc.	Date	11/11/20XX
Items	Foundation Concrete	By	LHF Checked JBC

Cost Code	Description	Q.T.O.	Waste Factor	Purch. Quan.	Unit	Crew	Prod. Rate	Wage Rate	Work Hours	Unit Cost Labor	Unit Cost Material	Unit Cost Equipment	Labor	Material	Equipment	Total
	Continous Foooting #5 Bar															
	(2804+1986+555+426)/2000	2.886	10.00%	3.17	Ton		15	$12.75	43.3	$191.25	$550.00		$607	$1,746	$0	$2,353
	Dowels From Ftg to Wall															
	(1406+321)/2000	0.864	10.00%	0.95	Ton		15	$12.75	13.0	$191.25	$550.00		$182	$523	$0	$704
	Foundation Walls															
	(3154+2576+1348+1277)/2000	4.178	10.00%	4.60	Ton		11	$12.75	46.0	$140.25	$550.00		$645	$2,528	$0	$3,172
	Spread Footings w/Dowels															
	(117+50)/2000	0.084	10.00%	0.09	Ton		15	$12.75	1.3	$191.25	$550.00		$18	$51	$0	$68
	Column Piers															
	#5 Bar	0.023	10.00%	0.03	Ton		24	$12.75	0.6	$306.00	$550.00		$8	$14	$0	$22
	#3 Bar	0.010	10.00%	0.01	Ton		24	$12.75	0.2	$306.00	$550.00		$3	$6	$0	$9
	Driller Piers															
	#5 Bar	0.188	10.00%	0.21	Ton		24	$12.75	4.5	$306.00	$550.00		$63	$114	$0	$177
	#3 Bar	0.064	10.00%	0.07	Ton		24	$12.75	1.5	$306.00	$550.00		$22	$39	$0	$60
	Grade Beam															
	#5 Bar	0.216	10.00%	0.24	Ton		22	$12.75	4.8	$280.50	$550.00		$67	$131	$0	$197
	#3 Bar	0.049	10.00%	0.05	Ton		22	$12.75	1.1	$280.50	$550.00		$15	$30	$0	$45
	Slab on Grade															
	(1348+1277)/2000	1.313	10.00%	1.44	Ton		13	$12.75	17.1	$165.75	$550.00		$239	$794	$0	$1,034
															9/15/20099/15/	
									133.21				$1,868	$5,974	$0	$7,843

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10:22 AM
PROJECT:________________
LOCATION:_______________
BID DATE:____________________

LAST CHANCE CONSTRUCTION COMPANY

ESTIMATE SUMMARY

2/23/2002
REVISION:_____
BY:_____
CHECKED:_____

DIV. DESCRIPTION	WORKHOURS	LABOR $	MATERIAL $	EQUIPMENT $	SUBCONTRACT $	TOTAL $
DIRECT FIELD COSTS						
2 SITEWORK						0
3 CONCRETE						0
4 MASONRY						0
5 METALS						0
6 WOODS & PLASTICS						0
7 MOISTURE - THERMAL CONTROL						0
8 DOORS, WINDOWS & GLASS						0
9 FINISHES						0
10 SPECIALTIES						0
11 EQUIPMENT						0
12 FURNISHINGS						0
13 SPECIAL CONSTRUCTION						0
14 CONVEYING SYSTEMS						0
15 MECHANICAL						0
16 ELECTRICAL						0
						0
						0
TOTAL DIRECT FIELD COSTS	0	0	0	0	0	0
INDIRECT FIELD COSTS						
FIELD STAFF						0
TEMPORARY OFFICES						0
TEMPORARY FACILITIES						0
TEMPORARY UTILITIES						0
REPAIRS & PROTECTION						0
CLEANING						0
PERMITS						0
PROFESSIONAL SERVICES						0
BONDS						0
INSURANCE						0
MISC. EQUIPMENT						0
						0
						0
LABOR BURDENS (STAFF)						0
LABOR BURDENS (CRAFT)						0
SALES TAX						0
TOTAL INDIRECT FIELD COSTS	0	0	0	0	0	0
HOME OFFICE COSTS						0
LAST MINUTE CHANGES						0
						0
						0
						0
						0
TOTAL LAST MINUTE CHANGES	0	0	0	0	0	0
PROFIT						0
TOTAL PROJECT COST	0	0	0	0	0	0

156

- Having priced everything, make one last call to the architect/engineer's office to check the number of addenda issued to be sure that you have received them all
- Double-check the time, date, and place that bids are being received
- Double-check that all of the requirements for the submission of the proposal have been followed; be sure the proposal is complete

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Construction Cost Analysis & Estimating – 110401543

Labor Cost

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Hashemite University

158

- Labor cost is a component of the direct costs to complete a project
- Can often ranges from 30 - 60% of the total project cost
- Labor cost includes
  - Wages (hourly rates)
  - Health insurance
  - Paid vacations
  - Overtime work

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- Estimating labor cost requires determining the labor time to do a specific task and then applying a wage rate
- Determining the labor time requires knowing
  - The quantity of work to be placed
  - The productivity rate for the specific crew that will perform the work
- The crew is an aggregation of construction trades working on a specific task

160

- Productivity rates can be determined from
  - Previous projects (historical records)
  - Published cost books
  - Field observations
  - Mathematical modeling
  - Combination of multiple methods

161

- Productivity = quantity of work / time
- For example, if a bricklayer can lay 400 bricks in 8 hours, then the productivity is 50 brick/hr
- OR the time required to produce a specific quantity of work
- For example, 10 hours to lay 1000 bricks (0.01 hr/brick)

162

- Unit time = time needed/quantity (e.g., hr/m)
- Capacity = quantity/time unit (e.g., m/hr)
- Unit time = 1/capacity

- For example, a crew pours 4 m^3 concrete in 1.5 hours
- Crew capacity = 4 m^3 /1.5 hr = 2.67 m^3 /hr
- Unit time = 1.5 hr/4 m^3 = 0.38 hr/ m^3

163

- The productivity rate, if derived from historical data, is for the average or standard conditions for the projects used in calculating the historical production rate
- On many occasions, the project that is being bid deviates from these standard conditions and adjustments using factors are used
- Adjusted labor time = Labor time x Productivity factor

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Example

- Type of work is 8′′ x 8′′ x 16′′ decorative concrete masonry units
- Historical productivity rate is 0.1 labor hours per SF
- Productivity factor is 1.1
- Crew is three masons and two helpers
- For 1,000 SF job calculate labor, mason, and helper hours

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- Labor hours = 1,000 SF x 0.10 labor hours per SF = 100 labor hours
- Adjusted labor hours = 100 labor hours x 1.1 = 110 labor hours

166

- Sixty percent (3/5) of the hours will be performed by masons and 40 percent (2/5) will be performed by their helpers
- Mason labor hours = 0.60 x 110 labor hours = 66 labor hours
- Mason helper labor hours = 0.40 x 110 labor hours = 44 labor hours

167

Example

- Estimate the labor cost for laying decorative masonry units that has a quantity of 800 SF area
- The activity is constructed by a crew that has a daily output of 340 SF/day, and consists of: 3 bricklayers ($38.05/hr) and 2 bricklayers helpers ($28.65/hr)
- 1 day = 8 hours of work

168

- Crew Labor Cost = Σ (hourly rate x 8 hours/day)

= (3 x 38.05 + 2 x 28.65) x 8 = $1,371.6/day

- Unit Labor Cost = $\frac{\$1,371.6/\text{day}}{340\ \text{SF/day}}$ = $4.03/SF
- Total Labor Cost = $4.03/SF x 800 SF = $3,224

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Published Productivity Rates (RSMeans)

04 22 Concrete Unit Masonry

04 22 10 – Concrete Masonry Units

			Daily	Labor-		Bare Costs				Total
		Crew	Output	Hours	Unit	Material	Labor	Equipment	Total	Incl O&P
04 22 10.23 Concrete Block, Decorative										
0010	**CONCRETE BLOCK, DECORATIVE**									
0020	Embossed, simulated brick face									
0100	8″ x 16″ units, 4″ thick	D-8	400	.100	S.F.	3.02	3.43		6.45	8.55
0200	8″ thick		340	.118		4.17	4.03		8.20	10.75
0250	12″ thick	↓	300	.133	↓	5.50	4.57		10.07	13
0400	Embossed both sides									
0500	8″ thick	D-8	300	.133	S.F.	4.68	4.57		9.25	12.10
0550	12″ thick	″	275	.145	″	5.90	4.99		10.89	14.10

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Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew D-7	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Tile Layer	$35.50	$284.00	$52.10	$416.80	$31.38	$46.05
1 Tile Layer Helper	27.25	218.00	40.00	320.00		
16 L.H., Daily Totals		$502.00		$736.80	$31.38	$46.05
Crew D-8	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
3 Bricklayers	$38.05	$913.20	$57.90	$1389.60	$34.29	$52.18
2 Bricklayer Helpers	28.65	458.40	43.60	697.60		
40 L.H., Daily Totals		$1371.60		$2087.20	$34.29	$52.18
Crew D-9	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
3 Bricklayers	$38.05	$913.20	$57.90	$1389.60	$33.35	$50.75
3 Bricklayer Helpers	28.65	687.60	43.60	1046.40		
48 L.H., Daily Totals		$1600.80		$2436.00	$33.35	$50.75

171

- Daily labor cost = \$913.2 + \$458.4 = \$1,371.6/day
- Daily output = 340 SF/day
- Unit Labor Cost = $\frac{\$1,371.6/\text{day}}{340\ \text{SF/day}}$ = \$4.03/SF

172

04 22 Concrete Unit Masonry

04 22 10 – Concrete Masonry Units

04 22 10.23 Concrete Block, Decorative		Crew	Daily Output	Labor-Hours	Unit	Bare Costs Material	Bare Costs Labor	Bare Costs Equipment	Bare Costs Total	Total Incl O&P
0010	**CONCRETE BLOCK, DECORATIVE**									
0020	Embossed, simulated brick face									
0100	8" x 16" units, 4" thick	D-8	400	.100	S.F.	3.02	3.43		6.45	8.55
0200	8" thick		340	.118		4.17	4.03		8.20	10.75
0250	12" thick		300	.133		5.50	4.57		10.07	13
0400	Embossed both sides									
0500	8" thick	D-8	300	.133	S.F.	4.68	4.57		9.25	12.10
0550	12" thick	"	275	.145	"	5.90	4.99		10.89	14.10

173

- Workers seldom work a full 60 minutes during the hour
- Studies of the actual amount of time worked per hour averaged 30 to 50 minutes
- This is often referred to as system efficiency
- The productivity factor is based upon the variance from average conditions, not from the ideal

174

- A system efficiency lower than average will require a productivity factor greater than one
- A system efficiency greater than average will require a productivity factor less than one
- When keeping historical records for labor productivity, it is important that a record of the productivity rate be kept, and under what conditions that productivity rate was achieved so that an appropriate productivity factor can be used

175

- Another method of determining the productivity rate is cycle time analysis
- Used when the work is performed in a repeatable cycle
- An example of a cycle is a truck hauling materials from the borrow pit to the job site and returning to the borrow pit to make a second trip
- Productivity rate =

$$\frac{\text{Average cycle time x productivity factor x crew size}}{\text{System efficiency x quantity per cycle}}$$

176

- Productivity rate =

$$\frac{\text{Average cycle time x productivity factor x crew size}}{\text{System efficiency x quantity per cycle}}$$

- The average cycle time is determined by summing the cycle time and by dividing the sum by the number of observations
- The crew size is the number of people in the crew and determines the number of labor hours per hour
- The quantity per cycle is the number of units of work produced by one cycle

177

Example

- Type of work: Hauling materials from a borrow pit
- Average cycle time: 35 minutes
- Truck capacity: 17 tons
- Crew: One driver
- Productivity factor: 0.95
- System efficiency: 45 minutes per hour
- Calculate the productivity rate

178

- Productivity rate =

$$\frac{\text{Average cycle time x productivity factor x crew size}}{\text{System efficiency x quantity per cycle}}$$

- Productivity rate = $\dfrac{\text{35 minutes x 0.95 x 1}}{\text{45 minutes x 17 tons}}$

= 0.04 labor hours/ton

179

- Work can be performed linearly
- Examples, paving or striping a road, placing a concrete curb using slip-forming machine, or grading a road
- The rate of progress may be used to determine the productivity rate
- Productivity rate = $\dfrac{\left(\dfrac{\text{Quantity}}{\text{Rate of progress}} + \text{Travel time}\right) \text{ x crew size}}{\text{System efficiency x quantity}}$

180

181

- The quantity is the quantity of work to be performed; in the case of placing concrete curb, it would be the length of the curb to be placed with the slip-forming machine
- The rate of progress is the number of units of work that can be performed by the crew each minute when they are performing the work
- In the case of placing a concrete curb, the rate of progress would be the number of feet or m of curb that is placed in one minute

182

- The travel time is the time (in minutes) that the equipment is not working because it is being moved from one section of work to another section of work
- In the case of placing the concrete curb, sections of curb will be left out where there is a tight radius or a driveway approach
- The travel time would be the time it takes to move the equipment forward through the driveway approaches and sections where the curb is not being placed by the machine

183

- Work can be performed linearly
- Examples, paving or striping a road, placing a concrete curb using slip-forming machine, or grading a road
- The rate of progress may be used to determine the productivity rate
- Productivity rate = $\dfrac{\left(\dfrac{\text{Quantity}}{\text{Rate of progress}} + \text{Travel time}\right) \text{ x crew size}}{\text{System efficiency x quantity}}$

184

Example

- Type of work: Slip forming concrete curb
- Quantity: 2,200'
- Number of approaches: 30 (3 minutes each)
- Number of curves: 5 (5 minutes each)
- Rate of progress:3’ per minute
- Crew: One operator and two helpers
- System efficiency: 45 minutes per hour

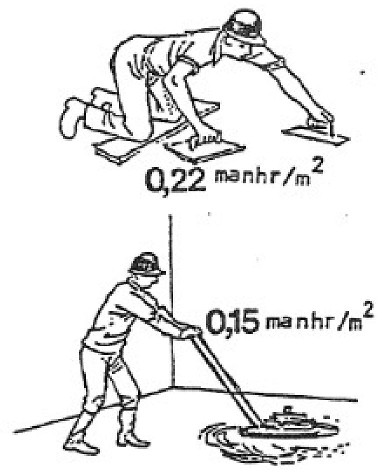
185

- Travel time = 30 x 3 + 5 x 5 = 115 minutes
- Productivity rate = $\dfrac{\left(\dfrac{\text{Quantity}}{\text{Rate of progress}} + \text{Travel time}\right) \text{ x crew size}}{\text{System efficiency x quantity}}$
- Productivity rate = $\dfrac{\left(\dfrac{2{,}200}{3} + 115\right) \text{ x } 3}{45 \text{ x } 2{,}200}$ = 0.03 labor hours per foot

186

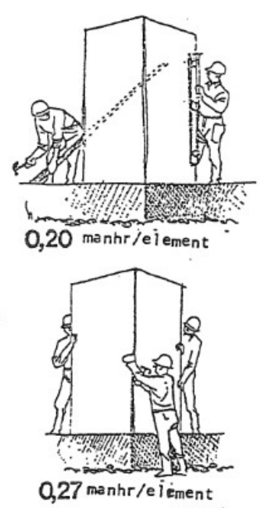
Factors Impacting Productivity

- Equipment
  - Frequently, but not always, quicker with machines
  - Example, surface treatment of concrete floor
  - In smaller areas manual method is better



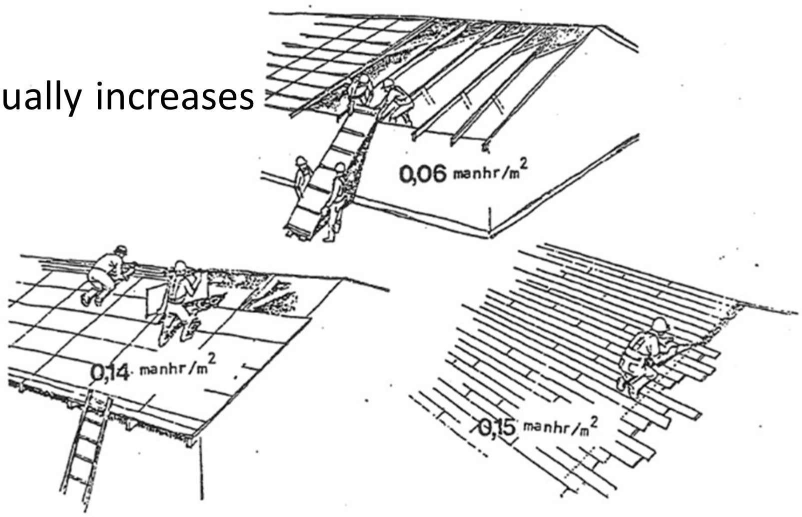
187

- Crew size
  - Example, erection of elements (wood) in a small house. If speed essential, it can be necessary to add extra resources
  - Excessive increase of crew size might reduce productivity due to conflicts and space congestion



188

- Material
  - Prefabrication usually increases productivity
  - Example, roofing



189

- Planning and scheduling
  - To minimize disturbances, balance and optimize crew size, and optimize total project costs
- Working space
- Weather conditions
  - Rain/snow/wind/humidity
  - Extreme hot/cold weather negatively impacts productivity
- Location and local workforce

190

- Excessive overtime
  - As overtime work increases productivity declines
- Learning curve
  - Productivity in performing a task improves with experience and practice

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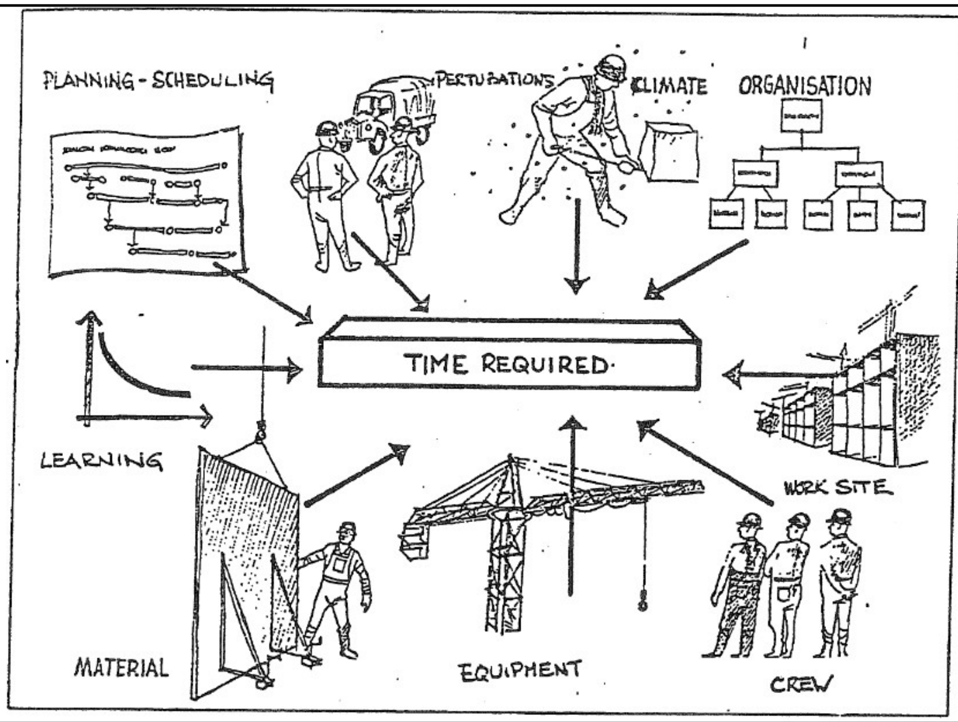

192

TABLE 1.2 Production Range Index

Production elements	Production efficiency, per cent 25 35 45 55 65 75 80 85 90 95 1		
	Low	*Average*	*High*
1 *General economy*	*prosperous*	*normal*	*hard tim*
local business trend	stimulated	normal	depressed
construction volume	high	normal	low
unemployment	low	normal	high
2 *Amount of work*	*limited*	*average*	*extensive*
design areas	unfavorable	average	favorable
manual operations	limited	average	extensive
mechanized operations	limited	average	extensive
3 *Labor*	*poor*	*average*	*good*
training	poor	average	good
pay	low	average	good
supply	scarce	normal	surplus
4 *Supervision*	*poor*	*average*	*good*
training	poor	average	good
pay	low	average	good
supply	scarce	normal	surplus
5 *Job conditions*	*poor*	*average*	*good*
management	poor	average	good
site and materials	unfavorable	average	favorable
workmanship required	first rate	regular	passable
length of operations	short	average	long
6 *Weather*	*bad*	*fair*	*good*
precipitation	much	some	occasional
cold	bitter	moderate	occasional
heat	oppressive	moderate	occasional
7 *Equipment*	*poor*	*normal*	*good*
applicability	poor	normal	good
condition	poor	fair	good
maintenance, repairs	slow	average	quick
8 *Delays*	*numerous*	*some*	*minimum*
job flexibility	poor	average	good
delivery	slow	normal	prompt
expediting	poor	average	good

193

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194

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195

Increasing the Workforce (Crowding)

- A contractor may decide to add extra workers to the workforce
- This added workforce may be asked to work on the regular shift or on a second shift
- Management must consider the impact that these additional workers will have on the existing resources
- For example, is there an adequate supply of hand tools and various pieces of equipment?

196

- The next consideration is the impact that the additional workers on the site might have on labor productivity
- The possible reduction in productivity can be attributed to the crowding that can occur in a work area, shown in the following formula

$$\text{Eff}(\%) = 115\% - 15\left(\frac{\text{size of expanded workforce}}{\text{size of normal workforce}}\right)\%$$

- Eff = Worker efficiency based on 100% for a normal workforce

197

- The impact of crowding on labor productivity

Relative Size of Workforce	Relative Productivity (%)
Normal	100
10% above normal	98.5
2 times normal	85
3 times normal	70
4 times normal	55
5 times normal	40
6 times normal	25

198

- Based on the computed impacts of crowding on productivity, it can be seen that a 10 percent increase in the crew size will have only a minor impact on worker productivity
- The evaluation should not be based on the total workforce but rather on the actual work being done
- For example, if a project has 100 workers and 10 additional pipefitters are hired, the impact on productivity, as assessed with the use of the crowding formula, will be small

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- However, the impact might be quite adverse if the pipefitters are assigned to a work area where two pipefitters were already working
- This would result in 12 workers in an area previously occupied by 2

200

Example

- A specialty contractor employs a workforce of 20 carpenters on a construction site who are paid an average wage of \$12 per hour
- The carpentry work is running behind schedule and the contractor is being faced with a liquidated damages provision of \$1,000 per day for every day that the carpentry work is extended beyond the contractual deadline
- The contractor would like to explore the possibility of increasing the workforce to 30 carpenters
- If the contractor expects to make up or shorten the project duration by 5 days, is this a viable option?

201

- $\text{Eff}(\%) = 115\% - 15\left(\frac{\text{size of expanded workforce}}{\text{size of normal workforce}}\right)\%$

  $= 115\% - 15\ (30/20)\% = 92.5\%$
- The 20 workers would each accomplish 40 hours of work each week for a total of 800 productive hours per week for the entire crew
- With the additional 10 workers, the productivity level per worker will be reduced to 37 hours each week per worker, or a total of 1,110 productive hours per week for the crew

202

- The 30 workers will reduce the schedule by 0.39 week ((1,110–800)/800), or 1.95 days for each week that is worked
- If the additional 10 carpenters are employed for 3 weeks, the carpentry work will be reduced by more than 5 days (1.95 x 3 = 5.85)

203

- What is the cost of lost productivity?
- Working with the additional carpenters, the workforce will have 37 productive hours each week
- The contractor will lose three productive hours for each carpenter each week (40 - 37), which equates to 90 hours lost each week for the entire crew, or 270 hours over a 3-week period
- This will cost the contractor $3,240 in lost production over the 3-week period ($12 x 270 hrs)

204

- What are the savings?
- By working a crew of 30 workers, the schedule will be shortened by 5 days
- When considering the liquidated damages of $1,000 per day, it is apparent that $5,000 will be saved in liquidated damages by employing the additional 10 workers

205

- There are other considerations
- Are the additional carpenters as skilled as the 20 already on the project, or are they relatively unskilled and unfamiliar with the company?
- This will dictate to a large extent whether the formula to compute productivity is even realistic
- The assumption in the formula is that the additional workers are of the same skill level as the existing crew
- If the added workers are less skilled than the existing carpenters, the productivity will probably be below 92.5%

206

- If the additional workers are assigned to perform work in the same location as the existing workers, the impact on productivity could be considerable
- For example, suppose two plumbers are installing plumbing fixtures in a bathroom
- If two additional plumbers are assigned to assist with the installation of these plumbing fixtures, the congested space could result in even less work being performed with the additional workers
- The unique conditions at the job site and the specific tasks being performed will dictate the reliability of the formula for computing productivity with the addition of workers

207

Increasing the Number of Starting Points

- To avoid crowding, it might be possible to assign workers to different areas
- For example, instead of doubling the number of workers at the face of a tunnel, it might be more effective to use the additional workers at a second tunnel face
- The same might apply to having additional sheet metal workers assigned to work on different floors
- This will spread out the job, and some losses in productivity can be expected

208

- With the additional starting places, making material deliveries and satisfying equipment needs on each floor will become more complex
- Use the following equation to compute the amount of schedule reduction that can be expected by increasing the number of starting points

$$T_{new} = \frac{T_{old}}{(Points_{new}/Points_{old})^{2/3}}$$

209

$$T_{new} = \frac{T_{old}}{(Points_{new}/Points_{old})^{2/3}}$$

- T_{new} = Time required to complete a new project/task
- T_{old} = Time to complete a past project/task
- $Points_{new}$ = Number of starting points on the new project/task
- $Points_{old}$ = Number of starting points on a past project/task

210

- This equation determines the amount of time required to complete a given project or task when the following are known
  - The number of starting points
  - The duration of a similar completed project/task
- The equation determines the duration of a similar existing project/task

- Impact of number of starting points on labor productivity

Relative to Known Project Task	Relative Duration (%)	Relative Productivity (%)
Same	100	100
2 times the number	63	79.4
3 times the number	48	69.3
4 times the number	40	63
5 times the number	34	58.5
6 times the number	30	55
8 times the number	25	50

- The table presents information on the relative productivity of work crews when additional starting points are utilized
- Note that productivity actually decreases at a smaller rate as more starting points are used
- This may or may not flag an error in the formulation; however, this is the only known formula to address this issue

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Example

- A contractor has a contract to build a 45-story high-rise building
- To make up for bad weather that occurred early in the project, the contractor is considering the possibility of employing additional crews on the building
- Since the building is dried in, the contractor is thinking about tripling the workforce from what was originally anticipated
- The original plan was to do the finish work inside the building by progressing from the first floor to the top floor

214

- The contractor is now considering having work take place at three locations
  - First floor
  - Sixteenth floor
  - Thirty-first floor
- From their respective starting points, the work would proceed upward to finish the interior work

215

- Initially, 30 workers would have been employed, and they were expected to finish the work in 80 workdays
- The workers are paid an average wage of $15 per hour
- The liquidated damages provision in the contract is for $3,000 per day for each day of late completion
- Should the three starting points be utilized?

216

- By increasing the number of starting points from one to three, the duration is expected to drop to 48 percent of the originally estimated duration of 80 days to about 38.4 (use 39) days (refer to the formula or to Table)
- The decision to be made then is whether it is more economically feasible to have 30 workers working for 80 days or 90 workers working for 39 days

217

- What Is the cost of lost productivity?
- The worker wages are an average of $15 per hour per worker, so 30 workers will accumulate 240 hours each day, for which the pay will be $3,600
- The wages for working 80 days will be $288,000
- With the workforce tripled, there will be 90 workers, who will accumulate 720 hours each day, for which the pay will be $10,800
- The total wages over a period of 39 days will be $421,200

218

- What are the savings?
- By tripling the number of starting points in the building, the number of days that the schedule is shortened is 41 days (80 – 39), for an additional cost of $133,200
- The cost will be $3,248.78 for each day of schedule reduction
- This is quite comparable to the liquidated damages amount

219

- Some considerations will be purely monetary, including savings in overhead
- Goodwill established with the owner by completing the project earlier than currently scheduled may also pay dividends
- However, the feasibility of actually tripling the workforce must also be assessed
- Factors to address include the availability of workers, ability to supply equipment and materials for all workers, and the logistics of actually having all floors ready for the crews

220

Learning Curves

- The skill and productivity in performing a task improves with experience and practice
- It is the result of several factors including
  - Job familiarity
  - Improvement in coordination
  - Improvement in management and supervision
  - Better methods and tools

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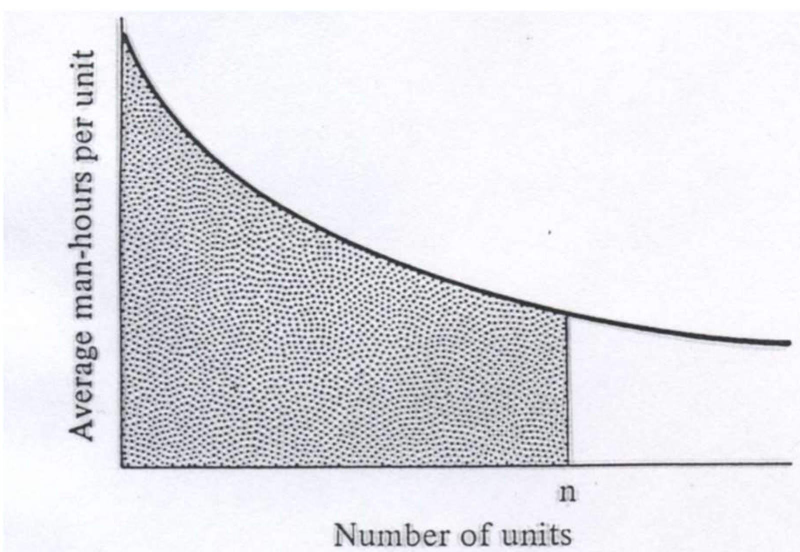


222

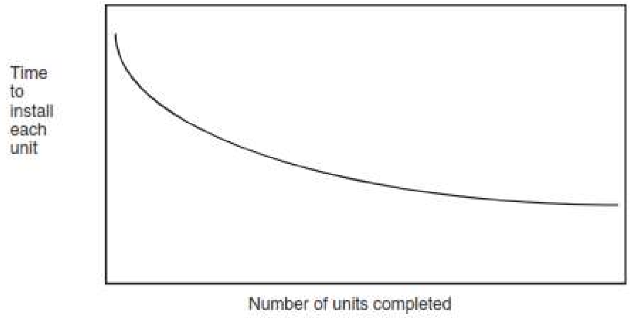
- Learning curve is also known as
  - Manufacturing process function
  - Experience curve
  - Dynamic curve
- Simply, it means that the costs of production can be lowered by increasing quantity of production or increasing learning
- If the learning rate is known, it may be possible to estimate the cost of producing additional units based on the learning information

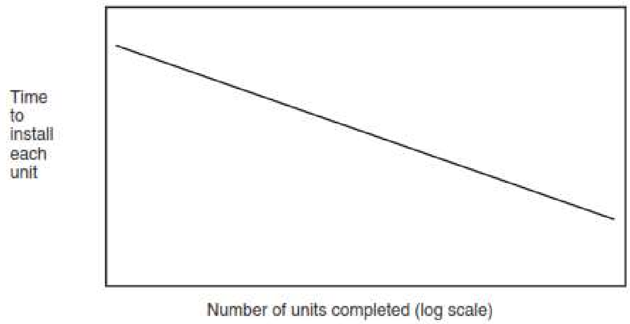
223

- General points that apply to learning curves
  - The amount of time and cost required to produce each unit tends to decrease for successive units
  - The amount of time to produce each unit decreases at a decreasing rate
  - The reduction in time required to produce each unit follows a specific estimating model; that is, the rate of improvement (learning) can be predicted by mathematical models

224

- The rate of improvement (learning) can be predicted by mathematical models
- General shapes of the learning curve





225

- The model for predicting the time to perform each unit of work

$$T_N = K_T \times N^s$$

- T_N = Effort required to complete the N^{th} unit
- N = Unit number
- K_T = Constant (theoretically $K_T = T_1$)
- s = Slope parameter or slope factor (this is a negative value)
- s = Log ϕ/log 2

226

- ϕ = Rate of improvement (generally based on doubled units; log 2 implies doubled units)
- If ϕ = 0.8, then the second unit is done with 80 percent of the effort of the first unit. The fourth unit would require 64 percent of the effort of the first unit

227

- For example, the first unit of construction is completed in 10,000 hours. A learning rate of 80 percent is expected on doubled units. How much time will be required to complete the eighth unit?
- $s = \log \phi / \log 2 = \log 0.8 / \log 2 = -0.32$
- $T_N = K_T \times N^s$
- $T_8 = 10{,}000 \times 8^{-0.32} = 5{,}140.57$ hours

228

- If the learning rate is not known, it must then be computed from the available information
- The learning rate can be determined if information on two units is known
- Suppose that the time of effort is known for two units (i, j)
- $s = (\log T_i - \log T_j) / (\log N_i - \log N_j)$
- $\log T_j = \log K_T + (s \times \log N_j)$

229

- For example, suppose the fifth unit was completed in 200 hours and the tenth unit was completed in 150 hours. Find the time required to complete the twentieth and the thirtieth units
- $s = (\log T_i - \log T_j) / (\log N_i - \log N_j)$
- $s = (\log 200 - \log 150) / (\log 5 - \log 10)$
- $s = - 0.42$
- $\log T_j = \log K_T + (s \times \log N_j)$
- $\log 150 = \log K_T + (-0.42 \times \log 10)$

230

- log K_T = 2.6
- K_T = 398.11 hours

- Find the learning rate
- s = log ϕ/log 2
- -0.42 = log ϕ/log 2
- ϕ = 0.75 or 75%

231

- For unit 20
  - $T_N = K_T \times N^s$
  - $T_{20} = 398.11 \times 20^{-0.42}$
  - T_{20} = 113.13 hours
- For unit 30
  - $T_{30} = 398.11 \times 30^{-0.42}$
  - T_{30} = 95.41 hours

232

- If several data points (more than two) are known, a more accurate and realistic learning curve can be developed as a predictive tool using the least squares fit method
- s = $\dfrac{M\sum(\log N \times \log T) - \sum \log N \times \sum \log T}{M\sum(\log N)^2 - (\sum \log N)^2}$
- M = number of data points
- log K_T = $\dfrac{\sum \log T \times \sum \log N^2 - \sum \log N \times \sum(\log N \times \log T)}{M\sum(\log N)^2 - (\sum \log N)^2}$

233

N	*T*	log *N*	log *T*	(log *N*)^2	(log*N*) × (log*T*)
10	510	1.0000	2.7076	1.0000	2.7076
30	210	1.4771	2.3222	2.1818	3.4301
100	190	2.0000	2.2788	4.0000	4.5576
150	125	2.1761	2.0969	4.7354	4.5631
300	71	2.4771	1.8513	6.1360	4.5859
		9.1303	11.2568	18.0532	19.8443

- s = $\dfrac{5(19.844\ \ )\quad .1303(11.2568)}{5(18.0532)-(9.1303)^2}$ = -0.52
- log K_T = $\dfrac{11.2568 \text{ x1 } \ .0532- \ \ .1303 \text{ x } 19.8443}{5(18.0532)\quad (9.1303)^2}$ = 3.19
- K_T = 1,548.82
- Once s and K_T are determined, other units can be estimated

234

- If the flow of work is interrupted the learning that has occurred will also be affected
- Reasons for interruption
  - Inclement weather, labor strike, an extended holiday season, a plant shutdown, or job reassignment
- Eventually, the learning could regress to the level that existed earlier when the first unit was produced

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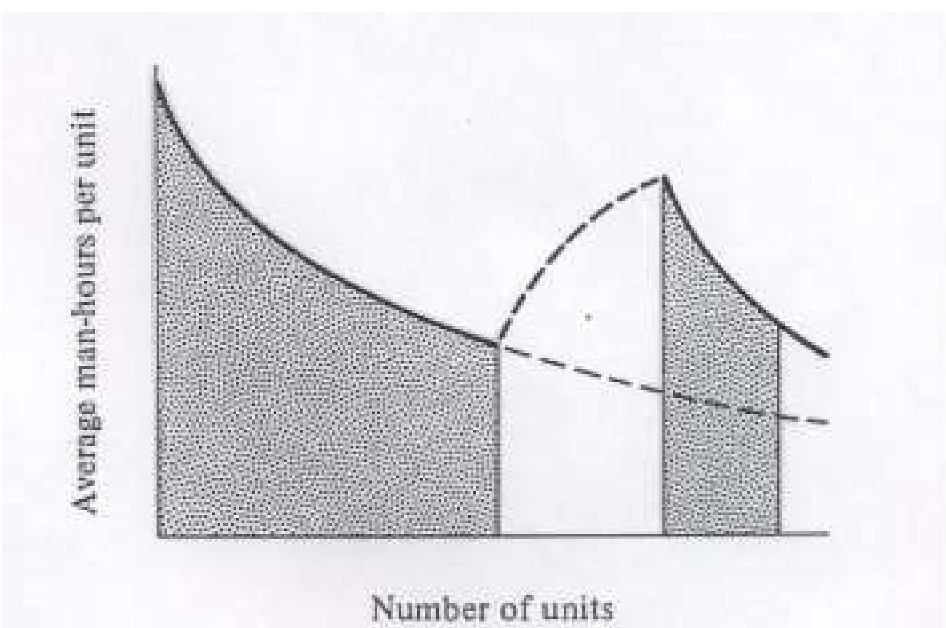


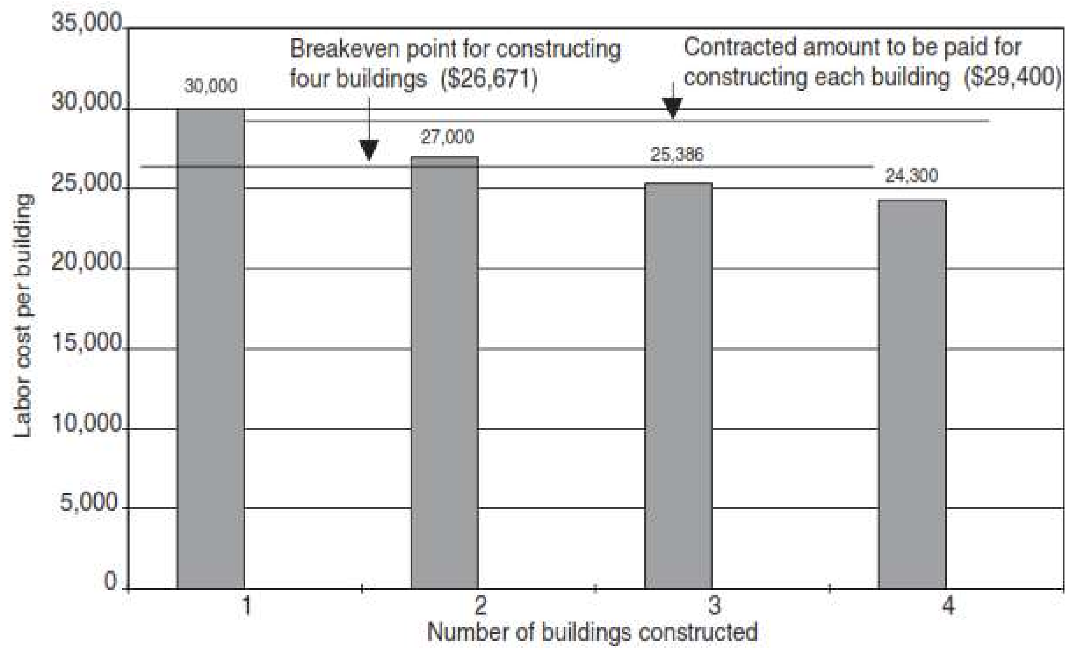
236

- Suppose a contractor has a labor contract with a facility owner to construct four identical buildings
- The contractor has estimated the actual labor cost (with benefits) of each building to be $26,671
- The amount to be paid to the contractor for each building is $29,400 (allowing for a margin to cover overhead and profit)

237

- After the third building is completed, the owner determines that the fourth building will not be needed, so the owner elects to cancel the contract
- The contractor asks the owner for additional money
- The contractor's records of labor costs per building have been accurately maintained

238



239

- If the learning curve principle is applicable, what will the profit margin be if the contractor is paid $29,400 for the three buildings that were completed? (overhead is 7%)
- What sum would be appropriate to provide the contractor with a 10% margin to cover overhead (7%) and profit (3%)?

240

- The average cost of constructing three buildings is $27,462 per building ($30,000 + $27,000 + $25,386)/3
- If the contractor is paid only $29,400 per building, the learning advantage gained in the fourth building is lost
- The margin realized with a payment of $29,400 per building if only three buildings are constructed is 7.06% ($29,400/$27,462)

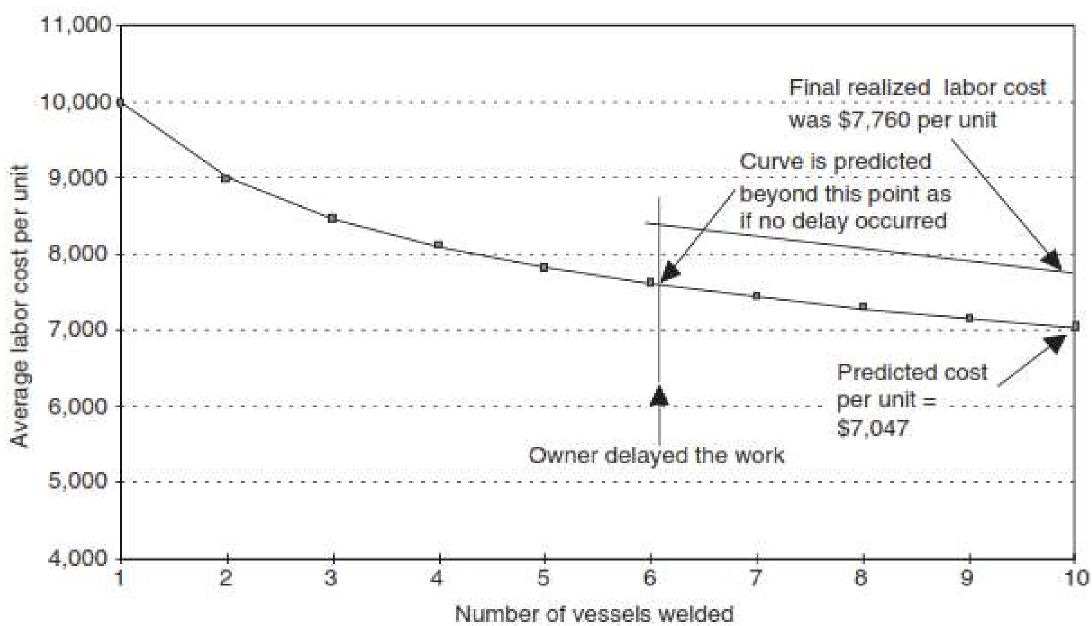
241

- Allowing 7% for overhead, the remainder would be profit
- The contractor will essentially break even with the payment of $29,400, earning only 0.06% in profit or essentially no profit
- Allowing for a 10% margin, the contractor will want to seek compensation of $30,208.2 per building ($27,462 x 1.1)

242

- A contractor made an agreement with a firm to weld 10 vessels for them. After six vessels were completed, the owner suspended the contractor’s work
- The reason for the delay was never disclosed to the contractor, but it was not associated with the contractor’s operation
- When the work was permitted to resume, the contractor noticed that the labor cost per unit was much higher than it had been previously
- What was the cost of the delay to the contractor?

243



244

- If the delay had not occurred, the learning curve prediction was that the average labor cost per unit would be $7,047
- Since the realized cost was $7,760, it can be computed that the average added labor per unit was $713 per unit, or $7,130 for the 10 units
- The contractor would probably make a claim to recover $7,130 from the owner to compensate for the impact of the delay

245

- Labor cost includes basic wages, fringe benefits (e.g., health insurance, vacations, and retirement plans), workers' compensation (insurance based on payroll), and overtime (wage premiums)
- For example, if unit productivity for tiling is 0.6 hr/m^2 and the wage rate including fringe benefits is $15/hr then the unit labor cost is $9/$m^2$

246

Example

- What is the workers' compensation for a crew of 3 workers if the cost per worker is $50/day and compensation rate is 15%

247

- What is the workers' compensation for a crew of 3 workers if the cost per worker is $50/day and compensation rate is 15%

- Workers' compensation = 3 x $50/day x 15%

= $22.5/day

248

Example

- What is the workers' compensation rate for a crew of
  - 2 workers (daily cost is \$100/day and compensation rate is 20%) and
  - 1 helper (daily cost is \$50/day and compensation rate is 10%)

249

- What is the workers' compensation rate for a crew of
  - 2 workers (daily cost is \$100/day and compensation rate is 20%) and
  - 1 helper (daily cost is \$50/day and compensation rate is 10%)

- Average compensation rate by number of workers = 2/3 x 0.2 + 1/3 x 0.1 = 16%
- Workers' compensation = (2x100 + 1x50) x 16% = \$40/day

250

- What is the workers' compensation rate for a crew of
  - 2 workers (daily cost is \$100/day and compensation rate is 20%) and
  - 1 helper (daily cost is \$50/day and compensation rate is 10%)
- Average compensation rate by trade = 2x100/250 x 0.2 + 1x50/250 x 0.1 = 18%
- Workers' compensation = 250 x 18% = \$45/day

251

- What is the workers' compensation rate for a crew of
  - 2 workers (daily cost is \$100/day and compensation rate is 20%) and
  - 1 helper (daily cost is \$50/day and compensation rate is 10%)
- Workers' compensation = 2x100 x 0.2 + 1x50 x 0.1 = \$45/day

252

Published Cost Data (RSMeans)

- Adjustment for labor cost= Workers' Comp. + Average Fixed Overhead + Overhead

		A		B	C	D	E	F	G	H	I
		Base Rate Incl. Fringes		Workers' Comp. Ins.	Average Fixed Overhead	Overhead	Profit	Total Overhead & Profit		Rate with O & P	
Abbr.	Trade	Hourly	Daily					%	Amount	Hourly	Daily
Skwk	Skilled Workers Average (35 trades)	$53.40	$427.20	10.8%	18.3%	13.0%	10%	52.1%	$27.85	$ 81.25	$650.00
	Helpers Average (5 trades)	38.85	310.80	14.2		11.0		53.5	20.80	59.65	477.20
	Foreman Average, Inside ($0.50 over trade)	53.90	431.20	10.8		13.0		52.1	28.10	82.00	656.00
	Foreman Average, Outside ($2.00 over trade)	55.40	443.20	10.8		13.0		52.1	28.85	84.25	674.00
Clab	Common Building Laborers	41.05	328.40	12.0		11.0		51.3	21.05	62.10	496.80
Asbe	Asbestos/Insulation Workers/Pipe Coverers	57.35	458.80	10.1		16.0		54.4	31.20	88.55	708.40
Boil	Boilermakers	65.10	520.80	6.4		16.0		50.7	33.00	98.10	784.80
Bric	Bricklayers	51.05	408.40	13.4		11.0		52.7	26.90	77.95	623.60
Brhe	Bricklayer Helpers	40.40	323.20	13.4		11.0		52.7	21.30	61.70	493.60
Carp	Carpenters	51.65	413.20	12.0		11.0		51.3	26.50	78.15	625.20

253

04 22 Concrete Unit Masonry

04 22 10 – Concrete Masonry Units

		Crew	Daily Output	Labor-Hours	Unit	Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
04 22 10.23 Concrete Block, Decorative										
0010	**CONCRETE BLOCK, DECORATIVE**									
0020	Embossed, simulated brick face									
0100	8" x 16" units, 4" thick	D-8	400	.100	S.F.	3.02	3.43		6.45	8.55
0200	8" thick		340	.118		4.17	4.03		8.20	10.75
0250	12" thick		300	.133		5.50	4.57		10.07	13
0400	Embossed both sides									
0500	8" thick	D-8	300	.133	S.F.	4.68	4.57		9.25	12.10
0550	12" thick	"	275	.145	"	5.90	4.99		10.89	14.10

254

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Labor-Hour	
Crew D-7	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
1 Tile Layer	$35.50	$284.00	$52.10	$416.80	$31.38	$46.05
1 Tile Layer Helper	27.25	218.00	40.00	320.00		
16 L.H., Daily Totals		$502.00		$736.80	$31.38	$46.05
Crew D-8	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
3 Bricklayers	$38.05	$913.20	$57.90	$1389.60	$34.29	$52.18
2 Bricklayer Helpers	28.65	458.40	43.60	697.60		
40 L.H., Daily Totals		$1371.60		$2087.20	$34.29	$52.18
Crew D-9	**Hr.**	**Daily**	**Hr.**	**Daily**	**Bare Costs**	**Incl. O&P**
3 Bricklayers	$38.05	$913.20	$57.90	$1389.60	$33.35	$50.75
3 Bricklayer Helpers	28.65	687.60	43.60	1046.40		
48 L.H., Daily Totals		$1600.80		$2436.00	$33.35	$50.75

255

		A		B	C	D	E	F	G	H	I
Abbr.	Trade	Base Rate Incl. Fringes Hourly	Base Rate Incl. Fringes Daily	Workers' Comp. Ins.	Average Fixed Overhead	Overhead	Profit	Total Overhead & Profit %	Total Overhead & Profit Amount	Rate with O & P Hourly	Rate with O & P Daily
Skwk	Skilled Workers Average (35 trades)	$53.40	$427.20	10.8%	18.3%	13.0%	10%	52.1%	$27.85	$ 81.25	$650.00
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Carp	Carpenters	51.65	413.20	12.0		11.0		51.3	[illegible]	[illegible]	[illegible]

256

- For crew D-8:
- Adjustment for bricklayer/helper cost = 13.4% + 18.3% + 11% = 43%
- Total wage for bricklayers = bare cost x adjustment

  = $913.2 x 1.43 = $1,305.88
- Total wage for bricklayer helpers = bare cost x adjustment

  = $458.4 x 1.43 = $655.51

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- For crew D-8:
- Total wage for crew D-8 = $1,305.88 + $655.51 = $1,961.39
- Total average labor overhead for crew D-8 = total wage / total bare cost

  = $1,961.39 / $1,371.6 = 1.43

Labor cost = quantity of work x unit labor cost x total average labor overhead

For a quantity of 500 SF: labor cost = 500 x $4.03/SF x 1.43 = $2,881.45

258

- Activity Duration (days) = Quantity of work (units)/Crew daily output(unit/day)
- For a quantity of 1,700 SF, the duration is 1,700/ 340 = 5 days

259

Working Overtime

- A common response to the need to accomplish more work in a smaller time frame is to have workers work overtime
- The workers are already on site, and they simply need to be informed of the need to work additional hours each day or to work on the weekends
- The adverse impact on productivity may hardly be noticeable if they are asked to work overtime for 2 or 3 days
- However, working overtime for an extended period of time adversely impacts productivity

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- The following formula is used to predict the productivity impact of working overtime

$$Eff(\%) = 100\% - 5[(days - 5) + (hours - 8)]\%$$

- Eff = Worker efficiency based on 100 percent for a regular 40 hour week
- Days = Number of days worked per week
- Hours = Number of hours worked per day

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Impact of Scheduled Overtime on Labor Productivity

Hours/Day	Days/Week	Hours/Week	Efficiency (Based on 40 hours)	Effective Hours/Week
8	5	40	100%	40
9	5	45	95	42.75
10	5	50	90	45
11	5	55	85	46.75
12	5	60	80	48
8	6	48	95	45.6
9	6	54	90	48.6
10	6	60	85	51
11	6	66	80	52.8
12	6	72	75	54
8	7	56	90	50.4
9	7	63	85	53.55
10	7	70	80	56
11	7	77	75	57.75
12	7	84	70	58.8

262

Example

- 20 workers on a construction site
- The project will not be completed on time
- The contractor is considering working 12 hours/day for 5 days each week
- How much overtime work is needed to shorten the project duration by 10 days?

263

- Hours/week = 60 hours
- Eff(%) = 80% (formula or table)
- Effective hours = 48 hours of work
- 8 hours (1 day) reduced per week
- To reduce project duration by 10 days: 10 weeks are needed

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Example

- For the previous example, if the average wage of the workers is \$12/hr
- Overtime rate = \$18/hr (above 40 hours)
- Calculate the overtime cost

265

- Overtime cost = \$18/hr x 20hr/week x 10 weeks =\$3,600 per worker
- For 20 workers: \$3,600 x 20 = \$72,000

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- If overtime work extends to multiple weeks, productivity will continue declining each week
- Further adjustments are needed

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Days per Week	Hours per Day	Production Efficiency					Payroll Cost Factors	
		1 Week	2 Weeks	3 Weeks	4 Weeks	Average 4 Weeks	@ 1-1/2 Times	@ 2 Times
5	8	100%	100%	100%	100%	100%	100%	100%
	9	100	100	95	90	96.25	105.6	111.1
	10	100	95	90	85	91.25	110.0	120.0
	11	95	90	75	65	81.25	113.6	127.3
	12	90	85	70	60	76.25	116.7	133.3
6	8	100	100	95	90	96.25	108.3	116.7
	9	100	95	90	85	92.50	113.0	125.9
	10	95	90	85	80	87.50	116.7	133.3
	11	95	85	70	65	78.75	119.7	139.4
	12	90	80	65	60	73.75	122.2	144.4
7	8	100	95	85	75	88.75	114.3	128.6
	9	95	90	80	70	83.75	118.3	136.5
	10	90	85	75	65	78.75	121.4	142.9
	11	85	80	65	60	72.50	124.0	148.1
	12	85	75	60	55	68.75	126.2	152.4

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- Labor Law of Jordan

المادة (٥٩)

العمل الاضافي و العمل ايام العطل و الاعياد

أ – يجوز تشغيل العامل بموافقتة أكثر من ساعات العمل اليومية او الاسبوعية على أن يتقاضى العامل عن ساعة العمل الاضافية أجرا لا يقل عن ١٢٥% من أجره المعتاد .

ب – إذا اشتغل العامل في يوم عطلته الأسبوعية أو أيام الأعياد الدينية أو العطل الرسمية يتقاضى لقاء عمله عن ذلك اليوم أجرا اضافيا لا يقل عن (١٥٠%) من أجره المعتاد .

269

Example

- 10 workers are expected to work 6 days per week (60 hours) for 3 weeks, calculate
  - Effective hours
  - Hours of lost productivity

270

- Effective hours
  - Week 1: 10 x 60 x 0.95 = 570 hrs
  - Week 2: 10 x 60 x 0.90 = 540 hrs
  - Week 3: 10 x 60 x 0.85 = 510 hrs
- Ineffective hours (lost productivity)
  - Week 1: 30 hrs
  - Week 2: 60 hrs
  - Week 3: 90 hrs

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Example

- For the previous example, if wage of worker is $15/hr
- Use an overtime rate of 1.5 to estimate labor cost

272

- For the previous example, if wage of worker is \$15/hr
- Use an overtime rate of 1.5 to estimate labor cost

- 10 workers x 60 hrs/week x 3 weeks x \$15/hr x 1.167 = \$31,509

273

Example

- Quantity of excavation is 9 m^3, budgeted cost for this activity is \$950, and hourly labor cost is \$33.2
- Find
    - Cost rate (\$/m^3)
    - Production rate (hr/m^3)
    - Activity duration (hrs)
    - Activity duration (days) if one or two workers employed

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- Cost rate = \$950 / 9 m^3 = \$105.56/m^3
- Production rate = $\dfrac{\$105.56/m^3}{\$33.2/hr}$ = 3.18 hr/m^3
- Activity duration = 3.18 hr/m^3 x 9m^3 = 28.62 hrs
- Duration (1 worker) = 28.62/8 = 3.58 days
- Duration (2 workers) = 28.62/16 = 1.79 days

275

Example

- Quantity of forming is 47 m^2, production rate is 1.8 hr/m^2
- Find how many days to finish the activity if 1, 2, 3, or 4 workers employed

276

- Quantity of forming is 47 m^2, production rate is 1.8 hr/m^2
- Find how many days to finish the activity if 1, 2, 3, or 4 workers employed
- Forming time = 1.8 hr/m^2 x 47 m^2 = 84.6 hrs
- Duration (1 worker) = 10.58 days
- Duration (2 workers) = 5.29 days
- Duration (3 workers) = 3.53 days
- Duration (4 workers) = 2.64 days

277

Example

- An ironworker works 10 hrs/day, 6 days/week
- The base wage is $21/hr for 8 hr/day, 5 day/week
- An overtime rate of 1.5 times is paid for all hours over 8 hr/day, Sunday through Thursday, and double time is paid for all Friday work
- The social security rate is 10% of actual wage
- The rate for insurance is $13 per $100 of base wage
- Calculate the average hourly cost to hire the ironworker

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- Base wage = $21 x 8 hrs x 5 days = $840
- Overtime @1.5 times = $21 x 2 hrs x 5 days x 1.5 = $315
- Overtime @2 times = $21 x 10 hrs x 1 day x 2 = $420
- Social security = 0.1 x ($840 + $315 + $420) = $157.5
- Insurance= 0.13 x 840 = $109.2
- Average hourly cost = ($840 + $315 + $420 + $157.5 + $109.2) / 60 = $30.70/hr

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- Other methods to determine productivity rates, cost rates, and activity durations
  - Field observations
  - Subject matter experts: obtain estimates from experienced professionals (Three-Point Estimate)

280

Three-Point Estimate

- The technique involves three different estimates that are usually obtained from subject matter experts
  - Optimistic (best case) estimate (O)
  - Pessimistic (worst case) estimate (P)
  - Most likely estimate (M)
- Triangular Distribution
  - E = (O + M + P) / 3
  - E = Expected amount

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- Beta distribution
  - E = (O + 4M + P) / 6
  - Standard deviation SD = (P – O) / 6, measures the variability or uncertainty in the estimate
- For example, A team of subject matter experts estimated the time it takes to complete an activity
- O = 8 days, M = 12 days, P = 20 days
- Expected activity duration E =
  - 13.33 days (triangular)
  - 12.67 days (Beta), SD = 2

282

- 1 SD means a 68.3% probability that the activity duration will be between (10.67, 14.67)
- 2 SD means a 95.5% probability that the activity duration will be between (8.67, 16.67)
- 3 SD means a 99.7% probability that the activity duration will be between (6.67, 18.67)

Construction Cost Analysis & Estimating – 110401543

Equipment Cost

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Equipment owning and operating costs (O & O costs)

- Owning costs
  - Fixed costs that are incurred each year whether the equipment is operated or not
- Operating costs
  - Incurred only when the equipment is used

- Owning costs are made up of the following principal elements
  - Depreciation
  - Investment (or interest) cost
  - Insurance cost
  - Taxes
  - Storage cost

- The major elements of operating cost include
  - Fuel cost
  - Service cost
  - Repair cost
  - Tire cost
  - Cost of special items
  - Operators’ wages
- Operators’ wages are sometimes not included in equipment operating costs and calculated as labor cost

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Published Cost Data (RSMeans)

03 31 Structural Concrete

03 31 13 – Heavyweight Structural Concrete

03 31 13.70 Placing Concrete		Crew	Daily Output	Labor-Hours	Unit	Material	Bare Costs Labor	Bare Costs Equipment	Bare Costs Total	Total Incl O&P
2500	With crane and bucket	C-7	45	1.600	C.Y.		73	24	97	137
2600	Over 5 C.Y., direct chute	C-6	120	.400			17.50	.45	17.95	26.50
2650	Pumped	C-20	150	.427			19.25	3.09	22.34	32.50
2700	With crane and bucket	C-7	100	.720			33	10.80	43.80	61.50
2900	Foundation mats, over 20 C.Y., direct chute	C-6	350	.137			6	.15	6.15	9.15

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Crew C-6	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Labor Foreman (outside)	$44.10	$352.80	$66.25	$530.00	$43.74	$65.45
4 Laborers	42.10	1347.20	63.25	2024.00		
1 Cement Finisher	49.95	399.60	73.45	587.60		
2 Gas Engine Vibrators		53.70		59.07	1.12	1.23
48 L.H., Daily Totals		$2153.30		$3200.67	$44.86	$66.68

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- Daily equipment cost (owning and operating) = $53.7/day
- Daily output = 120 CY/day
- Unit equipment cost = $\frac{\$53.7/\text{day}}{120\ \text{CY/day}}$ = $0.45/CY
- Equipment cost = quantity of work x unit equipment cost

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Depreciation

- Depreciation represents the decline in market value of an item of equipment due to
  - Age
  - Wear
  - Deterioration
  - Obsolescence

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- The equipment life used in calculating depreciation should correspond to the equipment's expected economic or useful life
- In calculating depreciation, the initial cost of an item of equipment should be the full delivered price, including transportation, taxes, and initial assembly and servicing

292

- For rubber tired equipment, the value of tires should be subtracted from the amount to be depreciated because tire cost will be computed separately as an element of operating cost
- Equipment salvage value should be estimated as realistically as possible based on historical data
- The most commonly used depreciation methods are the straight line method, the sum of the years' digits method, and the double declining balance method

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Straight Line Method

- Produces a uniform depreciation for each year of equipment life
- Annual depreciation is calculated as the amount to be depreciated divided by the equipment life in years
- The amount to be depreciated consists of the equipment's initial cost less salvage value (and less tire cost for rubber-tired equipment)

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- $D_n = \dfrac{\text{Cost} - \text{Salvage} (- \text{Tires})}{N}$
  - Cost = initial/purchasing cost
  - Salvage = value of equipment at the end of useful life
  - N = equipment useful life (years)
  - n = year of life (1,2,3, etc.)
- Book value: value of equipment after deducting depreciation

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Example

- Using the straight line method of depreciation, find the annual depreciation and book value at the end of each year for a track loader having an initial cost of $50,000, a salvage value of $5000, and an expected life of 5 years

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- $D_{1,2,3,4,5} = \dfrac{\$50,000 - \$5,000}{5} = \$9,000$

Year	Depreciation	Book value (end of period)
0	0	$50,000
1	$9,000	$41,000
2	$9,000	$32,000
3	$9,000	$23,000
4	$9,000	$14,000
5	$9,000	$5,000

297

Sum of the Years Digits Method

- Produces a nonuniform depreciation
- Depreciation is the highest in the first year of life and gradually decreases thereafter
- The amount to be depreciated is the same as that used in the straight line method
- The depreciation for a particular year is calculated by multiplying the amount to be depreciated by a depreciation factor

298

- $D_n = \dfrac{\text{Year digit}}{\text{Sum of years' digits}}$ x Amount to be depreciated
- The denominator of the depreciation factor is the sum of the years' digits for the depreciation period
  - 1 + 2 + 3 + 4 + 5 = 15 for a 5-year life
- The numerator of the depreciation factor is simply the particular year digit taken in inverse order
  - 5 - 4 - 3 - 2 - 1

299

Example

- For the previous example, find the annual depreciation and book value at the end of each year using the sum of the years digits method

300

- $D_1 = \frac{5}{15}$ x (\$50,000 - \$5000) = \$15,000
- $D_2 = \frac{4}{15}$ x (\$50,000 - \$5000) = \$12,000
- $D_3 = \frac{3}{15}$ x (\$50,000 - \$5000) = \$9,000
- $D_4 = \frac{2}{15}$ x (\$50,000 - \$5000) = \$6,000
- $D_5 = \frac{1}{15}$ x (\$50,000 - \$5000) = \$3,000

301

Year	Depreciation	Book value (end of period)
0	0	$50,000
1	$15,000	$35,000
2	$12,000	$23,000
3	$9,000	$14,000
4	$6,000	$8,000
5	$3,000	$5,000

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Double Declining Balance Method

- Like the sum of the years' digits method, produces its maximum depreciation in the first year of life
- The depreciation for a particular year is found by multiplying a depreciation factor by the equipment's book value at the beginning of the year
- The annual depreciation factor is found by dividing 2 (or 200%) by the equipment life in years

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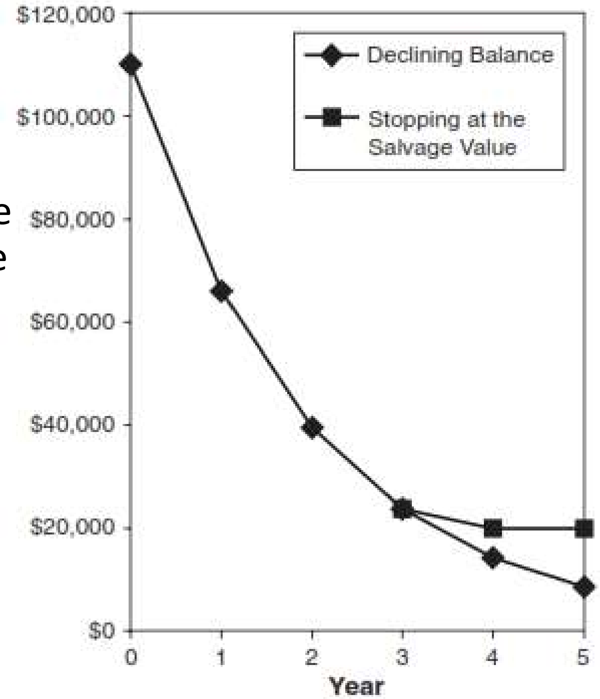
- $D_n = \frac{2}{N}$ x book value at beginning of year
- Unlike the other two depreciation methods, the double declining balance method does not automatically reduce the equipment's book value to its salvage value at the end of the depreciation period
- Since the book value of equipment is not permitted to go below the equipment's salvage value, care must be taken when performing the depreciation calculations to stop depreciation when the salvage value is reached

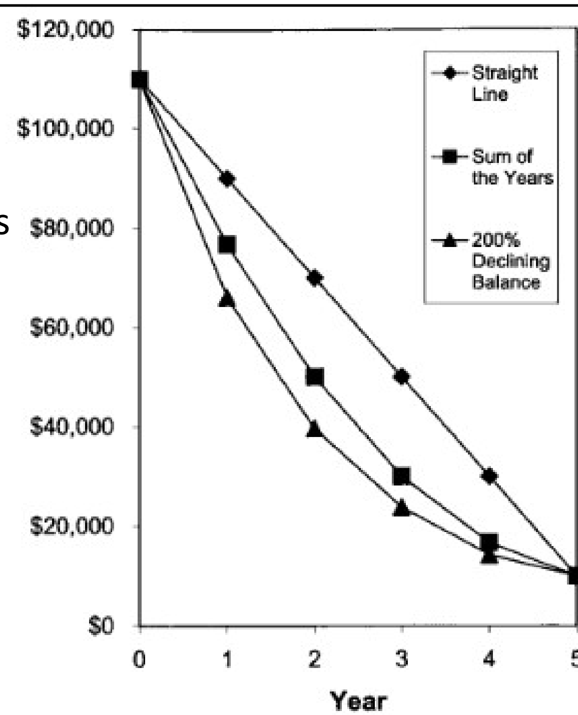
304

• Stopping the declining balance depreciation at the salvage value



305

• Comparison of depreciation methods



306

Example

- For the previous example, find the annual depreciation and book value at the end of each year using the double declining balance method

307

- $D_1 = \frac{2}{5}$ x \$50,000 = \$20,000
- $D_2 = \frac{2}{5}$ x \$30,000 = \$12,000
- $D_3 = \frac{2}{5}$ x \$18,000 = \$7,200
- $D_4 = \frac{2}{5}$ x \$10,800 = \$4,320
- $D_5 = \frac{2}{5}$ x \$6,480 = \$2,592 use \$1,480 (A depreciation of \$2,592 in the fifth year would reduce the book value to less than \$5000, only \$1480 (\$6480 - \$5000) may be taken as depreciation

308

Year	Depreciation	Book value (end of period)
0	0	$50,000
1	$20,000	$30,000
2	$12,000	$18,000
3	$7,200	$10,800
4	$4,320	$6,480
5	$1,480	$5,000

309

Investment Cost

- Investment cost (or interest) represents the annual cost (converted to an hourly cost) of the capital invested in a machine
- If borrowed funds are utilized, it is simply the interest charge on these funds
- However, if the item of equipment is purchased from company assets, an interest rate should be charged equal to the rate of return on company investments (income loss)

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- Investment cost is computed as the product of an interest rate multiplied by the value of the equipment, then converted to cost per hour
- The true investment cost for a specific year of ownership is properly calculated using the average value of the equipment during that year
- The average hourly investment cost may be more easily calculated using the value of the average investment over the life of the equipment given by the following equation

311

- Average investment = $\frac{\text{Initial cost + salvage}}{2}$
- The results obtained using this equation should be sufficiently accurate for calculating average hourly owning costs over the life of the equipment
- However, the investment cost calculated in this manner is not the actual cost for a specific year

312

Insurance, Tax, and Storage

- Insurance cost represents the cost of fire, theft, accident, and liability insurance for the equipment
- Tax cost represents the cost of property tax and licenses for the equipment
- Storage cost represents the cost of
  - Rent and maintenance for equipment storage yards
  - The wages of guards and employees involved in handling equipment in and out of storage
  - Associated direct overhead

313

- The cost of insurance and taxes for each item of equipment may be known on an annual basis
- These costs are simply divided by the hours of operation during the year to yield the cost per hour for these items
- Storage costs are usually obtained on an annual basis for the entire equipment fleet
- Insurance and tax cost may also be known on a fleet basis
- It is then necessary to prorate these costs to each item

314

- This is usually done by converting total annual cost to a percentage rate by dividing these costs by the total value of the equipment fleet
- The rate for insurance, tax, and storage may simply be added to the investment cost rate to calculate the annual cost of investment, tax, insurance, and storage

315

Total Owning Cost

- Total equipment owning cost is found as the sum of depreciation, investment, insurance, tax, and storage
- The individual elements of owning cost are calculated on an annual-cost basis or on an hourly basis
- Total owning cost expressed as an hourly cost

316

Operating Costs

- Operating costs are incurred only when equipment is operated
- Costs vary with the amount of equipment use and job operating conditions
- The major elements of operating cost include
  - Fuel cost
  - Service cost
  - Repair cost
  - Tire cost
  - Cost of special items
  - Operators' wages

317

Fuel Cost

- The hourly cost of fuel is simply fuel consumption per hour multiplied by the cost per unit of fuel (gallon or liter)
- Actual measurement of fuel consumption under similar job conditions provides the best estimate of fuel consumption
- When historical data are not available, fuel consumption may be estimated from manufacturer's data
- The following table provides approximate fuel consumption factors in gallons per hour per horsepower for major types of equipment under light, average, and severe load conditions

318

Table 17-1 Fuel consumption factors (gal/h/hp)

Type of Equipment	Load Conditions*		
	Low	*Average*	*Severe*
Clamshell and dragline	0.024	0.030	0.036
Compactor, self-propelled	0.038	0.052	0.060
Crane	0.018	0.024	0.030
Excavator, hoe, or shovel	0.035	0.040	0.048
Loader			
Track	0.030	0.042	0.051
Wheel	0.024	0.036	0.047
Motor grader	0.025	0.035	0.047
Scraper	0.026	0.035	0.044
Tractor			
Crawler	0.028	0.037	0.046
Wheel	0.028	0.038	0.052
Truck, off-highway	0.014	0.020	0.029
Wagon	0.029	0.037	0.046

*Low, light work or considerable idling; average, normal load and operating conditions; severe, heavy work, little idling.

319

Example

- Find the fuel cost for an excavator operating in severe conditions if it has a rated power of 300 hp. Fuel price is \$1.4/gal

320

- Estimated consumption = 0.048 x 300 = 14.4 gal/h
- Fuel cost = 14.4 x 1.40 = $20.16/h

321

Example

- Find the fuel cost for a 120-horsepower payloader
- A job condition analysis indicates that the unit will operate about 45 minutes per hour (75 percent) at about 70 percent of its rated horsepower
- Fuel cost is $1.10/gal
- Consumption rate is 0.06 gal/h/hp

322

- Fuel cost = 120 x 0.7 x 0.75 x 0.06 x 1.1 = $4.16/h

323

Service Cost

- Service cost represents the cost of oil, hydraulic fluids, grease, and filters as well as the labor required to perform routine maintenance service
- Equipment manufacturers publish consumption data or average cost factors for oil, lubricants, and filters for their equipment under average conditions
- Using such consumption data, multiply hourly consumption (adjusted for operating conditions) by cost per unit to obtain the hourly cost of consumable items

324

- Service labor cost may be estimated based on prevailing wage rates and the planned maintenance program
- Since service cost is related to equipment size and severity of operating conditions, a rough estimate of service cost may be made based on the equipment's fuel cost

Table 17–2 Service cost factors (% of hourly fuel cost)

Operating Conditions	Service Cost Factor
Favorable	20
Average	33
Severe	50

325

- For the previous example, if the fuel cost is \$4.16/h. The hourly service cost of the payloader operated under severe conditions would be estimated at 50% of the hourly fuel cost

326

Repair Cost

- Repair cost represents the cost of all equipment repair and maintenance
- Does not include tire repair and replacement, routine service, and the replacement of high-wear items, such as ripper teeth
- Repair cost usually constitutes the largest item of operating expense for construction equipment

327

- Lifetime repair cost is usually estimated as a percentage of the equipment’s initial cost less tires
- Lifetime repair cost = % x equipment's initial cost less tires
- It is then necessary to convert lifetime repair cost to an hourly repair cost
- This may be done simply by dividing lifetime repair cost by the expected equipment life in hours to yield an average hourly repair cost (uniform repair cost)

328

- Yearly repair cost= lifetime repair cost/expected equipment life in years
- Hourly repair cost= lifetime repair cost/expected equipment life in hours

329

Table 17–3 Typical lifetime repair cost (% of initial cost less tires)

Type of Equipment	Operating Conditions: *Favorable*	*Average*	*Severe*
Clamshell and dragline	40	60	80
Compactor, self-propelled	60	70	90
Crane	40	50	60
Excavator, hoe, or shovel	50	70	90
Loader			
Track	85	90	105
Wheel	50	60	75
Motor grader	45	50	55
Scraper	85	90	105
Tractor			
Crawler	85	90	95
Wheel	50	60	75
Truck, off-highway	70	80	90
Wagon	45	50	55

330

- Although this method is adequate for lifetime cost estimates, it is not valid for a particular year of equipment life
- Repair costs are typically low for new machines and rise as the equipment ages (non-uniform repair cost)
- It is suggested to use another method to obtain a more accurate estimate of repair cost during a particular year of equipment life
- Hourly repair cost = $\frac{\text{Year digit}}{\text{Sum of years' digits}} \times \frac{\text{Life time repair cost}}{\text{Hours operated}}$

331

- This method is essentially the reverse of the sum of the years' digits method of depreciation explained earlier
- The year digit used in the numerator of the equation is now used in a normal sequence (i.e., 1 for the first year, 2 for the second year, etc.)
- Deprecation is high at first year while repair cost is low at first year

332

Example

- Estimate the hourly repair cost for a crawler tractor costing \$136,000 and having a 5-year life
- Assume average operating conditions and 2,000 hours of operation during the year

333

- Lifetime repair cost factor = 0.90
- Lifetime repair cost = 0.90 x 136,000 = \$122,400
- Yearly repair cost= \$122,400/5 = \$24,480
- Hourly repair cost= \$24,480/2,000 = \$12.24

334

Example

- Estimate the hourly repair cost for the first year of operation of a crawler tractor costing \$136,000 and having a 5-year life
- Assume average operating conditions and 2,000 hours of operation during the year

335

- Lifetime repair cost factor = 0.90
- Lifetime repair cost = 0.90 x 136,000 = \$122,400
- Yearly repair cost = $\frac{1}{15}$ x 122,400 = \$8,160 (for year 1)
- Hourly repair cost = $\frac{1}{15} \times \frac{122{,}400}{2{,}000}$ = \$4.08 (for year 1)

336

Tire Cost

- Tire cost represents the cost of tire repair and replacement
- Among operating costs for rubber-tired equipment, tire cost is usually exceeded only by repair cost
- Tire cost is difficult to estimate because of the difficulty in estimating tire life
- Historical data obtained under similar operating conditions provide the best basis for estimating tire life
- However, the following table may be used as a guide to approximate tire life if historical data is not available

337

Table 17–4 Typical tire life (hours)

Type of Equipment	Operating Conditions		
	Favorable	*Average*	*Severe*
Dozers and loaders	3,200	2,100	1,300
Motor graders	5,000	3,200	1,900
Scrapers			
Conventional	4,600	3,300	2,500
Twin engine	4,000	3,000	2,300
Push-pull and elevating	3,600	2,700	2,100
Trucks and wagons	3,500	2,100	1,100

338

- Tire repair will add about 15% to tire replacement cost
- The following equation may be used to estimate tire repair and replacement cost
- Tire cost = 1.15 x $\frac{\text{Cost of a set of tires (\$)}}{\text{Expected tire life (hr)}}$

339

Example

- Estimate the hourly tire cost for a motor grader with a tire cost of $7,000. Assume severe operating conditions

340

- Tire cost = 1.15 x $\frac{\$7{,}000}{1{,}900\ \text{h}}$ = \$4.24/h

341

Special Items

- The cost of replacing high-wear items
- Examples: dozer, grader, and scraper blade cutting edges
- Should be calculated as a separate item of operating expense
- Unit cost is divided by expected life to yield cost per hour

342

Operators' wages

- Care must be taken to include all costs, such as worker's compensation insurance, social security taxes, overtime or premium pay, and fringe benefits, in the hourly wage figure
- Refer to labor cost calculations

343

Operating Costs

- The major elements of operating cost include
  - Fuel cost
  - Service cost
  - Repair cost
  - Tire cost
  - Cost of special items
  - Operators' wages

344

Total Owning and Operating Costs

- After owning cost and operating cost have been calculated, these are totaled to yield total owning and operating cost per hour of operation
- This cost may be used for estimating and for charging equipment costs to projects, notice that it does not include overhead or profit
- Overhead and profit must be added to obtain an hourly rental rate if the equipment is to be rented to others

345

Example

- Calculate the expected hourly owning and operating cost for the second year of operation of the twin-engine wheeled scraper described below

Cost delivered/total cost = $152,000	Tax, insurance, and storage rate = 8%
Estimated life = 5 years	Operating conditions = average
Tire cost = $12,000	Rated power = 465 hp
Salvage value = $16,000	Fuel price = $1.30/gal
Depreciation = sum of the years' digits	Operator's wages = $32/hr
Investment (interest) rate = 10%	2,000 hours of operation/year

346

Example

Owning cost

- Depreciation cost
  - $D_2 = \frac{4}{15}$ x (152,000 - 16,000 - 12,000) = \$33,066.67
  - Depreciation = \$33,066.67 / 2,000 = \$16.53/hr
- Investment, tax, insurance, and storage cost
  - Cost rate = Investment + tax, insurance, and storage =10 + 8 = 18%
  - Average investment = $\frac{152{,}000 + 16{,}000}{2}$ = \$84,000
  - Investment, tax, insurance, and storage = $\frac{84{,}000 \text{ x } 0.18}{2{,}000}$ = 7.56/hr

347

- Total owning cost = 16.53 + 7.56 = \$24.09/hr

348

Table 17–1 Fuel consumption factors (gal/h/hp)

Type of Equipment	Load Conditions* Low	Average	Severe
Clamshell and dragline	0.024	0.030	0.036
Compactor, self-propelled	0.038	0.052	0.060
Crane	0.018	0.024	0.030
Excavator, hoe, or shovel	0.035	0.040	0.048
Loader			
Track	0.030	0.042	0.051
Wheel	0.024	0.036	0.047
Motor grader	0.025	0.035	0.047
Scraper	0.026	0.035	0.044
Tractor			
Crawler	0.028	0.037	0.046
Wheel	0.028	0.038	0.052
Truck, off-highway	0.014	0.020	0.029
Wagon	0.029	0.037	0.046

*Low, light work or considerable idling; average, normal load and operating conditions; severe, heavy work, little idling.

349

Operating Cost

- Fuel cost
  - Estimated consumption = 0.035 x 465 = 16.28 gal/hr
  - Fuel cost = 16.28 x 1.30 = $21.16/hr

350

- Service cost
  - Service cost = 0.33 x 21.16 = $6.98/hr

Table 17–2 Service cost factors (% of hourly fuel cost)

Operating Conditions	Service Cost Factor
Favorable	20
Average	33
Severe	50

351

Table 17–3 Typical lifetime repair cost (% of initial cost less tires)

	Operating Conditions		
Type of Equipment	***Favorable***	***Average***	***Severe***
Clamshell and dragline	40	60	80
Compactor, self-propelled	60	70	90
Crane	40	50	60
Excavator, hoe, or shovel	50	70	90
Loader			
Track	85	90	105
Wheel	50	60	75
Motor grader	45	50	55
Scraper	85	90	105
Tractor			
Crawler	85	90	95
Wheel	50	60	75
Truck, off-highway	70	80	90
Wagon	45	50	55

352

- Repair cost
  - Lifetime repair cost = 0.90 x (152,000 - 12,000) = $126,000
  - Repair cost for year 2 = $\frac{2}{15} \times \frac{126{,}000}{2{,}000}$ = $8.40/hr
- Tire cost
  - Estimated tire life = 3,000 hrs
  - Tire cost = 1.15 x $\frac{12{,}000}{3{,}000}$ = $4.6/hr

353

Table 17–4 Typical tire life (hours)

	Operating Conditions		
Type of Equipment	***Favorable***	***Average***	***Severe***
Dozers and loaders	3,200	2,100	1,300
Motor graders	5,000	3,200	1,900
Scrapers			
Conventional	4,600	3,300	2,500
Twin engine	4,000	3,000	2,300
Push-pull and elevating	3,600	2,700	2,100
Trucks and wagons	3,500	2,100	1,100

354

- Special item cost: None
- Operator wages = $32/hr
- Total operating cost = 21.16 + 6.98 + 8.40 + 4.60 + 32 = $73.14/hr
- Total O & O Cost = 24.09 + 73.14 = $97.23/hr

355

Buy-Rent-Lease Decision

- Buy
  - Full control of equipment resources
  - Availability of equipment when needed
  - Lowest hourly equipment cost if the equipment is properly maintained and fully utilized
- Rent
  - Short-term agreement
  - little initial capital (usually none)
  - Least expensive for equipment with low utilization (equipment owning costs continue whether equipment is being utilized or sitting idle)
  - Access to newest/most efficient/ specialized equipment

356

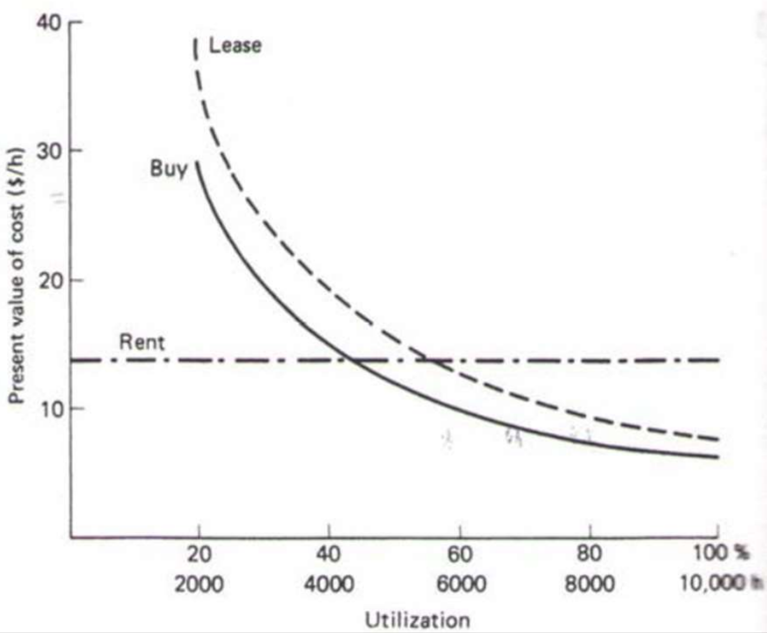
- Lease
  - Intermediate between renting and buying
  - Long-term agreement: more than 6 months
  - little initial capital
  - May be the best solution when capital is limited and equipment utilization is high
  - May include a purchase option in which a portion of the lease payments is credited toward the purchase price if the option is exercised

357

- A rational analysis of buy-rent-lease alternatives for obtaining equipment is complex and includes
  - Cost under the expected conditions
  - Equipment availability
  - Equipment productivity

358

Example - Hourly cost of buying, leasing, and renting



359

- Since total capital cost is constant over the 5-year period for both leasing and buying, hourly capital cost increases as utilization declines for both alternatives
- Since the 5-year cost of leasing is fixed, leasing is more expensive than owning in these circumstances
- Since the hourly cost for renting is constant, the hourly cost for renting and buying become equal at 42% utilization, or 4,200 hours of use
- As utilization continues to decline, renting becomes even more advantageous

360

Example

- Decide on buying or renting a dozer with the following ownership and rental costs
- Ownership cost = $14 per hour. 2,200 hours of operation per year

Rental duration	Rate ($)	Hours	Rental rate ($/hr)
Monthly	3,600	176	20.45
Weekly	1,100	40	27.5
Daily	400	8	50

361

- Yearly ownership cost = 14 x 2,200 = $30,800
- $30,800 < (20.45 x 2,200 = $44,990)
- It is more economical to buy the dozer
- Note: The actual rental cost is $46,800

362

Example

- Based on the previous example yearly ownership cost, find when it will be more economical to rent the equipment monthly, weekly, and daily against buying

Rental duration	Rate ($)	Hours	Rental rate ($/hr)
Monthly	3,600	176	20.45
Weekly	1,100	40	27.5
Daily	400	8	50

363

- 30,800 / 20.45 = 1,506.11 hours
- 1,506.11 / 176 = 8.56 (use 8 months: 8 x 176 = 1,408)
- Rent (monthly): 1,408 hours or less
- Buy: more than 1,408 hours

364

- 30,800 / 27.5 = 1,120 hours
- 1,120 / 40 = 28 weeks
- Rent (weekly): 1,120 hours or less
- Buy: more than 1,120 hours

365

- 30,800 / 50 = 616 hours
- 616 / 8 = 77 days
- Rent (daily): 616 hours or less
- Buy: more than 616 hours

366

Example

- Based on the previous example, find when it will be more economical to rent the equipment monthly, weekly, and daily

Rental duration	Rate ($)	Hours	Rental rate ($/hr)
Monthly	3,600	176	20.45
Weekly	1,100	40	27.5
Daily	400	8	50

367

- 3,600 / 27.5 = 130.91 hours
- 130.91 / 40 = 3.27 (use 3 weeks: 3 x 40 = 120)
- Rent (weekly): 120 hours or less
- Rent (monthly): more than 120 hours

368

- 1,100 / 50 = 22 hours
- 22 / 8 = 2.75 (use 2 days: 2 x 8 = 16)
- Rent (daily): 16 hours or less
- Rent (weekly): more than 16 hours

369

Replacement Decision

- A piece of equipment has two lives
  - A physically limited working life
  - A cost limited economic life
- A machine in good mechanical condition and working productively will likely to be kept in the equipment inventory
- Equipment manager may look only at the high initial cash outflow associated with the purchase of a replacement machine and consequently ignore the other cost factors involved
- All cost factors must be examined when considering a replacement decision

370

- If an owner considers only purchase price and expected salvage, the ownership cost shows that the machine should not be traded (fig. a)

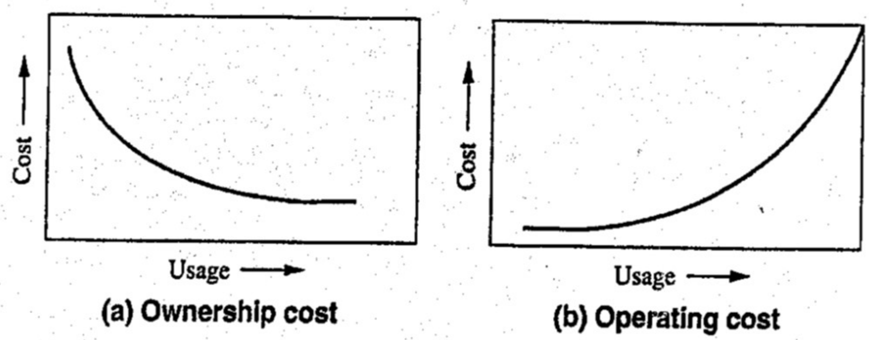


FIGURE 2.8 Effect of cumulative usage on cost.

371

- If only operating cost is examined, the owner would want to trade the machine after the first year, as operating expenses are continually rising with usage (fig. b)
- A correct analysis of the situation requires that total cost be considered

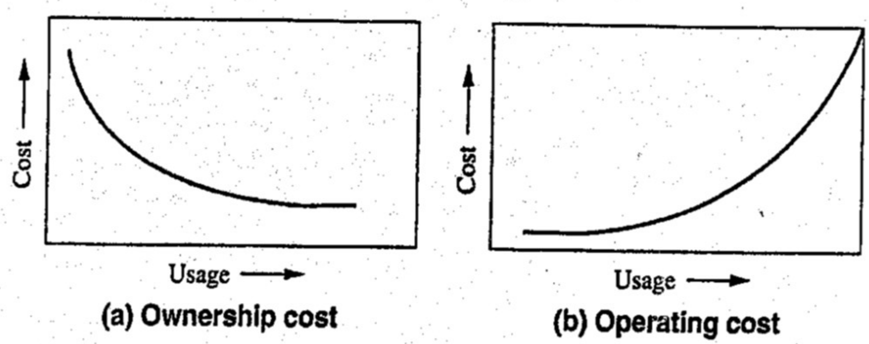


FIGURE 2.8 Effect of cumulative usage on cost.

372

- A small dozer is purchased for $106,000
- A forecast of expected operating hours, salvage values, and maintenance expense is shown below

Year	Operating hours	Salvage ($)	Maintenance expense ($)
1	1,850	79,500	3,340
2	1,600	77,000	3,900
3	1,400	76,320	4,460
4	1,200	73,000	5,000
5	800	70,000	6,600

373

Replacement analysis

Year	1	2	3	4	5
Purchase	$106,000	$106,000	$106,000	$106,000	$106,000
Salvage	$79,500	$77,000	$76,320	$73,000	$70,000
Cost	$26,500	$29,000	$29,680	$33,800	$36,000
Cumulative operating hours	1,850	3,450	4,850	6,050	6,850
Ownership cost $/hr	$14.32	$8.41	$6.12	$5.59	$5.26
Cumulative maintenance expense	$3,340	$7,240	$11,700	$16,700	$23,300
Operating cost $/hr	$1.81	$2.10	$2.41	$2.76	$3.40
Total $/hr	$16.13	$10.51	$8.53	$8.35	$8.66

374

- The most economical service life of this machine is 4 years, as \$8.35/operating hour is the minimum total cost
- The analysis is based on cumulative hours
- If the owner chooses to keep the machine 5 years, the effective loss is \$0.31 (\$8.66 - \$8.35) on every operating hour, not just the 800 hr of the last year
- When the total operating hours are large, the significance of this cumulative effect can become much greater than it would appear by simply looking at the combined cost per hour values

375

Construction Cost Analysis & Estimating – 110401543

Material Cost

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376

- Material cost is a component of the direct costs to complete a project
- The detailed estimate includes determination of the material quantities and costs
- The contractor must have a complete set of contract documents to perform a detailed material cost estimate
- Notify material suppliers and manufacturers' representatives that the company is preparing a proposal for a project to receive price quotations for material unit cost including delivery

377

- Sources of material prices
    - Material suppliers
    - Historical records
    - Published cost data
    - Market trend analysis
- Material cost = Quantity of work x material unit cost
- Material wastage (%) can be expressed as part of "Quantity of work" or as a separate term
- Material cost = Quantity of work x material unit cost x (1 + waste)

378

- Other adjustments for material cost includes
  - Sales tax (or can be part of project indirect cost)
  - Location

- Material cost = Quantity of work x material unit cost x adjustment factor
- Adjustment factor = waste + tax + location

379

Published Cost Data (RSMeans)

04 22 Concrete Unit Masonry

04 22 10 – Concrete Masonry Units

04 22 10.23 Concrete Block, Decorative		Crew	Daily Output	Labor-Hours	Unit	Material	Labor	Equipment	Total	Total Incl O&P
						Bare Costs				
0010	CONCRETE BLOCK, DECORATIVE									
0020	Embossed, simulated brick face									
0100	8" x 16" units, 4" thick	D-8	400	.100	S.F.	3.02	3.43		6.45	8.55
0200	8" thick		340	.118		4.17	4.03		8.20	10.75
0250	12" thick		300	.133		5.50	4.57		10.07	13
0400	Embossed both sides									
0500	8" thick	D-8	300	.133	S.F.	4.68	4.57		9.25	12.10
0550	12" thick	"	275	.145	"	5.90	4.99		10.89	14.10

380

- Crew daily output = 340 SF/day
- Unit material cost = $4.17/SF
- Material cost = quantity of work (SF) x $4.17/SF
- Apply adjustments as needed

381

Excavation

- Estimating excavation requires
  - Estimating of work quantities and job conditions
  - Selection of equipment (production rates)
  - Competent job management
- The cost of excavation is affected by various factors such as the type and properties of soil and whether groundwater will be encountered and pumping will be required

382

Table 2–4 Construction characteristics of soils (Unified System)

Soil Type	Symbol	Drainage	Construction Workability	Suitability for Subgrade (No Frost Action)	Suitability for Surfacing
Well-graded gravel	GW	Excellent	Excellent	Good	Good
Poorly graded gravel	GP	Excellent	Good	Good to excellent	Poor
Silty gravel	GM	Poor to fair	Good	Good to excellent	Fair
Clayey gravel	GC	Poor	Good	Good	Excellent
Well-graded sand	SW	Excellent	Excellent	Good	Good
Poorly graded sand	SP	Excellent	Fair	Fair to good	Poor
Silty sand	SM	Poor to fair	Fair	Fair to good	Fair
Clayey sand	SC	Poor	Good	Poor to fair	Excellent
Low-plasticity silt	ML	Poor to fair	Fair	Poor to fair	Poor
Low-plasticity clay	CL	Poor	Fair to good	Poor to fair	Fair
Low-plasticity organic	OL	Poor	Fair	Poor	Poor
High-plasticity silt	MH	Poor to fair	Poor	Poor	Poor
High-plasticity clay	CH	Very poor	Poor	Poor to fair	Poor
High-plasticity organic	OH	Very poor	Poor	Very poor to poor	Poor
Peat	Pt	Poor to fair	Unsuitable	Unsuitable	Unsuitable

383

Soil Volume-Change Characteristics

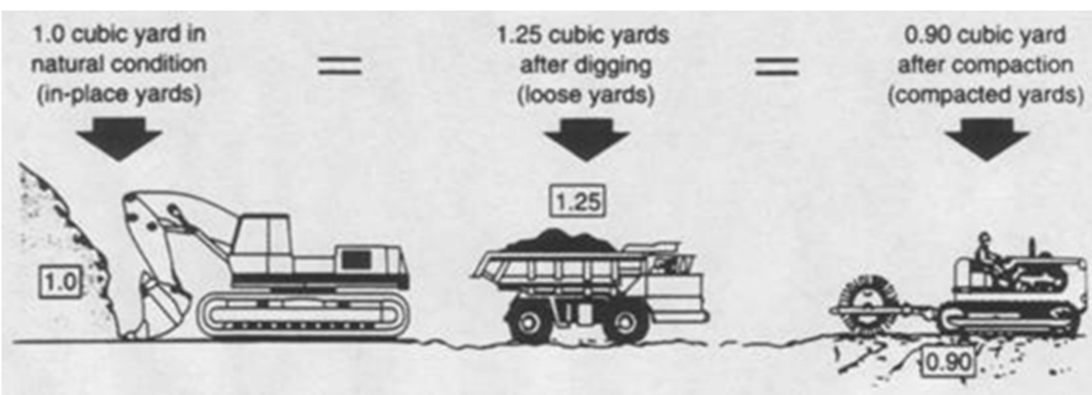


Figure 2–2 Typical soil volume change during earthmoving.

384

- Bank/in-place/natural condition
  - Material in its natural state before disturbance. Unit volume is Bank Cubic Meter/Yard (BCM/BCY)
- Loose
  - Material that has been excavated or loaded. Unit volume is Loose Cubic Meter/Yard (LCM/LCY). Highest volume
- Compacted
  - Material after compaction. Unit volume is Compacted Cubic Meter/Yard (CCM/CCY). Highest unit weight

385

Percentage of Swell & Shrinkage		
Material	**Swell**	**Shrinkage**
Sand and Gravel	10 to 18%	85 to 100%
Loam	15 to 25%	90 to 100%
Dense Clay	20 to 35%	90 to 100%
Solid Rock	40 to 70%	130%

- For example, a 1,000 BCM swells to 1,300 LCM and shrinks to 800 CCM

386

- In general, volume of excavation can be calculated as follows

$$\text{Volume} = \text{Horizontal area} \times \text{Average depth}$$

- The horizontal area can be divided into a set of rectangles, triangles, or circular segments
- After the area of each segment is calculated, the total area is found as the sum of the segment areas

387

- For simple rectangular shapes, the average depth can be taken as the average of the four corner depths
- For more complex areas, we can measure the depth at additional points along the perimeter of the excavation and average all depths
- Trench excavation requires knowing trench cross-sectional area and the linear distance along the trench line

388

Production of Earthmoving Equipment

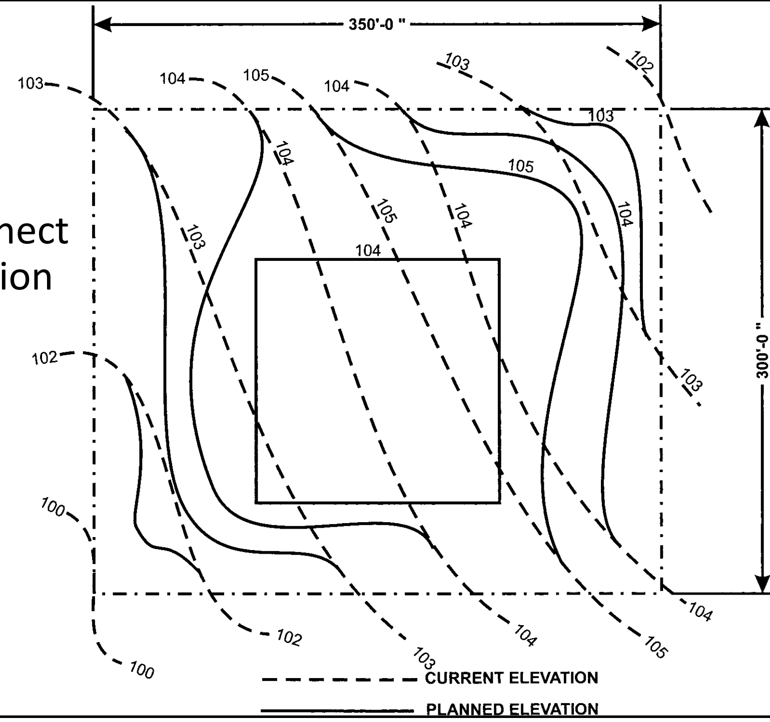
- Production = Volume per cycle × Cycles per hour
  - Volume per cycle: Average volume of material moved per equipment cycle
  - Cycles per hour: Number of cycles actually achieved (or expected to be achieved) per hour
- Cost per unit of production = Equipment cost per hour / Equipment production per hour

389

- To determine the amount of general excavation, it is necessary to determine the following
  - The size of building (building dimensions)
  - The distance the footing will project beyond the wall
  - The amount of working space required between the edge of the footing and the beginning of excavation
  - The elevation of the existing land, by checking the existing contour lines on the plot (site) plan

390

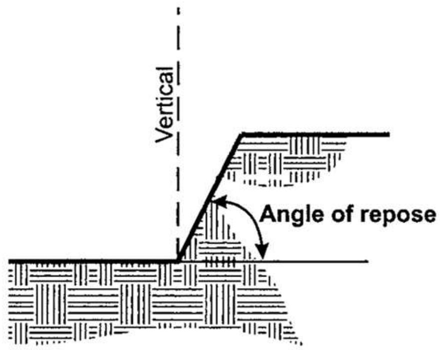
- Sample site plan
- Contour lines connect points of equal elevation



391

- To determine the amount of general excavation, it is necessary to determine the following
  - The type of soil that will be encountered. This is determined by first checking the soil borings (on the drawings), but must also be checked during the site investigation
  - Whether the excavation will be sloped or shored
  - The amount of slope required must be determined by the estimator who considers the depth of excavation, type of soil, and possible water conditions

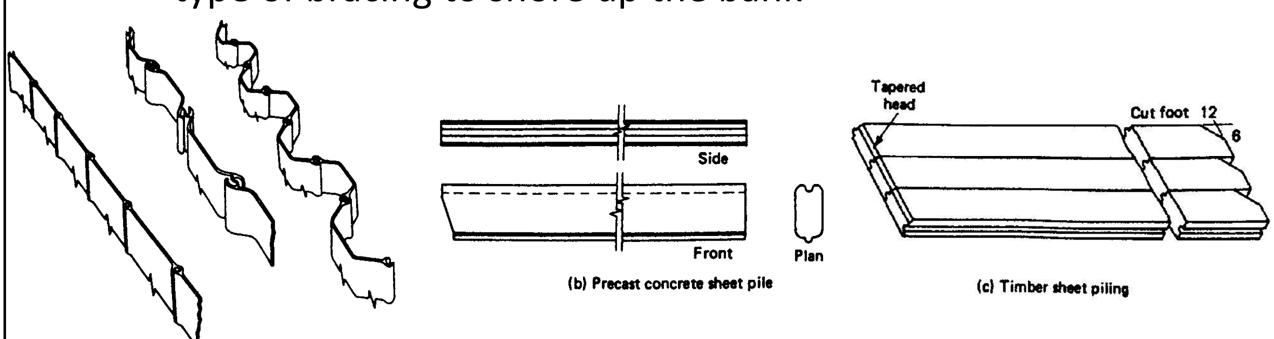
392



Material	Angle		
	Wet	Moist	Dry
Gravel	15-25	20-30	24-40
Clay	15-25	25-40	40-60
Sand	20-35	35-50	25-40

393

- To determine the amount of general excavation, it is necessary to determine the following
  - If job conditions will not allow the sloping of soil, the estimator will have to consider using sheet piling or some type of bracing to shore up the bank



(a) Steel sheet piling

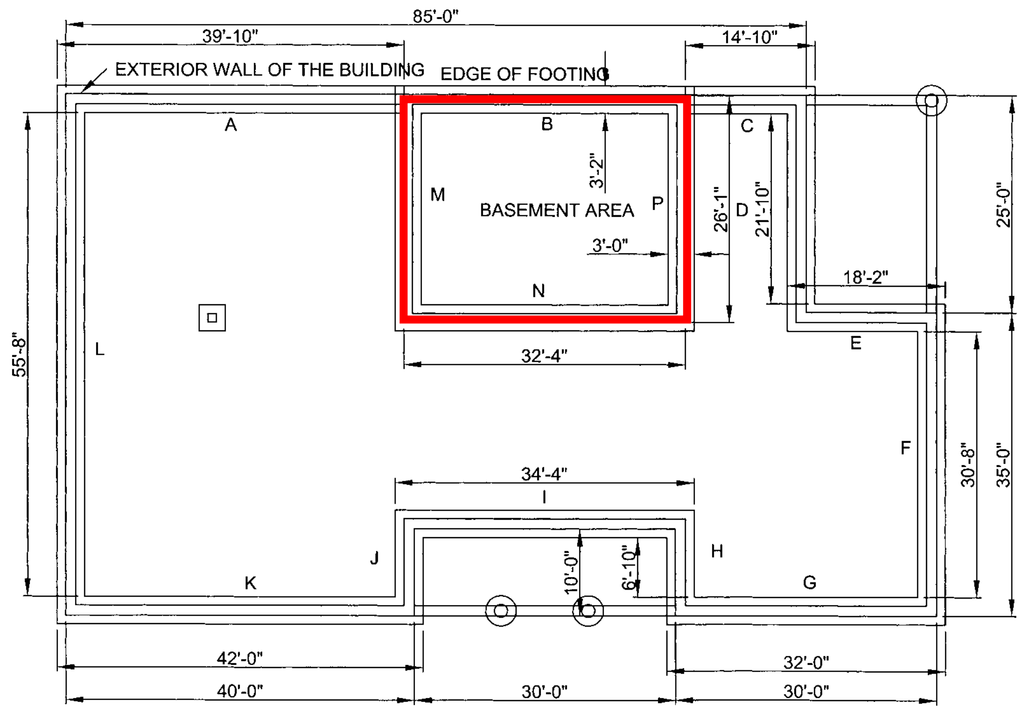
(b) Precast concrete sheet pile

(c) Timber sheet piling

394

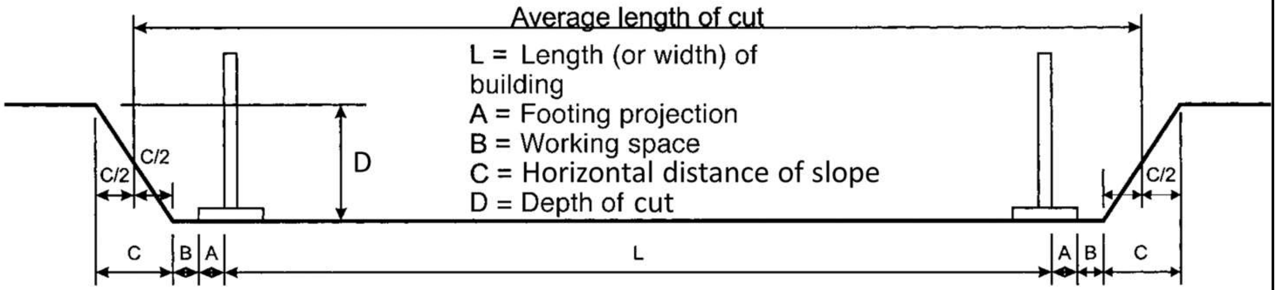
- When sloping sides are used for mass excavations, the volume of the earth that is removed is found by developing the average cut length in both dimensions and by multiplying them by the depth of the cut
- The average length of the cut can be found
- Another method is to average the top of cut and bottom of cut dimensions

395

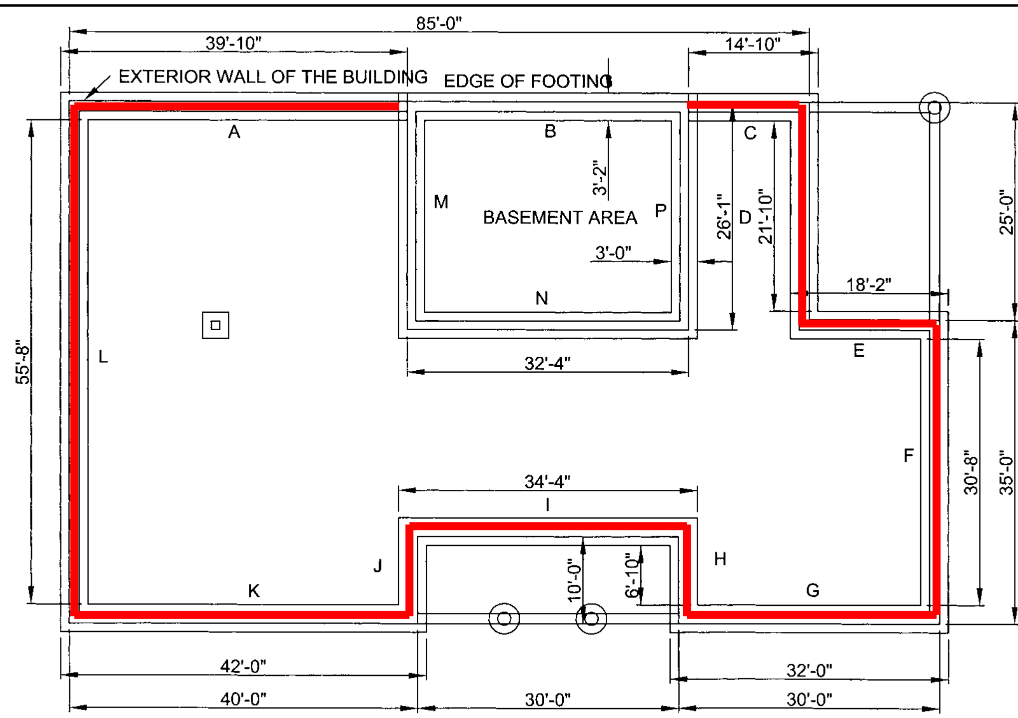


396

- Volume = average width x average length x depth of cut
- The amount of working space required between the edge of the footing and the beginning of excavation (approximately 0.5 m or 1.5 feet)



397

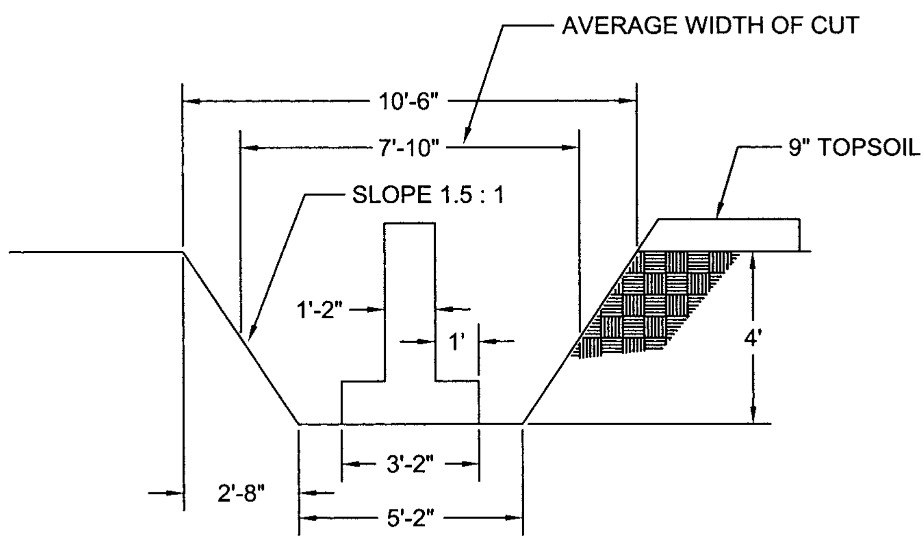


398

- The simplest way to approximate the continuous footing excavation is to multiply the average cut width times the perimeter of the building times the depth
- Volume = average width x depth x linear footing length

399

Continuous Footing Section



400

Backfilling

- Once the foundation of the building has been constructed, one of the next steps in construction is the backfilling required around the building
- Backfilling is the putting back of the excess soil that was removed from around the building during the general excavation

401

- One method for calculating the amount of backfill to be moved is to determine the total volume of the building within the area of the excavation
- This would be the total volume of the basement area, figured from the underside of the fill material, and would include the volume of all footings and foundation walls

402

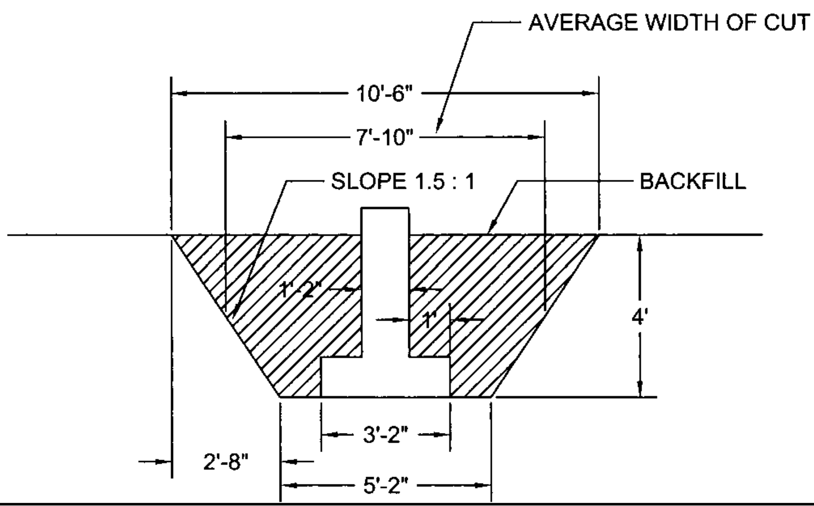
- This volume is deducted from the volume of excavation that had been previously calculated
- The volume of backfill required is the result of this subtraction
- The figures should not include the data for topsoil, which should be calculated separately

403

- A second method for calculating backfill is to compute the actual volume of backfill required
- The estimator usually makes a sketch of the actual backfill dimensions and finds the required amount of backfill

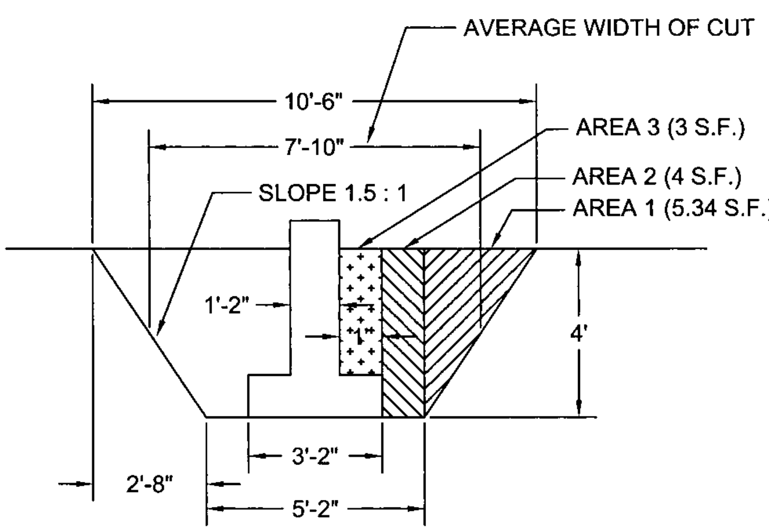
404

- Subtract the area of the footing from the area of backfill and multiply that number by the length of the footing
- Backfill volume = Excavation Volume - Wall Volume



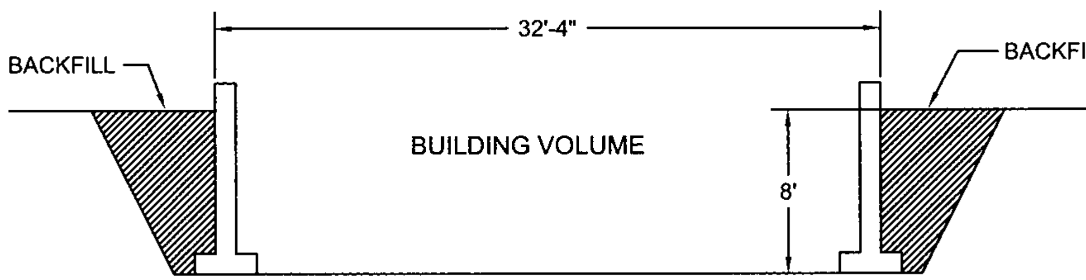
405

- Alternately, the area of backfill can be figured by computing the area and by multiplying that amount by the length



406

- Backfill volume = Excavation Volume – (Building Volume + Footing Volume)



407

- The earthwork is calculated in terms of excavation, backfill, and grading
- The estimator must compare the total amounts of cut and fill required and determine whether there will be an excess of materials that must be discarded, or whether there is a shortage of materials and some must be brought in (borrow)

408

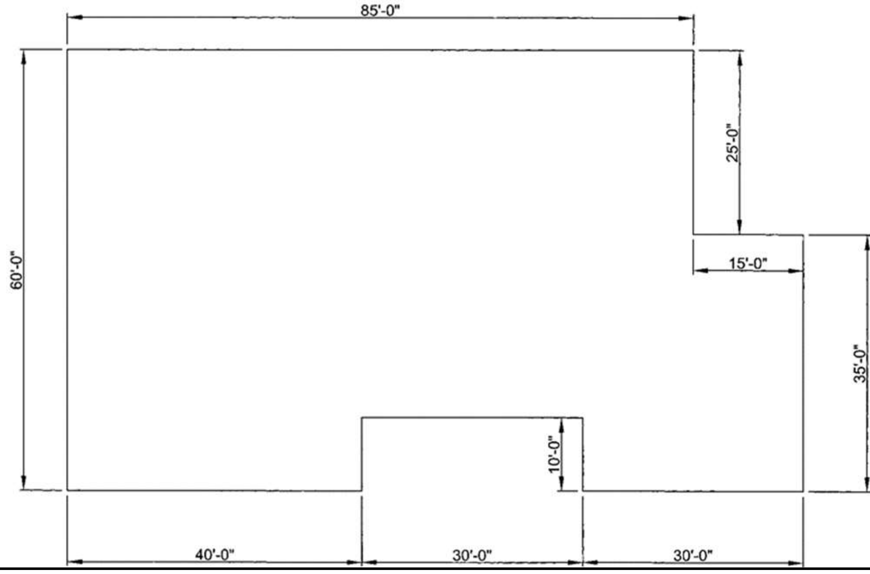
- The removal of topsoil to a designated area where it is to be stockpiled for finished grading and future use is included in many specifications
- The topsoil can be removed if it contains organic material and not suitable for construction
- The estimator must determine
  - The depth of the topsoil
  - Where it will be stockpiled
  - What equipment should be used to strip the topsoil and move it to the stockpile area

409

- Topsoil is generally removed from all building, walk, roadway, and parking areas
- The volume of topsoil is figured in cubic yards/meters
- A clearance around the entire basic plan must also be left to allow for the slope required for the general excavation
- The clearance is usually about 5 feet (1.5 m) on each side of a building and 1.5 feet (0.5 m) for walks, roadways, and parking areas

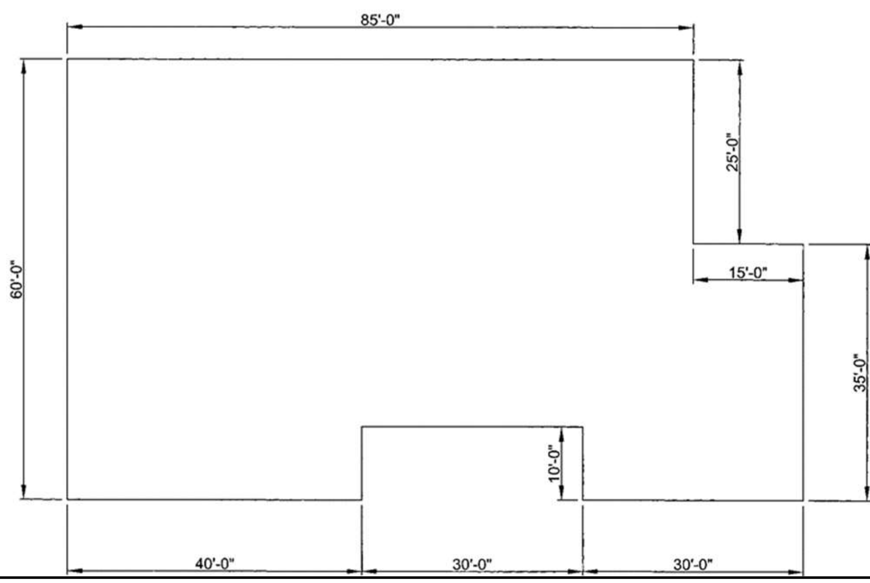
410

- The following building perimeter and area are calculated as follows
- Perimeter = 85’ + 25’ + 15’ + 35’ + 30’ + 10’ + 30’ + 10’ + 40’ + 60’ = 340’



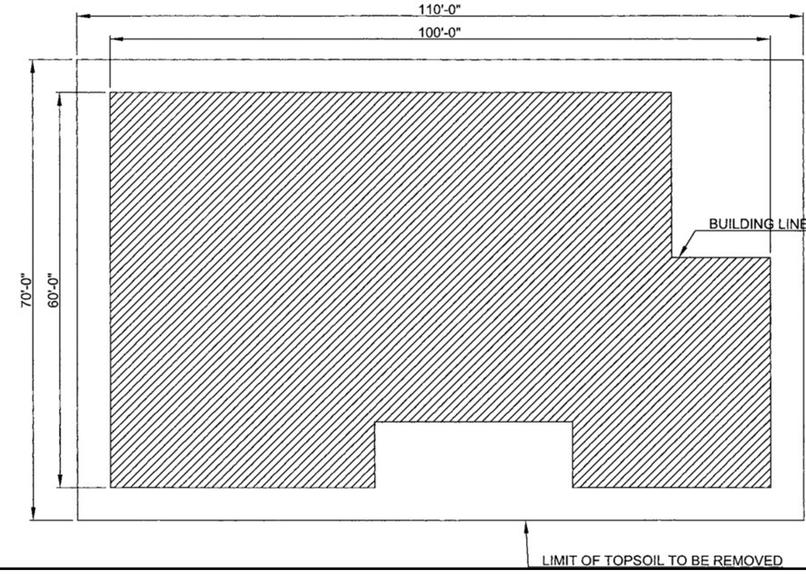
411

- The following building perimeter and area are calculated as follows
- Area = (100’ x 60’) – (10’ x 30’) – (15’ x 25’) = 5,325 SF



412

- If the footprint of the building has been enlarged by 5’ to compensate for accuracy and slope
- Assuming that the topsoil to be removed is 9’’ thick



413

- The quantity of topsoil to be removed and stockpiled can be calculated as follows
- Quantity of topsoil to be removed = 110’ x 70’ x (9/12)’ = 5,775 BCF
- 5,775 / 27 = 213.89 BCY

414

- If the equipment selected to remove the topsoil has the following specifications
  - Equipment type = Front end loader
  - Production = 24 BCY/hr
  - Equipment cost per hour = $12/hr
  - Operator cost per hour = $18/hr
- The equipment and labor cost can be calculated as follows
  - Hours of operation = 213.89 / 24 = 8.91 hrs
  - Equipment cost = 8.91 x 12 = $106.92
  - Labor cost = 8.91 x 18 = $160.38

415

- To get the production rate of 24 CY/hr, the volume of material moved per cycle (1 CY) and cycle time of the equipment (2.5 min) can be used as follows
- Production = Volume per cycle × Cycles per hour

$= 1 \text{ CY} \times \frac{60 \text{ min/hr}}{2.5 \text{ min}} = 24 \text{ CY/hr}$

- Equipment cost per unit of topsoil removed = Equipment cost per hour / Equipment production per hour

= 12 / 24 = $0.5/BCY

416

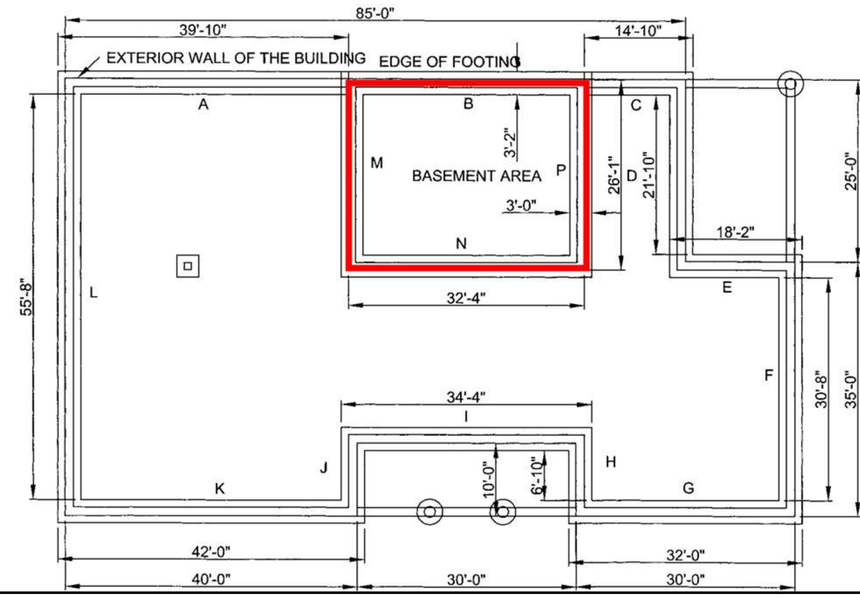
- If a rectangular trench is planned to be excavated to place a pipe. The trench has a width of 1.5 m, depth of 2 m, and length of 200 m
- The volume of excavation is 1.5 x 2 x 200 = 600 BCM
- If the excavated material is unsuitable for backfilling and will be transported away from the site. The estimator must plan for hauling (transporting) the material in its loose state
- If the soil swell is 20% the hauling units will transport 600 x 1.2 = 720 LCM

417

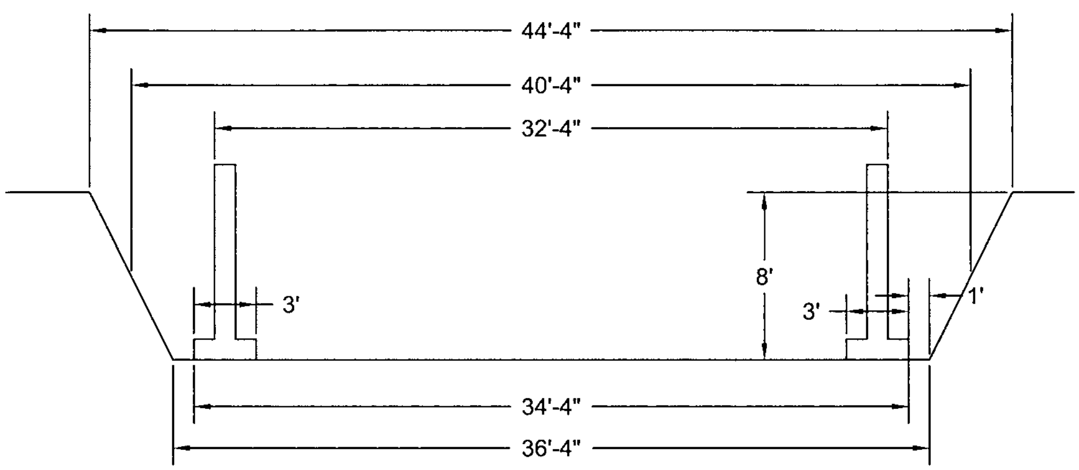
- Assume that 250 CCM sand (swell 15%, shrinkage 90%) bedding is needed for this trench
- The bank volume is 250/.9 = 277.78 BCM
- The hauling units will transport this material from a borrow pit
- The volume to be transported is 277.78 x 1.15 = 319.45 LCM

418

- The amount of excavation required for the basement portion of the building can be determined as follows

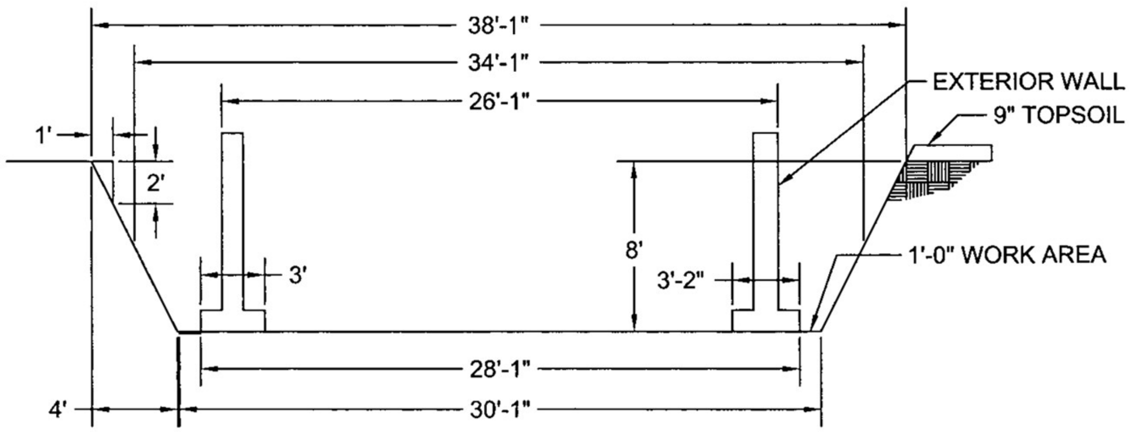


419



Basement cross-section (length)

420



Basement cross-section (width)

421

- From the building plan, the exterior dimensions of the basement are 26’ 1’’ by 32’ 4’’
- From the wall section, the footing projects out 1 foot from the foundation wall
- The workspace between the edge of the footing and the beginning of the excavation will be assumed as 1 foot
- In this example, the expected depth of the cut is 8 feet after a deduction for the topsoil that would have already been removed

422

- For this example, a slope of 2:1 will be used, which means for every 2 feet of vertical depth an additional 1 foot of horizontal width is needed
- Since the alternative is shoring or sheet piling on this project, the sloped excavation will be used
- Average width of cut = 2’ + 1’ + 28’ 1’’ + 1’ + 2’ = 34’ 1’’
- Average length of cut = 2’ + 1’ + 34’ 4’’ + 1’ + 2’ = 40’ 4’’

423

- Volume of excavation = 34’ 1’’ x 40’ 4’’ x 8’

= 34.08 x 40.33 x 8 = 10,995.57 BCF

10,995.57 BCF / 27 = 407.24 BCY

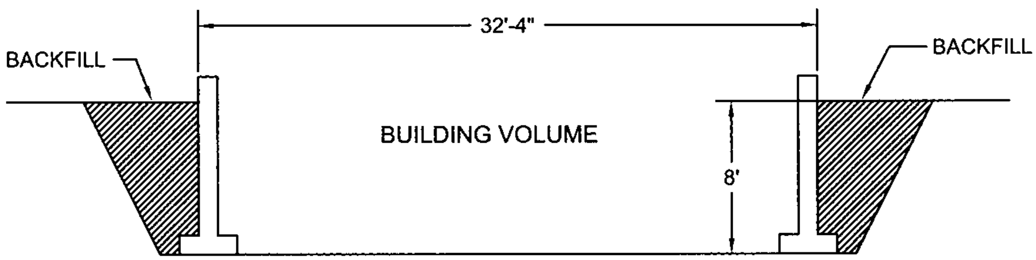
- If this were to be hauled off the site, assuming a 30% swell

factor, the number of truck loads using a truck with 7 CY capacity

= (407.24 x 1.3) / 7 = 75.63 = 76 truck loads

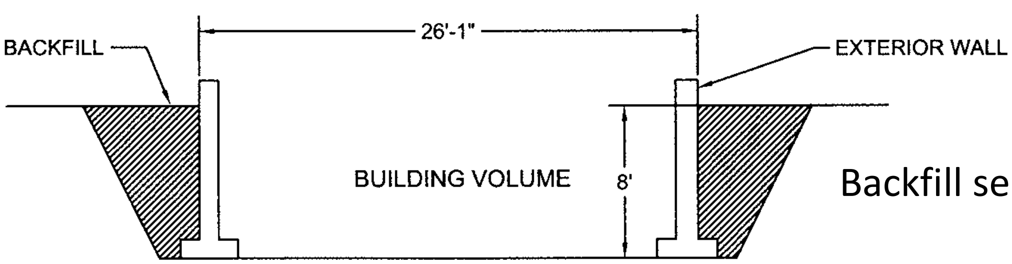
424

• Backfilling quantity for the basement walls can be calculated as follows

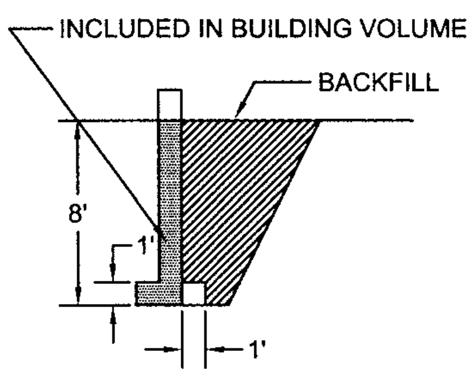


Backfill section (length)

425



Backfill section (width)



Footing backfill

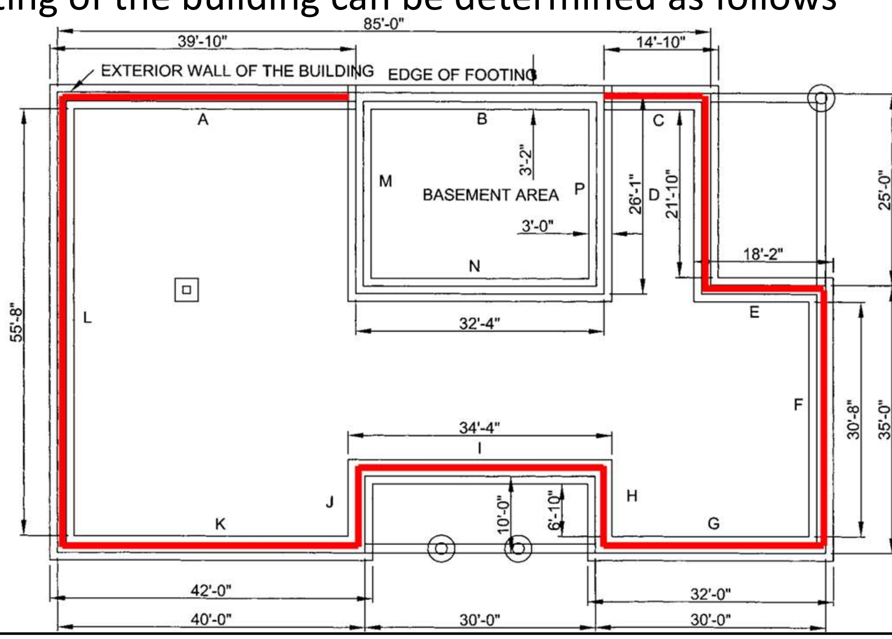
426

- Building volume = 32’ 4’’ x 26’ 1’’ x 8’ =32.33’ x 26.08’ x 8’ = 6,745.33 CF
- Footing volume = 1’ x 1’ x 32.33’ x 2 + 1’ x 1’ x 26.08’ x 2 = 116.82 CF
- Backfill volume = Excavation Volume – (Building Volume + Footing Volume) = 10,995.57 - 6,745.33 - 116.82 = 4,133.42 BCF

  4,133.42 BCF / 27 = 153.09 BCY
- The backfill material will be compacted. The calculated volume will be the volume filled with compacted material 153.09 CCY

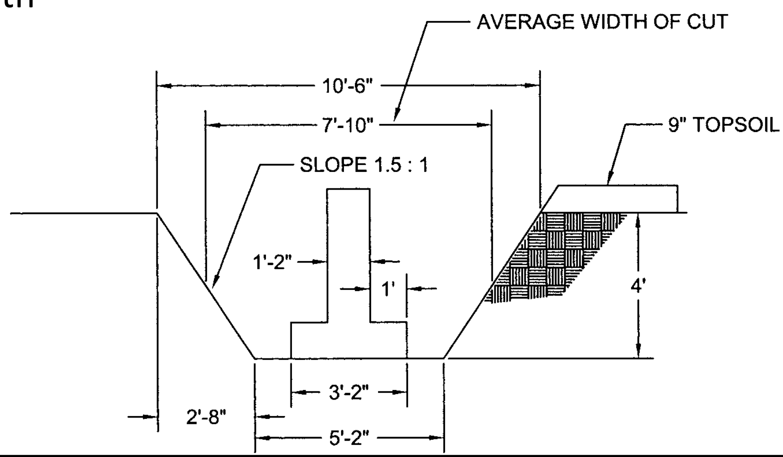
427

- The amount of excavation required for the continuous footing of the building can be determined as follows



428

- The slope is 1.5:1, which means that for every 1.5 feet of vertical rise, there is 1 foot of horizontal run
- The simplest way to approximate the amount of cut is to multiply the average cut width times the perimeter of the building times the depth

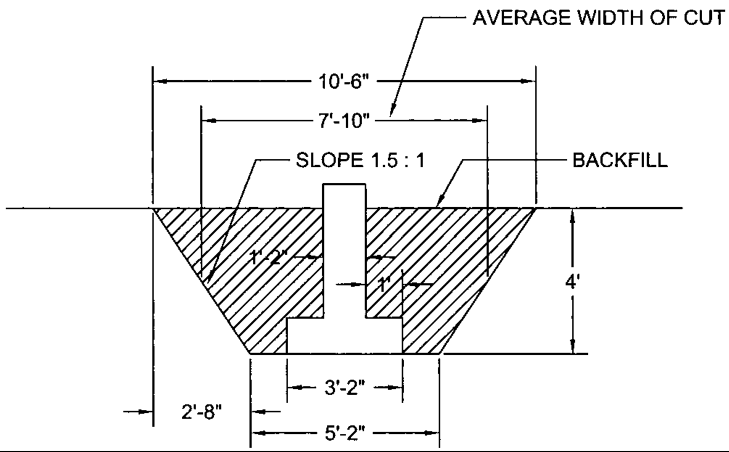


429

- Since 32’4’’ of the perimeter was included in the basement wall. The linear distance of continuous footing is 340’ – 32’4 = 307’8’’
- Volume of excavation = 7’10’’ x 307’8’’ x 4’ = 7.83’ x 307.67’ x 9,636.22 BCF
- 9,636.22 BCF/ 27 = 356.9 BCY

430

- Backfilling quantity for the foundation walls can be calculated as follows
- Subtract the area of the footing from the area of backfill and multiply that number by the length of the footing

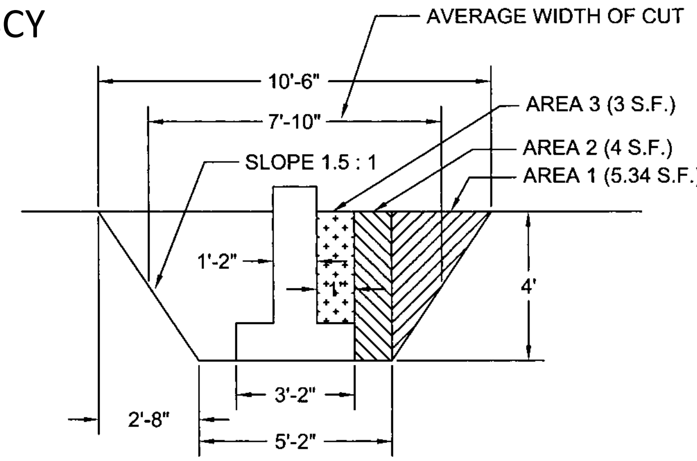


431

- Volume of footing = 3’2’’ x 1’ x 307’8’’ = 3.17’ x 1’ x 307.67’ = 975.31 CF
- Volume of foundation wall = 3’ x 1’2’’ x 307’8’’ = 3’ x 1.17’ x 307.67’ = 1,079.92 CF
- Volume of footing and foundation wall = 975.31 + 1,079.92 = 2,055.23 CF
- Volume of backfill = 9,636.22 - 2,055.23 = 7,580.99 CF
- 7,580.99 BCY / 27 = 280.78 BCY
- The backfill material will be compacted. The calculated volume will be the volume filled with compacted material 280.78 CCY

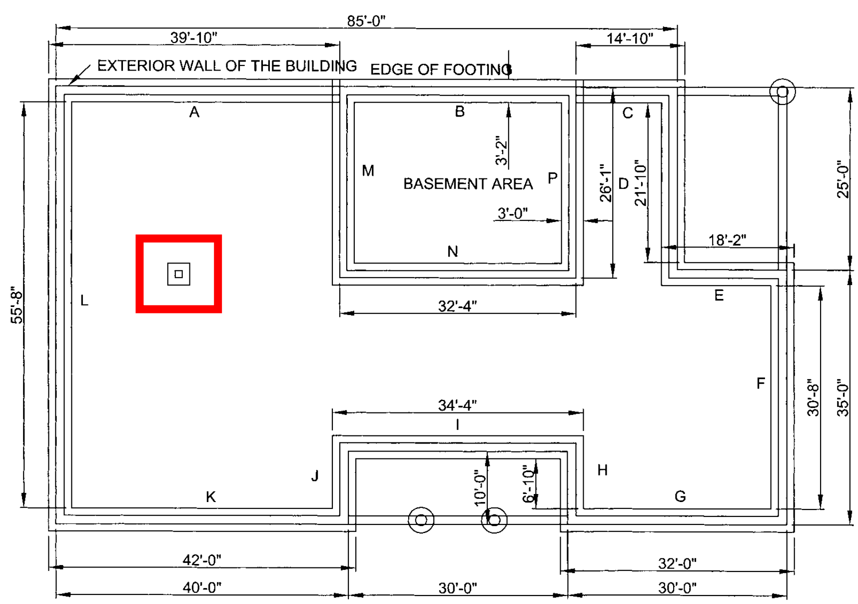
432

- Alternately, the area of backfill can be computed by figuring the area and by multiplying that amount by the length
- Backfill area = (5.34 + 4 + 3) x 2 = 24.68 SF
- Volume of backfill = 24.68 SF x 307.67’ = 7,593.3 CF
- 7,593.3 CF / 27 = 281.23 BCY



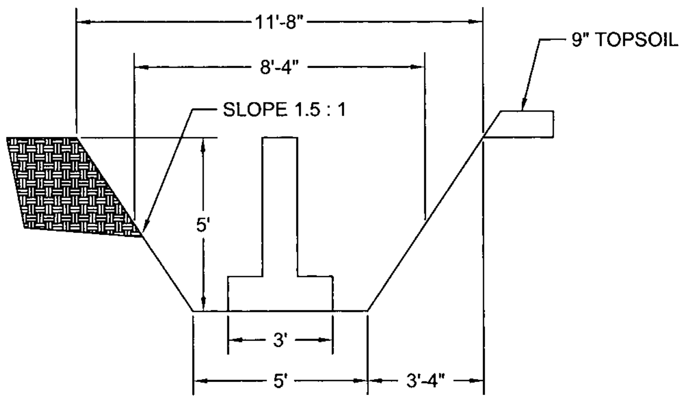
433

- Excavation for the spread footing



434

- Since the spread footing is square, the general excavation can be found by squaring the average cut width and by multiplying that by the depth



435

- Volume of excavation = 8’4’’ x 8’4’’ x 5’ = 8.33’ x 8.33’ x 5’ = 346.94 CF
- 346.94 CF / 27 = 12.85 BCY

436

Asphalt Paving

- Asphalt paving is generally classified by traffic (heavy, medium, or light) and use (walks, streets, and driveways)
- The estimator should determine which items will be required, the material and equipment necessary for each portion of the work, and the required thickness and amount of compaction
- The number of m^2 / SF to be covered is determined, and the thickness (compacted) of each course and the type of materials required are noted

437

Approximate Asphalt Paving Materials Tonnage

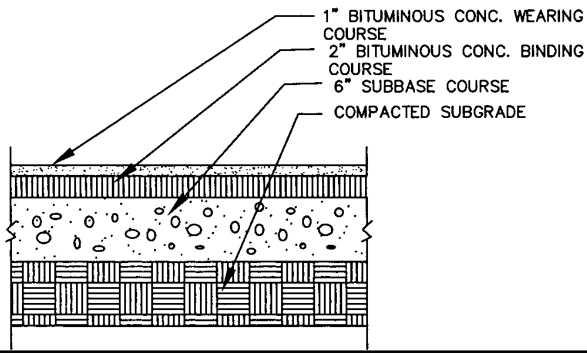
Compacted Thickness	Asphalt[1] Paving	Granular[2] Material	Subgrade[3] Material
1"	6.5	5.25	4.6
2"	13.0	10.5	9.2
3"	19.5	15.75	13.8
4"	26.0	21.0	18.4
5"	32.5	26.25	23.0
6"	39.0	31.5	27.6
8"	52.0	42.0	36.8
10"	65.0	52.5	46.0
12"	78.0	63.0	55.2

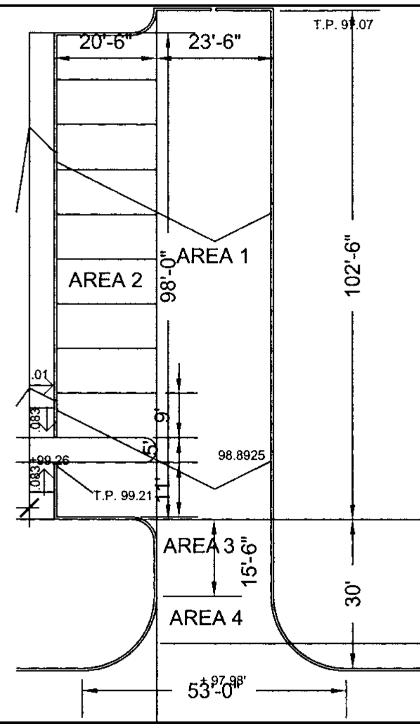
Per 1,000 s.f. of surface area, figures include 10 percent waste.

1. *Asphalt paving, 140 – 150 pounds per c.f.*
2. *Granular material, 110- 120 pounds per c.f.*
3. *Subgrade material, 95 – 105 pounds per c.f.*

438

- Assume that the asphalt required is 3 inches thick and the subgrade is 6 inches thick
- The quantity of asphalt and subgrade material required for the parking lot in the commercial building can be determined as follows





439

- Area 1 = 23.5’ x 102.5’ = 2,408.75 SF
- Area 2 = 20.5’ x 98’ = 2,009 SF
- Area 3 = 15.5’ x 23.5’ = 364.25 SF
- Area 4 = [(53’ + 23.5’) x 14.5’] / 2 = 554.63 SF
- Total area = 5,336.63 SF
- Quantity of asphalt = (19.5 ton/ 1000 SF) X 5,336.63 SF = 104.06 tons
- Quantity of subgrade = (27.6 ton/ 1000 SF) X 5,336.63 SF = 147.29 tons

440

Concrete Work

- Because concrete has little strength in tension, virtually all concrete used for structural purposes contains reinforcing material embedded in the concrete to increase the concrete member's tensile strength
- Such concrete is called reinforced concrete
- Steel reinforcing (rebar) most commonly used, metal and plastic fibers dispersed in the concrete mix are also available

441

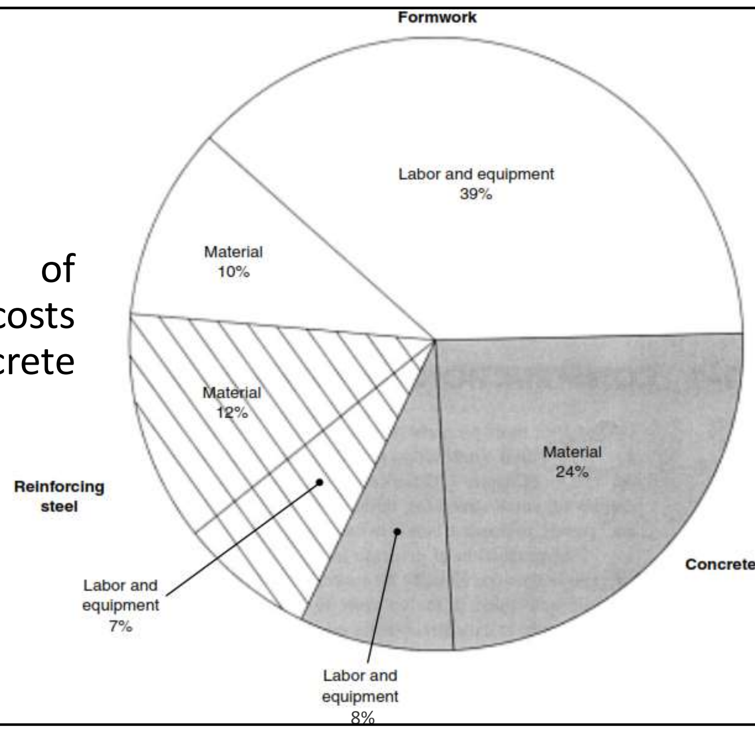
- The concrete for a project may be either ready mixed or mixed on the job
- Most of the concrete used on commercial and residential work is ready mixed and delivered to the job by the ready-mix company
- Quality control, proper gradation, water, and design mixes are easily obtained by the ready-mix producers
- When ready-mix is used, the estimator must determine the amount of concrete required and the type and amount of cement, aggregates, and admixtures
- These are discussed with the supplier, who then gives a proposal for supplying the specific concrete

442

- Concrete is usually estimated by the cubic meter/cubic yard
- Major elements of a concrete construction cost analysis include
  - Formwork costs including labor, equipment, and materials
  - Cost of reinforcing steel and its placement
  - Concrete materials, equipment, and labor for placing, curing, and finishing the concrete

443

- A typical distribution of concrete construction costs for a reinforced concrete building



444

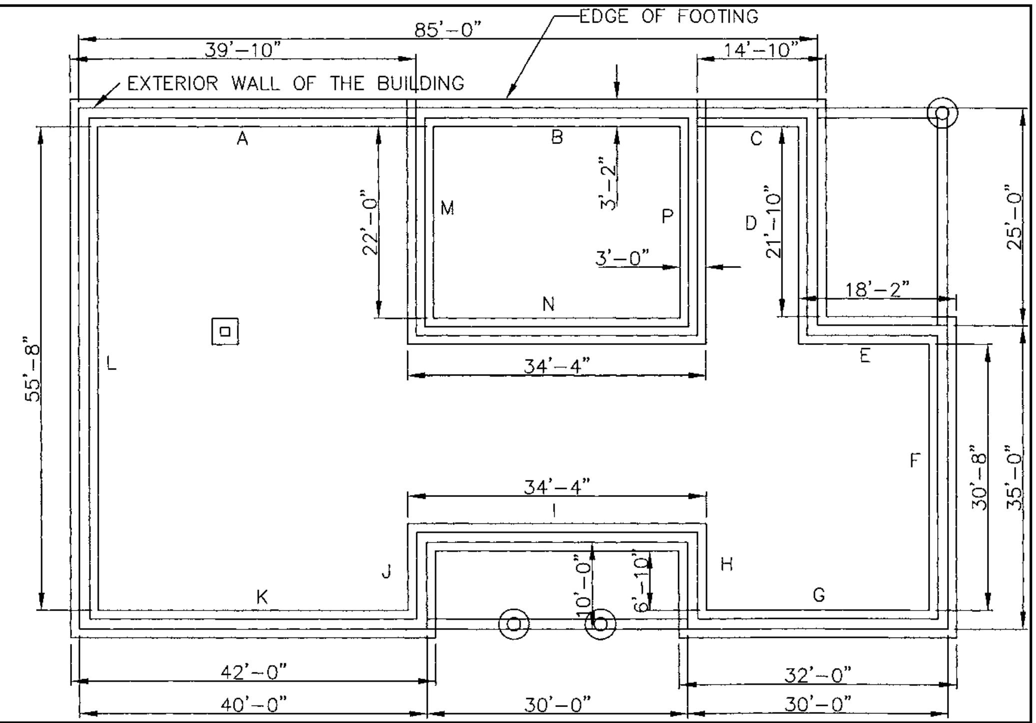
- In estimating concrete quantities, waste ranges from 5% for footings, columns, and beams to 8% for slabs. Waste can be assumed based on job size (5% for large job and 10% for a smaller job)
- The procedure that should be used to estimate the concrete on a project is as follows
  1. Review the specifications to determine the requirements for each area in which concrete is used separately (such as footings and slabs) and list type and strength of concrete and any special curing or testing required

445

2. Review the drawings to be certain that all concrete items shown on the drawings are covered in the specifications
3. Determine the quantities required from the drawings
   - Footing sizes are checked on the wall sections and foundation plans. Watch for different size footings under different walls
   - Concrete slab information will most commonly be found on wall sections, floor plans, and structural details
   - Exterior walks and driveways will most likely be identified on the plot (site) plan and in sections and details

446

- Foundation layout



447

- To determine the quantity for the continuous footing, check the different sizes of continuous footings
  - The continuous footings on the perimeter of the building are 3’2’’ wide
  - The continuous footings on interior of the building are 3’0’’ wide
- Determine the linear distance of footing for each width
- Determine the cross-sectional area for each of the differing sizes
- Determine the volume

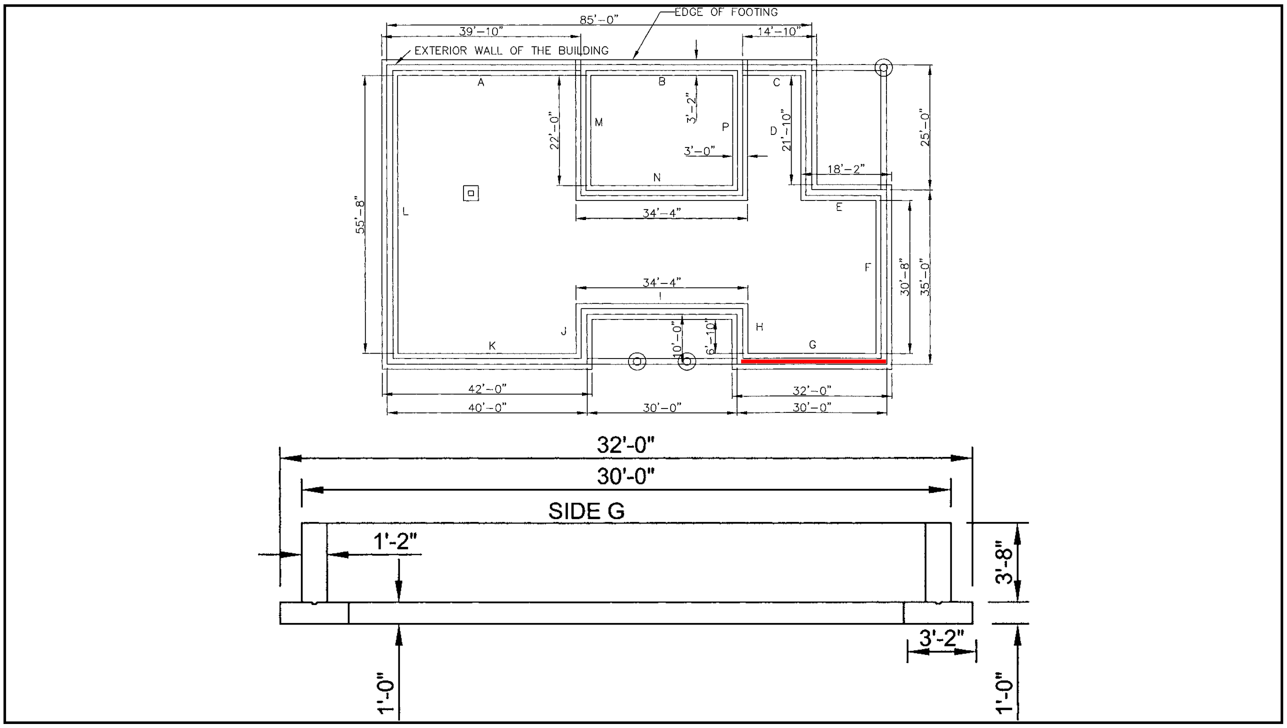
448

- Determining the linear feet/meter of continuous footing typically requires some minor calculations
- The dimensions listed on the drawings typically reference the exterior face of the building or the centerline of the structural framing
- Neither of these dimensions is appropriate for finding the linear feet of footing

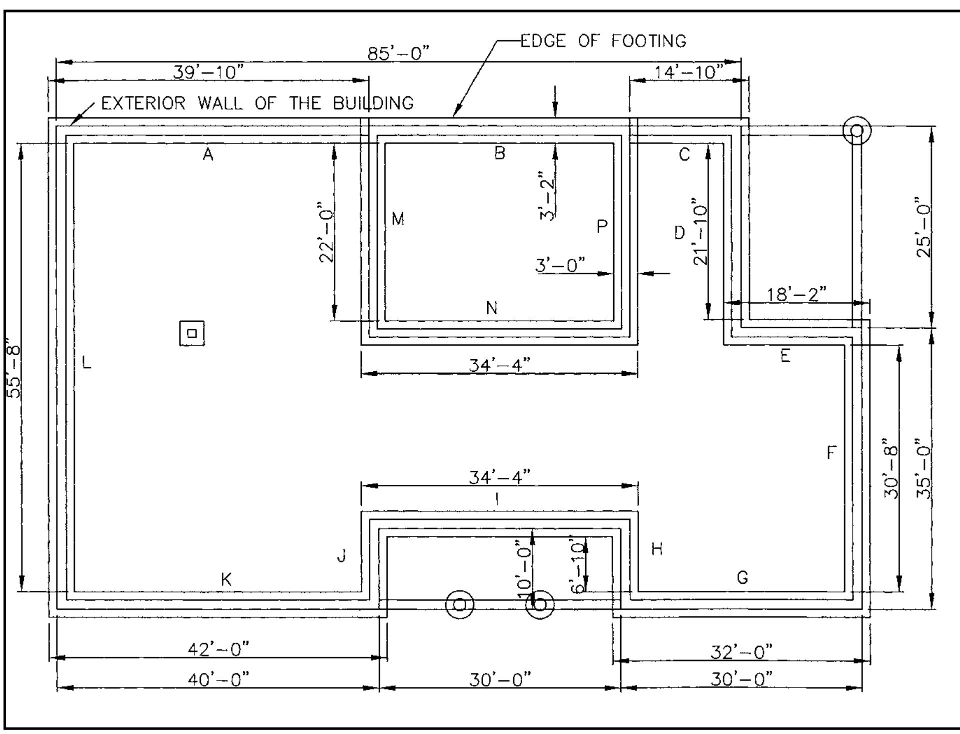
449

- In addition, the overlap that would occur in the corners by taking the measurement along the exterior face of the footing needs to be compensated
- Therefore, the best approach is to determine the dimensions along the exterior edge and dimension so that there is no overlap
- The overlap in the footings for walls A and B and walls B and C is because the footing in wall B is below the footings in walls A and C

450



451



Side	Length
A	39'-10"
B	34'-4"
C	14'-10"
D	21'-10"
E	18'-2"
F	30'-8"
G	32'-0"
H	6'-10"
I	34'-4"
J	6'-10"
K	42'-0"
L	55'-8"
TOTAL	337'-4"

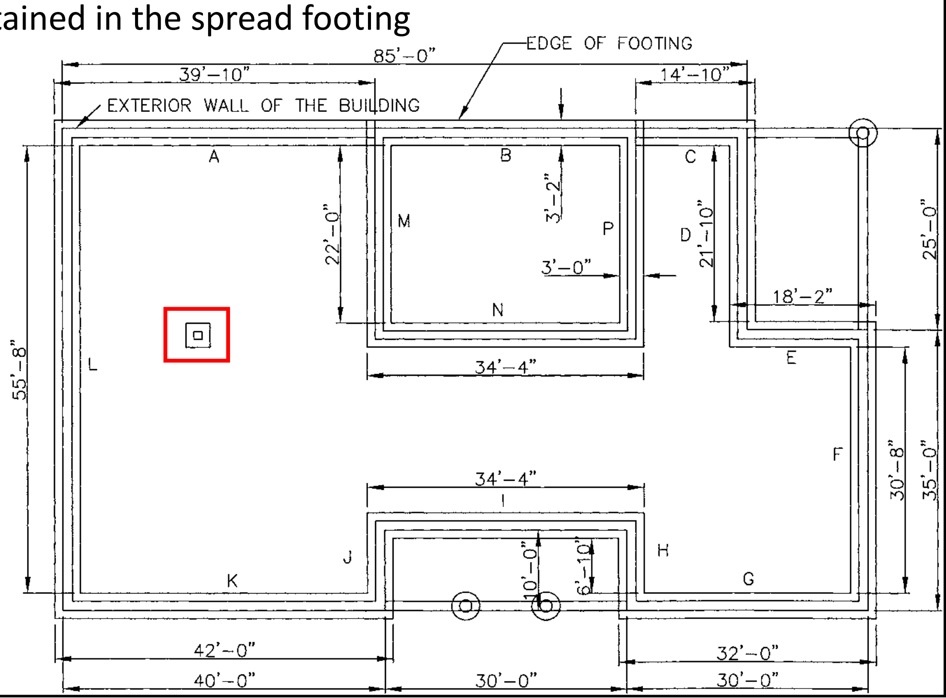
Linear feet of 3'2''wide continuous footing

452

- Cross-sectional area = width x height = 3’2’’ x 1’ = 3.17’ x 1’ = 3.17 SF
- Volume of concrete = Cross-sectional area x length = 3.17’ x 337’4’’ = 3.17’ x 337.33’ = 1,069.34 CF
- 1,069.34 / 27 = 39.61 CY
- Waste assumed as 5%: 39.61 x 1.05 = 41.59 CY

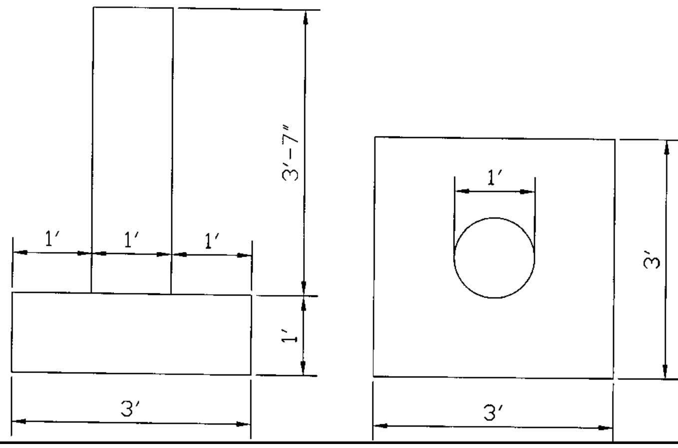
453

- The concrete contained in the spread footing

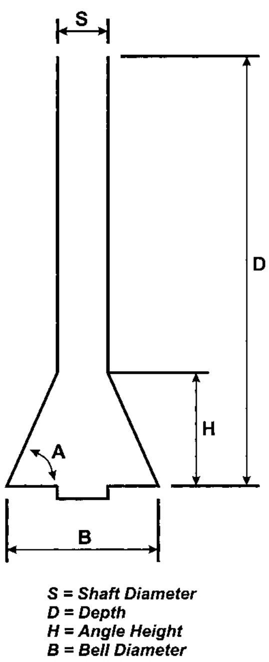


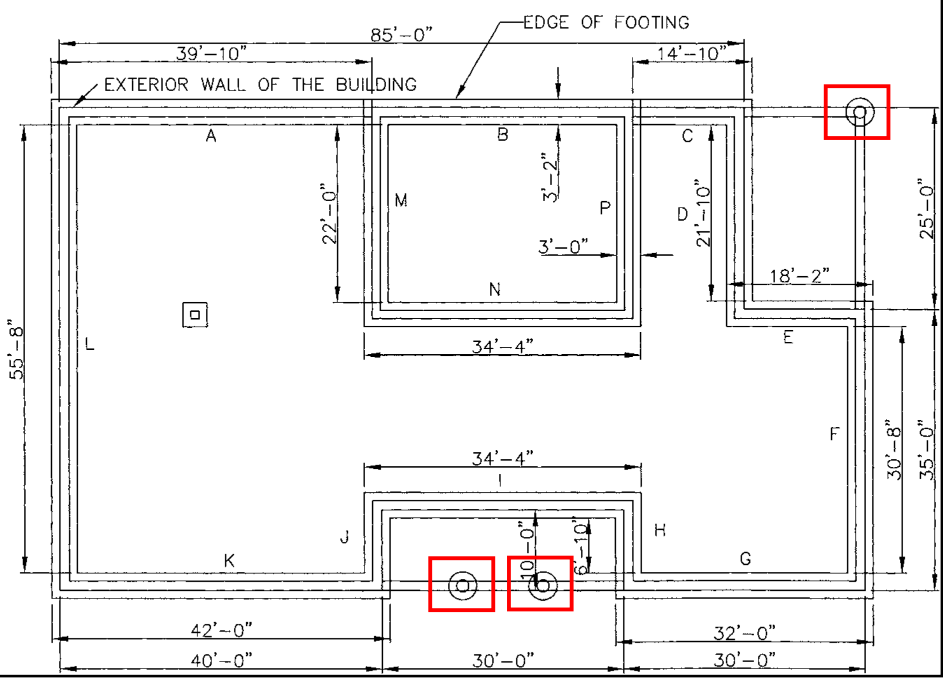
454

- Volume of concrete = length x width x height
= 3’ x 3’ x 1’ = 9 CF = 0.33 CY
- Waste (5%): 1.05 x 0.33 = 0.35 CY



455





456

- To quantify a drilled pier, the shaft diameter, bell diameter, and angle of the bell must be known
- The volume of the drilled piers can be calculated, or tables could be used to find the volume

VOLUME OF BELLS IN DRILLED PIERS

BELL ANGLE 50

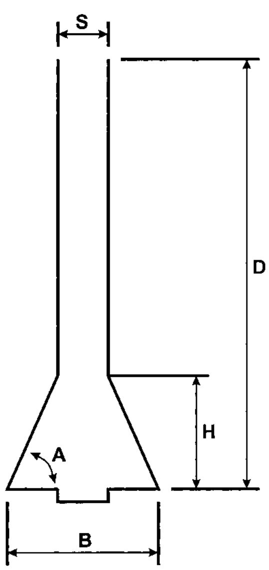
SHAFT DIAMETER (Inches)		BELL DIAMETER (Inches) 18	24	30	36	42	48	54	60	66	72
12	h (feet)	0.30	0.60	0.89	1.19	1.49	1.79	2.09	2.38	2.68	2.98
	C.F.	0.37	1.09	2.28	4.06	6.53	9.83	14.06	19.34	25.80	33.54
18	h (feet)		0.30	0.60	0.89	1.19	1.49	1.79	2.09	2.38	2.68
	C.F.		0.72	1.91	3.69	6.16	9.46	13.69	18.97	25.43	33.17
24	h (feet)			0.30	0.60	0.89	1.19	1.49	1.79	2.09	2.38
	C.F.			1.19	2.96	5.44	8.74	12.97	18.25	24.71	32.45
30	h (feet)				0.30	0.60	0.89	1.19	1.49	1.79	2.09
	C.F.				1.77	4.25	7.55	11.78	17.06	23.52	31.26
36	h (feet)					0.30	0.60	0.89	1.19	1.49	1.79
	C.F.					2.48	5.77	10.00	15.29	21.74	29.48
42	h (feet)						0.30	0.60	0.89	1.19	1.49
	C.F.						3.30	7.53	12.81	19.27	27.01

VOLUME OF BELLS IN DRILLED PIERS

BELL ANGLE 60

SHAFT DIAMETER (Inches)		BELL DIAMETER (Inches) 18	24	30	36	42	48	54	60	66	72
12	h (feet)	0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46	3.90	4.33
	C.F.	0.54	1.59	3.32	5.89	9.49	14.28	20.43	28.11	37.49	48.75
18	h (feet)		0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46	3.90
	C.F.		1.05	2.78	5.36	8.96	13.75	19.90	27.58	36.96	48.21
24	h (feet)			0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46
	C.F.			1.73	4.31	7.91	12.70	18.85	26.53	35.91	47.16
30	h (feet)				0.43	0.87	1.30	1.73	2.17	2.60	3.03
	C.F.				2.58	6.18	10.97	17.12	24.80	34.18	45.43
36	h (feet)					0.43	0.87	1.30	1.73	2.17	2.60
	C.F.					3.60	8.39	14.54	22.22	31.60	42.85
42	h (feet)						0.43	0.87	1.30	1.73	2.17
	C.F.						4.79	10.94	18.62	28.00	39.25

457



S = Shaft Diameter
D = Depth
H = Angle Height
B = Bell Diameter
A = Bell Angle

VOLUME OF BELLS IN DRILLED PIERS

BELL ANGLE 50

SHAFT DIAMETER (Inches)		BELL DIAMETER (Inches) 18	24	30	36	42	48	54	60	66	72
12	h (feet)	0.30	0.60	0.89	1.19	1.49	1.79	2.09	2.38	2.68	2.98
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	C.F.		0.72	1.91	3.69	6.16	9.46	13.69	18.97	25.43	33.17
24	h (feet)			0.30	0.60	0.89	1.19	1.49	1.79	2.09	2.38
	C.F.			1.19	2.96	5.44	8.74	12.97	18.25	24.71	32.45
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	C.F.				1.77	4.25	7.55	11.78	17.06	23.52	31.26
36	h (feet)					0.30	0.60	0.89	1.19	1.49	1.79
	C.F.					2.48	5.77	10.00	15.29	21.74	29.48
42	h (feet)						0.30	0.60	0.89	1.19	1.49
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VOLUME OF BELLS IN DRILLED PIERS

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	C.F.				2.58	6.18	10.97	17.12	24.80	34.18	45.43
36	h (feet)					0.43	0.87	1.30	1.73	2.17	2.60
	C.F.					3.60	8.39	14.54	22.22	31.60	42.85
42	h (feet)						0.43	0.87	1.30	1.73	2.17
	C.F.						4.79	10.94	18.62	28.00	39.25

458

- If the volume is to be manually calculated, the bell diameter and angle can be used to find the height of the bell by using the formula
- Height of bell on reamed footing (H) = $\frac{\sin(A) \text{ x } \frac{B - S}{2}}{\text{Sin } (90 - A)}$

Or

- H = tan (A) x $\frac{B - S}{2}$

459

- Then the volume of the bell is found using the formula
- Volume of bell = $\left(\frac{\pi S^2 \text{ x } H}{4}\right)$ + $\left(2\pi\left(\left(\frac{2S+B}{6}\right) \text{x} \left(\frac{(B - S)\text{x } H}{4}\right)\right)\right)$

Or

- Volume of bell = $\frac{\pi H}{12}(S^2 + B^2$ + SB)

460

- The volume of bell is added to the volume of the shaft to determine the volume for a specific pier
- Shaft volume = $\left(\frac{\pi S^2}{4}\right)$ x length of shaft

461

- The three identical drilled piers have the following dimensions
- Shaft diameter = 18'' (1.5')
- Bell diameter = 42'' (3.5')
- Angle of bell = 60°
- H = $\frac{\sin(60) \text{ x } \frac{3.5-1.5}{2}}{\text{Sin } (90-60)}$ = 1.73'

Or

- H = tan (60) x $\frac{3.5-1.5}{2}$ = 1.73'

462

- Volume of bell = $\left(\frac{\pi(1.5)^2 \text{ x } 1.73}{4}\right)$ + $\left(2\pi\left(\left(\frac{(2 \text{ x } 1.5)+3.5}{6}\right) \text{x} \left(\frac{(3.5 - 1.5)\text{x } 1.73}{4}\right)\right)\right)$ = 8.95 CF

Or

- Volume of bell = $\frac{\pi \text{ x } 1.73}{12}((1.5)^2 + (3.5)^2 + (1.5 \text{ x } 3.5))$ = 8.95 CF

463

VOLUME OF BELLS IN DRILLED PIERS											
BELL ANGLE	60										
SHAFT DIAMETER (Inches)		BELL DIAMETER (Inches)									
		18	24	30	36	42	48	54	60	66	72
12	h (feet)	0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46	3.90	4.33
C.F.		0.54	1.59	3.32	5.89	9.49	14.28	20.43	28.11	37.49	48.75
18	h (feet)		0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46	3.90
C.F.			1.05	2.78	5.36	8.96	13.75	19.90	27.58	36.96	48.21
24	h (feet)			0.43	0.87	1.30	1.73	2.17	2.60	3.03	3.46
C.F.				1.73	4.31	7.91	12.70	18.85	26.53	35.91	47.16
30	h (feet)				0.43	0.87	1.30	1.73	2.17	2.60	3.03
C.F.					2.58	6.18	10.97	17.12	24.80	34.18	45.43
36	h (feet)					0.43	0.87	1.30	1.73	2.17	2.60
C.F.						3.60	8.39	14.54	22.22	31.60	42.85
42	h (feet)						0.43	0.87	1.30	1.73	2.17
C.F.							4.79	10.94	18.62	28.00	39.25

464

- The remaining element of the drilled piers is to determine the volume of the shaft
- This is done by subtracting the height of the bell from the pier depth
- However, the shaft typically extends 6 inches (0.5') through the bell requiring an extra 6 inches to be added to the shaft length
- Length of the shaft = 16' -1.73' + 0.5' = 14.77'

465

- This length of the shaft is then multiplied by its cross-sectional area to determine its volume
- Shaft volume = $\left(\frac{\pi(1.5)^2}{4}\right)$ x 14.77 = 26.1 CF
- The volume of the shaft and pier can then be added together and multiplied times the number of piers to determine the total volume
- Volume of concrete in piers = count x (volume in bell + volume in shaft) = 3 x (8.95 + 26.1) = 105.15 CF = 3.89 CY
- If waste is 10%: 1.1 x 3.89 = 4.28 CY

466

Workup sheet for the spread and continuous footings for the building

ESTIMATE WORK SHEET

Project: *Little Office Building*
Location: *Littleville, Tx*
Architect: *U.R. Architects*
Items: *Foundation Concrete*

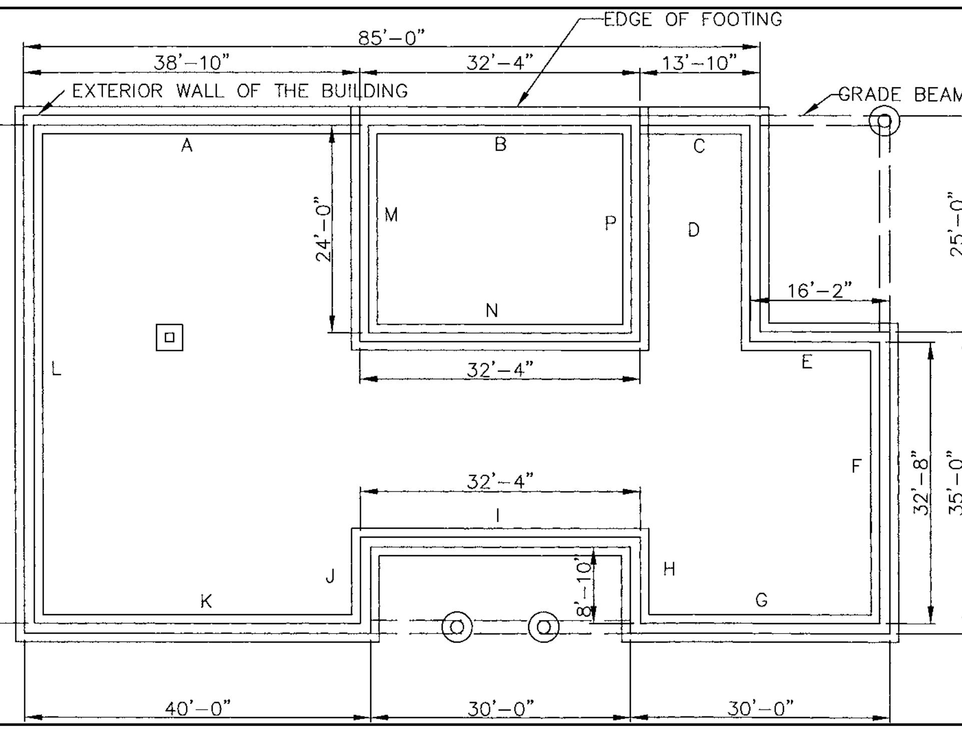
FOOTING CONCRETE

Estimate No. *1234*
Sheet No. *1 of 1*
Date *11/11/20xx*
By *LHF* Checked *JBC*

Cost Code	Description	Dimensions Length Ft.	Length In.	Width Ft.	Width In.	Height Ft.	Height In.			Length Ft.	Width Ft.	Height Ft.	Volume C.F.	Quantity	Unit
	3-2" Wide Footing (2,800 psi)														
	Side A	39	10	3	2	1	0			39.83	3.17	1.00	126.14		
	Side B	34	4	3	2	1	0			34.33	3.17	1.00	108.72		
	Side C	14	10	3	2	1	0			14.83	3.17	1.00	46.97		
	Side D	21	10	3	2	1	0			21.83	3.17	1.00	69.14		
	Side E	18	2	3	2	1	0			18.17	3.17	1.00	57.53		
	Side F	30	8	3	2	1	0			30.67	3.17	1.00	97.11		
	Side G	32	0	3	2	1	0			32.00	3.17	1.00	101.33		
	Side H	6	10	3	2	1	0			6.83	3.17	1.00	21.64		
	Side I	34	4	3	2	1	0			34.33	3.17	1.00	108.72		
	Side J	6	10	3	2	1	0			6.83	3.17	1.00	21.64		
	Side K	42	0	3	2	1	0			42.00	3.17	1.00	133.00		
	Side L	55	8	3	2	1	0			55.67	3.17	1.00	176.28		
										337.33			1,068.22		
	Add 5 % for Waste												1,121.63		
	Total Concrete In 3'-2" Wide Footings													41.5	C.Y.
	3'-0" Wide Footing (2,800 psi)														
	Side M	22	0	3	0	1	0			22.00	3.00	1.00	66.00		
	Side N	34	4	3	0	1	0			34.33	3.00	1.00	103.00		
	Side O	22	0	3	0	1	0			22.00	3.00	1.00	66.00		
										78.33			235.00		
	Add 5 % for Waste												246.75		
	Total Concrete In 3'-2" Wide Footings													9.1	C.Y.
	Spread Footing								Quantity						
	3' Square Column Footings	3	0	3	0	1	0		1	3.00	3.00	1.00	9.00		
	Add 5 % for Waste												9.45		
	Total Concrete In 3' Square Sp. Ftg													1.0	C.Y.
	Use 1 C.Y.														

467

- Foundation walls



468

- The building perimeter foundation walls are 1’2’’ thick and the interior walls are 1’ thick
- Side B is 8’4’’ tall as compared with 3’8’’ high for the remaining 1’2’’ thick walls
- This is why, side B is not included in the table for linear feet of 1’2’’thick foundation walls

Side	Foundation Wall Length
A	38’-10”
C	13’-10”
D	23’-10”
E	16’-2”
F	32’-8”
G	30’-0”
H	8’-10”
I	32’-4”
J	8’-10”
K	40’-0”
L	57’-8”
TOTAL	303’-0”

469

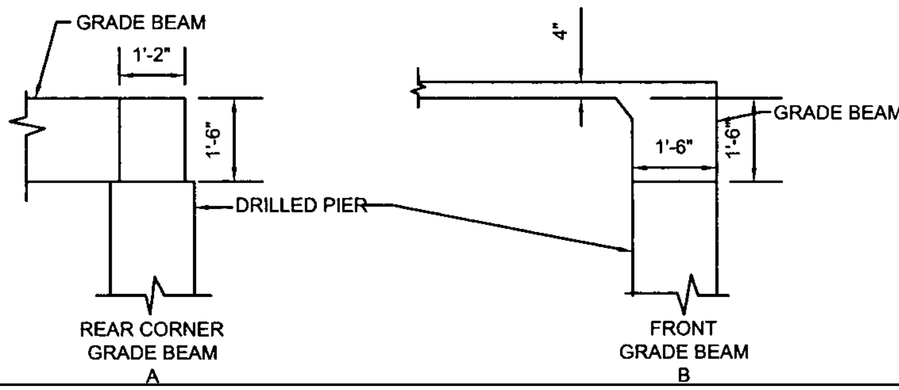
- Exterior foundation wall concrete = linear feet x height x thickness = (303’ x 3’8’’ x 1’2’’) + (32’4’’ x 8’4’’ x 1’2’’)

= (303 x 3.67 x 1.17) + (32.33 x 8.33 x 1.17) = 1,616.14 CF = 59.86 CY

- 59.86 X 1.05 (waste) = 62.85 CY

470

- Grade beams are required to tie the drilled piers to the remainder of the building foundation
- The volume of concrete in the grade beam is found by multiplying the cross-sectional area of the grade beams by their length
- The grade beams have different cross-sectional areas



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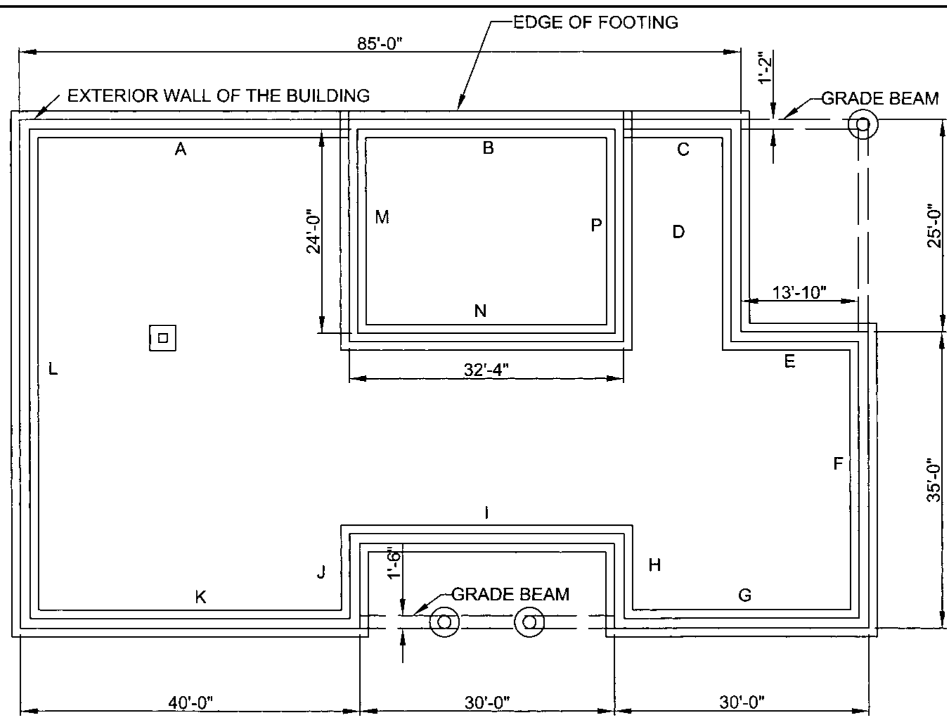


472

- Volume of concrete = (1’2’’ x 1’6’’ x (25’+ 13’10’’)) + (1’6’’ x 1’6’’ x 30’)

= (1.17’ x 1.5’ x 38.83’) + (1.5’ x 1.5’ x 30’) = 135.65 CF

= 5.02 CY

- 5.02 X 1.08 (waste) = 5.42 CY

473

Workup sheet for the concrete in the foundation walls and grade beams

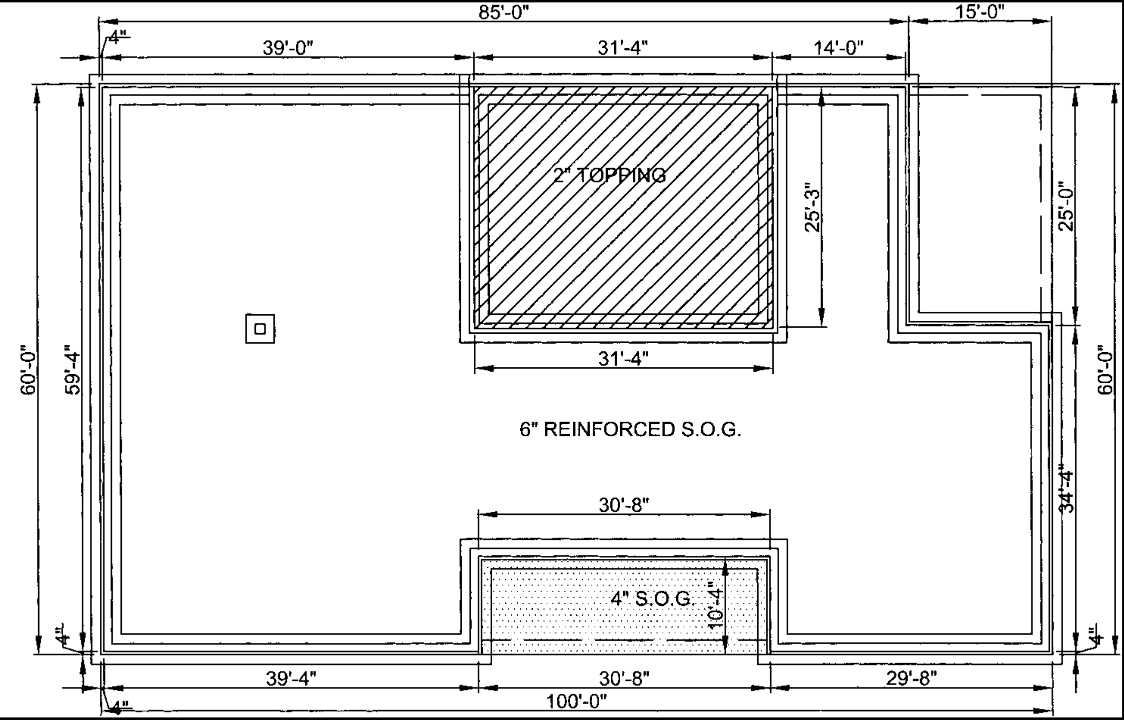
ESTIMATE WORK SHEET

Project: *Little Office Building* | Estimate No. *1234*
Location: *Littleville, Tx* | Sheet No. *1 of 1*
Architect: *U.R. Architects* | Foundation Wall & Grade Beams | Date: *11/11/20xx*
Items: *Foundation Concrete* | By: *LHF* | Checked: *JBC*

Cost Code	Description	Dimensions Length Ft.	Length In.	Width Ft.	Width In.	Thickness Ft.	Thickness In.			Length Ft.	Width Ft.	Height Ft.	Volume C.F.	Quantity	Unit
	3'-8" Highe Foundation Walls														
	1'-2" Wide (2,800 psi)														
	Side A	38	10	1	2	3	8			38.83	1.17	3.67	166.12		
	Side C	13	10	1	2	3	8			13.83	1.17	3.67	59.18		
	Side D	23	10	1	2	3	8			23.83	1.17	3.67	101.95		
	Side E	16	2	1	2	3	8			16.17	1.17	3.67	69.16		
	Side F	32	8	1	2	3	8			32.67	1.17	3.67	139.74		
	Side G	30	0	1	2	3	8			30.00	1.17	3.67	128.33		
	Side H	8	10	1	2	3	8			8.83	1.17	3.67	37.79		
	Side I	32	4	1	2	3	8			32.33	1.17	3.67	138.31		
	Side J	8	10	1	2	3	8			8.83	1.17	3.67	37.79		
	Side K	40	0	1	2	3	8			40.00	1.17	3.67	171.11		
	Side L	57	8	1	2	3	8			57.67	1.17	3.67	246.69		
	8'-4" High Founfation Wall														
	1'-2" Wide (2,800 psi)														
	Side B	32	4	1	2	8	4			32.33	1.17	8.33	314.35		
	8'-4" High Foundation Wall														
	1'-0" Wide (2,800 psi)														
	Side M	24	0	1	0	8	4			24.00	1.00	8.33	200.00		
	Side N	32	4	1	0	8	4			32.33	1.00	8.33	269.44		
	Side P	24	0	1	0	8	4			24.00	1.00	8.33	200.00		
	Total Foundation Walls												2,279.96		
	Add 5% for Waste												88.67	89	C.Y.
	Grade Beams														
	1'-2" X 1'-6" Rear of Building	25	0	1	2	1	6			25.00	1.17	1.50	43.75		
	1'-2" X 1'-6" Rear of Building	13	10	1	2	1	6			13.83	1.17	1.50	24.21		
	1'-6" X 1'-6" Front of Building	30	0	1	6	1	6			30.00	1.50	1.50	67.50		
	Total Grade Beams												135.46		
	Add 8% fo Waste												5.42	6	C.Y.
	1 Only Formed Pier	1	0	1	0	4	0			1.00	1.00	4.00	4.00		
	Add 5 % for Waste												0.16	1	C.Y.

474

Slab area



475

- The volume of a reinforced slab is found by taking the area (SF/m^2) and by multiplying it by the depth of the slab
- For example, the 2 inch (0.17’) thick topping: 25’3’’ x 31’4’’= 25.25’ x 31.33’ = 791.08 SF
- There is a stair opening (46 SF): net area = 745.08 SF
- Volume of concrete = 745.08 x 0.17 = 126.66 CF = 4.69 CY
- 5% waste: 4.69 x 1.05 = 4.92 CY

476

- To find the labor cost for placing concrete in the continuous footings (41.59 CY of concrete), the quantity takeoff can be multiplied by the appropriate productivity rate

Type of Placement	Productivity Rate (Labor Hours/c.y)
Continuous Footing—Direct Chute	0.4
Spread Footing—Direct Chute	0.873
Drilled Piers	0.320
Formed Piers	0.873
Foundation Walls—Direct Chute	0.5
Grade Beams	0.4
Slab—Direct Chute	0.32

477

- Labor hours = 41.59 x 0.4 = 16.64 hrs
- If wage rate is $14/hr
- Labor cost = 14 x 16.64 = $232.96

478

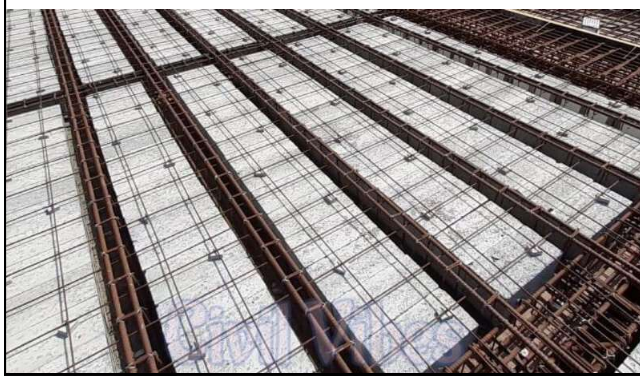
- A concrete pump of 100 m^3/hr maximum output is used to place 270 m^3 of concrete
- The concrete is supplied by 9 m^3 transit-mix trucks arriving to the site every 12 min

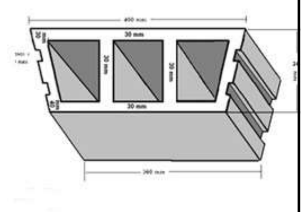
479

- If the pump utilization rate is 90% (10% downtime allowance), and assuming no interruptions, the hours of operation would be 270 / (100 x 0.9) = 3 hrs
- Effective output, however, is governed by concrete supply rate
  - Number of cycles = 60 min/hr /12 min = 5/ hr
  - Output per truck = 9 m^3 x 5 = 45 m^3 /hr
  - Placing duration = 270 m^3 / 45 m^3 /hr = 6 hrs

480

- In a ribbed slab, hollow block volume is 0.02 m^3, a total of 1,500 blocks are needed
- If the slab area (without stairs) is 250 m^2 with a 0.31 m thickness, the volume of concrete is 250 x 0.31 – 1,500 x 0.02 = 47.5 m^3





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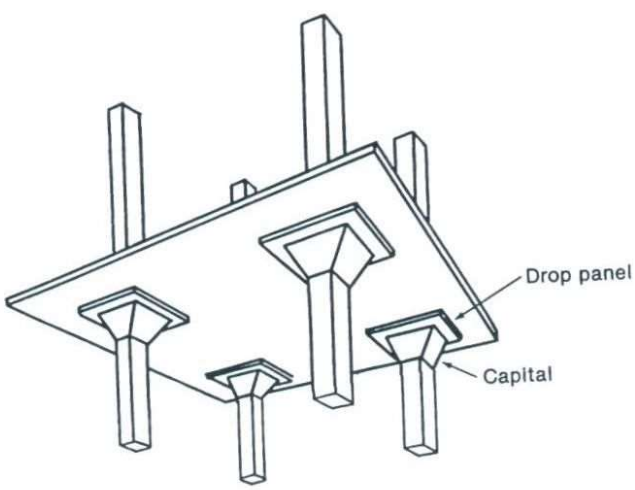
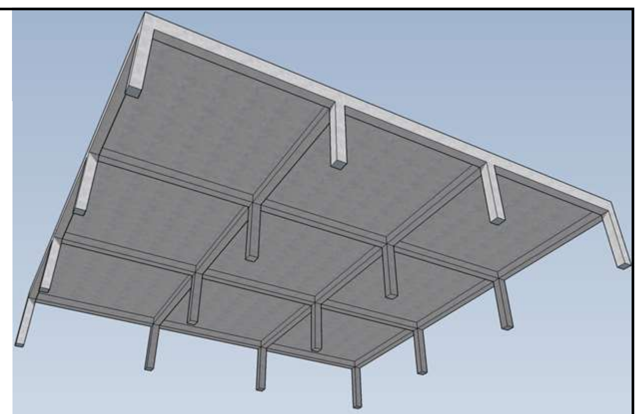
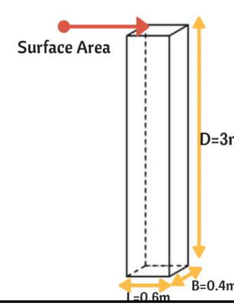






482

Reinforcing Steel

- Concrete reinforcing steel is available as
  - Standard reinforcing bars
  - Welded wire fabric/mesh (WWF)
  - A combination of the two
- Reinforcing bars are usually deformed; that is, they are manufactured with ridges that provide an interlocking bond with the surrounding concrete

483

- The No. 2 bar is a plain round bar, but all the rest are deformed round bars

484

• ASTM standard reinforcing bar sizes

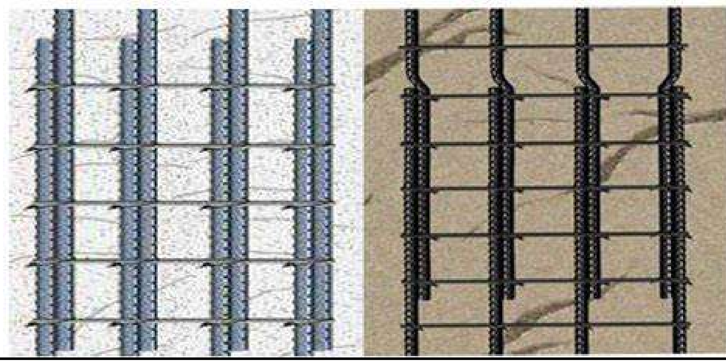
Size Number	Metric Size Number	Weight lb/ft	Weight kg/m	Diameter in.	Diameter mm	Section Area sq in.	Section Area mm²
3	10	0.376	0.560	0.375	9.52	0.11	71
4	13	0.668	0.994	0.500	12.70	0.20	129
5	16	1.043	1.552	0.625	15.88	0.31	200
6	19	1.502	2.235	0.750	19.05	0.44	284
7	22	2.044	3.042	0.875	22.22	0.60	387
8	25	2.670	3.973	1.000	25.40	0.79	510
9	29	3.400	5.059	1.128	28.65	1.00	645
10	32	4.303	6.403	1.270	32.26	1.27	819
11	36	5.313	7.906	1.410	35.81	1.56	1006
14	43	7.650	11.384	1.693	43.00	2.25	1452
18	57	13.600	20.238	2.257	57.33	4.00	2581

485

- Reinforcing bars are taken off by linear feet/meter
- The takeoff (workup) sheet should be set up to include the number of the bars, lengths, and bends
- Check the specifications to determine the type of steel required and whether it is plain, coated with zinc, painted with epoxy paint (typically green), or galvanized
- Zinc coating and galvanizing can increase the material cost by as much as 150 % and often delays delivery
- Rebar painted with epoxy paint increases the cost by about 20 %

486

- Allowance for splicing (lapping) the bars must also be included
- Lap splicing costs may range from 5 to 15 %, depending on the size of the bar and yield strength of steel used
- Waste may range from less than 1 % for precut and preformed bars to 10 % when the bars are cut and bent on the job site



487

- Splice Requirements (Minimum splice is 1')

Bar Size	Splice required when specified as a number of bar diameters	
	24 d	30 d
3	1'-0"	1'-0"
4	1'-0"	1'-3"
5	1'-3"	1'-7"
6	1'-6"	1'-11"
7	1'-9"	2'-3"
8	2'-0"	2'-6"
9	2'-4"	2'-10"
10	2'-7"	3'-3"
11	2'-10"	3'-7"

488

- Welded wire mesh is an economical reinforcing for
  - Floors
  - Driveways
  - Temperature reinforcing
  - Beam and column wrapping
- It is usually furnished in flat sheets or by the roll

489

- The takeoff must be broken up into the various sizes required and the number of square feet required of each type
- The mesh may be either plain or galvanized; this information is included in the specifications
- Galvanized mesh may require special ordering and delivery times of two to three weeks

490

- Welded wire fabric is available with smooth wire or deformed wire
- Welded wire fabric is identified by the letters WWF followed by
  - The spacing of longitudinal wires [in. (mm)],
  - The spacing of transverse wires [in. (mm)],
  - The size of longitudinal wires [sq in. 100 (mm^2)],
  - The size of transverse wires [sq in. 100 (mm^2)]

491

- Metric sizes are identified by the letter M preceding the wire sizes
- Deformed wire is indicated by the letter D preceding the wire size
- For example, "WWF 6 x 6 – 4 x 4 [152 x 152 MW25.8 x MW25.8]"
  - A square wire pattern with both transverse and longitudinal wires spaced 6 in. (152 mm) on center
  - Both wires are size W4 [0.04-sq in. (25.8-mm^2) section area]

492

- Steel wire data for welded wire fabric

Wire Size Number		Diameter		Area		Weight	
Smooth	*Deformed*	*in.*	*mm*	*sq in.*	*mm^2*	*lb/ft*	*kg/m*
W31	D31	0.628	16.0	0.31	200	1.054	1.568
W28	D28	0.597	15.2	0.28	181	0.952	1.417
W26	D26	0.575	14.6	0.26	168	0.934	1.390
W24	D24	0.553	14.1	0.24	155	0.816	1.214
W22	D22	0.529	13.4	0.22	142	0.748	1.113
W20	D20	0.505	12.8	0.20	129	0.680	1.012
W18	D18	0.479	12.2	0.18	116	0.612	0.911
W16	D16	0.451	11.5	0.16	103	0.544	0.810
W14	D14	0.422	10.7	0.14	90	0.476	0.708
W12	D12	0.391	9.9	0.12	77	0.408	0.607
W11	D11	0.374	9.5	0.11	71	0.374	0.557
W10	D10	0.357	9.1	0.10	65	0.340	0.506
W9.5		0.348	8.8	0.095	61	0.323	0.481
W9	D9	0.338	8.6	0.09	58	0.306	0.455
W8.5		0.329	8.4	0.085	55	0.289	0.430
W8	D8	0.319	8.1	0.08	52	0.272	0.405
W7.5		0.309	7.8	0.075	48	0.255	0.379
W7	D7	0.299	7.6	0.07	45	0.238	0.354
W6.5		0.288	7.3	0.065	42	0.221	0.329
W6	D6	0.276	7.0	0.06	39	0.204	0.304
W5.5		0.265	6.7	0.055	35	0.187	0.278
W5	D5	0.252	6.4	0.05	32	0.170	0.253
W4.5		0.239	6.1	0.045	29	0.153	0.228
W4	D4	0.226	5.7	0.04	26	0.136	0.202
W3.5		0.211	5.4	0.035	23	0.119	0.177
W2.9		0.192	4.9	0.029	19	0.099	0.147
W2.5		0.178	4.5	0.025	16	0.085	0.126
W2		0.160	4.1	0.02	13	0.068	0.101
W1.4		0.134	3.4	0.014	9	0.048	0.071

493

- To provide protection of reinforcing steel against corrosion and fire, a minimum cover of concrete must be furnished
- Building codes usually specify minimum cover requirements
- The American Concrete Institute (ACI) recommends the following minimum cover when not otherwise specified
  - Slabs, joists, and walls not exposed to weather or ground: 0.75’’ (1.9 cm)
  - Beams, girders, and columns not exposed to weather or ground: 1.5’’ (3.8 cm)

494

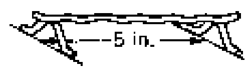
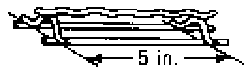
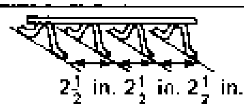
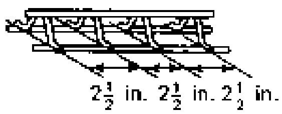
- The American Concrete Institute (ACI) recommends the following minimum cover when not otherwise specified
  - Concrete placed in forms but exposed to weather or ground: 1.5’’ (3.8 cm) for No. 5 bars or smaller; 2’’ (5.1 cm) for bars larger than No. 5
  - Concrete placed without forms directly on the ground: 3’’ (7.6 cm)
  - At least one bar diameter of cover should be used in any case

495

- The reinforcing steel must be elevated into the concrete to some specified distance
- This can be accomplished by using concrete bricks, bar chairs, spacers, or it may be suspended with wires
- The supports may be plastic, galvanized or zinc-coated steel, steel with plastic-coated legs, and other materials
- If the finished concrete will be exposed to view and the supports are touching the portion to be exposed, consideration should be given to using noncorrosive supports

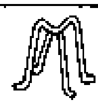
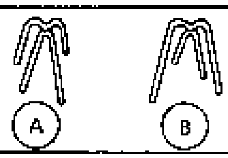
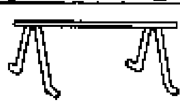
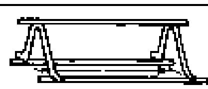
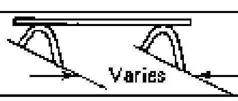
496

- Bars are maintained in their specified position by tying to adjacent bars or by the use of bar supports

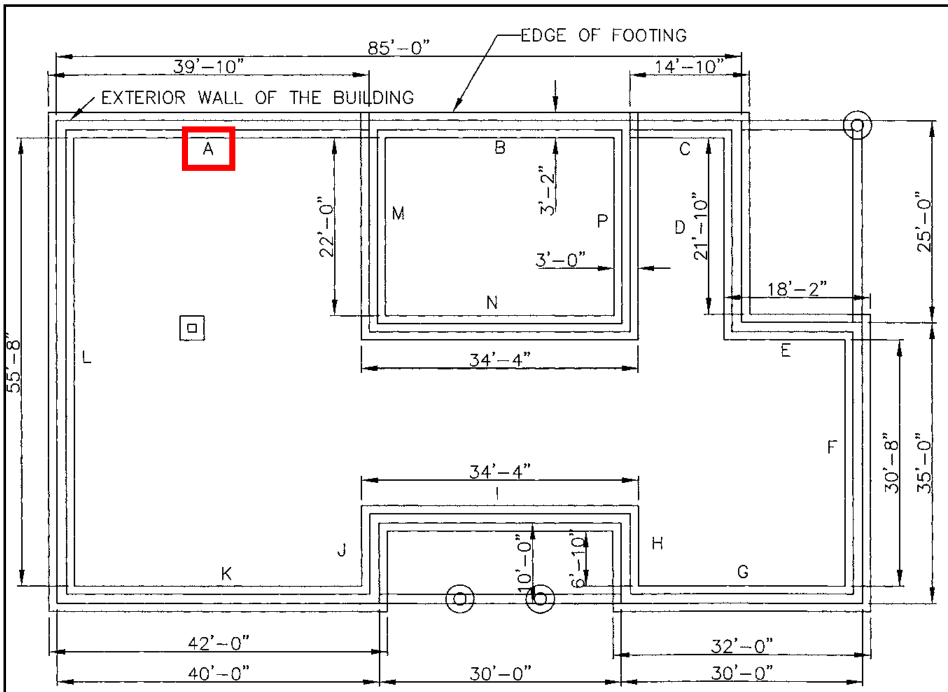
Symbol	Bar support illustration	Type of support	Standard sizes
SB		Slab bolster	$\frac{3}{4}$, 1, $1\frac{1}{2}$, and 2 in. heights in 5 ft and 10 ft lengths
SBU*		Slab bolster upper	Same as SB
BB		Beam bolster	1, $1\frac{1}{2}$, 2; over 2 in. to 5 in. height in increments of $\frac{1}{4}$ in. in lengths of 5 ft
BBU*		Beam bolster upper	Same as BB
BC		Individual bar chair	$\frac{3}{4}$, 1, $1\frac{1}{2}$, and $1\frac{3}{4}$ in. heights

497

- Bars are maintained in their specified position by tying to adjacent bars or by the use of bar supports

JC		Joist chair	4, 5, and 6 in. widths and $\frac{3}{4}$, 1, and $1\frac{1}{2}$ in. heights
HC		Individual high chair	2 to 15 in. heights in increments of $\frac{1}{4}$ in.
HCM*		High chair for metal deck	2 to 15 in. heights in increments of $\frac{1}{4}$ in.
CHC		Continuous high chair	Same as HC in 5 foot and 10 foot lengths
CHCU*		Continuous high chair upper	Same as CHC
CHCM*		Continuous high chair for metal deck	Up to 5 in. heights in increments of $\frac{1}{4}$ in.

498

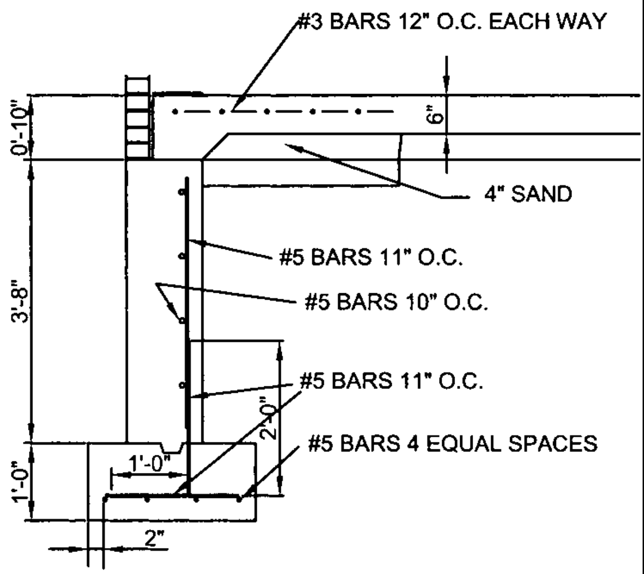


Side	Length
A	39'-10"
B	34'-4"
C	14'-10"
D	21'-10"
E	18'-2"
F	30'-8"
G	32'-0"
H	6'-10"
I	34'-4"
J	6'-10"
K	42'-0"
L	55'-8"
TOTAL	337'-4"

Linear feet of 3'2''wide continuous footing

499

- Side A continuous footing of the building 39'10''
- This footing has reinforcing bars that run both the long and short dimensions



500

- Continuous Footing Short Bars
  - Number of short bar spaces = (39’10’’ – 4’’)/ 11’’ spacing
  - Number of short bars = 39.5’ / 0.91’ = 43.41 (44 spaces)
  - Add 1 to get the number of bars: use 45 bars
  - The bar length is 2’10’’, which is derived by subtracting the coverage distance (2’’ x 2) from the footing width (3’2’’)
  - Total bar length = Number of bars x length of individual bars

501

- Continuous Footing Short Bars
  - Total bar length = 45 bars x 2’10’’ per bar
  - Total bar length = 45 bars x 2.83’ per bar = 127.35’
  - No. 5 bar weighs 1.043 lb/ft
  - Total weight = 127.35’ x 1.043 = 132.83 lb

502

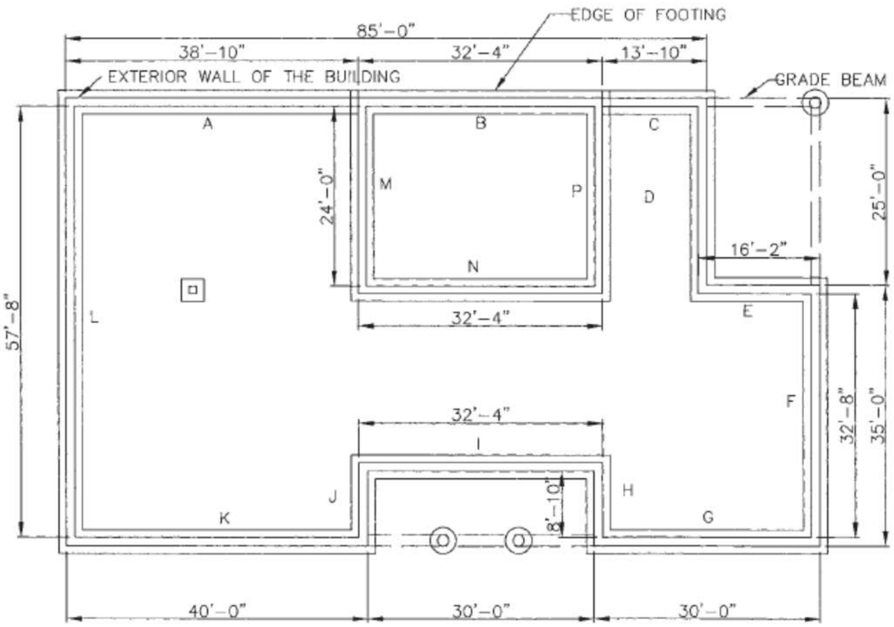
- ASTM standard reinforcing bar sizes

Size Number	Metric Size Number	Weight lb/ft	Weight kg/m	Diameter in.	Diameter mm	Section Area sq in.	Section Area mm^2
3	10	0.376	0.560	0.375	9.52	0.11	71
4	13	0.668	0.994	0.500	12.70	0.20	129
5	16	1.043	1.552	0.625	15.88	0.31	200
6	19	1.502	2.235	0.750	19.05	0.44	284
7	22	2.044	3.042	0.875	22.22	0.60	387
8	25	2.670	3.973	1.000	25.40	0.79	510
9	29	3.400	5.059	1.128	28.65	1.00	645
10	32	4.303	6.403	1.270	32.26	1.27	819
11	36	5.313	7.906	1.410	35.81	1.56	1006
14	43	7.650	11.384	1.693	43.00	2.25	1452
18	57	13.600	20.238	2.257	57.33	4.00	2581

503

- Continuous Footing Long Bars
  - Length of long bars = 39’6’’
  - Total bar length = 39’6’’ x 4 bars
  - Total bar length = 39.5’ x 4 bars = 158’
  - Total weight = 158’ x 1.043 lb/ft = 164.79 lb
- Total actual weight = 164.79 + 132.83 = 297.62 lb
- Add 10% for waste and lap: use 327.38 lb

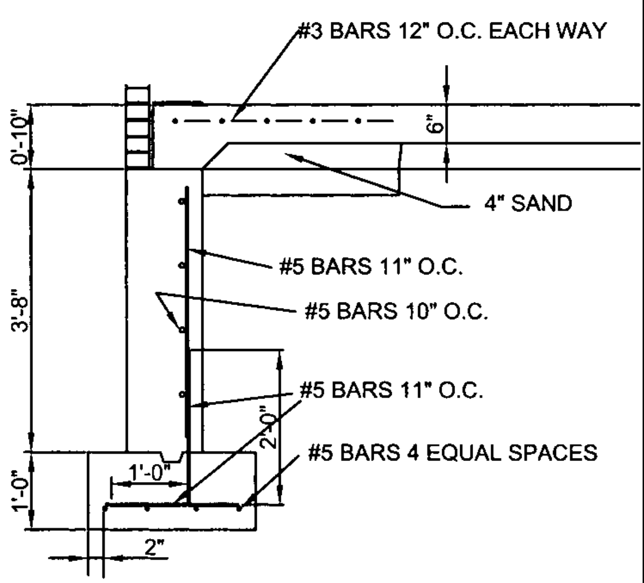
504



Side	Foundation Wall Length
A	38'-10"
C	13'-10"
D	23'-10"
E	16'-2"
F	32'-8"
G	30'-0"
H	8'-10"
I	32'-4"
J	8'-10"
K	40'-0"
L	57'-8"
TOTAL	303'-0"

505

- Side A is of the foundation wall is 38'10''
- Vertical bar spacing at 11'' on center (o.c.)



506

- Foundation wall vertical bars (Side A)
  - Number of vertical bar spaces = (38’10’’- 4’’) / 11’’ = 38.5 / 0.92 = 41.85 (42 spaces)
  - Add 1 to get number of bars: 43 bars
  - Bar length = wall height – bar coverage = 3’8’’ – 4’’ = 3’4’’ (3.33’)
  - Total bar length = bar count x length of individual bars = 43 x 3.33 = 143.19’
  - Total weight = 143.19 x 1.043 = 149.35 lb
  - Waste and lap (10%): 164.29 lb

507

- Foundation wall horizontal bars (Side A)
  - Number of horizontal spaces = (3’8’’- 4’’) / 10’’ = 3.33’/0.83’ = 4.01 (5 spaces)
  - Number of bars = spaces + 1 = 6 bars
  - Bar length = 38’10’’ – 4’’ = 38’6’’
  - Total bar length = 38.5’ x 6 = 231’
  - Total weight = 231 x 1.043 = 240.93 lb
  - Waste and lap (10%): 265.02 lb

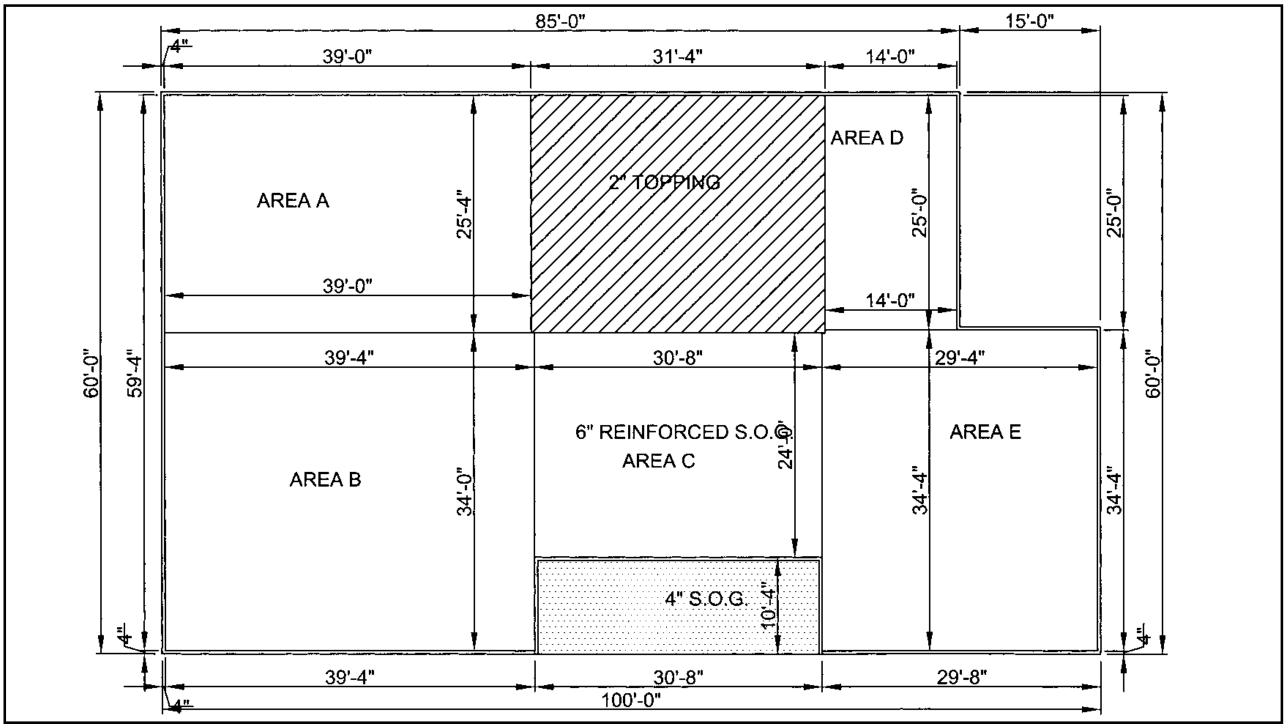
508

- Dowels
  - Each dowel is 3’
  - Number of dowels = 43
  - Total length = 43 x 3’ = 129’
  - Total weight = 129 x 1.043 = 134.55 lb
  - Waste and lap (5%): 141.28 lb

509

- If the reinforcing in a slab is done with sized deformed bars, the bars are quantified in the exact manner as the footings and foundation walls
- The quantity of long and short bars needs to be determined
- The slab can be divided into unique areas so that the quantity of reinforcing bars can be determined

510



511

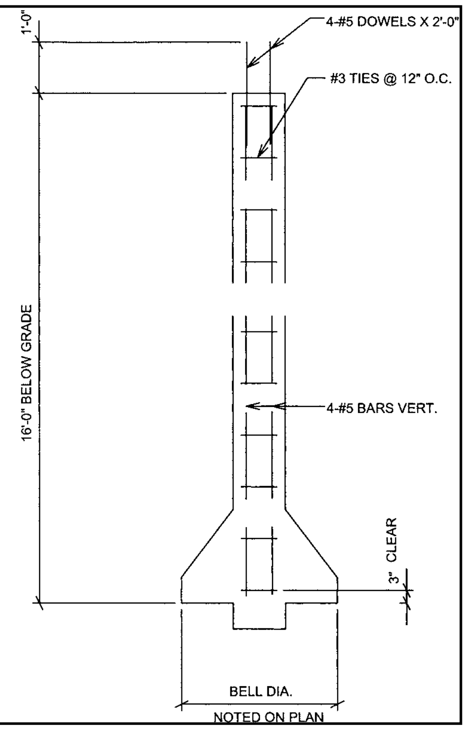
- For area A
  - Long bars: 39’ – 2’’ = 38’10’’ (38.83’)
  - Short bars: 25’4’’ – 2’’ = 25’2’’ (25.17’)
  - Long bar spaces = 25’4’’/12’’ = 25.33’ / 1’ = 25.33 (26 spaces)
  - Number of bars = 26 + 1 = 27 bars
  - Short bar spaces = 39’ / 12’’ = 39’ / 1’ = 39 spaces
  - Number of bars = 40

512

- For area A
  - Total length of long bars = 38.83’ x 27 = 1,048.41’
  - Total length of short bars = 25.17’ x 40 = 1,006.8’
  - Total length of bars = 2,055.21’
  - Total weight = 2,055.21’ x .376 lb/ft (No. 3 bar) = 772.76 lb
  - Waste and lap (10%): 850.04 lb

513

- Estimating the reinforcing in the drilled piers consists of counting the number of vertical bars and determining their length
- Since there are three drilled piers, results will be multiplied by three to determine the total
- There are four No. 5 vertical bars and No. 3 ties that are horizontal at 12’’ on center



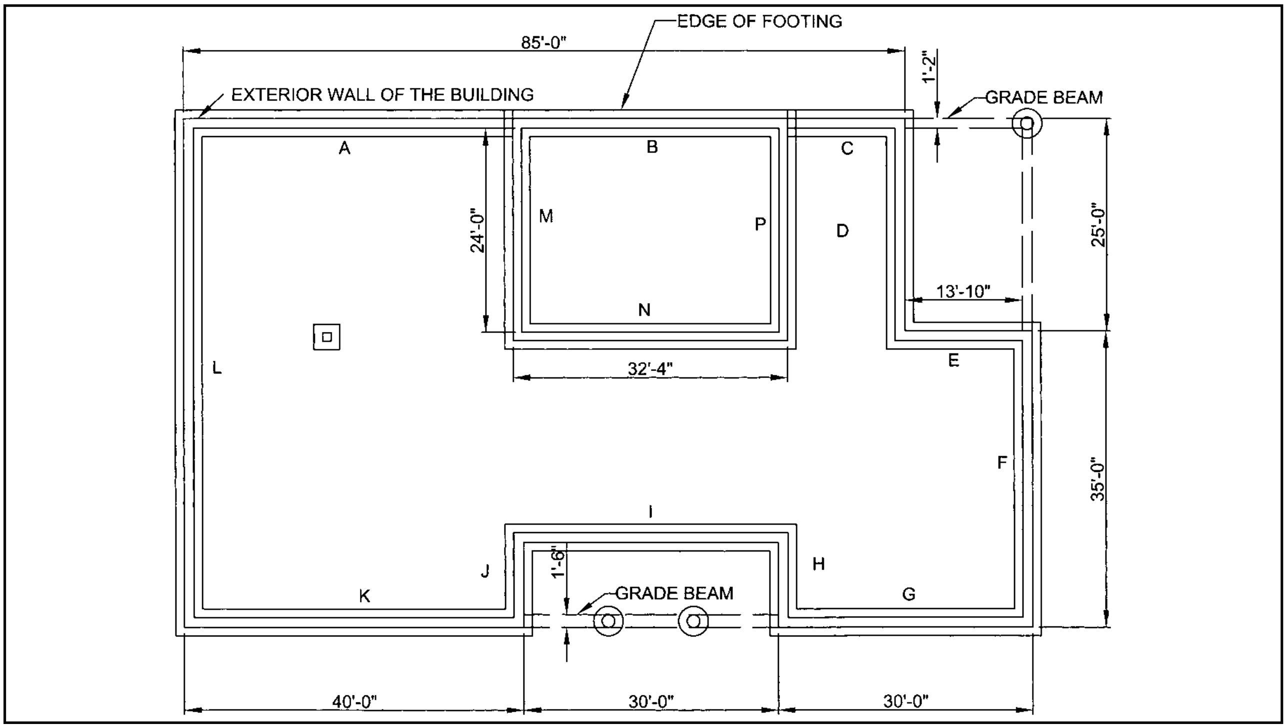
514

- Vertical bars (#5)
  - Length of bar = pier length – coverage = 16’ – (2 x 3’’) = 15’6’’ (15.5’)
  - 15.5’ x 4 bars = 62’
  - Vertical dowels = 2’ x 4 dowels = 8’
  - Total quantity = (62 + 8) x 3 piers = 210’
  - Total weight of bars = 210 x 1.043 lb/foot = 219.03 lb
  - Waste and lap (10%): 240.93 lb

515

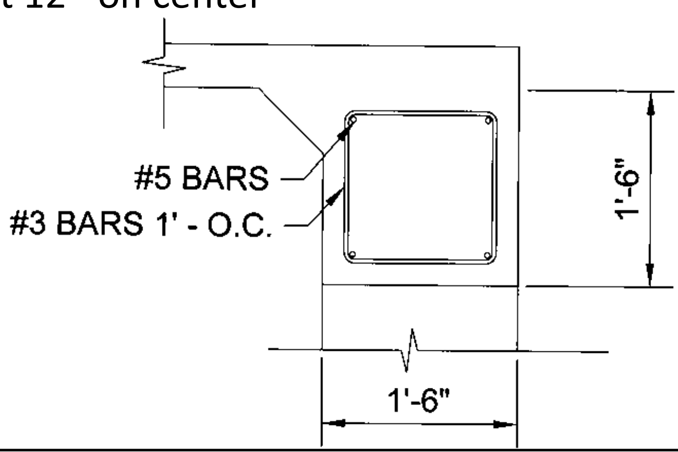
- Horizontal bars (#3)
  - Shaft diameter = 18’’
  - Tie diameter = shaft diameter – cover = 18’’ – (2 x 2’’) = 14’’
  - Tie length = $2\pi r$ = (2 x π x 7) / 12 = 3.67’ per tie
  - Number of vertical spaces = 16’ / 1’ = 16 spaces
  - Number of ties = 16 + 1 = 17
  - Total length of ties = 17 x 3.67 per tie x 3 piers = 187.17’
  - Total weight of bars = 187.17 x 0.376 lb/foot = 70.38 lb
  - Waste and lap (10%): 77.42 lb

516



517

- The grade beam in the front of the building is 30'long
- There are four No. 5 horizontal bars and No. 3 bars used for stirrups at 12'' on center



518

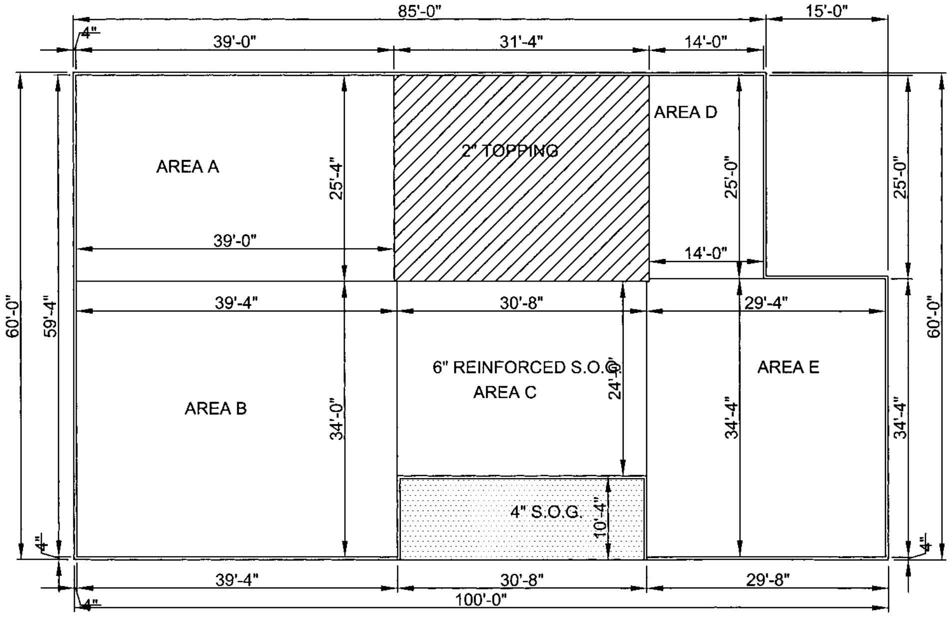
- Total quantity of #5 bars = 4 bars x 30’ per bar = 120’
  - Weight of bars = 120’ x 1.043 = 125.16 lb
  - Waste and lap (10%): 137.68
  - Stirrup length = 1’2’’ (1.17) x 4 = 4.68’ per stirrup
  - Stirrup spaces = 30’/1’ = 30 spaces
  - Number of stirrups = 31
  - Length of stirrups = 31 x 4.68 = 145.08’
  - Weight of stirrups = 145.08’ x 0.376 lb/foot = 54.55 lb
  - Waste and lap (10%): 60.01 lb

519

- Estimating wire mesh
  - The square footage of the floor area to be covered may be taken from the slab concrete calculations
  - Check the sections and details for the size of the mesh required
  - To determine the number of rolls required, add the lap required to the area to be covered and divide by 750 (the square footage in a roll)
  - Waste averages about 5% unless much cutting is required; only full rolls may be purchased in most cases

520

- The wire mesh is used for the basement floor and over the precast hollow core planks
- Both of these areas are roughly the same square footage (25’4’’ x 30’8’’)



521

- SF of concrete requiring mesh = 25’4’’ x 30’8’’ x 2 = 25.33’ x 30.67’ x 2 =1,553.74 SF
- Waste and lap (15%): (1,553.74 x 1.15) / 750 SF per roll = 2.38 (3 rolls)

522

Reinforcing steel quantity takeoff (foundation footings and walls)

ESTIMATE WORK SHEET

Reinforcing Steel

Project: *Little Office Building*
Location: *Littleville, Tx*
Architect: *U.R. Architects*
Items: *Reinforcing Steel*

Estimate No. *1234*
Sheet No. *1 of 1*
Date *11/11/20XX*
By *LHF* Checked *JBC*

Cost Code	Description	Slab Width		Bar Spacing	Pcs	Slab Length		Coverage	Bar Length		Bar Size						Bar Weight						Quantity	Unit
		Ft	In	In. -O.C.		Ft.	In.	In.	Ea	Total	3	4	5	6	7	8	3 0.376	4 0.668	5 1.043	6 1.502	7 2.044	8 2.67		
	Continuous Footing - Long Bars																							
	3'-2" Wide Footing	3	2	13	4	337	4	2	337.0	1348.0			X						1406					
	3'-0" Wide Footing	3	2	13	4	78	4	2	78.0	312.0			X						325					
	Continuous Footing - Short Bars																							
	3'-2" Wide Footing	337	4	11	369	3	2	2	2.8	1045.5			X						1090					
	3"0" Wide Footing	78	4	11	87	3	2	2	2.8	246.5			X						257					
	Continuous Footings - Dowels	337	4	11	369	3	2	0	3.2	1168.5			X						1219					
	Total Continuous Footings																						4298	Pounds
	Foundation Walls																							
	Short Walls (Short Bars)	303	0	11	332	3	8	2	3.3	1106.7			X						1154					
	Short Walls (Long Bars)	3	8	10	6	303	0	2	302.7	1816.0			X						1894					
	Foundation Walls																							
	Tall Walls (Short Bars)	112	8	11	124	8	4	2	8.0	992.0			X						1035					
	Tall Walls (Long Bars)	8	4	10	11	112	8	2	112.3	1235.7			X						1289					
	Total Foundation Walls																						5372	Pounds
	Grade Beams																							
	Front (Long Bars)				4	30		0	30.0	120.0			X						125					
	Stirrups	30	4	12	32	4	8	0	4.7	149.3	X						56							
	Back (Long Bars)				4	38	10	0	38.8	155.3			X						162					
	Stirrups	38	10	12	40	4	0	0	4.0	160.0	X						60							
	Total Grade Beams																						403	Pounds
	S.O.G.																							
	A Long Bars	39	0	12	40	25	4	2	25.0	1000.0	X						376							
	A Short Bars	25	4	12	27	39	0	2	38.7	1044.0	X						393							
	B Long Bars	39	4	12	41	34	0	2	33.7	1380.3	X						519							
	B Short Bars	34	0	12	35	39	4	2	39.0	1365.0	X						513							
	C Long Bars	30	8	12	32	24	0	2	23.7	757.3	X						285							
	C Short Bars	24	0	12	25	30	8	2	30.3	758.3	X						285							
	D Long Bars	25	0	12	26	14	0	2	13.7	355.3	X						134							
	D Short Bars	14	0	12	15	25	0	2	24.7	370.0	X						139							
	E Long Bars	34	4	12	36	29	4	2	29.0	1044.0	X						393							
	E Short Bars	29	4	12	31	34	4	2	34.0	1054.0	X						396							
	Total Slab On Grade																						3432	Pounds
	Total Weight																3549	0	9957	0	0	0.00		

523

Reinforcing steel quantity takeoff (foundation footings and walls)

ESTIMATE WORK SHEET

Project: *Little Office Building*
Location: *Littleville, Tx*
Architect: *U.R. Architects*
Items: *Reinforcing Steel*

Reinforcing Steel

Cost Code	Description	Slab Width		Bar Spacing	Pcs	Slab Length		Coverage	Bar Length		Bar Size							
		Ft	In	In. -O.C.		Ft.	In.	In.	Ea	Total	3	4	5	6	7	8	3 0.376	4 0.668
	Continuous Footing - Long Bars																	
	3'-2" Wide Footing	3	2	13	4	337	4	2	337.0	1348.0			X					
	3'-0" Wide Footing	3	2	13	4	78	4	2	78.0	312.0			X					
	Continuous Footing - Short Bars																	
	3'-2" Wide Footing	337	4	11	369	3	2	2	2.8	1045.5			X					
	3"0" Wide Footing	78	4	11	87	3	2	2	2.8	246.5			X					

524

- Sample productivity rates for tying and placing the reinforcing steel

Type of Placement	Productivity Rate (Labor Hrs./Ton)
Beams #3 to #7	22
Columns #3 to #7	24
Footings #4 to #7	15
Walls #3 to #7	11
Slab on Grade #3 to #7	13
Wire Mesh	1/Roll

525

- To determine the labor cost for placing 4,298 lb reinforcing steel for continuous footings
- Labor hours = (4,298 / 2,000 lb per ton) x 15 labor hr/ton

= 32.24 hrs

- Labor cost = 32.24 x $15/hr = $483.6

526

Priced estimate for the reinforcing steel

ESTIMATE SUMMARY SHEET

Project	*Little Office Building*	Estimate No.	*1234*
Location	*Littleville, Tx*	Sheet No.	*1 of 1*
Architect	*U.R. Architects, Inc.*	Date	*11/11/20xx*
Items	*Reinforcing Steel*	By	*LHF* Checked *JBC*

Cost Code	Description	Q.T.O.	Waste Factor	Purch. Quan.	Unit	Crew	Prod. Rate	Wage Rate	Labor Hours	Unit Cost Labor	Unit Cost Material	Unit Cost Equipment	Labor	Material	Equipment	Total
	Continuous Footings	2.149	10.00%	2.364	Ton		15	14.25	32.2	213.75	550.00		505.28	1,300.15	0.00	1,805.43
	Foundation Walls	2.686	10.00%	2.955	Ton		11	14.25	29.5	156.75	550.00		463.13	1,625.03	0.00	2,088.16
	Grade Beams	0.202	10.00%	0.222	Ton		22	14.25	4.4	313.50	550.00		69.49	121.91	0.00	191.39
	Slab On Grade	1.716	10.00%	1.888	Ton		13	14.25	22.3	185.25	550.00		349.68	1,038.18	0.00	1,387.86
	Drilled Piers	0.196	10.00%	0.215	Ton		24	14.25	4.7	342.00	550.00		73.55	118.28	0.00	191.82
	Spread Footing	0.027	10.00%	0.030	Ton		15	14.25	0.4	213.75	550.00		6.35	16.34	0.00	22.68
	Exterior Slab On Grade	0.129	10.00%	0.141	Ton		13	14.25	1.7	185.25	550.00		26.19	77.74	0.00	103.93
	Wire Mesh	3.000	0.00%	3.000	Roll		1	14.25	3.0	14.25	65.00		42.75	195.00	0.00	237.75
																0.00
																0.00
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																0.00
									98.29				1,536.41	4,492.62	0.00	6,029.03

527

Priced estimate for the reinforcing steel

ESTIMATE SUMMARY SHEET

Project	*Little Office Building*
Location	*Littleville, Tx*
Architect	*U.R. Architects, Inc.*
Items	*Reinforcing Steel*

Cost Code	Description	Q.T.O.	Waste Factor	Purch. Quan.	Unit	Crew	Prod. Rate	Wage Rate	Labor Hours	Labor
	Continuous Footings	2.149	10.00%	2.364	Ton		15	14.25	32.2	213.75
	Foundation Walls	2.686	10.00%	2.955	Ton		11	14.25	29.5	156.75
	Grade Beams	0.202	10.00%	0.222	Ton		22	14.25	4.4	313.50
	Slab On Grade	1.716	10.00%	1.888	Ton		13	14.25	22.3	185.25
	Drilled Piers	0.196	10.00%	0.215	Ton		24	14.25	4.7	342.00
	Spread Footing	0.027	10.00%	0.030	Ton		15	14.25	0.4	213.75
	Exterior Slab On Grade	0.129	10.00%	0.141	Ton		13	14.25	1.7	185.25
	Wire Mesh	3.000	0.00%	3.000	Roll		1	14.25	3.0	14.25

528

Priced estimate for the reinforcing steel

.RY SHEET

Estimate No. 1234
Sheet No. 1 of 1
Date 11/11/20xx
By LHF Checked JBC

Labor Hours	Unit Cost Labor	Unit Cost Material	Unit Cost Equipment	Labor	Material	Equipment	Total
32.2	213.75	550.00		505.28	1,300.15	0.00	1,805.43
29.5	156.75	550.00		463.13	1,625.03	0.00	2,088.16
4.4	313.50	550.00		69.49	121.91	0.00	191.39
22.3	185.25	550.00		349.68	1,038.18	0.00	1,387.86
4.7	342.00	550.00		73.55	118.28	0.00	191.82
0.4	213.75	550.00		6.35	16.34	0.00	22.68
1.7	185.25	550.00		26.19	77.74	0.00	103.93
3.0	14.25	65.00		42.75	195.00	0.00	237.75
							0.00
							0.00

529

Formwork

- The principal requirements for formwork are that it is
  - Safe
  - Produce the desired shape and surface texture
  - Economical
  - True to grade and alignment
  - Braced against displacement
  - Resistant to leaking through tight joints

530

- Procedures for designing formwork ensures that it will be safe under the loads imposed by
  - Plastic concrete
  - Workers and other live loads
  - External forces (such as wind loads)
- The pressure on the forms is the biggest consideration in the actual design of the forms

531

- In the design of wall and column forms, the two most important factors are
  - The rate of placement of the concrete (feet/m per hour)
  - The temperature of the concrete in the forms
- From these two variables, the lateral pressure (psf[kg/m^2]) may be determined
- Floor slab forms are governed primarily by the actual live and dead loads that will be carried

532

- The forms for concrete footings, foundations, retaining walls, and floors are estimated by the area (SF/m^2) of the concrete that comes in contact with the form
- The plans should be studied carefully to determine whether it is possible to reuse the form on the building and the number of times it may be reused
- It may be possible to use the entire form on a repetitive pour item, or the form may have to be taken apart and reworked into a new form

533

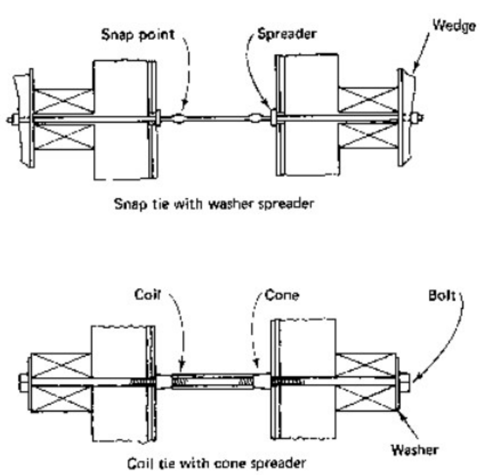
- Wood Forms
  - Wood is one of the most common materials used to build forms
  - The advantages of wood are that it is
    - Readily accessible
    - Easy to work with
    - Once used, it may be taken apart and reworked into other shapes
  - Once it has been decided to use wood, the estimator must determine the quantity of lumber required and the number of uses (plywood, if a smooth surface is required)

534

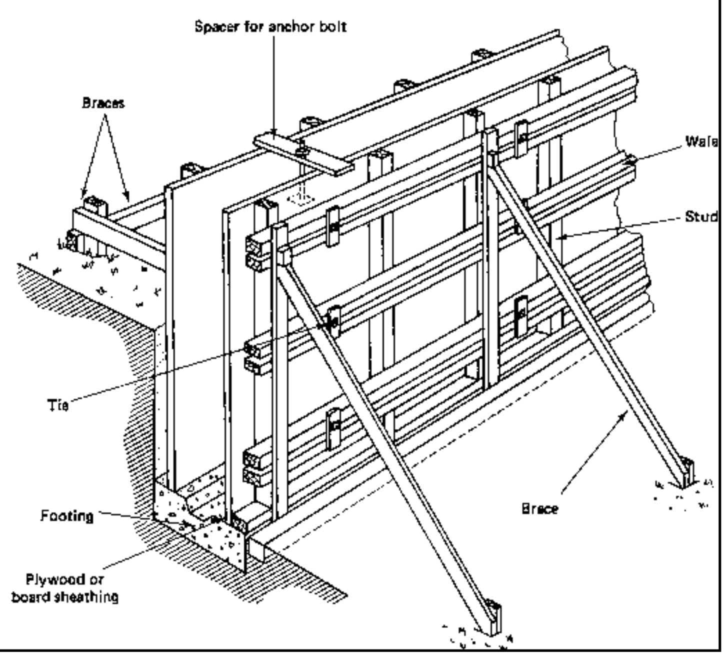
- Wood Forms
  - This means the construction of the forms must be decided upon with regard to plywood sheathing, wales, studs or joists, bracing, and ties
  - The estimator can easily determine all of this if the following are known
    - Height of the fresh concrete pour (for columns and walls)
    - The temperature of the placed concrete
    - The thickness of the slab (for floors)

535

Typical form ties

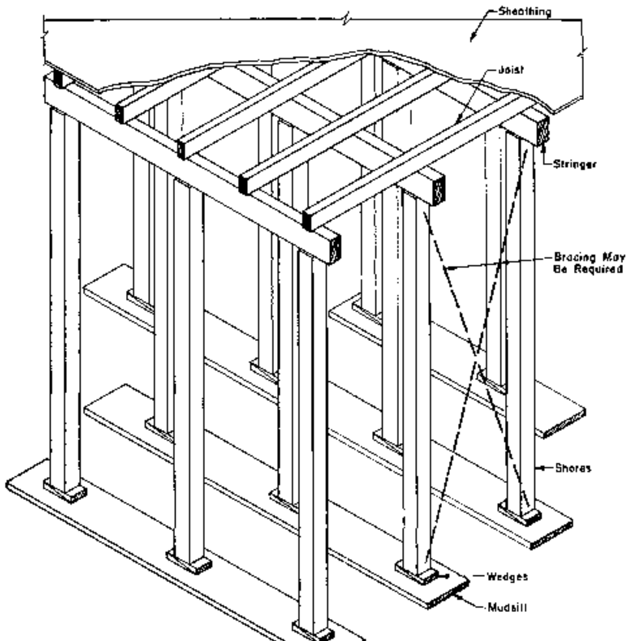


Typical wall form

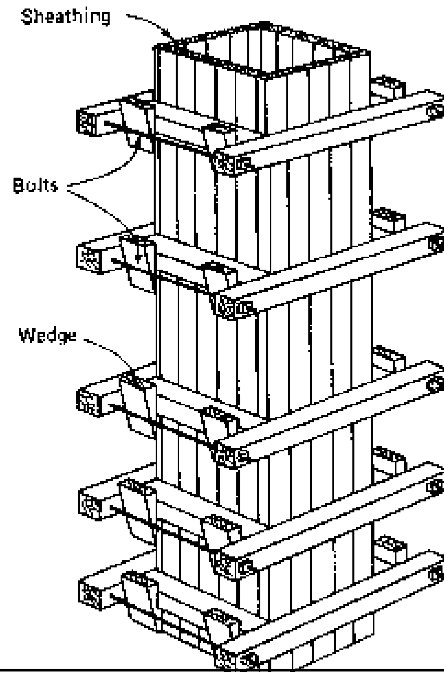


536

Form for elevated slab

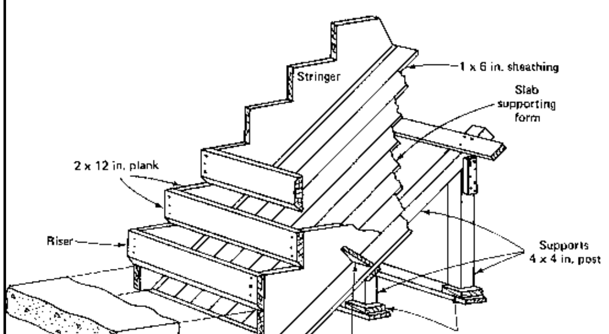


Typical column form

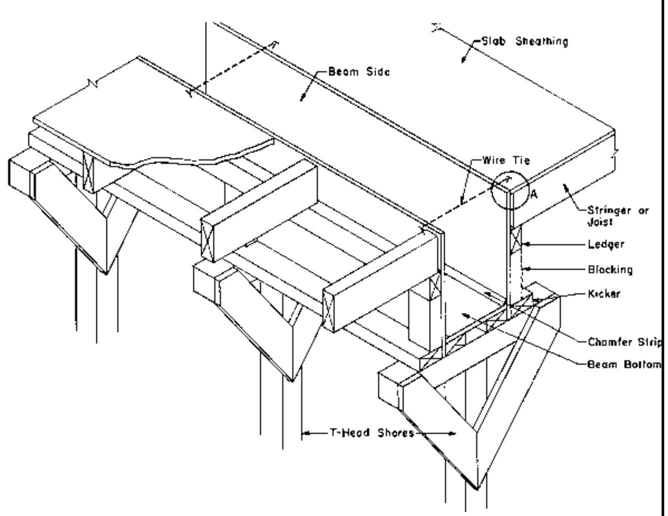


537

Wood form for stairway



Beam and slab form



538

- Metal Forms
  - Prebuilt systems of metal forms are used extensively on poured concrete not only on large projects, but even for foundation walls in homes
  - Advantages are that these systems are
    - Reusable several times
    - Easily adaptable to the various required shapes
    - Interchangeable
    - Require a minimum of hardware and a minimum of wales and ties, which are easily placed

539

- Metal Forms
  - They may be purchased or rented, and several timesaving methods are employed
  - Heavy-duty forms are available for heavy construction jobs in which a high rate of placement is desired
  - Engineering data and other information pertaining to the uses of steel forms should be obtained from the metal form supplier

540

- Metal Forms
  - The supplier can give information regarding
    - Costs (rental and purchase)
    - Tie spacing
    - Number of forms required for the project
    - Labor requirements

541

- Miscellaneous Forms
  - Column forms are available in steel and laminated plies of fiber for round, square, and rectangular columns
  - Many manufacturers will design custom forms of steel, fiber, and fiberglass to meet project requirements
  - These would include triangular, and half rounded shapes
  - Fiber tubes are available to form voids in cast in-place (or precast) concrete; various sizes are available

542

- Miscellaneous Forms
  - Most of these forms are sold by the linear footage required of a given size
  - The fiber forms are not reusable
  - The steel forms may be used repeatedly

543

- The unit of measurement used for forms is the actual contact area (in square feet) of the concrete against the forms
- The forms required throughout the project must be listed and described separately
- Usually, no deductions in the area for openings of less than 30 SF

544

- Materials in the estimate should include everything required for the construction of the forms
- Items affecting the cost of concrete wall forms are the
  - Height of the wall (since the higher the wall, the more lumber that will be required per square foot of contact surface)
  - The shape of the building

545

- Items affecting the cost of concrete floor forms include
  - Floor-to-floor height
  - Reusability of the forms
  - Length of time the forms must stay in place
  - Type of shoring and supports used
  - Number of drop beams required

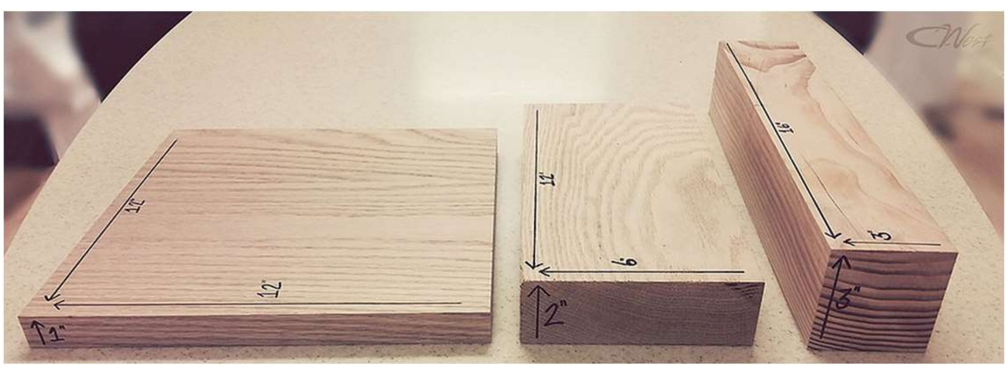
546

- Wood forms, approximate quantity of materials, and labor hours

Type of Form	Lumber fbm	Labor Hours			
		Assemble	Erect	Strip & Clean	Repair
Footings	200–400	2–6	2–4	2–5	1–4
Walls	200–300	6–12	3–6	1–3	2–4
Floors	170–300	2–12	2–5	1–3	2–5
Columns	170–350	3–7	2–6	2–4	2–4
Beams	250–700	3–8	3–5	2–4	2–4
Stairs	300–800	8–14	3–8	2–4	3–6
Moldings	170–700	4–14	3–8	2–6	3–6
Sill, Coping	150–600	3–12	2–6	2–4	2–6

fbm = Foot Board Measure

547



548

- Approximate quantity of labor hours

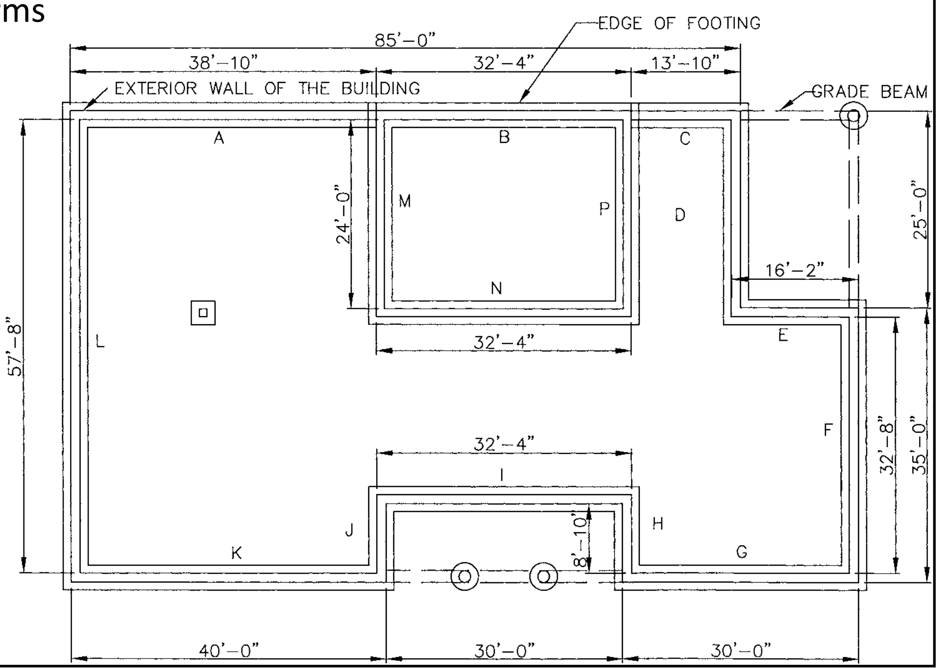
Application	Productivity Rate Labor Hours/SFCA
Foundation Wall (Plywood)	
1 Use	0.44
2 Use	0.28
3 Use	0.25
4 Use	0.22
Footings	
1 Use	0.14
2 Use	0.09
3 Use	0.08
4 Use	0.07
Slab on Grade	
1 Use	1.2
2 Use	1.1
3 Use	1.0
4 Use	0.8

Application	Productivity Rate Labor Hours/SFCA
Columns	
1 Use	0.180
2 Use	0.146
3 Use	0.143
4 Use	0.140
Beams	
1 Use	.2
2 Use	0.18
3 Use	0.15
4 Use	0.14

549

- Foundation wall forms

Side	Foundation Wall Length
A	38'-10"
C	13'-10"
D	23'-10"
E	16'-2"
F	32'-8"
G	30'-0"
H	8'-10"
I	32'-4"
J	8'-10"
K	40'-0"
L	57'-8"
TOTAL	303'-0"



550

- To determine the quantity of formwork associated with placing the 3’8’’high foundation wall, there are 303’ of 3’8’’high foundation wall
- The contact area is found by multiplying these two dimensions and then by doubling that quantity to compensate for both sides being formed
- Contact area (SFCA) = length x width x sides formed

= 303’ x 3’8’’ x 2 sides

= 303’ x 3.67’ x 2 = 2,224.02 SFCA

551

- Assuming that the forms will be used twice, the following calculation can be performed
- Labor hours = quantity x productivity rate

= 2,224.02 SFCA x 0.28 labor hours/SFCA = 622.73 labor hours

- Labor cost = labor hours x wage rate

= 622.73 x $14 = $8,718.22

552

- Form liners
  - A form liner is any sheet, layer or plate material that imparts a texture to the surface of the concrete or alters its surface finish
  - The type of liner used with the form will determine the texture or pattern obtained on the surface of the concrete

553

- Depending on the specified finish, formed concrete surfaces requiring little or no additional treatment can be easily obtained
- A variety of patterns and textures may be produced by using various materials as liners
- Fiberglass liners, plastic coated plywood, and steel are among the most commonly used
- These textures may be used on floors or walls

554

• Liners are also used to form waffle slabs and tee beam floor systems; they may be fiberglass, steel, or fiber core

555

• When liners of this type are used, the amount of void must be known so that the quantity of concrete may be determined

• Form liners are often available on a rental or purchase arrangement

• The drawings should be checked for types of texture, patterns, or other requirements of the form liner

556

- Estimators take off the area of the surface requiring a particular type of liner and decide how many liners can be used effectively on the job
- This will be the total number of square feet/m^2 of the liner or the number of pieces required
- Being able to use them several times is what reduces the cost
- Dividing the total cost of the liners by the square feet/m^2 of surface provides a cost per square foot/m^2 for liners

557

- Void area in concrete

Waffle Slab Form Liners	
Void Size and Depth	Concrete voided c.f.
19" x 19" x 4"	.77
6"	1.09
8"	1.41
10"	1.9
12"	2.14
30" x 30" x 8"	3.85
10"	4.78
12"	5.53
14"	6.54
16"	7.44
20"	9.16

558

Minimizing cost of formwork

- Since formwork may account for 40 to 60% of the cost of concrete construction, it is essential that the formwork plan be carefully developed and thoroughly evaluated
- A cost comparison should be made of all feasible forming systems and methods of operation
- Such an analysis must include the cost of equipment and labor required to install reinforcing steel and to place and finish the concrete, as well as the cost of formwork, its erection, and removal

559

- The formwork plan that provides the required safety and construction quality at the minimum overall cost should be selected for implementation
- In general, lower formwork cost will result from repetitive use of forms
- Multiple use forms may be either standard commercial types or custom-made by the contractor

560

- Flying forms (large sections of formwork moved by crane from one position to another), are often economical in repetitive types of concrete construction

561

- Where appropriate, the use of slip forms and the tilt-up construction techniques can greatly reduce forming costs

562

Example

- A construction company considers the purchase of a set of flying table forms to be used 110 times on a new project at a rate of 10 times per month
- Further reuse of the forms on another project is uncertain, (the entire cost of the forms is to be charged to the current project)
- The forms cost $23/SF
- Another option is to rent the forms for $0.90/SF per month
- Should the company buy or rent the forms?

563

- If purchased, material cost per use is purchase cost / overall number of uses before disposal = 23 / 110 = $0.21/SF
- If rented, the forms are to be used 110 / 10 = 11 months, and material cost is ($0.9/SF/month x 11 months) / 110 = $0.09/SF
- Therefore, the company should favor rental over purchase in this case

564

- What is the number of uses for which purchase and rental costs become even?

565

- The breakeven number of uses = 23/0.09 = 255.56 (256)
- Therefore, if the number of uses is expected to be greater than 256, the company should favor purchase over rental
- If the length of service exceeds 1 year. Further analysis is required that considers capital recovery and annual interest rate (time value of money)

566

Metals

- General contractors typically handle structural metal in one of two ways
  - Purchase it fabricated and erect it with their own construction crew
  - Have the company fabricate and erect
- Many contractors do not have the equipment and skilled personnel required to erect the structural metals

567

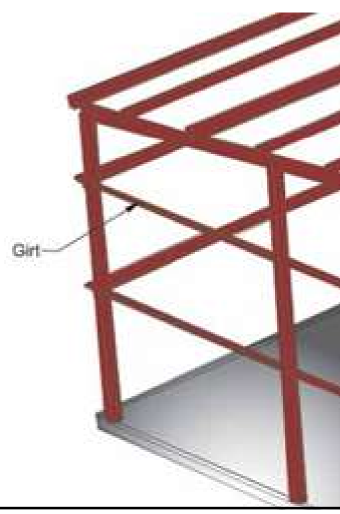
- The structural metal includes
  - Columns
  - Beams
  - Lintels

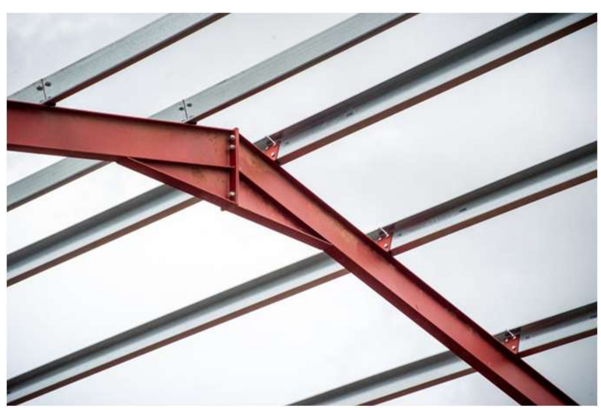
568

- The structural metal includes
  - Trusses
  - Joists
  - Bearing plates

569

- The structural metal includes
  - Girts
  - Purlins





570

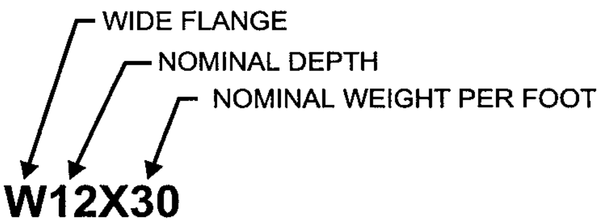
- The structural metal includes
  - Decking
  - Bracing

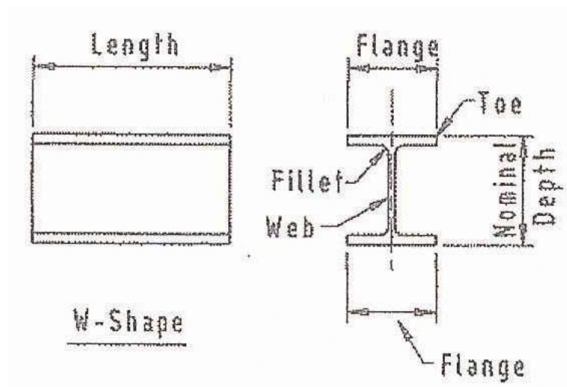
571

- Structural metals are purchased by the ton
- The cost per ton varies depending on the type and shape of metal required
- The estimate of the field cost of erecting structural metals will vary depending on
  - Weather conditions
  - Delivery of materials
  - Equipment available
  - Size of the building
  - Amount of bolting and welding required

572

- The wide flange shapes are the most commonly used today and are designated as shown



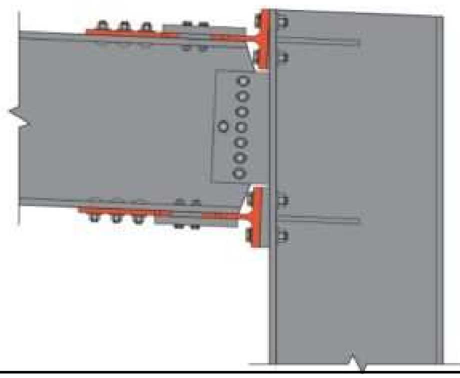


573

- The takeoff should first include a listing of all metals required for the structure
- A definite sequence for the takeoff should be maintained
- A commonly used sequence is
  - Columns and details
  - Beams and details
  - Bracing and flooring
- Floor by floor, a complete takeoff is required

574

- Structural drawings, details, and specifications do not always show required items
- Among the items that may not be shown specifically, but are required for a complete job
  - Field connections
  - Field bolts
  - Welds



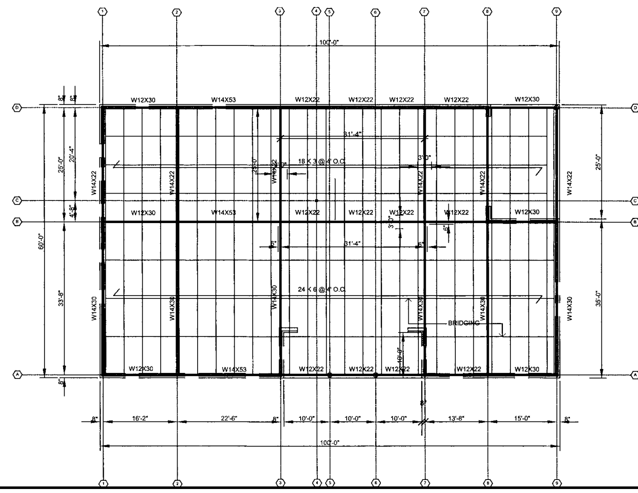
575

- The specification may require conformance with American Institute of Steel Construction (AISC) standards, with the exact methods to be determined by the fabricator and erector
- When this situation occurs, a complete understanding is required of the AISC and code requirements to do a complete estimate

576

Example

- Determine the quantity of beams in the roof framing plan



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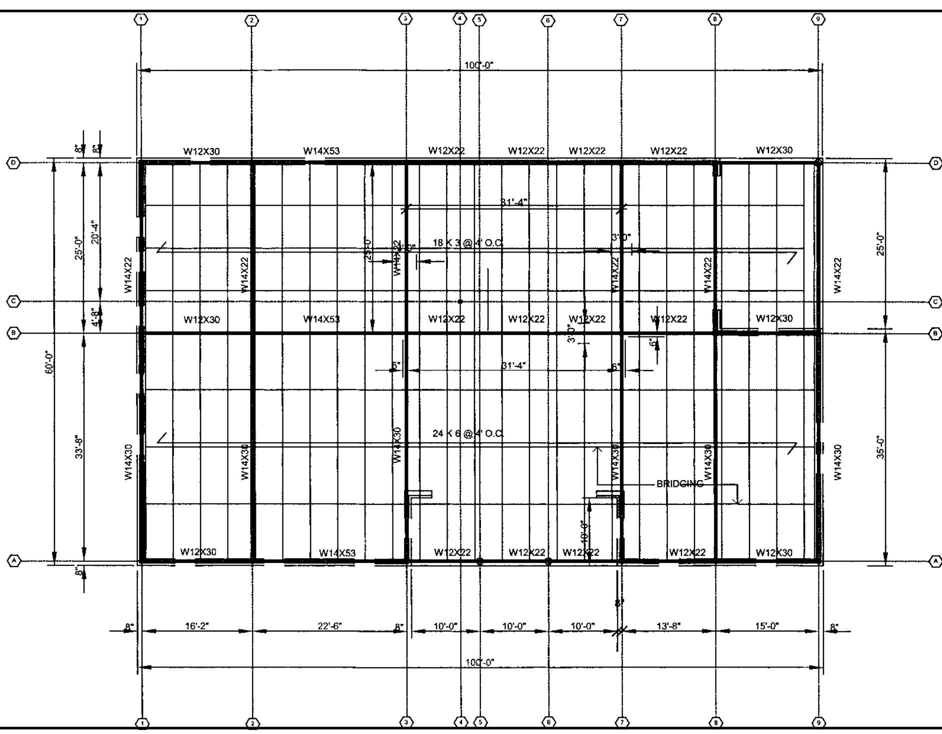

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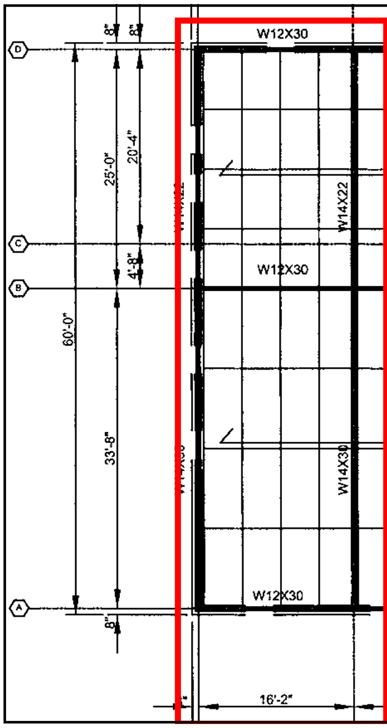
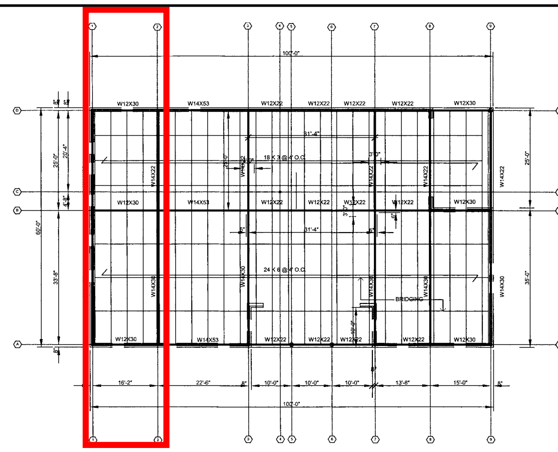
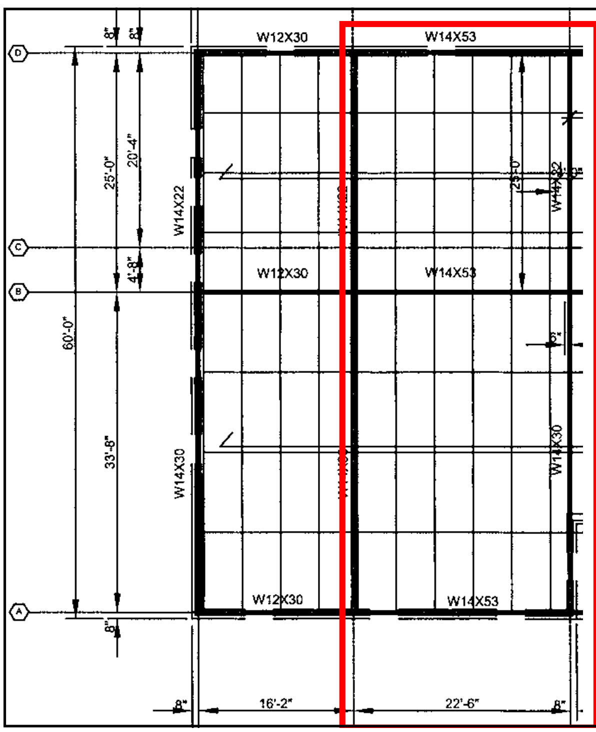


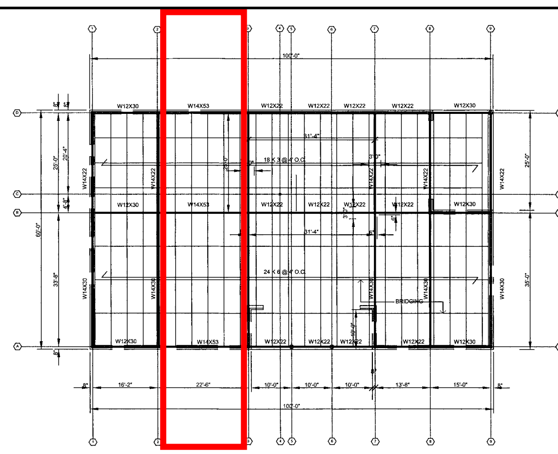


Designation	Length	Count
W12X30	16'-2"	3

- Weight of W12 X 30s that are 16'2'' long
  - Weight = 16'2'' X 30 lb/ft X 3
  - Weight = 16.167' X 30 lb/ft X 3 = 1,455 lb

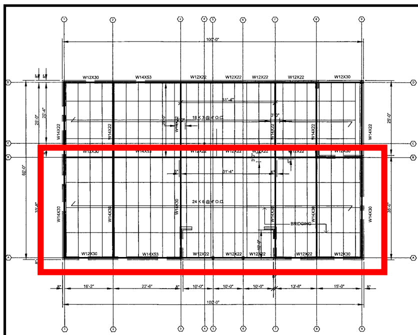
579



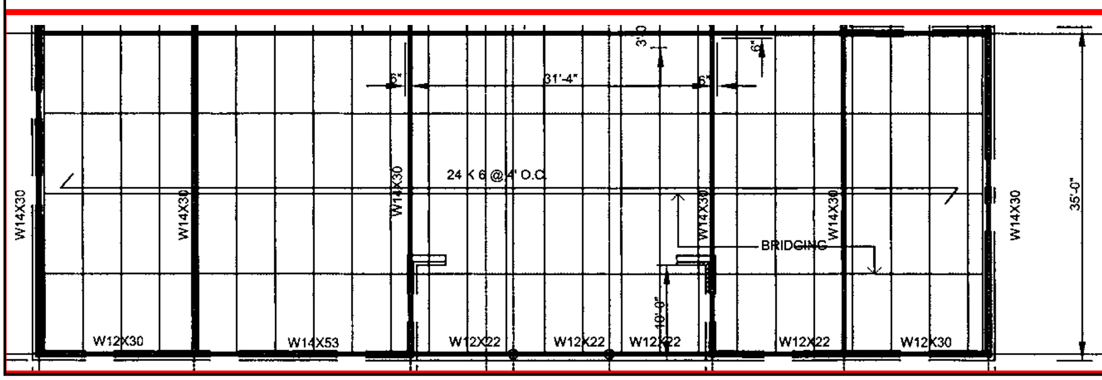


Designation	Length	Count
W14X53	22'-6"	3

580



Designation	Length	Count
W14X30	35'-0"	6



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Designation	Length	Count
W12X30	16'-2"	3
W12X30	15'-0"	3
W12X22	10'-0"	9
W12X22	13'-8"	3
W14X22	25'-0"	6
W14X30	35'-0"	6
W14X53	22'-6"	3

582

ESTIMATE WORK SHEET
STRUCTURAL STEEL

Little Office Building
Littleville, Tx
U.R. Architects

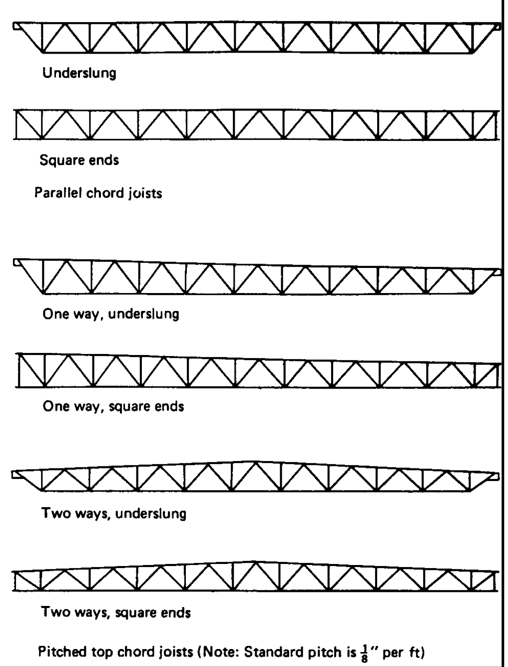
1234
1 of 1
11/11/20XX
Checked JBC

Description	Designation	Pounds / Foot	Length Ft.	Length In.	Length Ft.	Count	Quantity	Unit
Roof Framing (Beams)	W12X30	30.00	16.00	2.00	16.16667	3	1,455	Pounds
Roof Framing (Beams)	W12X30	30	15	0	15	3	1,350	Pounds
Roof Framing (Beams)	W12X22	22	10	0	10	9	1,980	Pounds
Roof Framing (Beams)	W12X22	22	13	8	13.66667	3	902	Pounds
Roof Framing (Beams)	W14X22	22	25	0	25	6	3,300	Pounds
Roof Framing (Beams)	W14X30	30	35	0	35	6	6,300	Pounds
Roof Framing (Beams)	W14X53	53	22	6	22.5	3	3,578	Pounds

583

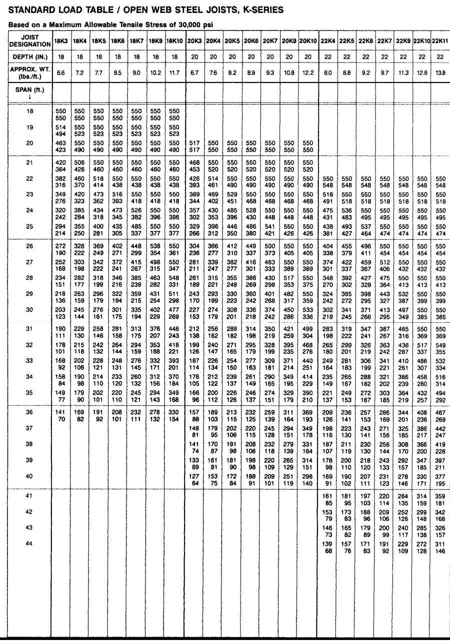
Joists

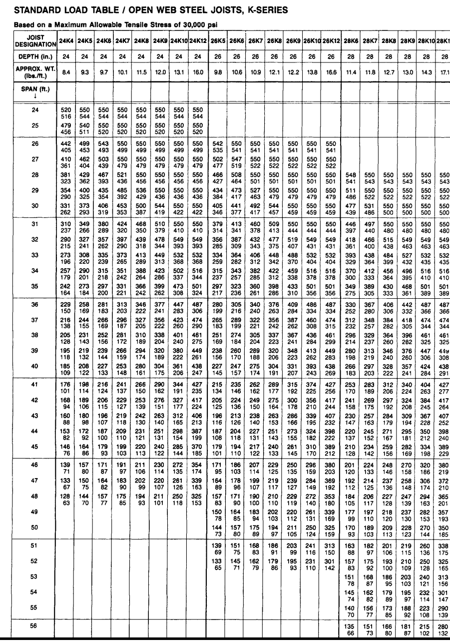
- Metal joists, also referred to as open web steel joists, are prefabricated lightweight trusses
- The weight per foot is typically found in the manufacturer’s catalog



584

- A bar joist catalog (joist loading table)





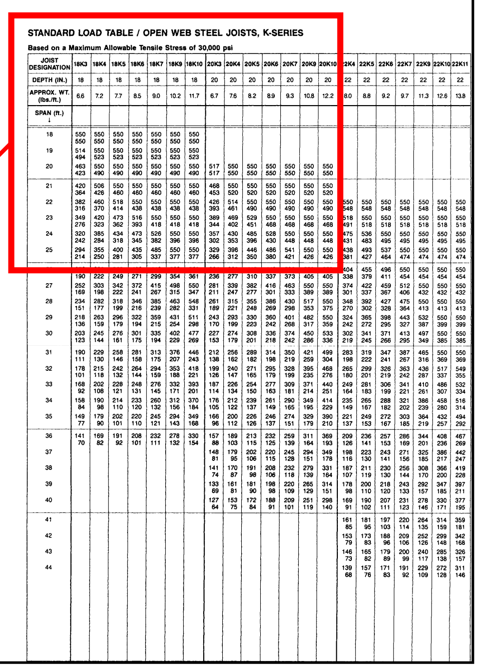
585

- A bar joist catalog (joist loading table)

STANDARD LOAD TABLE / OPEN WEB STEEL JOISTS, K-SERIES

Based on a Maximum Allowable Tensile Stress of 30,000 psi

JOIST DESIGNATION	18K3	18K4	18K5	18K6	18K7	18K9	18K10	20K3	20K4	20K5	20K6	20K7	20K9	20K1
DEPTH (IN.)	18	18	18	18	18	18	18	20	20	20	20	20	20	20
APPROX. WT. (lbs./ft.)	6.6	7.2	7.7	8.5	9.0	10.2	11.7	6.7	7.6	8.2	8.9	9.3	10.8	12.2
SPAN (ft.) ↓														
18	550 550	550 550	550 550	550 550	550 550	550 550	550 550							
19	514 494	550 523	550 523	550 523	550 523	550 523	550 523							
20	463 423	550 490	550 490	550 490	550 490	550 490	550 490	517 517	550 550	550 550	550 550	550 550	550 550	550 550
21	420 364	506 426	550 460	550 460	550 460	550 460	550 460	468 453	550 520	550 520	550 520	550 520	550 520	550 520
22	382 316	460 370	518 414	550 438	550 438	550 438	550 438	426 393	514 461	550 490	550 490	550 490	550 490	550 490
23	349 276	420 323	473 362	516 393	550 418	550 418	550 418	389 344	469 402	529 451	550 468	550 468	550 468	550 468
24	320 242	385 284	434 318	473 345	526 382	550 396	550 396	357 302	430 353	485 396	528 430	550 448	550 448	550 448
25	294 214	355 250	400 281	435 305	485 337	550 377	550 377	329 266	396 312	446 350	486 380	541 421	550 426	550 426



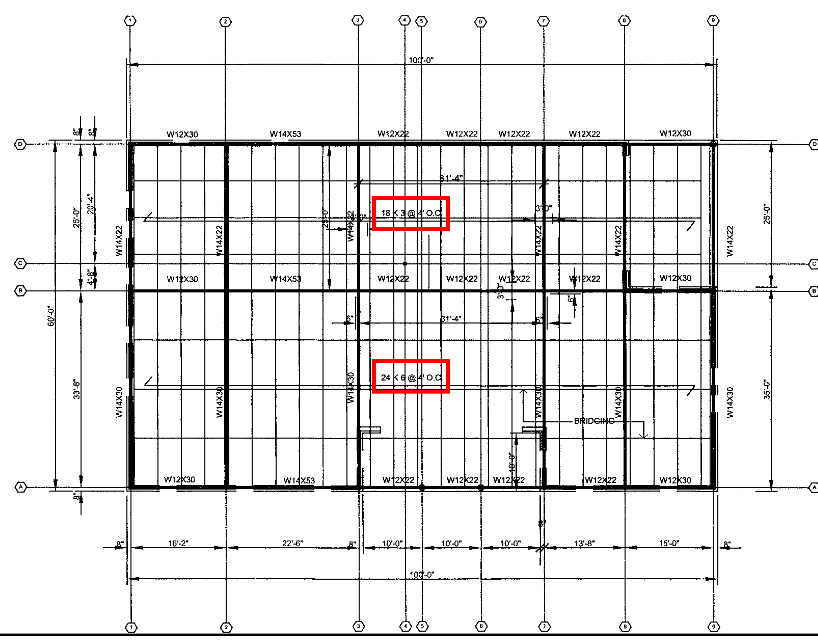
586

- To determine the quantity of bar joists
  - Calculate the linear footage of joists required
  - Multiply this number by its weight per foot
  - The product represents the total weight
- The cost per pound is considerably greater than that for some other types of steel (such as reinforcing bars or wide flange shapes) due to the sophisticated shaping and fabrication required

587

- Determine the quantity of bar joists required to frame the roof

- 18K3 @4’ O.C.
- 24K6 @4’ O.C.



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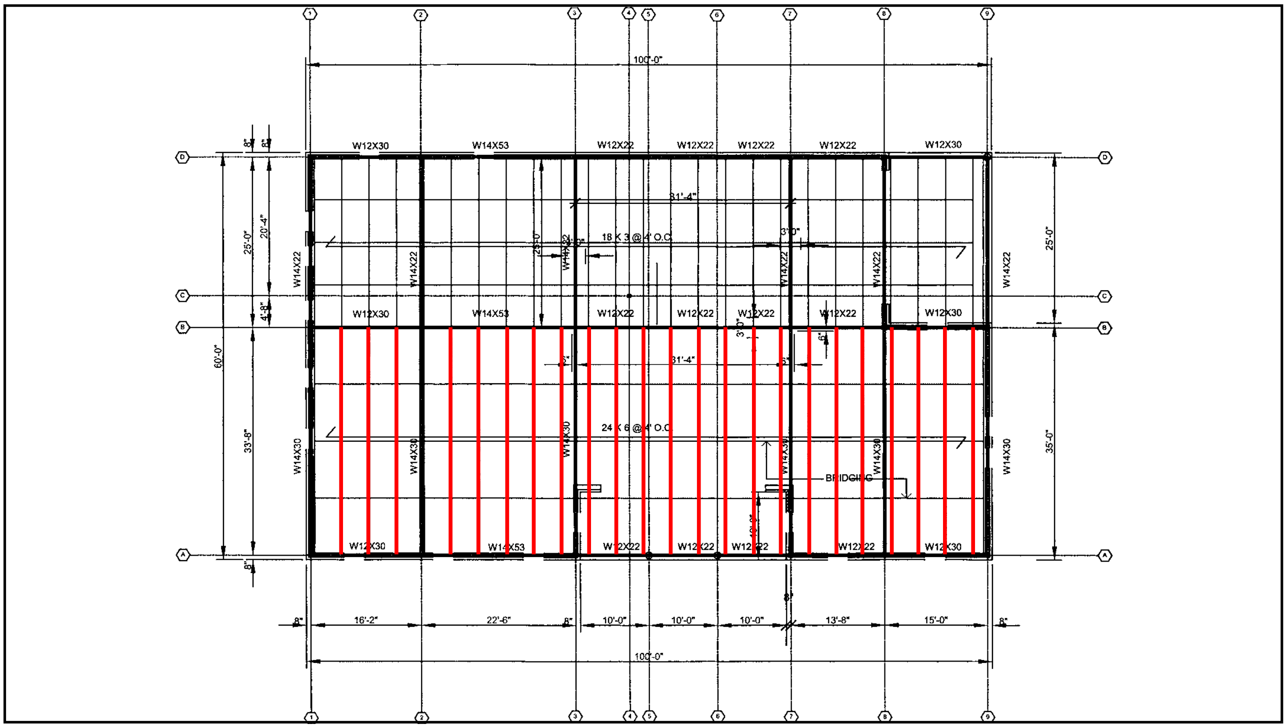


589

Designation	Length	Count
18K3	25'-0"	23
24K6	35'-8"	23

- The 18K3 weighs 6.6 pounds per foot
- The 24K6 weighs 9.7 pounds per foot

STANDARD LOAD TABLE / OPEN WEB STEEL JOISTS, K-SERIES

Based on a Maximum Allowable Tensile Stress of 30,000 psi

JOIST DESIGNATION	18K3	18K4	18K5	18K6	18K7	18K9	18K10	20K3	20K4	20K5	20K6	20K7
DEPTH (IN.)	18	18	18	18	18	18	18	20	20	20	20	20
APPROX. WT. (lbs./ft.)	$\boxed{6.6}$	7.2	7.7	8.5	9.0	10.2	11.7	6.7	7.6	8.2	8.9	9.3
SPAN (ft.) ↓												

STANDARD LOAD TABLE / OPEN WEB STEEL JOISTS, K-SERIES

Based on a Maximum Allowable Tensile Stress of 30,000 psi

JOIST DESIGNATION	24K4	24K5	24K6	24K7	24K8	24K9	24K10	24K12	26K5	26K6	26K7	26K8
DEPTH (in.)	24	24	24	24	24	24	24	24	26	26	26	26
APPROX. WT. (lbs./ft.)	8.4	9.3	$\boxed{9.7}$	10.1	11.5	12.0	13.1	16.0	9.8	10.6	10.9	12.1
SPAN (ft.) ↓												

590

- Length of 18K3 = 25’ X 23 = 575’
- Length of 24K6 = 35’8’’ X 23 = 35.67’ X 23 = 820.41’
- Weight of 18K3 = 575’ X 6.6 lb/ft = 3,795 lb
- Weight of 24K6 = 820.41’ X 9.7 lb/ft = 7,985 lb
- Total weight of bar joist = 3,795 + 7,985 = 11,753 lb
- 11,753 / 2,000 lb per ton = 5.88 tons

591

- Bar joist installation productivity rates

Joist Type	Labor Hours per Ton
J & K, up to 30 Ft.	5.5 to 9.0
J & K, over 30 Ft.	4.5 to 8.0
LJ & LH	4.0 to 6.0
DLJ & DLH	4.0 to 6.0

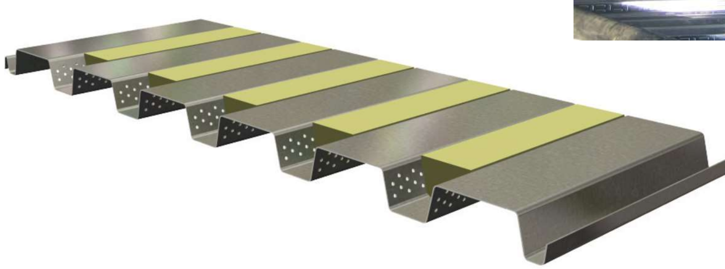
592

Metal Decking

- Metal decking is used for floor and roof applications
- Depending on the particular requirements of the job, a wide selection of shapes, sizes, thicknesses, and accessories
- Application types
  - Simple decks over which insulation board and built-up roofing are applied

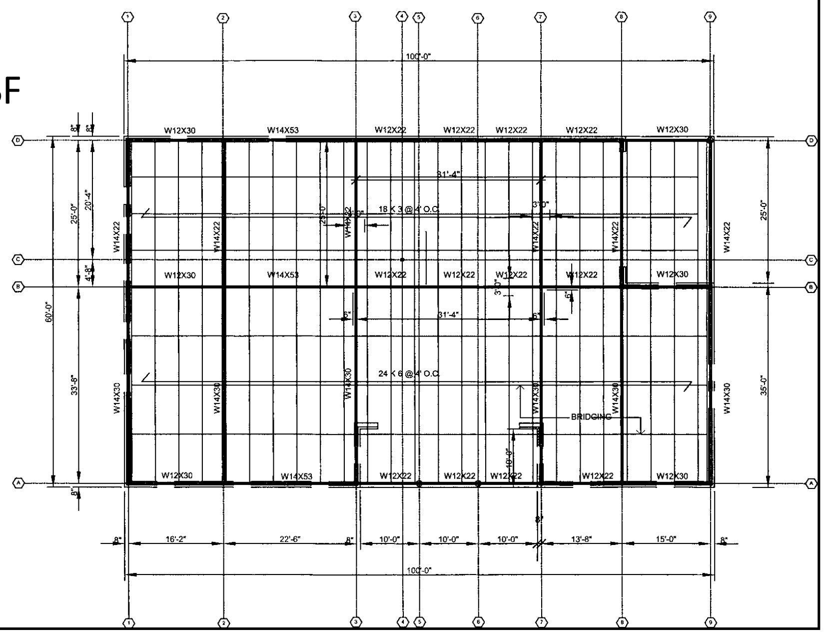
593

- Application types
  - Forms and reinforcing over which concrete may be poured
  - Decking that can receive recessed lighting and has acoustical properties



594

- Determine decking for the roof area
- Roof area
  60’ x 100’ = 6,000 SF
- Add 5% waste
  6,300 SF



595

Masonry

- The term masonry encompasses all the materials used by masons in a project, such as block, brick, clay, tile, or stone

596

- The amount of varied material available requires that estimators be certain they are bidding exactly what is required
- Read the specifications, check the drawings, and call local suppliers to determine the exact availability, costs, and special requirements of the units needed

597

- The amount of time required for a mason (with the assistance of helpers) to lay a masonry unit varies with
  - Size, weight, and shape of the unit
  - Bond (pattern)
  - Number of openings
  - Whether the walls are straight or have jogs (turns)
  - Distance the units must be moved (both horizontally and vertically)
  - Shape and color of the mortar joint

598

- The height of the walls becomes important in estimating labor for masonry units
- The masonry work that can be laid up without the use of scaffolding is generally the least expensive
- However, that is typically limited to 1.2 - 1.5 m (4 - 5 feet)
- Labor costs arise from the erection, moving, and dismantling of the scaffolding as the building goes up
- The units and mortar have to be placed on the scaffold, which further adds to the labor and equipment costs

599

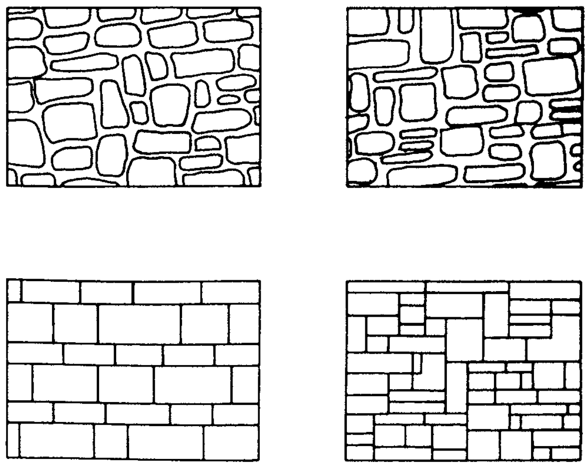
- Mortar specifications

	By Strength	By Proportion*		
Mortar Type	***28-d Compressive Strength-lb/sq in. (MPa)***	***Portland Cement***	***Masonry Cement***	***Hydrated Lime***
M	2500 (17.2)	1	None	¼
		1	1	None
S	1800 (12.4)	1	None	¼ to ½
		½	1	None
N	750 (5.2)	1	None	½ to 1
		None	1	None
O	350 (2.4)	None	1	1 to 2
PM	2500 (17.2)	1	1	None
PL	2500 (17.2)	1	None	¼ to ½

*Aggregate volume should be 2¼ to 3 times the sum of the volumes of cement and lime used.

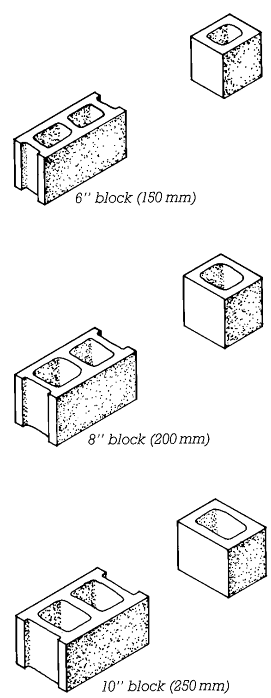
600

- Stone patterns



601

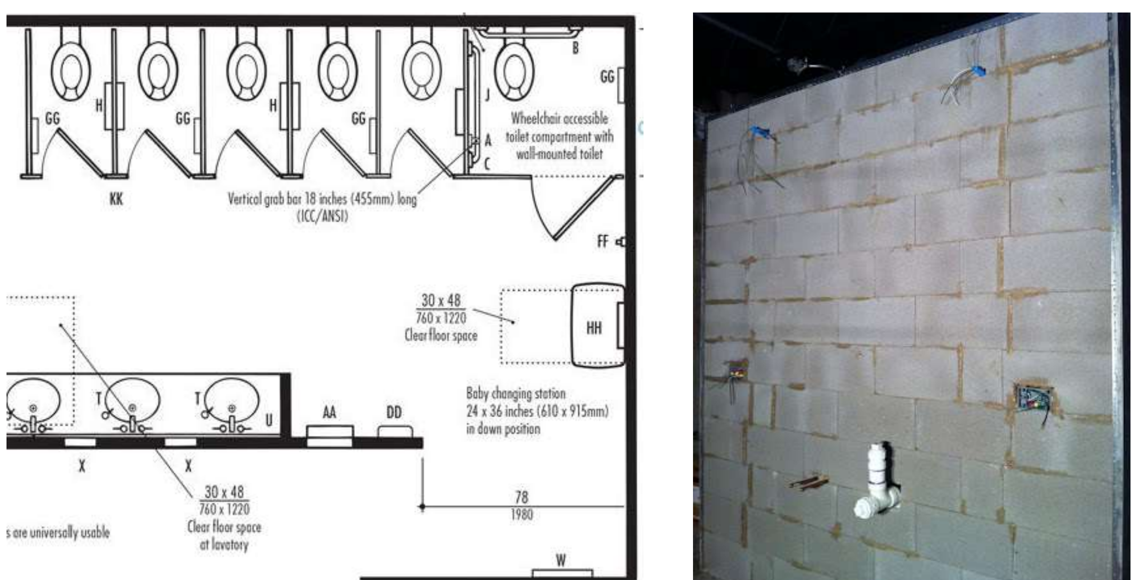
- Concrete masonry includes concrete brick, hollow and solid block, and decorative types of block
- There is considerable variation in shapes and sizes available
- For example, hollow block of size 40cm x 20cm x 10cm can be used for internal partitions while thicker hollow block size of 40cm x 20cm x 20cm can be used for external walls



602

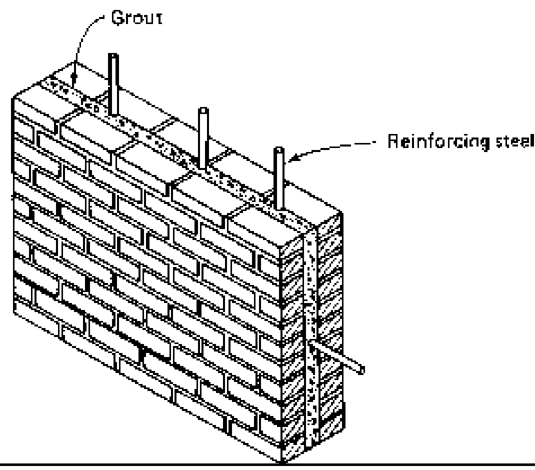

BATH
KITCHEN
BEDROOM
LIVING ROOM

603


B
GG
H
GG
H
GG
J
Wheelchair accessible toilet compartment with wall-mounted toilet
A
C
KK
Vertical grab bar 18 inches (455mm) long (ICC/ANSI)
FF
30 x 48
760 x 1220
Clear floor space
HH
Baby changing station 24 x 36 inches (610 x 915mm) in down position
T
T
U
AA
DD
X
X
30 x 48
760 x 1220
Clear floor space at lavatory
s are universally usable
78
1980
W

604

• Reinforced brick masonry: brick masonry in which reinforcing steel has been embedded to provide additional strength



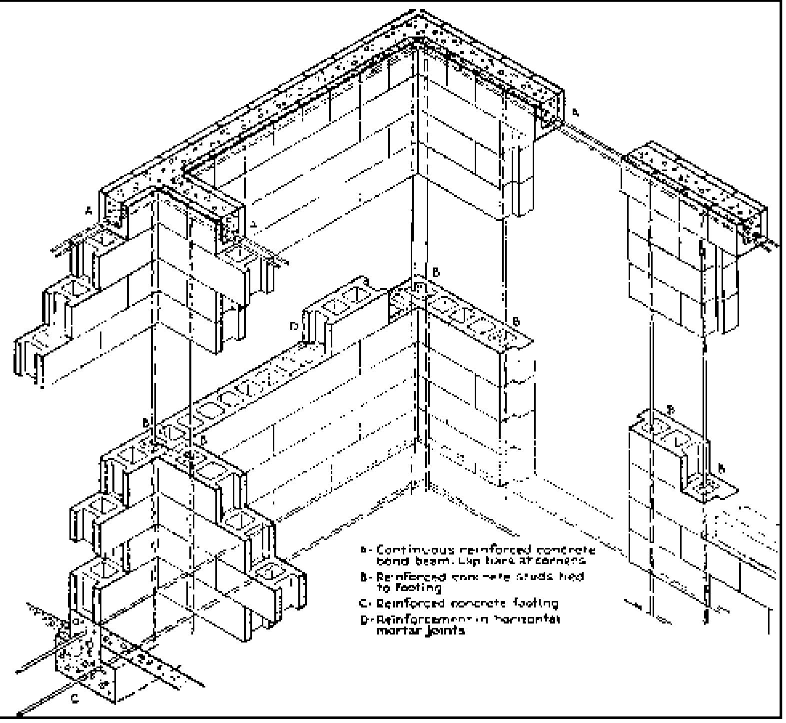
605

• Protection for masonry reinforcement

Application	Minimum Cover (Exposed Face)
Bottom of footings	3 in. (76 mm)
Columns, beams, or girders not exposed to weather or soil	1½ in. (38 mm)
Horizontal joint reinforcement bars ¼ in. (6 mm) or less in diameter	⅝ in. (16 mm)
All other	
Not exposed to weather or soil	1 bar diameter but at least ¾ in. (19 mm)
Exposed to weather or soil	2 in. (51 mm)

606

- Reinforced concrete masonry construction
- Provide additional structural strength and to prevent cracking



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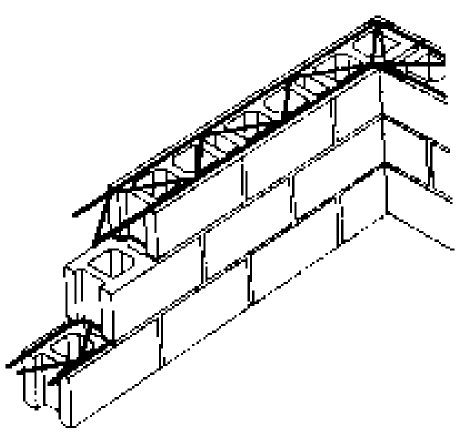

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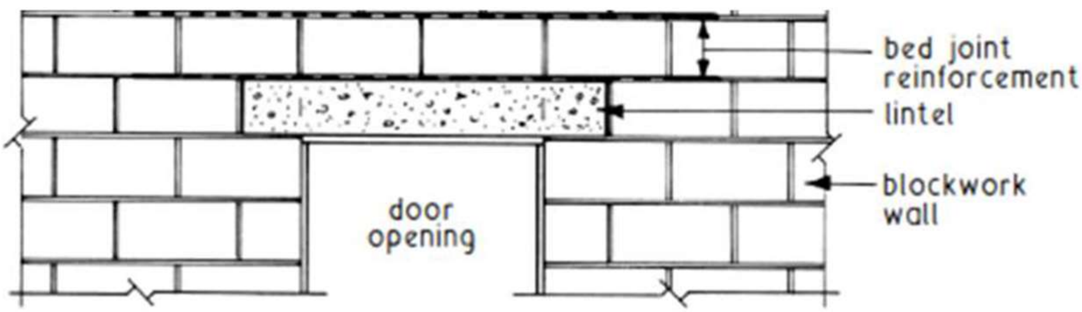


609

- Tables are available for estimating the quantity of brick required for standard walls
- Estimating the number of bricks required for a masonry wall involves five steps
    1. Calculating the net surface area of the wall
        - The gross surface area of the wall is calculated in m^2 (square feet), and the area of openings is subtracted to give the net surface area of the wall
        - Do not double count the area of corners where two walls intersect

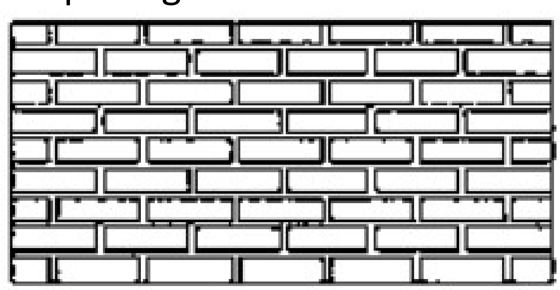
610

- Estimating the number of bricks required for a masonry wall involves five steps
  2. Calculating the surface area of one brick as positioned (including the mortar joint)
  3. Dividing the wall area by the surface area of one brick (including the mortar joint)
  4. Multiplying this number by the number of layers (vertical section one brick thick) of wall thickness
  5. Adding an amount for waste (usually 2–10%)

611

Example

- Calculate the number of bricks 203 mm long x 57 mm height x 95 mm thick laid in running bond required for a double brick (double layer) wall 2.44 m high by 4.27 wide having one opening 1.22 x 1.83 m and one opening 0.81 x 1.22 m
- Mortar joints are 13 mm
- Allow 3% for brick waste



Running bond

612

- Net wall area = (2.44 x 4.27) – (1.22 x 1.83) – (0.81 x 1.22) = 7.2 m^2
- Area of 1 brick = (0.057 + 0.013) (0.203 +0.013) = 0.01512 m^2
- Number of bricks required = (7.2 / 0.01512) x 2 x 1.03 = 980.95 (981)

613

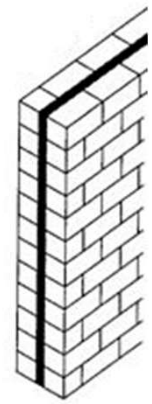
- A similar procedure can be used to calculate the quantity of mortar required for a particular wall
- First, the volume of mortar required for a single brick is calculated. The following equation may be used for this purpose

Volume per brick (m^3/cu in.) = t x W x (L + H + t)

- t = joint thickness (in. or m)
- W = brick width/depth (m)
- L = brick length (m)
- H = brick height (m)

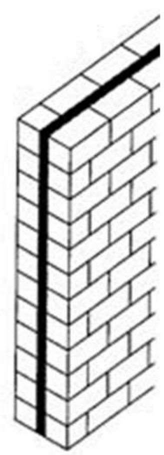
614

- Second, multiplying the mortar required per brick by the number of bricks and adding a waste factor (usually about 25%) yields the mortar required per layer
- When the wall is more than one brick (layer) thick, we must multiply by the number of layers and add the volume of mortar needed to fill the gap between layers



615

- The volume of mortar between layers is simply the product of the joint thickness times the net area of the wall
- Again, a waste factor must be added



616

Example

- For the previous example, estimate the quantity of mortar required. The joint thickness is 13 mm. waste is 25%

617

- Volume per brick = 0.013 x 0.095 (0.203 + 0.057 + 0.013) = 0.00033716 m^3
- Volume per layer = 0.00033716 x 981/2 = 0.165 m^3
- Volume between layers = 0.013 x 7.2 = 0.094 m^3
- Mortar required = 1.25 (2 x 0.165 + 0.094) = 0.53 m^3

618

Plastering

- Plaster is available in one-coat, two-coat, and three-coat work
- It is generally classified according to the number of coats required
- The last and final coat applied is called the finish coat
- The coat, or combination of coats, applied before the finish coat is referred to as the base coat

619

- The estimator must consider
  - The number of coats
  - Thickness of coats
  - Mixes to be used
  - Thickness and type of metal lath required
- Waste can be approximated to 5%

620

وصف العمل

مقدمة: ارتفاع الشرائح والزوايا المعدنية المستعملة في بند القصارة تكون بكامل ارتفاع الطابق أو بكامل العرض في حالة التقاء جدران الطوب بالسقف والجسور الخرسانية وفي حالة استعمال الشرائح بين القمط وجدران الطوب تكون بكامل طول القمط.

بالمتر المربع:

تقديم وعمل **قصارة داخلية** (Internal Plaster) **حسب** المواصفات وشمولية السعر والعمل المبينة أدناه

• ثلاثة وجوه، الوجه الأول الطرطشة (المسمار) بنسبة (1/2) والوجهين الاخرين البطانة (الخشنة) والظهارة (الناعمة) بنسبة (1/4) من مونة الإسمنت والرمل وذلك

وبحيث يكون ارتفاع الشبك المعدني بكامل ارتفاع الطابق (للأعمدة والزوايا) عند التقاء الأعمدة و الجدران مع بعضها و بكامل العرض والطول في حالة التقاء جدران الطوب بالسقف والجسور الخرسانية وبكامل طول القموط الخرسانية فوق الأبواب والشبابيك ولسلاحات الشبابيك والأبواب وفوق كافة انظمة الخدمات المخفية.

علاوات زيكال ضمن هذا البند سلاحات ونموط الشبابيك والأبواب).

• كل ما يلزم لإنجاز العمل على اكمل وجه حسب المواصفات والمخططات وتعليمات المهندس المشرف.

بالمتر المربع:

تقديم وعمل **قصارة خارجيه** (External Plaster) ثلاثة وجوه، حسب متطلبات بند 704 للتصوينات وحيثما يلزم

621

ملاحظة: على المقاول تقديم مخططات تنفيذية لكافة الطوابق تبين الشكل والرسمة والألوان Pattern and colors للبلاط ليتم اعتمادها من قبل المهندس المشرف.

بالمتر المربع:

تقديم وتركيب **بلاط سيراميك مزجج للجدران** بسماكة لا تقل عن 7ملم (Vitrified Ceramic Tiles) صناعة اوروبية (نخب أول) وذلك حسب الأماكن المبينة في جداول التشطيبات وبحيث يكون مزجج الوجه بحيث لا تزيد نسبة امتصاصه للماء عن (4 بالمئة) حسب البند (708/1/ب) و (708//2/أ) ومطابقاً للمواصفات القياسية الأردنية وحسب المواصفات وشمولية العمل والسعر المبينة أدناه

• الألوان والرسومات حسب المخططات واختيار المهندس المشرف

• التثبيت بمونة الإسمنت والركام بنسبة (1/3) حسب البند (708/6/ب) أو باللاصق المناسب وبموافقة المهندس مصدر أوروبي لأماكن الخرسانة الوسيمة وبحيث تتعامد حلول الجدران مع حلول الأرضيات.

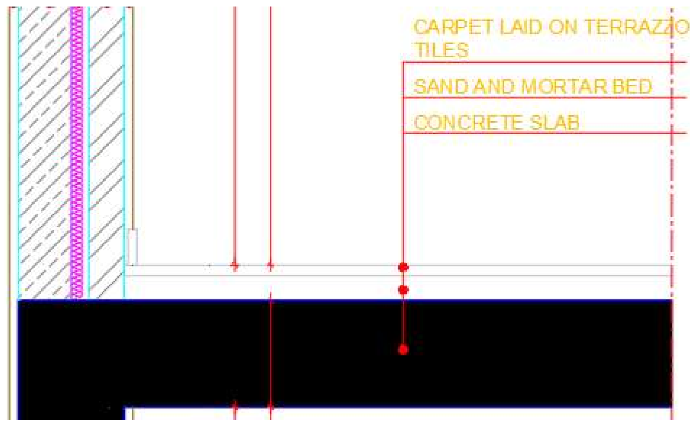
• الترويب بروبة جاهزة خاصة من مصدر اوروبي وذو لون يوافق عليه المهندس المشرف .

• **القصارة الخشنة وجهين خلف البلاط رشة مسمار وطبقة البطانة من القصارة الخشنة سماكة 2 سم**

- Areas covered with ceramic tiles usually require two coasts of plastering
- Example of these areas
    - Kitchens
    - Toilets
    - Cleaning areas
    - Pathways linking these areas
- External walls can also be specified to require two coats of plastering

622

- Height of plastering
  - Floor height
  - Allowance for height of one brick (20 cm)
  - Allowance for tile works/flooring
  - Suspended ceiling
- Windows and doors
  - Allowance for sides of the door frame (jambs) and heads



623

Example

- Based on the available information, determine the area of internal and external plastering
- Height to ceiling: 3.2 m
- Room area: 5.5 x 4.2 m (exterior dimensions)
- Slab thickness: 31 cm
- Wall thickness: 20 cm
- Door: 1.2 x 2.1 m
- Window: 1.4 x 2 m

624

- Internal plastering
  - [(5.5 – 0.4) + (4.2 – 0.4)] x 2 x 3.2 = 56.96 m^2
  - Remove openings = 56.96 – (1.2 x 2.1) – (1.4 x 2) = 51.64 m^2
- External plastering
  - (5.5 + 4.2) x 2 x 3.51 = 68.09 m^2
  - Remove openings = 68.09 - (1.2 x 2.1) – (1.4 x 2) = 62.77 m^2

625

Painting

- The variables that affect the cost of painting include
  - Material painted
  - Shape and location of the surface painted
  - Type of paint used
  - Number of coats required
- Each of the variables must be considered, and the takeoff must list the different conditions separately
- Painting is one of the items commonly subcontracted, the estimator should still take off the quantities so that the subcontractor's proposal can be checked

626

- In taking off the quantities, the area of the surface is taken off the drawings
- All surfaces that have different variables must be listed separately
- With this information, the amount of materials can be determined by the use of the manufacturer’s information on coverage per gallon

627

- The specifications should list
  - Type of coating
  - Number of coats
  - Finish required on the various surfaces throughout the project
- Interiors receive different treatment than exteriors; different material surfaces require different applications and coatings (all of this should be in the specifications)

628

- Paints may be applied by
  - Brush
  - Roller
  - Spray gun
- The method to be used is also included in the specifications
- Sometimes, the specifications call for prefinished and factory-finished materials to be job finished also
- The estimator should seek clarification from the architect/engineer's office

629

- The most common items to be factory finished are
  - Doors
  - Floorings
  - Windows
  - Grilles
- The estimator should keep a sharp eye out to see that each item of work is figured only once

630

<u>بالمتر المربع:</u>

تقديم وتنفيذ دهان مائي مستحلب املشن اكريليك
Eggshell (قابل للتنظيف) او ما يماثله وبموافقة
المهندس من اجود الاصناف للجدران والسقوف الداخلية
حسب جدول التشطيبات
يكون الدهان الداخلي ثلاثة وجوه (طبقة التأسيس حسب
البند (1304/1/ج) وطبقة البطانة حسب البند (1304/2)
وطبقة الظهارة حسب البند (1304/3/ج/2.1) والبند
(1035) ومتطلبات (م ق أ/31) وحسب المواصفات
وشمولية العمل والسعر المبينة أدناه.

631

Flooring

- Flooring may be made of
  - Wood
  - Resilient tile or sheets
  - Carpeting
  - Clay and ceramic tiles
  - Stone
  - Terrazzo

632

- Each type has its own requirements as to types of installation, depending upon
  - Job conditions
  - Subfloor requirements
  - Methods of installation
  - Moisture conditions
- Waste can be assumed using tables or approximated as 5%

633

- Floor and wall tiles are estimated by the area
- Each area must be kept separate, according to the size and type being used
- It is common to have one type of tile on the floor and a different type on the walls
- The different colors also vary in cost even if the size of the tile is the same, so caution is advised

634

- Because of the large variety of sizes and shapes at varying costs, the specifications must be checked carefully, and the bid must reflect what is required
- If Portland cement mortar is used as a base, it is installed by the tile contractor
- This requires the purchase of cement, sand, and sometimes wire mesh
- Tile available in sheets is much more quickly installed than individual tiles

635

- Area of tiling
  - Entire floor area
  - Room area
  - Allowance for thicknesses of walls and partitions

636

5/.

بالمتر المربع:

تقديم وتركيب **بلاط أرضيات بورسلان مانع للتزحلق منشأ أوروبي heavy duty full body fully vitrified porcelain tiles** وبالألوان المطلوبة صنف (أ) من أجود الأنواع وحسب متطلبات بند 805 والكيل وشمولية السعر حسب بند 817/4 من الباب الثامن وتكون سماكة الحل 2 ملم باستعمال مباعدات بلاستيك.

والسعر يشمل **الطمم الخاص من البوزولان** لا تزيد كثافته عن 10 كيلو نيوتن /م³ **والترويب بروبة خاصة جاهزة الصنع من** مصدر أوروبي معتمد بالون المطلوب وتنظيف البلاط بشكل **جيد** بعد الترويب كما يشمل السعر استبدال طبقة الطمم بطبقة طمم من البوزولان المخلوط بالاسمنت 150كغ/م³ سماكة (10) سم لأرضيات دورات المياه والبوفيه.

السعر يشمل دون أي علاوة تقديم وتنفيذ مرايا الدرجات في المدرجات من نفس نوع بورسلان الارضيات مع معالجة أنوف الدرجات بقص مناطق الالتقاء بزاوية 45°.

5/5

بالمتر المربع:

تقديم وتركيب **بلاط موزاييك** (Terrazzo Tiles) صنف (أ) مفتح للأرضيات وذلك حسب البند (803/2.1) وحسب المواصفات وشمولية العمل والسعر المبينة أدناه

- تسوية ورش ودك التربة تحت الأرضيات حتى المناسيب المطلوبة على المخططات وحسب البند (802/1/أ) وتنظيف العقدات الخرسانية جيداً حسب البند (802/2).
- **الطمم أسفل البلاط مهما كانت السماكات المطلوبة من البوزولان لا تزيد كثافته عن 10 كيلو نيوتن /م³ حسب البند (802/2/ج) .**
- المونة من الإسمنت والركام بنسبة (1/3)
- حجم كسر الرخام و الألوان حسب اختيار المهندس
- الترويب في الموقع بالإسمنت الأبيض وباللون حسب اختيار المهندس.
- الجلي والصقل والتنظيف والتنعيم والتلميع الميكانيكي بالمصنع والموقع بعد التركيب
- القص بالمنشار الميكانيكي لأغراض الغلق بحيث يكون الأغلاق من جهة واحدة.
- يكون التركيب حسب البند (803/11) .
- الكيل وشمولية السعر حسب بند (817/4).
- كل ما يلزم لإنجاز العمل على اكمل وجه حسب المواصفات والمخططات وتعليمات المهندس.

أ- بلاط موزاييك بزرة بلدية (كسر رخام عجلوني)

637

5/7

بالمتر الطولي

تقديم وتركيب كسوات **جرانيت محلي (روزا)** (صنف أول) وذلك **للأدراج** وحسب المواصفات والمخططات وشمولية السعر والعمل المبينة أدناه

- الألوان متجانسة حسب اختيار المهندس ويجب أن تكون سليمة الحواف والزوايا وخالية من الفتال.
- التثبيت بمونة الإسمنت والركام بنسبة (1/3).
- الترويب بروبة خاصة جاهزة الصنع وبالألوان حسب اختيار المهندس .
- الجلي والتلميع بالمصنع والتنظيف بعد التركيب.
- عمل أخاديد للدعسات وتعبئتها بمواد خاصة لمنع التزحلق والانزلاق.
- تقديم وتنفيذ بيش جرانيت من نفس النوع والسماكة بعرض 8سم على جوانب الدعسة والمرايا لمنع نزول المياه من الجوانب.

شطف وصقل جميع الحواف الظاهرة.

أ. سماكة الدعسة 3 سم ، سماكة المرآة 2 سم.

م.ط

5/8

بالمتر المربع:

تقديم وتركيب **كسوات جرانيت محلي (روزا) (صنف أول) وذلك لبسطات الادراج** وحسب المخططات والرسومات والتشكيلات والمواصفات وشمولية العمل والسعر المبينة أدناه:

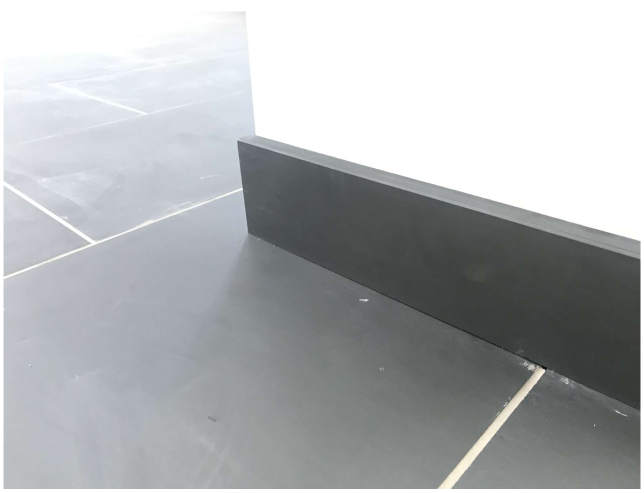
- الألوان المتجانسة حسب اختيار المهندس وأن يكون سليم الحواف والزوايا وخالي من الفتال
- التثبيت بمونة الإسمنت ورمل ناعم بنسبة (1/3).
- **الطمم أسفل البلاط من البوزولان لا تزيد كثافته عن 10 كيلو نيوتن /م³ بالسماكات المبينة على المخططات**
- الترويب بروبة جاهزة الصنع خاصة وبالألوان المطلوبة.
- الجلي والتلميع في المصنع والتنظيف بعد التركيب.
- كل ما يلزم لإنجاز العمل على اكمل وجه حسب المخططات والمواصفات وتعليمات المهندس وعلى المقاول تقديم مخططات تنفيذية لجميع الأعمال

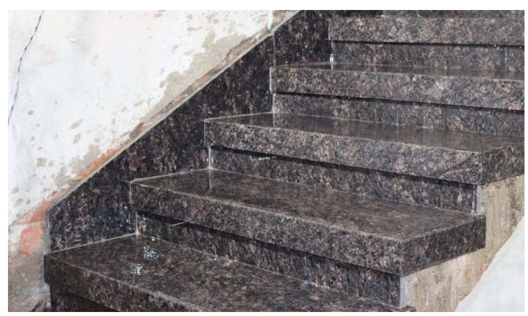
638

- Skirting (panel)

5/10	**بالمتر الطولي:** تقديم وتركيب **باتيل جرانيت محلي (روزا)** مصقول الوجه نخب أول **سمك 2سم** وحسب المخططات والمواصفات وشمولية العمل والسعر المبينة أدناه. • الألوان المتجانسة حسب اختيار المهندس وأن يكون سليم الحواف والزوايا وخالي من الفتال. • التثبيت بمونة الإسمنت والرمل بنسبة (1/3) أو اللاصق حسب المخططات وتوجيهات المهندس. • الترويب بروبة جاهزة الصنع خاصة و بالألوان المطلوبة. • الجلي والتلميع بالمصنع للأحرف الظاهرة والتنظيف بعد التركيب كل ما يلزم لإنجاز العمل على اكمل وجه حسب المخططات والمواصفات وتعليمات المهندس. أ- باتيل **أفقي** للأرضيات وبسطات الأدراج بارتفاع 10سم.	م.ط
	ب- باتيل **مائل للأدراج** موازٍ لأنوف الدرج نفس لون ونوع جرانيت الدرج والكيل وشمولية السعر حسب بند 817/8 من الباب الثامن مع مراعاة متطلبات م.ق.أ/618/1989 **ارتفاع الباتيل 10 سم عند أنف الدرجة**	م.ط

639





640

Doors and Windows

- Window and curtain wall frames may be made of
  - Wood
  - Steel
  - Aluminum
  - Bronze
  - Stainless steel
  - Plastic

641

- Each material has its particular types of installation and finishes, but from the estimator's viewpoint, there are two basic types of windows
  - Stock
  - Custom-made
- Custom-made and stock windows should require shop drawings so that the manufactured sizes will be coordinated with the actual job conditions

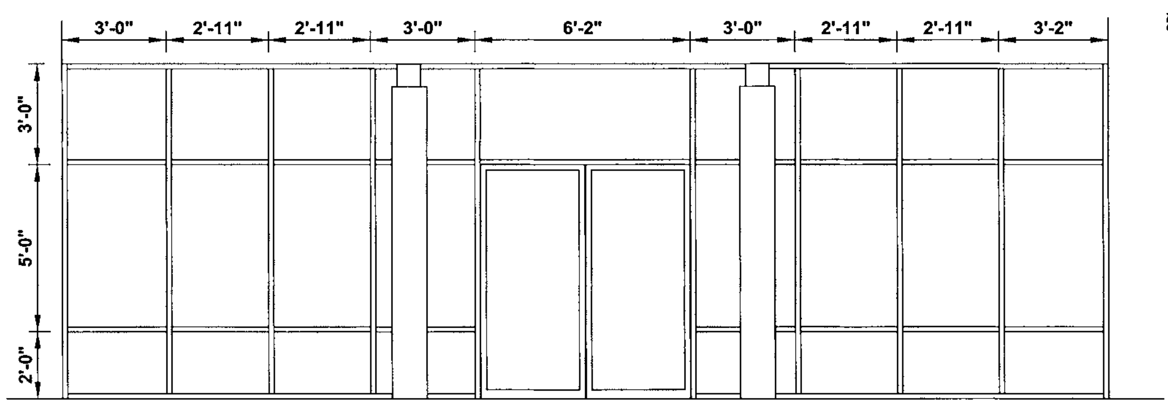
642

WINDOW SCHEDULE		
MARK	SIZE	TYPE / DESCRIPTION
1	6'-0" X 5'-0"	WOOD CASEMENT
2	4'-0" X 3'-0"	WOOD CASEMENT
3	3'-0" X 4'-0"	WOOD CASEMENT
4	4'-0" X 4'-0"	WOOD CASEMENT

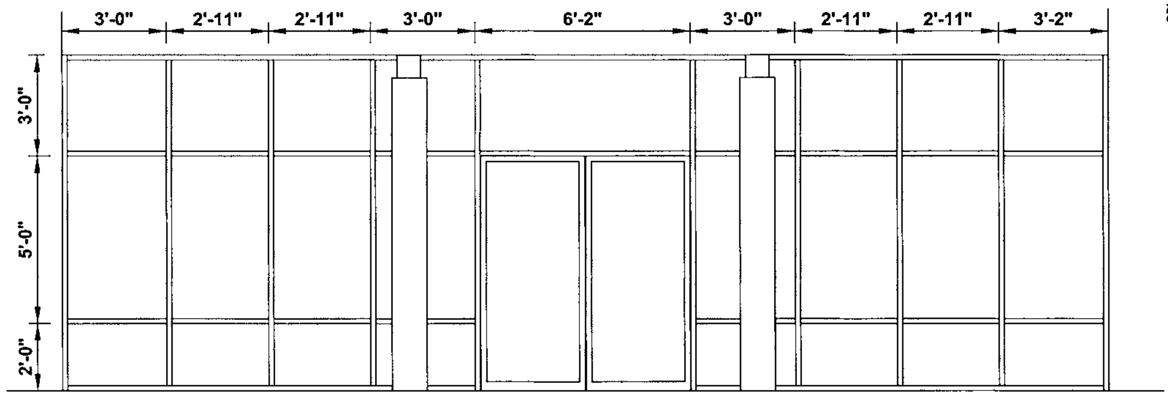
WINDOW SCHEDULE					
MARK	TYPE	SIZE	MATERIAL	DESCRIPTION	REMARKS
1	A	30X70	ALUMINUM	FIXED GLASS	
2	A	30X70	ALUMINUM	FIXED GLASS	
3	A	30X70	ALUMINUM	FIXED GLASS	
4	A	30X70	ALUMINUM	FIXED GLASS	
5	A	30X70	ALUMINUM	FIXED GLASS	
8	A	30X70	ALUMINUM	FIXED GLASS	
9	A	30X70	ALUMINUM	FIXED GLASS	
11	B	30X70	ALUMINUM	SINGLE HUNG	
12	B	30X70	ALUMINUM	SINGLE HUNG	
13	A	30X70	ALUMINUM	FIXED GLASS	
14	A	30X70	ALUMINUM	FIXED GLASS	
15	A	30X70	ALUMINUM	FIXED GLASS	
16	A	30X70	ALUMINUM	FIXED GLASS	
17	A	30X70	ALUMINUM	FIXED GLASS	
18	A	30X70	ALUMINUM	FIXED GLASS	
19	A	30X70	ALUMINUM	FIXED GLASS	

643

- Perform a takeoff of the materials for the storefront glass required for the building entrance



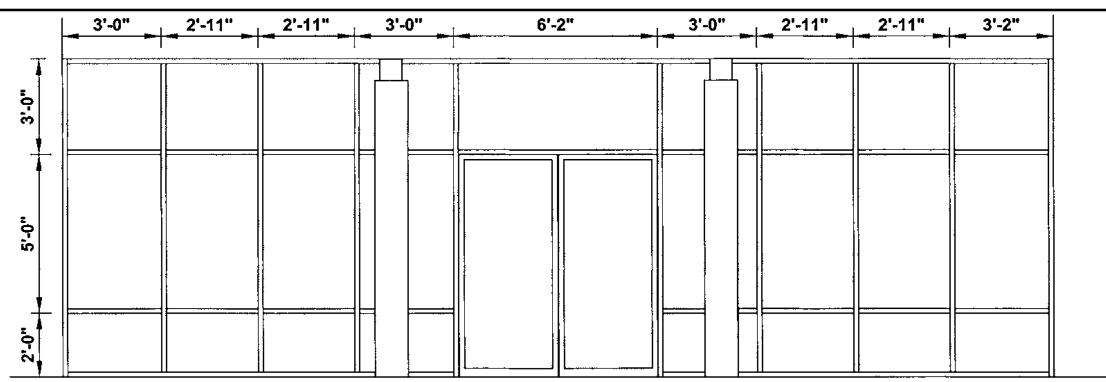
644



Length	Pcs.	Linear Ft.
10'-0"	10	100
3'-0"	12	36
2'-11"	16	47
3'-2"	4	13
6'-2"	2	13
Total l.f.		209

Aluminum Tubing Takeoff

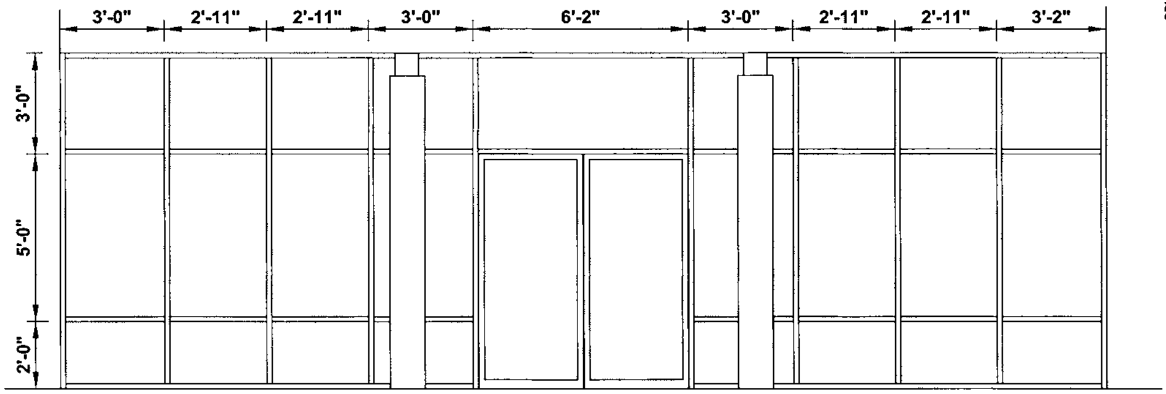
645



Size	Pcs.	s.f. Ea.	Total s.f.
3'-0" X 3'-0"	3	9	27
3'-0" X 5'-0"	3	15	45
3'-0" X 2'-0"	3	6	18
2'-11" X 3'-0"	4	8.75	35
2'-11" X 5'-0"	4	14.5	58
2'-11" X 2'-0"	4	5.8	23
3'-2" X 3'-0"	1	9.5	9.5
3'-2" X 5'-0"	1	15.8	15.8
3'-2" X 2'-0"	1	6.3	6.3
6'-2" X 3'-0"	1	18.5	18.5

Glass Takeoff

646



Metal Curtain Walls	S.F per Labor Hours
Up to 1 Story High	8 to 18
1 to 3 Stories	6 to 12
Over 3 Stories	6 to 10

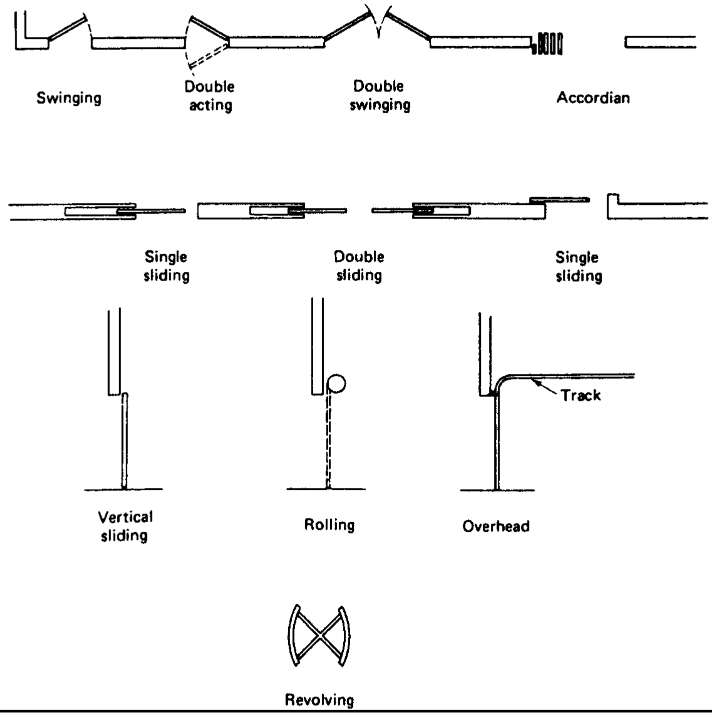
Productivity Rates

647

- Doors are generally classified as interior or exterior, although exterior doors are often used in interior spaces
- The list of materials of which doors are made includes
  - Wood
  - Aluminum
  - Steel
  - Glass
  - Stainless steel
  - Bronze
  - Copper
  - Plastics
  - Fiberglass

648

- Doors are also grouped according to the mode of their operation



649

DOOR SCHEDULE		
MARK	SIZE	TYPE / DESCRIPTION
1	6'-0" X 6'-8"	SOLID W/ SIDELITES
2	6'-0" X 6'-8"	ALUM & GLASS
3	2'-8" X 6'-8"	WOOD HOLLOW CORE
4	3'-0" X 6'-8"	WOOD SOLID CORE
5	2'-4" X 6'-8"	WOOD HOLLOW CORE
6	7'-0" X 8'-0"	O/H DOOR
7	2 - 2'-6" X 6'-8"	BYPASS HOLLOW CORE

DOOR SCHEDULE						
MARK	TYPE	SIZE	RATING (IN MINUTES)	MATERIAL	HW #	REMARKS
101	B	60X70X1-3/4		ALUMINUM	2	
102	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
103	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
104	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
105	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
106	A	30X70X1-3/4		METAL	3	
107	D	40X70X1-3/4	60 MIN	LAM PLAST	4	
108	D	40X70X1-3/4	60 MIN	LAM PLAST	4	
109	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
110	A	30X70X1-3/4	60 MIN	LAM PLAST	1	
111	A	30X70X1-3/4	60 MIN	LAM PLAST	5	
112	A	30X70X1-3/4	60 MIN	LAM PLAST	5	
113	A	30X70X1-3/4	60 MIN	LAM PLAST	5	

650

- Unit of measurement
  - Each
  - Area (m^2/SF). Waste may be added

<u>بالمتر المربع:</u>
تقديم وتركيب **أبواب منجور (Flush Doors)** درفة واحدة أو درفتين كبس حراري بحيث تكون الحشوات سويد صنف أول وذلك حسب المواصفات والمخططات وشمولية السعر والعمل المبينة لما يلي وكما هو موضح في مخطط تفاصيل الأبواب:

- الحلق الرئيسي للباب من الواح حديدية سوداء سمك (2) ملم وبعرض الجدار وزيادة (1) سم بعد القصارة يتم تشكيلها بطريقة التطعيج الميكانيكي بالشكل المبين بالمخططات وتعبأ خلف الحلق والجدار والعتبات العلوية بمونة إسمنتية درجة (15) بحيث لا يسمح بوجود الفراغ وتكون مدكوكة جيداً.
- يتم تثبيت الحلق بالجدار بواسطة براغي ستانلس ستيل خاصة Roll Plug حسب توجيهات المهندس كما يتم دهان الحلق بدهان زياتي مطفي او لميع ثلاثة وجوه عدا وجه التأسيس وباللون المطلوب.
- الحلق الرئيسي للدرف من جميع الجهات العمودية والأفقية من خشب السويد ذات مقطع (3.5*10) سم يتم تلبيسه بالواح خشب معاكس من الجهتين سمك (5 ملم) من اجود الاصناف مع حشوات داخلية من خشب السويد ذات مقطع (3.5*2.5) سم بحيث تكون مساحة الحشوات تساوي مساحة الفراغ ومثقبة عاموديأ للتهوية.

651

<u>بالمتر الطولي:</u>
تقديم وتركيب دربزينات للأدراج وللغرف الصفية حسب الأماكن المبينة بالمخططات المعمارية، من حديد مربوع 20×20 ملم مصمت مع شمسات نحاسية مصمنة 6×6×3 سم مصقولة والسعر يشمل مقبض من خشب مهوجوني مصمت 8×6 سم مثبت على حديد مبسط (5*40) ملم.
لسعر يشمل للدهان للهيكل المعدني اساس همر وجهين على الاقل و دهان تشطيب زياتي همر مبخوخ حراريا وجهين حسب اللون المعتمد و يشمل السعر الجلخ و التنظيف بواسطة القذف الرملي مع كل ما يلزم لإنجاز العمل على اكمل وجه حسب المخططات والمواصفات

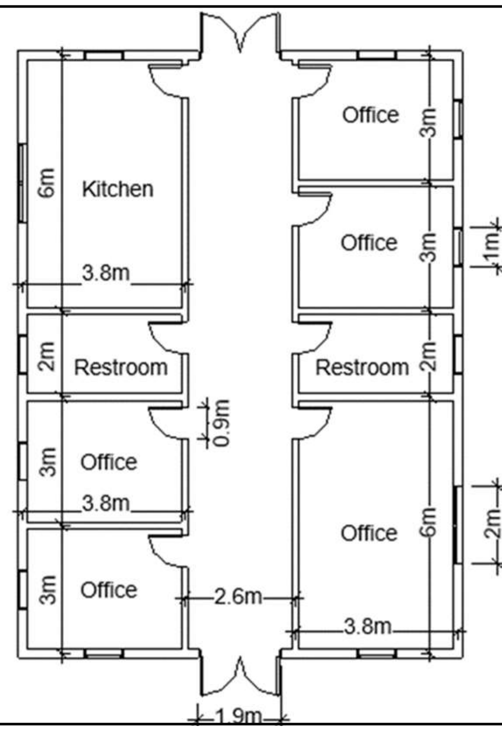
يشمل السعر دهان الخشب سلر ولكر وجهين لكل نوع
يشمل السعر التثبيت بالجدران والأرضية بواسطة بليتات وشمسات حسب التفاصيل المبينة بالمخططات مع براغي رول بلاك من الستانلس ستيل عدد (4) بسمك لا يقل عن 6 ملم وحسب ما هو مبين بالمخططات مع كل ما يلزم لانجاز العمل على اكمل وجه حسب المخططات والمواصفات.
السعر يشمل جميع الإكسسوارات اللازمة لإتمام العمل على أكمل وجه وذلك حسب التفاصيل المعمارية وتعليمات المهندس المشرف

652

- The sides of the door frame are called the jambs; the horizontal pieces at the top are called the heads
- When frames are ordered, the size and type of the door, the hardware to be used, and the swing of the door all must be known
- Standard frames may be acceptable on some jobs, but often special frames must be made
- The estimator must be aware of this item and how it may affect the flow of progress on the project

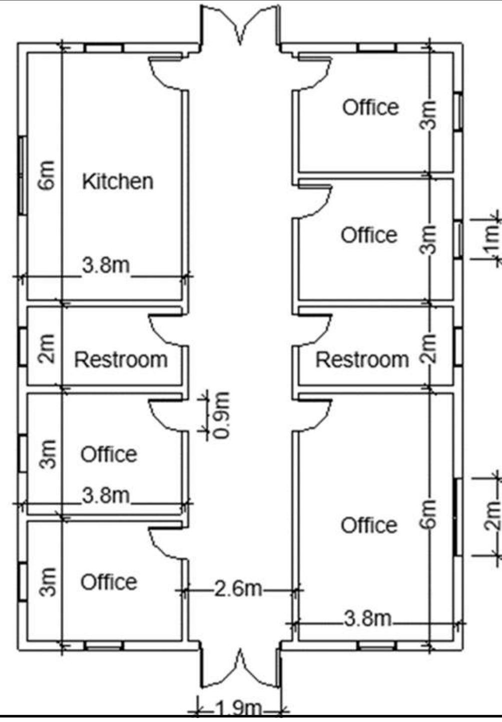
653

- Determine the area of internal plastering for walls and ceilings
- Wall dimensions are center to center
- Exterior wall thickness: 25 cm
- Interior wall thickness: 15 cm
- Small window: 1 m x 1.2 m
- Large window: 2 m x 1.5 m
- Exterior door: 1.9 m x 2 m
- Interior door: 0.9 m x 1.9 m
- Height to ceiling (structural): 3.5 m
- Slab thickness: 0.2 m
- Allowance for height of one brick (20 cm)
- Allowance for window sides



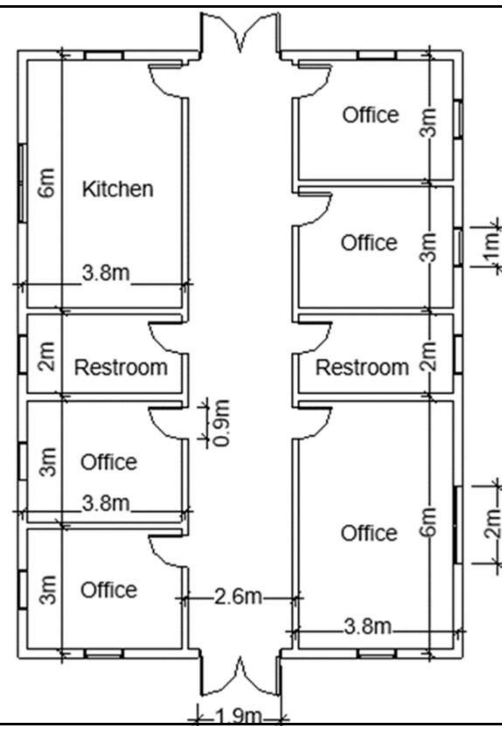
654

- Internal plastering (walls)
  - Kitchen
    - 2 x[3.8 – (0.25/2) – (0.15/2)] + 2 x[6 – (0.25/2) – (0.15/2)] = 2(3.6) + 2(5.8) = 18.8 m
    - Area = 18.8 x (3.5 – 0.2) = 62.04 m^2
    - Net area = 62.04 – 2 x 1.5 – 1x1.2 – 0.9 x 1.9 = 56.13 m^2
    - Window sides = [2 x 0.25 x (2 +1.5)]+ [2 x 0.25 x (1 +1.2)] = 1.75 + 1.1 = 2.85 m^2
    - Total for kitchen = 56.13 + 2.85 = 58.98 m^2
  - Large office = 58.98 m^2



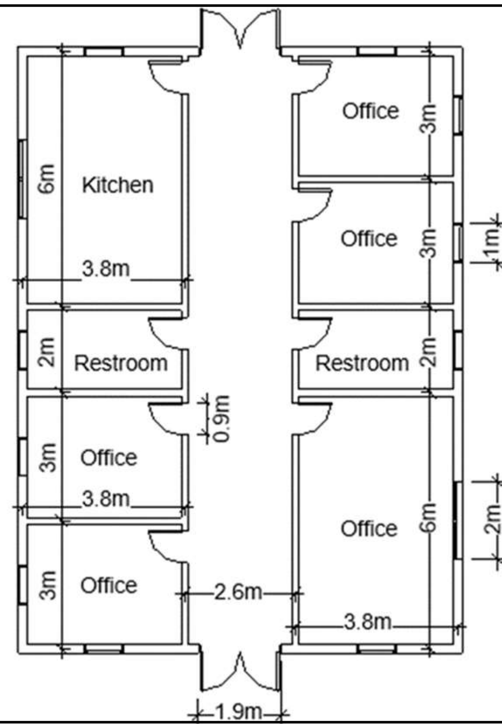
655

- Internal plastering (walls)
  - Small corner office (2 windows)
    - 2 x[3.8 – (0.25/2) – (0.15/2)] + 2 x[3 – (0.25/2) – (0.15/2)] = 2(3.6) + 2(2.8) = 12.8 m
    - Area = 12.8 x (3.5 – 0.2) =42.24 m^2
    - Net area = 42.24 – 2x1x1.2 – 0.9 x 1.9 = 38.13 m^2
    - Window sides = 2[2 x 0.25 x (1 +1.2)] = 2.2 m^2
    - Total for corner office = 38.13 + 2.2 = 40.33 m^2
  - Repetition = 2 x 40.33 m^2 = 80.66 m^2



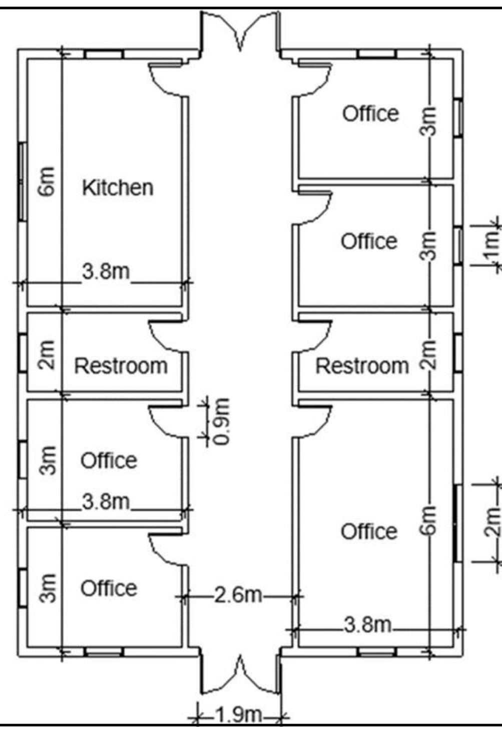
656

- Internal plastering (walls)
  - Small office (1 window)
    - 2 x[3.8 – (0.25/2) – (0.15/2)] + 2 x[3 – 2(0.15/2)] = 2(3.6) + 2(2.85) = 12.9 m
    - Area = 12.9 x (3.5 – 0.2) =42.57 m^2
    - Net area = 42.57 –1x1.2 – 0.9 x 1.9 = 39.66 m^2
    - Window sides = 2 x 0.25 x (1 +1.2) = 1.1 m^2
    - Total for office = 39.66 + 1.1 = 40.76 m^2
  - Repetition = 2 x 40.76 m^2 = 81.52 m^2



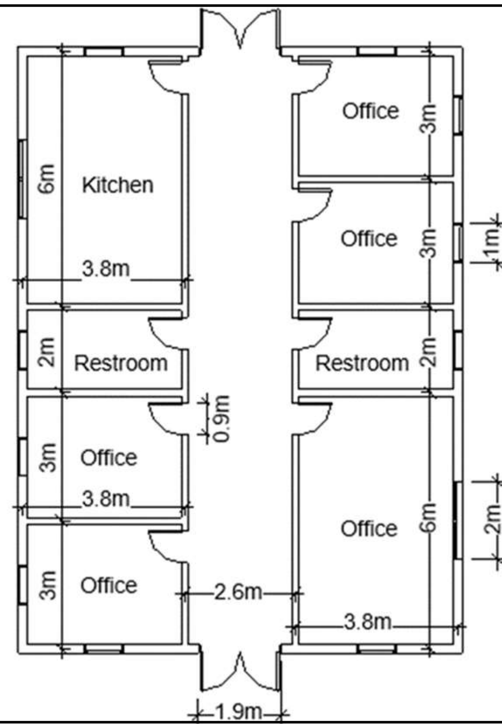
657

- Internal plastering (walls)
  - Restroom
    - 2 x[3.8 – (0.25/2) – (0.15/2)] + 2 x[2 – 2(0.15/2)] = 2(3.6) + 2(1.85) = 10.9 m
    - Area = 10.9 x (3.5 – 0.2) = 35.97 m^2
    - Net area = 35.97 – 1x1.2 – 0.9 x 1.9 = 33.06 m^2
    - Window sides = 2 x 0.25 x (1 +1.2) = 1.1 m^2
    - Total for restroom = 33.06 + 1.1 = 34.16 m^2
  - Repetition = 2 x 34.16 m^2 = 68.32 m^2



658

- Internal plastering (walls)
  - Corridor
    - 2 x[2.6 – 2(0.15/2)] + 2 x[14 – 2(0.25/2)] = 2(2.45) + 2(13.75) = 32.4 m
    - Area = 32.4 x (3.5 – 0.2) = 106.92 m^2
    - Net area = 106.92 – 2x1.9x2 – 8x0.9 x 1.9 = 85.64 m^2
    - Total for corridor = 85.64 m^2
  - Total Internal plastering (walls) = 2(58.98) + 80.66 + 81.52 + 68.32 + 85.64 = 434.1 m^2

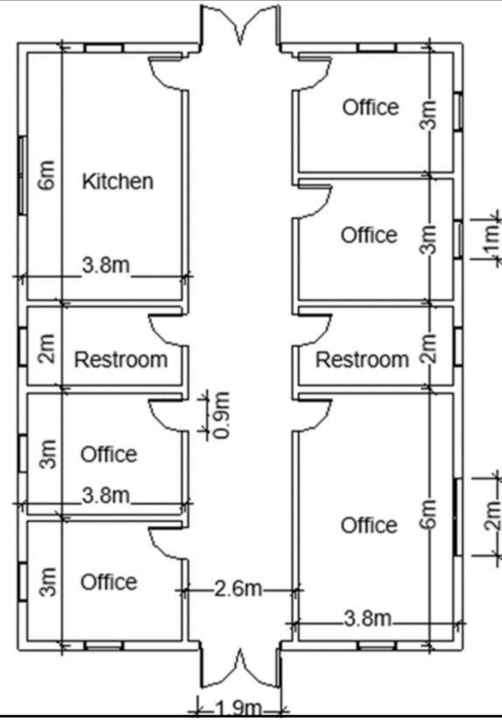


659

- Internal plastering (ceilings)
  - Kitchen = 3.6 x 5.8 = 20.88 m^2
  - Large office = 20.88 m^2
  - Small corner office = 2 (3.6 x 2.8) = 20.16 m^2
  - Small office = 2 (3.6 x 2.85) = 20.52 m^2
  - Restroom = 2 (3.6 x 1.85) = 13.32 m^2
  - Corridor = 2.45 x 13.75 = 33.69 m^2
- Total Internal plastering (ceilings) = 129.45 m^2
- Total Internal plastering (walls and ceilings) = 434.1 + 129.45 = 563.55 m^2

660

- Determine the area of external plastering
- Wall dimensions are center to center
- Exterior wall thickness: 25 cm
- Interior wall thickness: 15 cm
- Small window: 1 m x 1.2 m
- Large window: 2 m x 1.5 m
- Exterior door: 1.9 m x 2 m
- Interior door: 0.9 m x 1.9 m
- Height to ceiling (structural): 3.5 m
- Slab thickness: 0.2 m
- Allowance for height of one brick (20 cm)
- Allowance for window sides

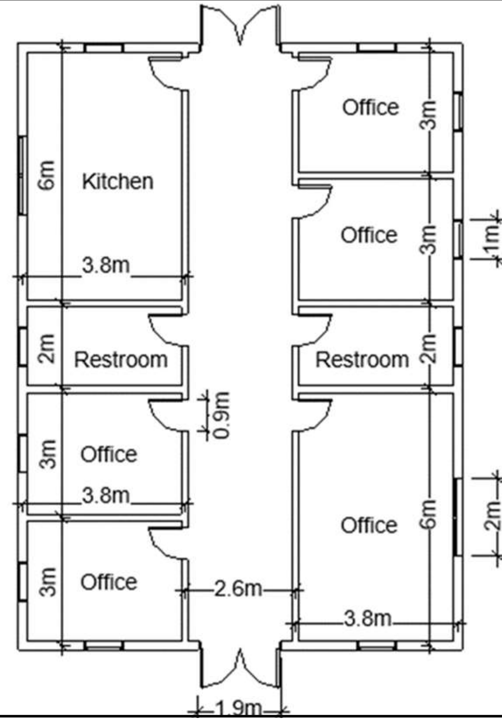


661

- External plastering
  - $2(3.8 + 2.6 + 3.8 + 0.25) + 2(6+2+3+3+0.25) = 2(10.45) + 2(14.25) = 49.4$ m
    - Area = $49.4 \times (3.5 + 0.2) = 182.78$ m^2
    - Net area = $182.78 - 2\text{x}1.9\text{x}2 - 10\text{x}1\text{x}1.2 - 2\text{x}2\text{x}1.5 = 157.18$ m^2
- Total external plastering = 157.18 m^2

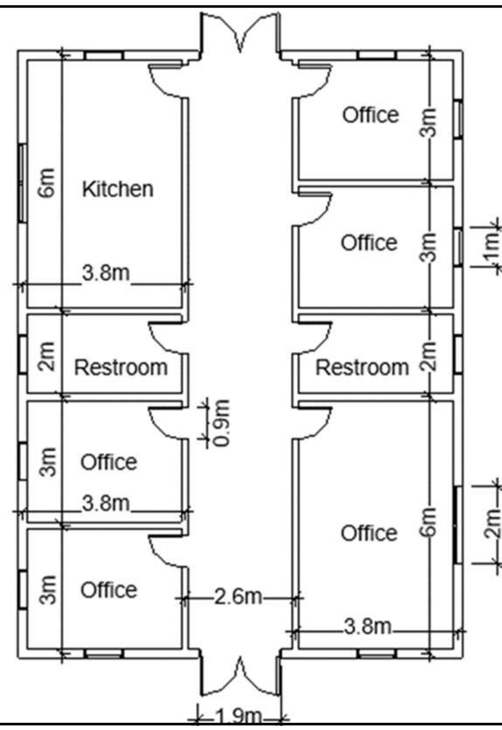
662

- Determine the area of internal painting
  - Semi gloss paint (3 coats): corridor walls at 1.6 m high
  - Emulsion paint: walls and ceilings (except kitchen and restroom walls)
  - Note the difference when calculating area of painting: semi gloss paint (3 coats) and semi gloss paint (1 coat)
- Determine the area of flooring
  - Floor tiles
  - Wall tiles (kitchen ad restrooms)



663

- Painting
  - Semi gloss paint
    - Area = 32.4 x 1.6 = 51.84 m^2
    - Net area = 51.84 – 2x1.9x1.6 – 8x0.9 x 1.6 = 34.24 m^2
  - Emulsion paint (walls and ceilings)
    - 563.55 - 34.24 - 56.13 – 2(33.06) = 407.06 m^2

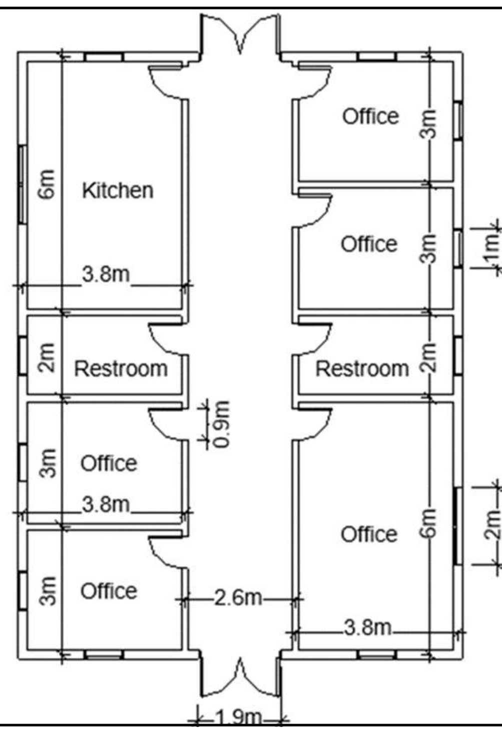


664

5/	**بالمتر المربع:** تقديم وتركيب عتبات وجبه جرانيت محلي وباللون الذي يحدده المهندس المشرف والذي يتناسب مع الوان ارضيات البورسلان حسب ما هو مبين بالمخططات ومطابق للمواصفات القياسية الأردنية (م.ق.أ / 851) وشمولية السعر حسب البند (817/10) كما يشمل السعر البرم والتنظيف والتكحيل بالروبة الخاصة مع عمل الحروف والميول المناسبة وكل ما يلزم لإنجاز الأعمال حسب المخططات والمواصفات وتعليمات المهندس أ- عتبات جرانيت محلي لمداخل الوحدات الصحية والادراج الجانبية والمصاعد وحسب الاماكن المبينة بالمخططات المعمارية .			

665

- Flooring
  - Floor tiles: 129.45 + 8(0.15x0.9) + 2 (0.25x1.9) =131.48 m^2
  - Wall tiles (kitchen ad restrooms): 56.13 + 66.12 = 122.25 m^2



666

- Determine the following costs
- Plastering
  - Internal plastering (3 coats for walls and ceilings (except kitchen and restroom walls)): \$12/ m^2
  - Internal plastering (2 coats for kitchen and restroom walls): \$10/m^2
- Painting
  - Semi gloss paint: \$6/ m^2
  - Emulsion paint (walls and ceilings): \$5.3/ m^2

667

- Determine the following costs
- Tiling
  - Floor tiles (30 x 30 cm): \$25/ m^2
  - Ceramic wall tiles (20 x 40 cm): \$22/ m^2
  - Skirting: \$6.7/m (linear meter)
  - Grout joints 3 mm for all tiling works (floor and walls)
- Aluminum window: \$98/ m^2
- Galvanized security iron for windows: \$51/ m^2
- Interior wooden door: \$340/each
- Exterior steel door: \$370/m^2

668

- Plastering
  - Internal plastering (3 coats for walls and ceilings (except kitchen and restroom walls)): [563.55 - 56.13 – 2(33.06)] x $12/ m^2 = $5,295.6
  - Internal plastering (2 coats for kitchen and restroom walls) = [56.13 + 2(33.06)] x $10/m^2 = $1,222.25
- Painting
  - Semi gloss paint= 34.24 x $6/m^2 = $205.44
  - Emulsion paint (walls and ceilings)= 407.06 x $5.3/m^2 =$2,157.42

669

- Tiling
  - Floor tiles (30 x 30 cm) = 131.48 x $25/ m^2 = $3,287
  - If number of floor tiles is required
    - Area of 1 floor tile = (0.3m+0.003m)^2 = 0.091809 m^2
    - Number of floor tiles required = 131.48/ 0.091809 = 1,432.1 (1,433)
  - Ceramic wall tiles (20 x 40 cm)= 122.25 x $22/ m^2 = $2,689.5
  - Skirting = [(18.8 – 0.9) + 2(12.8 – 0.9) + 2(12.9 - 0.9) + (32.4 - 2x1.9 - 8x0.9)] x $6.7/m = 87.1 m x $6.7/m = $583.57

670

- Aluminum window = [(10 x 1 m x 1.2 m) + (2 x 2 m x 1.5 m)] x \$98/ m^2 = 18 m^2 x \$98/ m^2 = \$1,764
- Galvanized security iron for windows=18m^2 x \$51/ m^2 = \$918
- Interior wooden door = 8 x \$340/each = \$2,720
- Exterior steel door = 2(1.9 m x 2 m) x \$370/m^2 = \$2,812

671

Electrical Work

- Before beginning the takeoff, the contractor should
  - Review the plans
  - Carefully read the specifications
- Often the specifications will require that all work and installations be in conformance with all applicable national and local codes
- This statement means that contractors are responsible for compliance with the laws; if they are responsible for them, then they better be familiar with them

672

- The codes contain information regarding wiring methods and materials, equipment, and other information

DESCRIPTION
This bill of quantities shall be read along with electrical drawings and electrical specifications The unit price shall include the price of materials installation, testing, operation and maintenance in any place and level in the project .

Rough Estimating

- Can be completed with a minimum amount of information and a small expenditure of time
- RSMEANS

50 17 | Square Foot Costs

				UNIT COSTS			% OF TOTAL		
		50 17 00 | SF Costs	**UNIT**	**1/4**	**MEDIAN**	**3/4**	**1/4**	**MEDIAN**	**3/4**
01	0010	**APARTMENTS Low-Rise (1 to 3 story)**	SF	73	92.50	123			
	0020	Total project cost	CF	6.55	8.70	10.75			
	0100	Site work	SF	5.35	8.55	15	6.05%	10.55%	13.95%
	0500	Masonry		1.44	3.55	5.80	1.54%	3.92%	6.50%
	1500	Finishes		7.75	10.65	13.15	9.05%	10.75%	12.85%
	1800	Equipment		2.40	3.63	5.40	2.71%	3.99%	5.95%
	2720	Plumbing		5.70	7.30	9.30	6.65%	8.95%	10.05%
	2770	Heating, ventilating, air conditioning		3.63	4.47	6.55	4.20%	5.60%	7.60%
	2900	Electrical		4.25	5.65	7.65	5.20%	6.65%	8.35%
	3100	Total: Mechanical & Electrical	↓	15.10	19.60	24	16.05%	18.20%	23%
	9000	Per apartment unit, total cost	Apt.	68,000	104,000	153,500			
	9500	Total: Mechanical & Electrical	"	12,900	20,300	26,500			

Detailed Estimating (Unit Price)

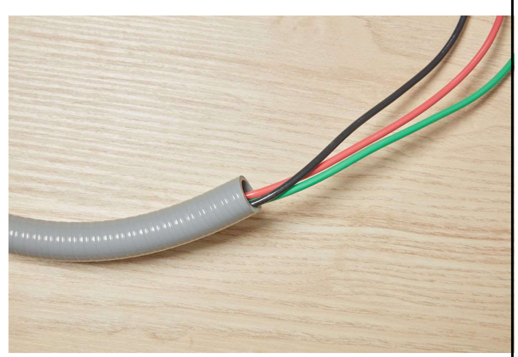
26 51 Interior Lighting

26 51 13 - Interior Lighting Fixtures, Lamps, and Ballasts

26 51 13.50 Interior Lighting Fixtures		Crew	Daily Output	Labor-Hours	Unit	2014 Bare Costs Material	Labor	Equipment	Total	Total Incl O&P
5500	12", four 60 watt lamps	1 Elec	6.70	1.194	EA	69.50	63.50		133	172
5510	Pendant, round, 100 watt		8	1		111	53.50		164.50	202
5520	150 watt		8	1		121	53.50		174.50	213
5530	300 watt		6.70	1.194		169	63.50		232.50	282
5540	500 watt		5.50	1.455		320	77.50		397.50	465
5550	Square, 100 watt		6.70	1.194		149	63.50		212.50	260
5560	150 watt		6.70	1.194		156	63.50		219.50	267
5570	300 watt		5.70	1.404		227	75		302	360
5580	500 watt		5	1.600		310	85.50		395.50	470
5600	Wall, round, 100 watt		8	1		64.50	53.50		118	151
5620	300 watt		8	1		113	53.50		166.50	204
5630	500 watt		6.70	1.194		375	63.50		438.50	505
5640	Square, 100 watt		8	1		102	53.50		155.50	192
5650	150 watt		8	1		104	53.50		157.50	194
5660	300 watt		7	1.143		164	61		225	272
5670	500 watt		6	1.333		288	71		359	420

675

- The wiring is considered the rough work, and the fixtures are considered the finish work
- The wiring will usually be concealed in a conduit, which is installed throughout the building as it is erected
- The wiring is pulled through the conduit later in the job
- The fixtures are usually the last items to go into the building, often after the interior finish work is complete



676

- It is the estimator’s job to determine exactly where the responsibility begins for the wiring
- Does it begin at the property line, at the structure, or 10 feet from the structure?
- If a transformer is required, who pays for it, who installs it, and who provides the base on which it will be set?

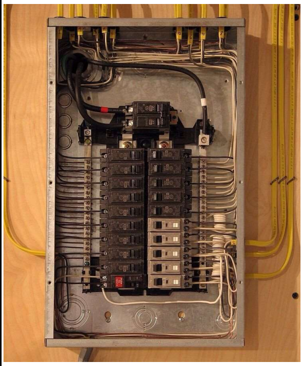
677

Generators and Transformers

Generators
Number:
Supply ,install ,connect and commission (185 kVA),400,50Hz, super silent with sound proof canopy stand by diesel generator set complete with related ATS, fittings, exhaust chimney to outdoor with its louver at the top daily diesel tank and all related works according to manufacturer's recommendations ,and all related accessories ,as detailed in technical specifications and as shown in drawings.

678

Panels and Switchboards



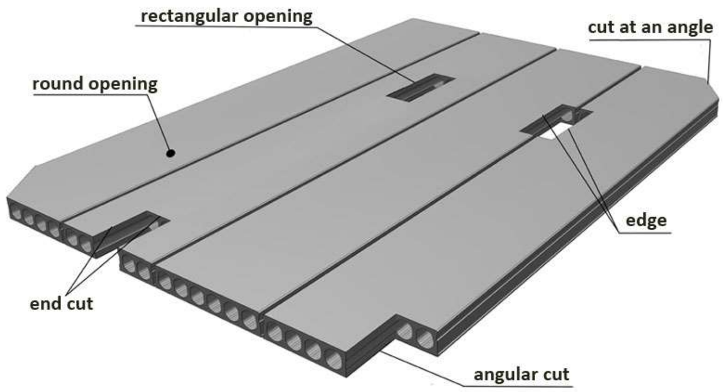
Electrical Distribution Board
Number:
Supply, install, connect & commission panel boards including all necessary civil works, ducts, .etc., as shown in drawings & specifications
a- Distribution Board, 3-phase, (48MCB-SP) or (16 MCB-TP) complete with main isolator switch as shown in drawings and specifications, (DB-TL1-P)

679

- Different types of construction affect the installation of rough and finish work
- When using steel joists, there is usually ample space through which to run conduits easily
- Cast-in-place concrete requires that there be closer cooperation between the general contractor and the electrical contractor, because the conduit often must be cast in the concrete

680

- The use of hollow-core precast concrete causes other problems, such as where to run the conduit and how to hang fixtures properly
- The conduit can be run in the holes (or joints) that are in the direction of the span, but care must be taken to run them in other directions unless the conduit can be exposed in the room



681

- Major areas of coordination required between the electrical (subcontractor) and general contractors
  - Underground utilities: location, size, excavation by whom, from where?
  - Distribution: in walls, under floor, overhead
  - Fixtures: material, location, finish, color
  - Scheduling: When electrical work packages start and finish

682

- Coordination of work among the electrical, HVAC, and plumbing contractors themselves is also important, since the electrical, HVAC, and plumbing contractors may all have work to do on a particular piece of equipment
- For example, the HVAC contractor may install the boiler unit in place, the electrical contractor may make all power connections, and the plumbing contractor may connect the water lines

683

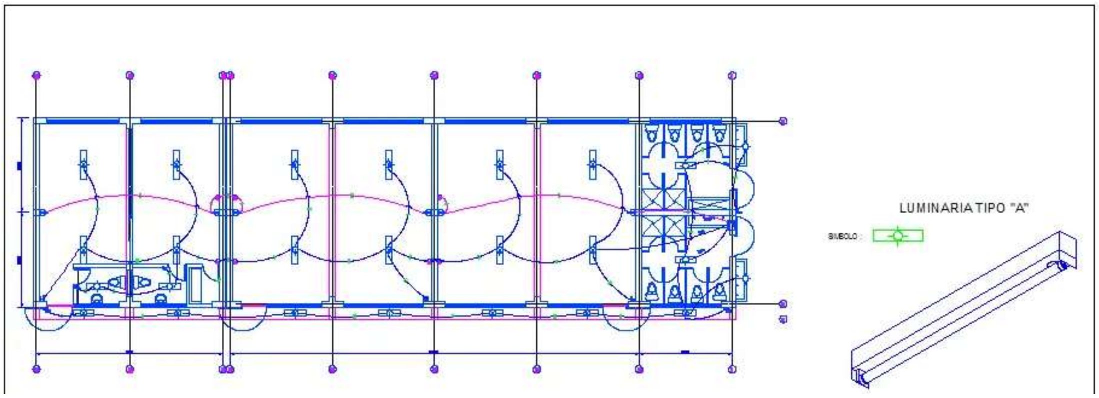
Counting Light Fixtures

- On a work sheet, list all of the light fixtures by their designation type, the number and type of lamps in the fixture, and how the fixture is to be mounted

Light Fixtures			Total	E-1	E-2	E-3		
A	4-F40/CW	R						
B	1-100/IF	W						
C	1-75/R40	S						
D	2-F96/HO	P						
E	Included	S						

684

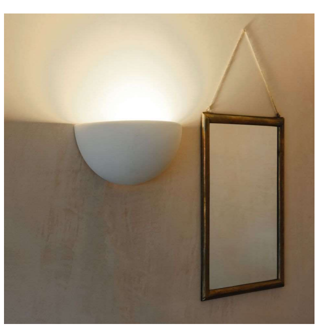
Lighting Fixtures
Supply, install, connect & commission the following lighting fixtures complete with all accessories needed as specified and shown in drawings.
Number:



685

Pendant

Recessed

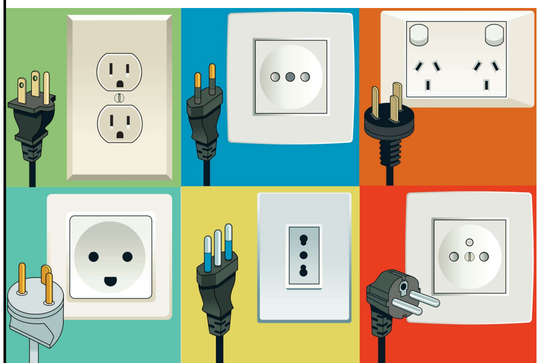


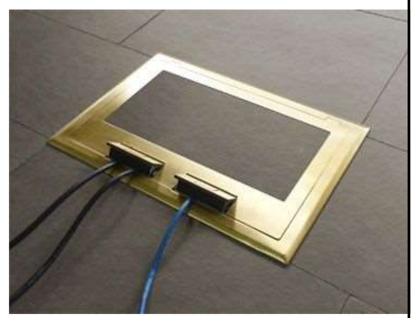
Wall

Surface

686

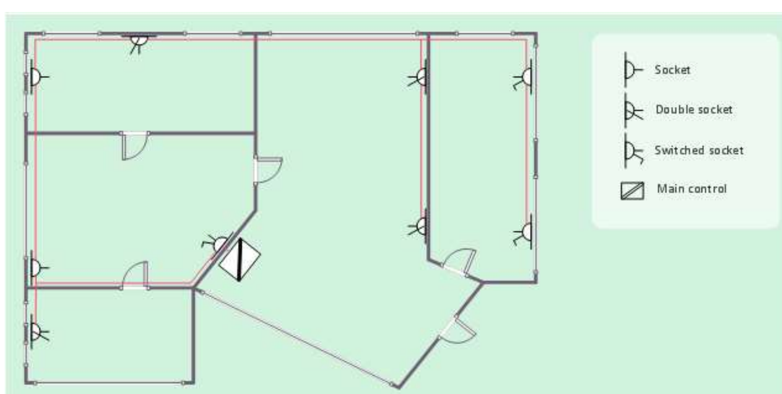
Counting Power Outlets, Phone Outlets, and Floor Boxes





687

Number:
Supply, install, connect &commission power socket outlets, (floor, ceiling or wall mounted) including conduits, conduit fittings, pull boxes, accessories and circuit wiring or cables between socket outlet up to its sub-panel board as specified and as shown in drawings.



688

Counting Switches

Single pole switch (controls one light fixture from a single location)

Three way switch (controls one fixture from two locations)

Four way switch (controls one fixture from three locations) Good option for large rooms with several entrances

Rotary dimmer switch

689

Cables and Wires

Meter Run:

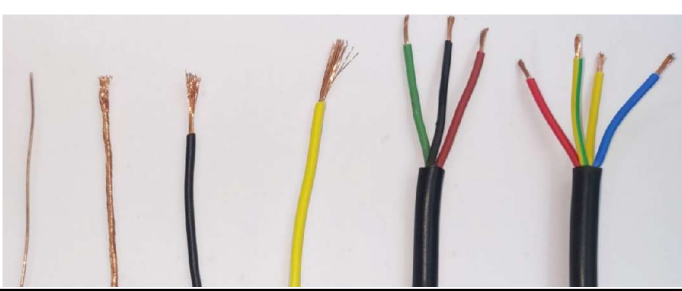
Supply, install, connect and commission main and sub-main feeders complete with conduits, pull boxes, fittings and all necessary materials and civil works needed in PVC Conduits for wires and cables in slabs & walls or on cable trays or cable ladders for cables in horizontal or vertical run, (price of cable trays or cable ladders are not included in price) according to drawings and specifications.

Isolating Switches:

Number:

Supply, install, connect & commission isolating switches including all necessary civil works, ducts, .etc and all accsessories needed as shown in drawings & specifications

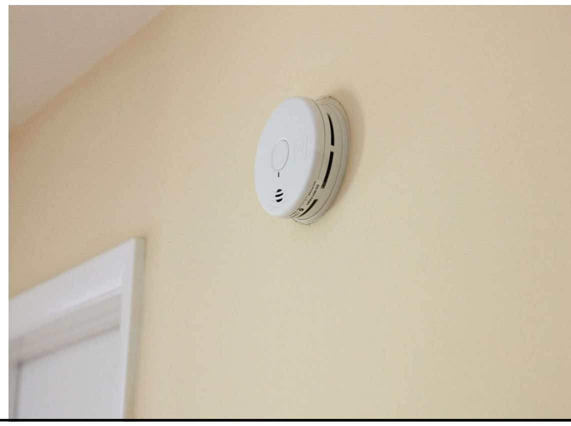
a-125A Isolating switch–TP in W.P. Enclosure (IP65) as specified .



690

Counting Special Systems

- For example, in a fire alarm system, the most predominant item may be the smoke detectors (count each detector)



691

Data System
Data cabinets
Number:
Supply, install, test, and commission the following data cabinets for complete work:

a- Main Data Rack (MDC) in server room at ground floor, 42U-39" wide free stand including UTP (4x24port) patch panel with power point and (3x24) fiber patch panel with space for layer 2 Edge switch (2x24ports) and space for layer 2 PoE switch (2x24ports) in addition to space for Server & core switch devices.

Fiber Optic Cables
Meter Run :
Supply ,install ,connect and commission fiber optic cables for data system as shown in drawings and specifications.

692

DESCRIPTION	UNIT	Qty
Elevators		
Number:		
supply , install, commission and maintain		
a- Electrical elevator for passengers with 21 passenger capacity, 1600 kg load.1.6 m/s speed, 4 stops, 4 openings, with all necessary equipment and accessories needed as specified and as shown in drawings .		
Two	No.	2
b- Electrical elevator for passengers with 10 passenger capacity, 1000 kg load , 1.0 m/s speed , 4 stops, 4 openings, with all necessary equipment and accessories needed as specified and as shown in drawings .		
One	No.	1

Earthing System
Lump Sum:
Supply, install, connect and commission a typical earthing system, including, copper tapes, earthing cables, earthing rods, earthing pits, covers, conductors and all accessories as specified and as shown in drawings.
a- For Main Distribution Board (Earthing resistance not to exceed 2 ohms).

693

Plumbing Work

- Using the working drawings and specifications, estimators prepare a complete list of everything that will be required
- First, they determine exactly where the responsibility for the plumbing begins
- It may begin at the property line, 10 feet outside the structure, at the structure, or somewhere else; they should always check so as to have a clear picture of the project in mind

694

- The takeoff for plumbing includes the costs of water pipes, gas pipes, sewer pipes, drains, and all rough work required for fixtures
- Information required includes size, length, pipe material, weight, and fittings (hangers, elbows, etc.)

695

- The trenches required for plumbing pipe, especially from the road to the building, may be the responsibility of the plumbing subcontractor or the general contractor
- If the general contractor is responsible for trenching, it should be noted as such on the estimate
- Pipe materials include cast iron, copper, galvanized, and plastic

696

Sinks
<u>Number:</u>
Supply, install, test and maintain as shown on specification and drawings (Balanco or equivalent) 0.8mm thickness stainless steel single bowl sinks, with single lever water mixer with stop mousseur and swivel spout (Grohe, Eurostyle or equivalent) . The price includes: all fittings, bottle traps, waste pipes, angle valves, flexible connections, drainage pipes & fittings of UPVC class-B push to fit with rubber between the fixtures and floor traps, cross-linked polythylene (PEX-A) pipes running in non-corrugated plastic sleeves for hot and cold water between fixtures and domestic water cabinets.

a- Single Bowl Sink (size 100x60cm)
Six.

Drainage System
MANHOLES
<u>Number:</u>
Supply, install, test and maintain as shown on drawings & specifications: Manholes for drainage and rain drain systems, totally water and air tight. Manhole walls and ground shall be covered with extra smooth plastering with semi circular channels inside consists of concrete grade not less than 18 N/mm2 and the surface to be trowelled well. channel diameters are equivalent to the connected pipes and with 15% slopes in the direction of the flow. Manholes deeper than 1.5 meters shall be supplied with galvanized steel ladders made of rods or pipes of at least 20 mm diameter. The walls and bed of the manhole shall be of concrate and at least 15 cm thick. Manhole covers shall be heavy duty (weight = 100 kg) cast iron coated with a grease material.

697

HVAC Work

- Heating, Ventilating, and Air-conditioning
- The takeoff includes piping, ductwork, and equipment
- The specifications will state who is responsible for trenching, both from the road to the building and within the building
- The takeoff list should include all equipment separately as to types and sizes
- Estimators need a general knowledge of heating, ventilating, and air-conditioning to understand the equipment involved

698

- There are many different systems that could be used on a building. If the estimator is unfamiliar with a system, it is wise to call the manufacturer's representative to get a full explanation
- In this way, the estimator will understand what is required of the general contractor and the subcontractor to guarantee a successful installation

699

HVAC System
Exhaust and Supply Air Fans
Number:
Supply, install, test and maintain as shown on drawings and as per specifications: Completely factory assembled centrifugal roof-mounted fans, in-line mixed flow or centrifugal fans and wall-mounted propeller fans. Roof Mounted fans shall be American made of the Alumium (Greenheck or equivalent). In-line fans and Small wall mounted and in-line fans shall be American or west Eouropean, propeller fans made of best quality plastic for capacity less than 150 L/sec (Greenheck, Manrose, S&P, Vortice). All wall mounted fans Shall incorporate back draught automatic motorized shutters, while roof mounted and in-line fans shall have gravity shutters.The price should include flexible canvas connections, electrical isolating switch (for roof – mounted fans), electrical and control connections, vibration isolators, sound absorbers or attenuator and all accessories required to put the fans in place and operate in excellent manner.

Packaged A/C unit
Number:
supply, install, test, commission and maintain as shown on drawings and as per specifications: complete Heat pump Roof-Top Packaged A/C Units (Carrier, Trane,York)of
~~single (DX - coil) with mixing box and~~ automatic dampers (Economizer). Units shall have low noise fans with speed does not exceed 900 rpm. Price shall include valves and controls, easily accessible flat and bag filters, anti- vibration R.C and including all accessories.

700

Construction Cost Analysis & Estimating – 110401543

Subcontractors

Dr. Mohammad Almashaqbeh
Department of Civil Engineering
Hashemite University

- The costs of labor, equipment, and materials constitute the bulk of what goes into most construction projects. When a particular task requires specialized skills, certain work items might be subcontracted
- Subcontractors may be individuals, companies, or corporations hired by the general contractor to do a particular portion of the work on the project
- It is common to subcontract at least some of the work on virtually every project

- It is typical for general contractors to include a provision in the subcontract agreements that payments will be made to the subcontractors only after the general contractor has received payment for that work from the owner
- This "pay when paid" provision essentially assures the general contractors that they will not suffer a negative cash flow on the subcontracted work
- The general contractor will commonly withhold a portion of the payments due to the subcontractor as retainage
- The retainage amount, stated as a percent of the amount due, is typically the same as the retainage withheld from the general contractor by the owner

703

- Subcontractors are available for all the different types of work required to build any project and include
  - Excavation, concrete, masonry (block, brick, stone), interior partitions, acoustical ceilings, painting, steel and precast concrete, windows, roofing, flooring, and interior wall finishes

704

- The list continues to include all materials, equipment, and finishes required
- The use of subcontractors to perform all of the work on the project is becoming an acceptable model in building construction (when permitted by law)
- The advantage of this model is that the general contractor can distribute the risk associated with the project to a number of different entities

705

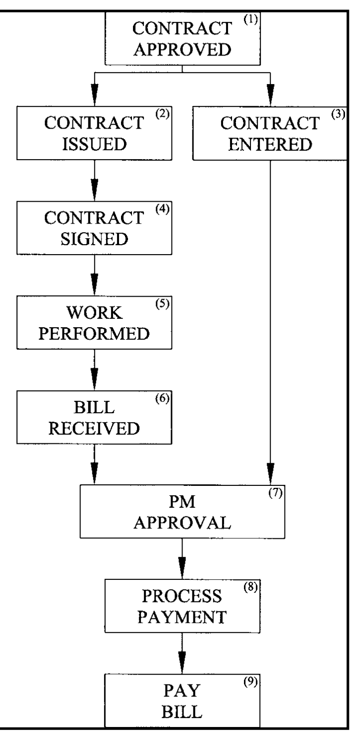
- However, the general contractor relinquishes a substantial amount of control over the project when this method is employed
- The more that the contractor subcontracts out, the more the field operation becomes involved in coordination rather than direct supervision of craft personnel
- The subcontractor carefully checks the drawings and project manual and submits a price to the construction companies that will be bidding on the project
- The price given may be a unit or lump sum price

706

- The subcontractor needs the completed estimate to determine what is a reasonable amount for overhead and profit
- Typically, as the quantity of work increases, the associated unit cost of jobsite overhead decreases
- If subcontractors submits a lump-sum bid, then they are proposing to install, or furnish and install, a portion of work: For example, the bid might state, “agrees to furnish and install all Type I concrete curbing for a sum of $12,785.”

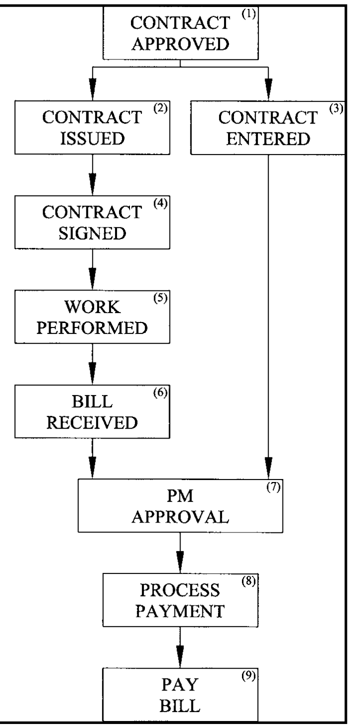
707

- Subcontracts may be processed as follows
- Contract approved (step 1)
  - The subcontractors’ bids are checked against the scope of work and the budget
  - After selecting the best bid, a subcontract is prepared and approved by the project manager



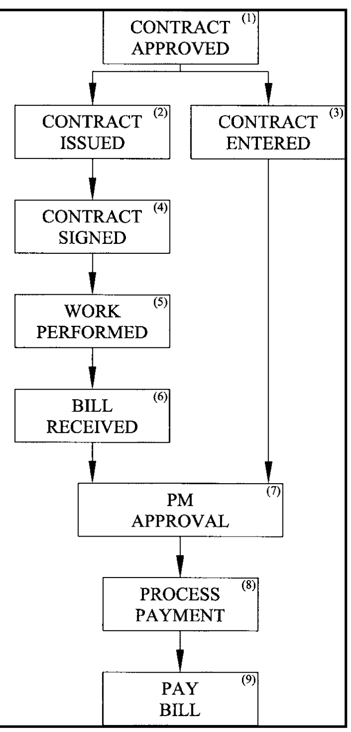
708

- Subcontracts may be processed as follows
- Contract approved (step 1)
  - This gives the project manager the opportunity to check the cost of the work against the budget, to seek other bids, make corrections to the scope of work, and negotiate the finer point of the contract before issuing the subcontract



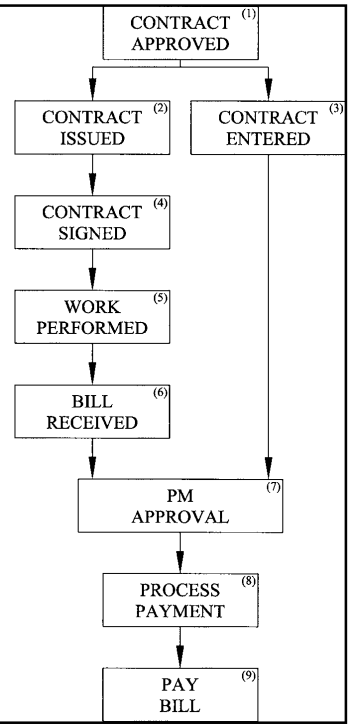
709

- Contract issued (step 2)
  - Once the check is completed, the contract is issued to the subcontractor
- Contract entered (step 3)
  - The contract (subcontract) is entered into the accounting system as a committed cost by the accounting department



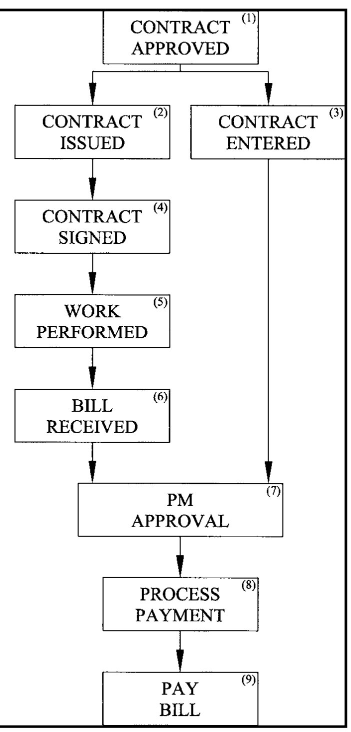
710

- Contract signed (step 4)
  - The project manager receives a signed contract from the subcontractor
- Work performed (step 5)
  - The project manager notifies the superintendent that the subcontractor can work on the project
  - The project manager should send the superintendent a copy of the contract so that the superintendent is aware of the contractor and subcontractor's responsibilities under the contract



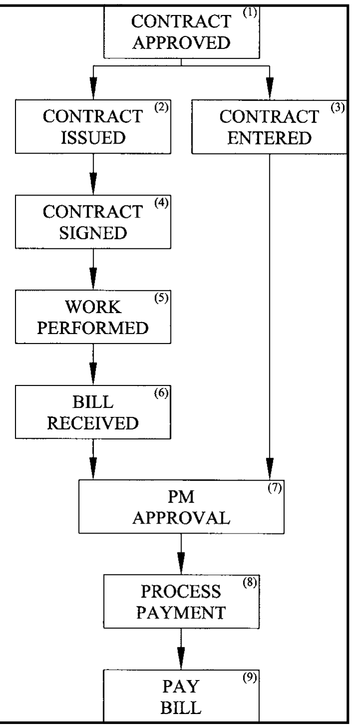
711

- Bill received (step 6)
  - At the end of a billing period, the subcontractor submits a progress bill to the contractor
- Project manager approval (step 7)
  - The project manager, often in consultation with the superintendent, reviews the bill and approves it for payment, resolving any differences in the amount of the work the subcontractor has billed for and the amount of the work performed on the job



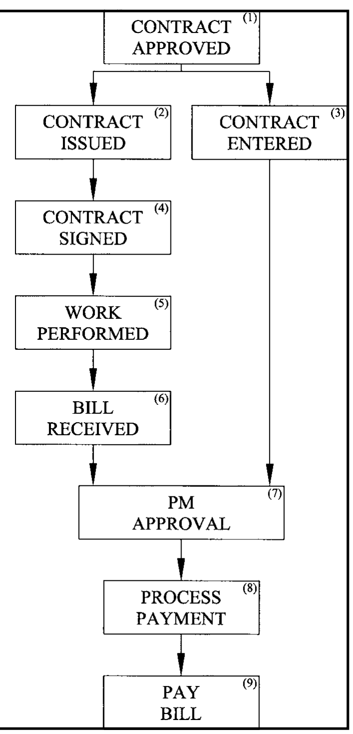
712

- Project manager approval (step 7)
  - The review of the bill may include a trip to the jobsite to inspect the progress or may rely on progress reports from the jobsite
  - When reviewing the bill, the project manager should check the bill against the contract amount



713

- Process payment (step 8)
  - After approval the payment is processed
- Pay bill (step 9)
  - Bill is paid by the accounting department
- Change orders to the contract are handled in the same manner as was the original contract



714

Construction Cost Analysis & Estimating – 110401543

Indirect Cost

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715

Overhead Cost

- Overhead costs are generally divided into home office overhead costs and job (field) overhead costs
- The home office overhead costs include items that cannot be readily charged to any one project, but represent the cost of operating the construction company
- The job overhead costs include all overhead expenses that will be incurred as a result of executing a specific project
- The major difference between the two is that the home office overhead costs are incurred regardless of any specific project

716

- Job overhead costs constitute a large percentage of the total cost of a construction project
- The job overhead costs can range from 15 to 40 percent of the total project cost
- Because these costs are such a large portion of the total project costs, they must be estimated with the same diligence and precision as the direct cost

717

Home Office Overhead

- Home office overhead costs, also known as general overhead or indirect overhead costs
- Are costs that are not readily chargeable to one particular project
- These costs are fixed expenses that must be paid by the contractor and are the costs of staying in business
- These expenses must be shared proportionally among the projects undertaken

718

- Usually the home office cost items are estimated based on a fiscal year budget and reduced to a percentage of the anticipated annual revenue
- Main office expenses: about 7.7% of total direct cost (RSMEANS)

719

- The following items should be included in a home office overhead budget
  - Office
    - Rent, electricity, heat, water, office supplies, insurance (fire, theft), taxes (property), telephone, office machines, and furnishings
  - Salaries
    - Office employees such as executives, accountants, estimators, purchasing agents, and secretaries

720

- The following items should be included in a home office overhead budget
  - Miscellaneous
    - Advertising, legal fees (not applicable to one particular project), professional services (architects, engineers, accountants) not billable to a job, travel (including company vehicles not charged to jobs), and association dues

721

- The following items should be included in a home office overhead budget
  - Depreciation
    - Expenditures on office equipment, computers, and any other equipment not billed to a job
    - A certain percentage of the cost is written off as depreciation each year and is part of the general overhead expense of running a business
    - A separate account should be kept for these expenses

722

Estimated Home Office Costs for One Year

Non-Reimbursable Salaries			
	Exempt Employees		
	President	$100,000	
	Vice President for Operations	$95,000	
	Comptroller	$60,000	
	Chief Estimator	$60,000	
	Estimator	$29,000	
	Director of Human Resources	$22,000	
	Non-exempt Employees		
	Secretaries (2)	$40,000	
	Payroll Clerk	$15,000	
	Accounts Payable Clerk	$15,000	
	Total Office Labor Costs	**$436,000**	$436,000
Benefits @ 38%			$165,680
Office Rent (Gross Lease) 2000 sq. ft. @ $12.00			$24,000
Telephone			$3,600
Office Supplies			$1,200
Office Equipment			$11,500
Advertising			$5,000
Trade Journals			$200
Donations			$15,000
Legal Services			$2,000
Accounting Services			$3,600
Insurance on Office Equipment			$800
Club & Assoc. Dues			$1,000
Travel & Entertainment			$12,000
Cars (2) w/ Insurance			$9,000
	Anticipated Office Expense for Year		$690,580

723

- For smaller contractors the list would contain considerably fewer items, and for large contractors it could fill pages, but the idea is the same
- The more work that can be handled by field operations, the smaller the amount that must be charged for general overhead and the better the chance of being the lowest bidder
- As a contractor's operation grows, attention should be paid to how much and when additional staff should be added

724

- The current staff may be able to handle the extra work if the additional workload is laid out carefully and through the use of selective spot overtime
- Another consideration to adding new staff is the cost of supporting that person with computers, communications equipment, office space, and furniture
- Once the home office overhead has been estimated, it becomes necessary to estimate the sales for the year
- If that amount is to rise over the coming year, the plan must state how to make that happen with the associated costs included in the budget

725

- Will this growth come about by bidding for additional jobs, and will that require additional estimators? Will the growth come by expanding into new markets; and, if so, what are the costs of becoming known in these new markets? These are very important strategic issues that need to be addressed by the key people in the construction company
- Once the sales for the year are estimated, a percentage can be developed
- This percentage can then be applied to all work that is pursued

726

- For example, if the anticipated home office costs for fiscal year is \$690,580
- Anticipated sales volume for fiscal year is \$9.5 million
- Home office cost allocation = Annual estimated home office costs / Estimated annual revenue

= \$690,580 / \$9,500,000 = 7.27%

Non-Reimbursable Salaries		
Exempt Employees		
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Travel & Entertainment		\$12,000
Cars (2) w/ Insurance		\$9,000
Anticipated Office Expense for Year		\$690,580

727

- Some contractors do not allow for the category “General Overhead Expense” separately in their estimates
- Instead they figure a larger percentage for profit or group overhead and profit together
- This, in effect, “buries” part of the expenses. From the estimator’s viewpoint, it is desirable that all expenses be listed separately so that they can be analyzed periodically
- In this manner, the amount allowed for profit is actually figured as profit—the amount left after all expenses are figured

728

- Examples of home office overhead

Salaries	
Owners	President
Officers	Estimator
Engineers	Accountant
Secretarial staff	Clerical
Receptionist	Roving or general superintendent
Equipment Costs	
Computers	Typewriters
Photocopiers	Fax machines
Company vehicles	Vehicle operation (gasoline, oil, and maintenance)
Idle equipment in the yard	Yard and maintenance shop
Building or Office Costs	
Rent, lease, or mortgage costs	Building maintenance
Furniture and fixtures	Real estate taxes
Insurance	
Supplies	
Stationery	Company forms
General office supplies	

729

- Examples of home office overhead

Operating Expenses	
Electric	Water and sewer
Telephone	Postage
Insurance: liability, etc.	Landscape maintenance
Radio	Business taxes and licenses
Legal and consulting fees	Sales promotion, entertainment
Custodial services	Site investigation costs
Study courses	Contractor association dues
Travel	Conventions
Other	
Lost plan deposits	Interest expense/finance charges
Charitable donations	Goodwill expenditures
Political donations	Licensing fees
Company picnic	Lost interest on retainage
Supervisory training expenses	Manuals (software, estimating guides, etc.)

730

Job Overhead

- Job overhead, also known as general conditions, direct overhead, or indirect field costs
- Comprises all costs that can be readily charged to a specific project but not to a specific item of work on that project
- Most of these items are a function of the project duration; therefore, having a good estimate of the project duration is critical in developing a good job overhead estimate

731

- Salaries
  - Salaries include those paid to the project superintendent, material clerk, all foremen required, and security personnel if needed
  - Some companies and some contracts also include the project manager and assistant project mangers in the project overhead
  - These costs must also include vehicle, mobile phone, travel, and job-related living expenses for these people

732

- Salaries
  - The salaries of the various workers required are estimated per week or per month, and that amount is multiplied by the estimated time it is expected that each will be required on the project
  - The estimator must be neither overly optimistic nor pessimistic with regard to the time each person will be required to spend on the job

733

- A bar chart schedule can be used to estimate the labor costs and then used during construction to control these costs

PROJECT STAFF PLAN AND ESTIMATE

Title	Monthly Gross Pay	Months On Project	Cost	Month 1	2	3	4	5	6	7	8	9	10	11	12
Project Manager	6,500	10	$65,000.00												
Assistant Project Manager	5,500	10	$55,000.00												
Civil Superintendent	5,000	2	$10,000.00												
Concrete Superintendent	4,000	5	$20,000.00												
Purchasing Agent	2,500	4	$10,000.00												
Clerical	1,500	8	$12,000.00												
Payroll	1,400	12	$16,800.00												
Total Project Staff Costs			$188,800.00												

734

- Temporary office
  - The cost of providing a temporary job office for use by the contractor and architect during the construction of the project should also include office expenses such as electricity, gas, heat, water, telephone, and office equipment
  - Check the specification for special requirements pertaining to the office
  - A particular size may be required; the architect may require a temporary office, or other requirements may be included

735

- Temporary office
  - If the contractor owns the temporary office, a charge is still made against the project for depreciation and return on investment
  - If the temporary office is rented, the rental cost is charged to the project
  - Because the rental charges are generally based on a monthly fee, carefully estimate the number of months required. At $250 per month, three extra months amount to $750 from the profit of the project
  - Check whether the monthly fee includes setup and return of the office. If not, these costs must also be included

736

- Temporary buildings, barricades, enclosures
  - The cost of temporary buildings includes material storage spaces
  - Necessary enclosures include fences, temporary doors and windows, ramps, and protection over equipment
- Temporary Utilities
  - The costs of temporary water, light, power, and heat must also be included

737

- Temporary Utilities
  - For each of these items, the specifications must be read carefully to determine which contractor must arrange for the installation of the temporary utilities and who will pay for the actual amounts of each item used (power, fuel, water)
- Sanitary Facilities
  - All projects must provide toilets for the workers
  - The most common type in use is the portable toilet, which can be rented or owned by the contractor

738

- Drinking Water
  - The cost of providing drinking water in the temporary office and throughout the project must be included
- Photographs/videos
  - Many project specifications require photographs at various stages of construction
  - The superintendent should make use of them at all important phases of the project to record progress
  - The cost of processing and any required enlarging of the pictures should be considered

739

- Surveys
  - If a survey of the project location on the property is required, the estimator must include the cost for the survey in the estimate
  - A survey may be used to lay out the corners and grid lines of a building, which costs need to be included in the estimate

740

- Cleanup
  - Throughout the construction's progress, construction waste and garbage will have to be removed from the project site
  - In addition, a plan needs to be devised concerning dumping
  - The debris may have to be hauled for long distances
  - Recycling of construction waste and "green construction" is an area that is receiving lots of attention, which may require waste to be separated by type

741

- Winter Construction
  - When construction will run through winter, several items of extra cost must be considered, including the cost of temporary enclosures, heating the enclosure, heating concrete and materials, and the cost of protecting equipment from inclement weather conditions

742

- Protection of property
  - Miscellaneous items that should be contemplated include the possibility of damaging adjacent buildings, such as breaking windows, and the possible undermining of foundations or damages by workers or equipment
  - Protection of the adjacent property is critical
  - All sidewalks and paved areas that are damaged during construction must be repaired
  - Many items of new construction require protection to avoid their damage during construction, including wood floors, finished hardware, and wall finishes

743

- Examples of job site overhead

Salaries		
Project manager	Superintendent	Assistant superintendent
Office manager	Payroll clerk	Safety director
Project engineer	Field engineer	
Timekeeper	Security watch	
Party chief	Quality control personnel	
Equipment Costs		
Trucks	Automobiles	Cranes
Computers	Photocopiers	Hoists
Fax machines	Project pickup	Scaffolding
Mobilization ($/mile)	Air compressors	Water pumps
Water truck	Electric generators	
Welding machine	Forklift	
Temporary Facilities Costs		
Job office trailer	Architect's field office	Janitor service
Storage sheds	Electric service	Water service
Tool bins	Security fence	Signs
Lights	Temporary toilets	Carpenter shed
Lavatories	File cabinets	
Temporary Protection and Safety Requirements		
Fence	Canopies	Barricades
Safety nets	Security services	Vandalism/theft
Alarm system	Noise control	Fire extinguishers
Safety rails	Winter protection	Summer protection
Rain protection	Tree protection	Safety equipment

744

- Examples of job site overhead

Engineering Support Services		
Site survey	Project layout	Road layout
Soil borings	Field survey	
Reporting Expenses		
CPM schedules	Progress reports	Certified payrolls
Photography		
Testing and Inspection		
Concrete	Masonry	Steel
Load	Watertight testing	
Job Cleanup		
Cutting and patching	General housekeeping	Disposal and dump charges
Dewatering	Dumpster fees	
Taxes and Insurance		
Truck and auto	Public liability	Builder's risk
Special risk	Sales tax	Workers' compensation
Performance bond	Social security	
Communications Costs		
Telephone/telegraph	Loudspeaker	Radios
Telephone service		
Permits		
Building	Demolition	Sidewalk
Blasting	Water and sewer fees	

745

- Examples of job site overhead

Expendables (Tools and Consumables Costing Less Than $500)		
Hammers	Blades	Bits
Shovels	Bars	Cutters
Clamps	Fuels	Lubricants
Welding rods		
Supplies		
Stationery	File folders	Plans
Specifications	As-built drawings	Postage
Drinking water	Ice	Dispensers
First aid supplies	Cups	
Other		
Travel	Storage fees	Job sign
Ads (help wanted)	Data processing	Petty cash
Job parties	Temporary roads	Community education

746

Scheduling

- A major determinant of indirect costs associated with a project is how long it will take to complete the project
- This length of time especially affects the estimator with regard to project overhead items, wages paid to supervisory and home office personnel, rental on trailers and toilet facilities, guards, and barricading required
- It also affects the estimate in terms of how long equipment will be required on the project

747

- The job site overhead costs often impact whether a particular contractor is the lowest bidder
- The speed at which the project is constructed has a heavy impact on the ultimate project cost
- Traditionally, the estimator assumes an approximate project duration that is the basis for the estimated project overhead costs
- Software tools can be used in sequencing the construction process and assisting in developing the project duration
- At minimum, a bar chart schedule should be developed to estimate a reasonable project duration

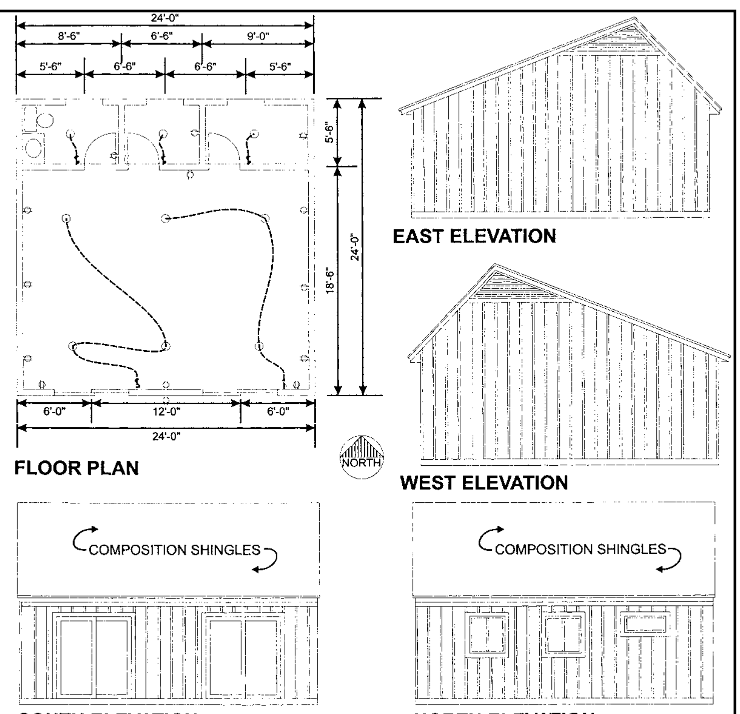
748

- Scheduling the project can be broken into four steps

1. List all activities required for the completion of the project
2. Assign a duration to each of the activities listed in step 1
   All of the times must be reasonably accurate
   If the work is to be subcontracted, contact the subcontractors for their input
3. Record each activity and its duration and develop a network diagram that shows the sequence in which the activities will be performed
4. Perform a schedule calculation to determine the estimated project duration

749

- Sample office building

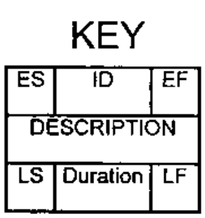


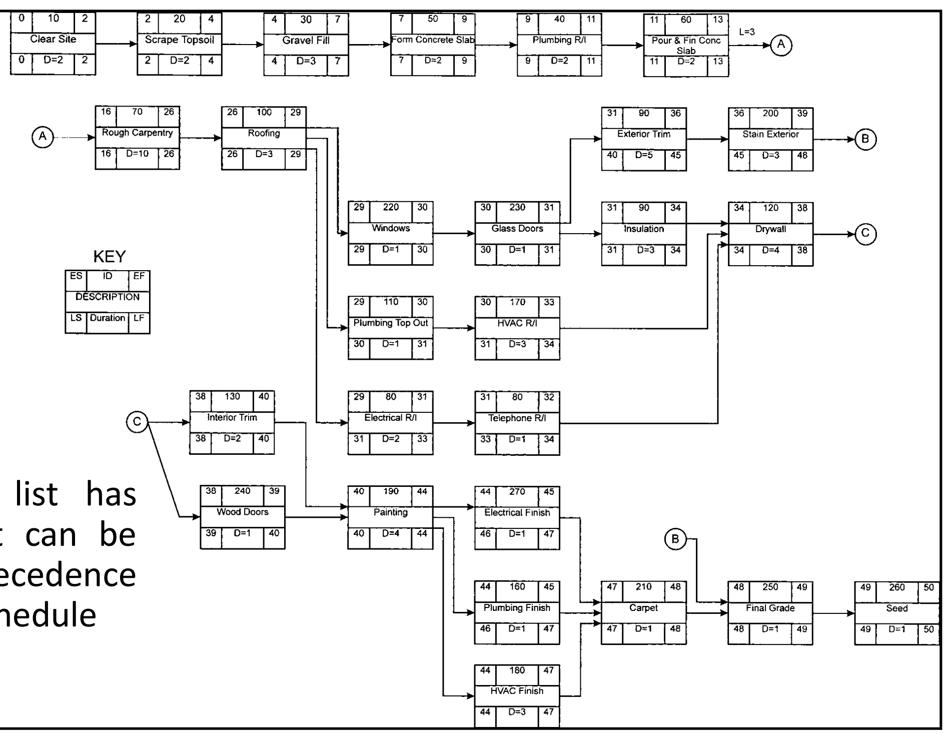
750

- Using the drawings, the activity list was developed

Activity Id.	Description	Duration
10	Clear site	2
20	Scrape topsoil	2
30	Gravel fill	3
40	Plumbing rough-in	2
50	Form, concrete slab	2
60	Pour and finish concrete	1
70	Rough Carpentry	10
80	Electrical, rough-in	2
90	Insulation	2
100	Roofing	3
110	Plumbing, top out	1
120	Drywall	4
130	Interior trim	2
140	Exterior trim	5
150	Telephone, rough-in	1
160	Plumbing, finish	1
170	H.V.A.C., rough in	3
180	H.V.A.C., finish	3
190	Painting	4
200	Stain, exterior	3
210	Carpet	1
220	Windows	1
230	Glass doors	1
240	Wood Doors	1
250	Final grade	1
260	Seed	1
270	Electrical, finish	1

751





- Once the activity list has been developed, it can be organized into a precedence diagram network schedule

752

- Once the project duration has been determined, it needs to be converted into calendar days
- In the example, the project duration is 50 days
- For a 5-day workweek, the duration is 10 weeks or 70 calendar days
- If there are nonwork periods in that intervening 70 days, the calendar duration would be extended by the number of nonwork periods
- Typical nonwork periods are public holidays

753

Contingencies

- On virtually every construction project, some items are left out or not foreseen when the estimates are prepared
- In some cases, the items left out could not have been anticipated at the time of estimating
- Should a contingency amount be included? That is, should a sum of money (or percentage) be added to the bid for items overlooked or left out?
- This money would provide a fund from which the items could be purchased

754

- If an accurate estimate is not made, an estimator never knows how much to allow for these forgotten items
- Contingencies are often an excuse for using poor estimating practices
- The most rational use for contingencies is for price escalation
- Changes to project scope should not be included in contingencies

755

- Contingency reserve
  - Included in the cost and schedule baseline of the project
  - Could be included in specific item (activity level)
  - Could be included in direct cost estimation: material, labor, equipment, and subcontract costs
- Management reserve
  - Allowance for future events that are impossible to predict
  - Utilization requires change to cost baseline
  - Project level

756

Bonds

- Often referred to as surety bonds
- Bonds are written documents that describe the conditions and obligations relating to the agreement
- A surety is one who guarantees payment of another party's obligations
- The bond is not a financial loan or insurance policy, but serves as an endorsement of the contractor
- The bond guarantees that the contract documents will be complied with, and all costs relative to the project will be paid
- If the contractor is in breach of contract, the surety must complete the terms of the contract

757

- Bid bond
  - Ensures that if a contractor is awarded the bid within the time specified, the contractor will enter into the contract and provide all other specified bonds
  - If the contractor fails to do so without justification, the bond will be forfeited to the owner
  - The amount forfeited will in no case exceed the amount of the bond or the difference between the original bid and the next highest bid that the owner may accept
  - The usual contract requirements for bid bonds specify that they must be 5 to 10 percent of the bid price, but higher percentages are sometimes used

758

- Performance bond
  - Guarantees the owner that the contractor will perform all work in accordance with the contract documents and that the owner will receive the project built in substantial agreement with the documents
  - It protects the owner against default on the part of the contractor up to the amount of the bond penalty
  - Most commonly these bonds must be made out in the amount of 100 percent of the contract price
  - Surety will either reimburse the owner or complete the work (fund original contractor or obtain new bids)

759

- Labor and material bond
  - Also referred to as a payment bond
  - Guarantees the payment of the contractor’s bill for labor and materials used or supplied on the project
  - It acts as protection for the owner, who are exempted from any liabilities in connection with claims against the project

760

- Subcontractor bonds
  - Performance, and labor and materials (payment) bonds are those that the subcontractors must supply to the general contractor
  - They protect the general contractor against financial loss and litigation due to default by a subcontractor

761

Insurance

- Contractors must carry insurance for the protection of the assets of their business, and because it is often required by the contract documents
- Insurance is not the same as a bond. With an insurance policy, the responsibility for specified losses is carried by the insurance company
- In contrast, with a bond, the bonding companies will fulfill the obligations of the bond and turn to the contractor to reimburse them for all the money that they expended on their behalf
- Examples include Workers’ compensation (accidents/injuries), vehicle, theft, and fire insurances

762

Construction Cost Analysis & Estimating – 110401543

Profit

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763

- The amount of money added to the total estimated cost of the project (contractor's return on investment)
- All costs relating to the project, including project and office overhead and salaries, are included in the estimated cost of the project
- Contractors use a markup (margin/percentage of total cost) to cover
  - Profit (clear profit)
  - Profit, contingencies, and office overhead

764

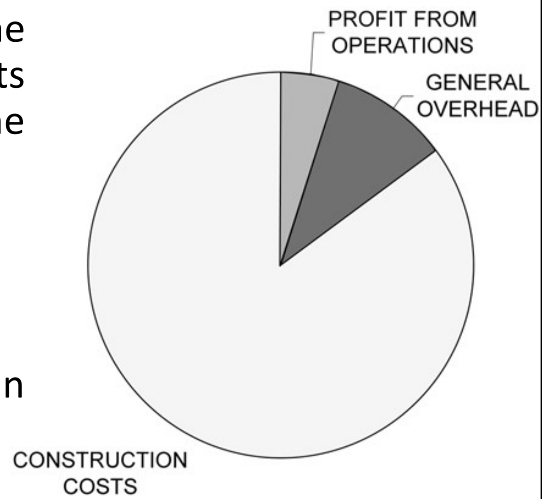
- Approaches to determine profit
  - Add a percentage of profit to each item as it is estimated
    - Allowing varying amounts for the different items
    - For example, 8 to 15% for concrete work, but only 3 to 5% for work subcontracted out
  - Add a percentage of profit to the total price tabulated for materials, labor, overhead, and equipment
    - The percentage would vary from small jobs to larger jobs (20 to 25% on a small job and 5 to 10% on a larger one)

765

- Other approaches to determine profit depend on strategy of bidding and computer simulation
- Since profit is added at the end of the estimate, the estimator has a pretty good idea of the risks and problems that may be encountered
- It is far better to bid what you feel is high enough to cover the risks than to neglect the risks, bid low, and lose money
- Consider competition (lower profit margin to win the bid but yet cover the costs)

766

- For a construction company the revenues are in the form of payments from the project owners or from the sale of projects
- These revenues are then used to pay
  - Construction costs
  - General overhead costs
  - Provide the profit for the investors in the construction company



767

- Construction costs include both the direct and indirect (project overhead) costs from all the construction projects
- The general overhead costs include those costs that are not attributable to any specific construction project (home office overhead)
- Revenues = Construction Costs + Overhead + Profit
- Profit = Revenues - Construction Costs - Overhead

768

Example

- The income statement shows a company's revenues, expenses, and the resulting profit generated over a period of time
- For the company's income statement shown, determine the company's profit from operations for the year and the percentage of the construction revenues that became profit

BIG W CONSTRUCTION
INCOME STATEMENT

REVENUES	3,698,945	100.0%
CONSTRUCTION COSTS		
Materials	712,564	19.3%
Labor	896,514	24.2%
Subcontract	1,452,352	39.3%
Equipment	119,575	3.2%
Other	5,452	0.1%
Total Construction Costs	3,186,457	86.1%
EQUIPMENT COSTS		
Rent and Lease Payments	35,425	1.0%
Depreciation	32,397	0.9%
Repairs and Maintenance	21,254	0.6%
Fuel and Lubrication	29,245	0.8%
Taxes, Licenses, and Insurance	1,254	0.0%
Equipment Costs Charged to Jobs	119,575	3.2%
Equipment Costs Charged to Employees	0	0.0%
Total Equipment Costs	0	0.0%
GROSS PROFIT	512,488	13.9%
OVERHEAD	422,562	11.4%
NET PROFIT FROM OPERATIONS	89,926	2.4%
OTHER INCOME AND EXPENSE	21,521	0.6%
PROFIT BEFORE TAXES	111,447	3.0%
INCOME TAX	33,434	0.9%
PROFIT AFTER TAXES	78,013	2.1%

769

- Profit = \$3,698,945 - \$3,186,457 - \$422,562 = \$89,926
- Profit % = \$89,926 / \$3,698,945 = 0.024 or 2.4%

BIG W CONSTRUCTION
INCOME STATEMENT

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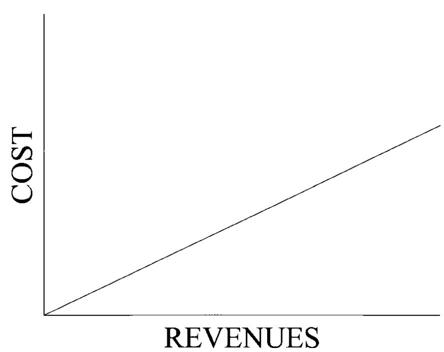
770

- General overhead costs may be broken down into its variable and fixed components as follows
- Overhead = Variable Overhead + Fixed Overhead
- Variable costs
  - Costs that tend to vary with the volume of work, which is most commonly expressed as a percentage of the revenues from construction projects

771

- For example, for a residential construction company that pays its sales force a commission in the form of a percentage of sales, the commission paid to the sales force would be a variable cost
- The relationship between cost and revenues for variable costs:

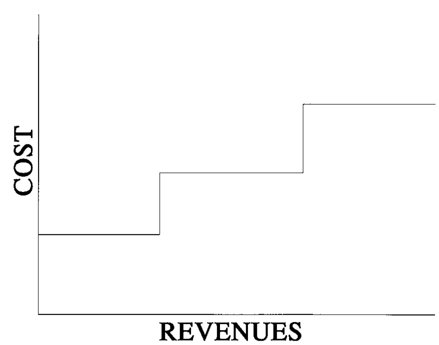


772

- Fixed costs
  - Costs that tend to be fixed over a specific range of revenues
- For example, if a company currently has two salaried employees working as estimators, the cost of these employees is fixed over the volume of work that can be won by these employees
- Fixed costs increase in steps with each step representing the fixed cost for a range of revenue

773

- The relationship between cost and revenues for fixed costs:



- Profit = Revenues - Construction Costs - Variable Overhead - Fixed Overhead

774

- The contribution margin is the amount of money that a project or projects contributes to the company to be used to pay for the fixed overhead and provide a profit for the stakeholders
- The contribution margin is what is left over from the revenues after paying the construction costs—which are considered a variable cost—and the variable portion of the overhead
- Contribution Margin = Revenues - Construction Costs - Variable Overhead

775

- Dividing the contribution margin by revenues we get the contribution margin ratio
- CM Ratio = Contribution Margin / Revenues
- Contribution Margin = CM Ratio(Revenues)
- Also,
- Profit = Contribution Margin - Fixed Overhead
- Profit = CM Ratio(Revenues) - Fixed Overhead

776

Example

- What are the contribution margin and the contribution margin ratio for the company's income statement shown if $45,000 of the overhead is considered variable overhead
- Contribution Margin = Revenues - Construction Costs - Variable Overhead
- Contribution Margin = $3,698,945 - $3,186,457 - $45,000 = $467,488
- CM Ratio = Contribution Margin / Revenues = $467,488 / $3,698,945 = 12.6%

BIG W CONSTRUCTION
INCOME STATEMENT

REVENUES	3,698,945	100.0%
CONSTRUCTION COSTS		
Materials	712,564	19.3%
Labor	896,514	24.2%
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PROFIT AFTER TAXES	78,013	2.1%

777

Break-Even Volume of Work

- Once a company has established a general overhead budget for a year, it can use the historical contribution margin ratio to determine the break-even volume of work that it needs to produce during the year to cover overhead costs and provide a specified profit
- By setting profit equal to zero we can determine the breakeven volume of work for a specific contribution margin and fixed overhead
- Profit = CM Ratio(Revenues) - Fixed Overhead

778

Example

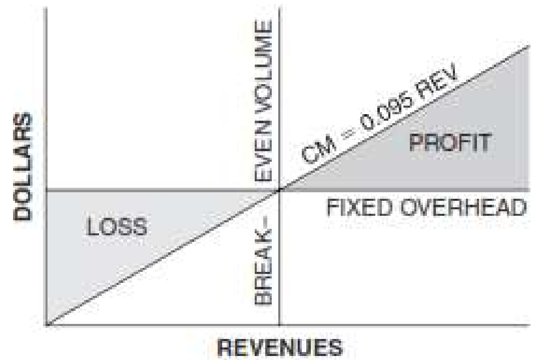
- Determine the break-even volume of work for a company with a fixed overhead of $350,000 and a contribution margin ratio of 9.5%
- Profit = CM Ratio(Revenues) - Fixed Overhead
- $0 = 0.095(Revenues) - $350,000
- 0.095(Revenues) = $350,000
- Revenues = $350,000 / 0.095 = $3,684,211

779

- The company will need to generate $3,684,211 in revenues to cover its fixed overhead
- If it generates less than $3,684,211 the company will not cover the fixed overhead and will lose money on construction operations
- For the revenues in excess of $3,684,211, the entire contribution margin will be profit from operations

780

- Relationship between the revenues and the break-even volume
- The diagonal line represents the contribution margin equal to 0.095 x Revenues
- The horizontal line represents the fixed overhead for the example
- The break-even volume occurs where these two lines intersect



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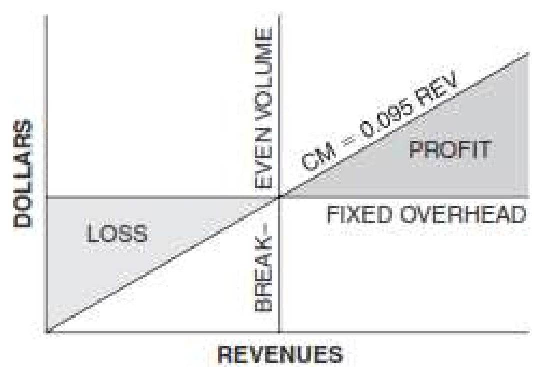
- For revenues to the left of the break-even volume, the distance between these two lines represents the size of the loss
- For revenues to the right of the break-even volume, the distance between these two lines represents the size of the profit



782

- Alternately, a company may have a required level of profit
- By setting profit in the equation equal to the required level of profit we can determine the breakeven volume of work for a specific contribution margin and fixed overhead
- The break-even volume of work is expressed in dollars of revenue

783

Example

- Determine the break-even volume of work for a company with a fixed overhead of $350,000, a contribution margin ratio of 9.5%, and a required level of profit of $190,000

- Profit = CM Ratio(Revenues) - Fixed Overhead
- $190,000 = 0.095(Revenues) - $350,000
- Revenues = $5,684,211

784

- The company will need to generate \$5,684,211 in revenues to cover its fixed overhead and make \$190,000 in profit
- If it generates less than \$5,684,211 it will not meet its profit requirements
- If the company generates more than \$5,684,211 it will exceed its profit requirements

785

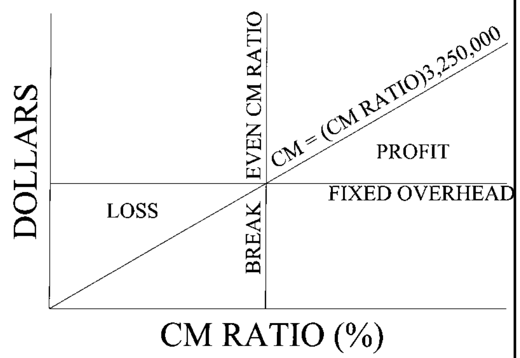
Example

- Determine the break-even contribution margin ratio for a company with a fixed overhead of \$350,000 and revenues of \$3,250,000

- Profit = CM Ratio(Revenues) - Fixed Overhead
- \$0 = CM Ratio(\$3,250,000) - \$350,000
- CM Ratio = \$350,000 / \$3,250,000 = 10.77%
- The company will need to maintain a contribution margin ratio of 10.77% to cover its fixed overhead (10.77% will be charged to every project)

786

- The break-even CM Ratio occurs where the two lines intersect
- If the contribution margin ratio is greater than 10.77%, the difference between the actual contribution margin ratio and 10.77% will be profit
- If the contribution margin ratio were 15%
- 15.00 - 10.77 = 4.23% of the company's revenues would be profit from construction operations



787

Example

- Determine the break-even contribution margin ratio for a company with a fixed overhead of \$350,000, revenues of \$3,250,000, and a required level of profit of \$190,000

- Profit = CM Ratio(Revenues) - Fixed Overhead
- \$190,000 = CM Ratio(\$3,250,000) - \$350,000
- CM Ratio = 16.62%

788

- The company will need to maintain a contribution margin ratio of 16.62% (on every single project) in order to meet profit requirements of $190,000
- If the contribution margin ratio is less than 16.62% the company will not meet its profit requirement
- If the contribution margin ratio is greater than 16.62% the company will exceed its profit requirement

789

- If the calculated break-even volume of work exceeds the volume of work that the company thinks it can perform, the contribution margin ratio needs to be increased
- This may be done by raising prices; however, this often results in a reduced volume of work
- If the company's clients are not price sensitive, raising prices may solve the problem

790

- If the company’s clients are price sensitive—as is the case when clients solicit multiple bids for their work—raising prices may further reduce the volume of work and may only aggravate the problem
- When raising prices is not an option, the company must reduce the fixed overhead costs, construction costs, or variable overhead costs

791

- After raising prices and reducing construction costs, if the break-even contribution margin ratio exceeds the contribution margin ratio that the company thinks it can obtain from its customers, the contribution margin needs to be decreased
- This may be done by increasing the volume of work, thereby spreading the overhead and required profit over a higher volume of work
- Alternately, the contribution margin may be decreased by decreasing overhead costs or profit expectations

792

- A key goal of any construction company should be to make a profit
- Too often a company is focused on increasing the volume of its work rather than on its profitability
- When a company focuses on volume of work without considering profit, it often settles for smaller profit margins or takes unprofitable work in order to increase its volume of work
- These increases in the volume of work are often accompanied by the need to increase its main office support, thus increasing general overhead

793

- Many companies have found that profits could increase by being more selective as to the type of project to bid on, in essence specializing in certain areas of the construction market
- As similar work is performed over and over the company and its employees move down the learning curve, learning where the common pitfalls occur and how to avoid them
- By reducing the number of construction problems that occur, the company can reduce the time it takes to construct the project and reduce the project overhead
- Additionally, it learns to avoid costly construction mistakes

794

- Once a company has set a target level for the gross profit margin, it often requires that all projects meet a minimum gross profit margin, which is included in its bids in the form of a profit and overhead markup (P&O Markup)
- The profit and overhead markup is not the same as the gross profit margin
- However, they are mathematically related

795

Example

- A construction project with revenues of $1,000,000 and construction costs of $850,000
- The gross profit equals the revenues less the construction costs or $150,000 ($1,000,000 - $850,000)
- Gross Profit Margin = Gross Profit / Revenues = $150,000 / $1,000,000 = 15%
- If we were to mark up the construction costs by 15% to get the bid price (revenue from the project) we would get the following
- Revenue = $850,000(1 + 0.15) = $977,500. P&O is $22,500 ($1,000,000 - $977,500) less than Gross profit (actual revenue)

796

- P&O Markup = Gross Profit Margin / (1 - Gross Profit Margin)
- The profit and overhead markup that is equal to a 15% gross profit margin is calculated as follows
- P&O Markup = 15 / (1 – 0.15) = 17.65%
- Applying a profit and overhead markup of 17.65 to the construction costs of $850,000 we get the following
- Revenue = $850,000(1 + 0.1765) = $1,000,025 (difference than 1,000,000 due to rounding of P&O Markup)

797

Example

- Determine the profit and overhead markup for a company that wants to maintain a 16% gross profit margin

- P&O Markup = Gross Profit Margin / (1 - Gross Profit Margin)

  = 16 (100 - 16) = 19.05%

798

- To assist in determining when to charge a higher profit and overhead markup, a company must track how a competitor's prices compared to its own
- The easiest way to do this is to keep a record of all the competitors who have bid against the company along with each of the bids and the profit and overhead markup that our company would have had to add to our construction costs for our bid to equal the competitor's bid
- P&O Markup = (Bid Price /Construction Costs) - 1

799

Example

- Your construction company recently bid against ABC Construction Company
- Your construction costs were $157,260 and you added a 15% profit and overhead markup for a total bid of $180,849
- ABC's bid was $179,249
- What profit and overhead markup would you need to add to your construction costs to get ABC's bid
- P&O Markup = (Bid Price /Construction Costs) - 1 = ($179,249 / $157,260) - 1 = 13.98%

800

Example

- Your construction company is bidding against two construction companies on a municipal project with an engineer's estimate of cost = $750,000 to $850,000. Your company's minimum profit and overhead markup is 8%
- What are the chances of increasing your profit and overhead markup above the minimum 8%?

ABBCO			
Project	Bid	Costs	P&O
West City Park	$ 875,256	$ 798,952	9.55%
Platt Park Restrooms	$ 52,326	$ 42,165	24.10%
ABC Construction			
Project	Bid	Costs	P&O
South Street Improvements	$ 179,249	$ 157,260	13.98%
West City Park	$ 859,462	$ 798,952	7.57%
East Side Community Center	$ 1,152,634	$ 1,092,215	5.53%

801

- West City Park project (cost = $750,000)
- P&O Markup = (Bid Price /Construction Costs) - 1
- Your P&O Markup that you need to add to your construction costs to get the two construction companies bids
  = (875,256 / 750,000) – 1 = 16.7% [ABBCO]
  = (859,462 / 750,000) – 1 = 14.59% [ABC, lowest bidder]
- Your company bid price: 8% = (Bid Price / 750,000) – 1 = $810,000 [you can raise your 8% P&O Markup]

802

- West City Park project (cost = $850,000)
- P&O Markup = (Bid Price /Construction Costs) - 1
- Your P&O Markup that you need to add to your construction costs to get the two construction companies bids
  = (875,256 / 850,000) – 1 = 2.97% [ABBCO]
  = (859,462 / 850,000) – 1 = 1.11% [ABC, lowest bidder]

- Your company bid price: 8% = (Bid Price / 850,000) – 1 = $918,000 [you need to lower your 8% P&O Markup]

803

Winning all competitors

- Friedman
  - $P_{win} = P_1 \times P_2 \times P_3 \times \ldots \times P_n$
- Gate
  - $P_{win} = \dfrac{1}{\left(\frac{1-P_1}{P_1} + \frac{1-P_2}{P_2} + \ldots + \frac{1-P_n}{P_n}\right)+1}$
- P_{win} = probability to win the bid against all competitors
- P_n = probability of winning known competitor n (lower bid price than n)
- Expected profit = Probability of winning x Profit

804

Example

- Determine the profit to include in your bid to win against the following competitors

P_1 (competitor 1)	P_2 (competitor 2)	Profit (%)
0.8	0.77	3
0.7	0.73	4
0.5	0.65	5

805

- Friedman
- Profit = 4% (The highest expected profit of 2.044)

P_1 (competitor 1)	P_2 (competitor 2)	Profit (%)	P_{win}	Expected profit
0.8	0.77	3	0.616	1.848
0.7	0.73	4	0.511	2.044
0.5	0.65	5	0.325	1.625

806

- Gate
- Profit = 4% (The highest expected profit of 2.224)

P_1 (competitor 1)	P_2 (competitor 2)	Profit (%)	P_{win}	Expected profit
0.8	0.77	3	0.646	1.938
0.7	0.73	4	0.556	2.224
0.5	0.65	5	0.394	1.97

807

Construction Cost Analysis & Estimating – 110401543

Risk Cost

Dr. Mohammad Almashaqbeh
Department of Civil Engineering
Hashemite University

808

- Risk
  - Probability of occurrence is known
  - Poor estimating, investment, financial loss
- Uncertainty
  - Probability of occurrence is not known
  - Global financial crisis, volcano, earthquake

809

- Examples of risks in construction
  - Poor estimating
  - Poor contracting strategy
  - Delays
  - Material price escalation
  - Adverse weather
  - Change orders
  - Insufficient funds
  - Poor subcontractor selection

810

ارتفاع طفيف على أسعار الحديد الجاهز بالسوق المحلية

نسخ الرابط

عمان الأول من آذار(بترا)- أكد ممثل قطاع الصناعات الإنشائية في غرفة صناعة الأردن علاء أبو صوفة، وجود ارتفاع طفيف طال أسعار الحديد الجاهز بالسوق المحلية متزامنا مع الأزمة الروسية –الأوكرانية باعتبارهما من أكبر المصدرين لمواده الأولية بالعالم.

وقال أبو صوفة في تصريح لـ (بترا) إن سعر مادة الحديد الجاهز الذي يباع للمواطنين وصل إلى 660 دينارا للطن الواحد، بزيادة مقدارها 20 دينارا بداية الأسبوع الماضي.

وأرجع الزيادة إلى ارتفاع أسعار المواد الأولية بشكل كبير جدا وأجور النقل والتأخير الكبير بسلاسل التوريد العالمية وقلة المعروض، بالإضافة إلى ارتفاع أثمان الخردة بالسوق المحلية.

وبين أبو صوفة أن أسعار الحديد الجاهز بالأردن أقل وأرخص عن مثيله بالكثير من دول المنطقة، لوجود منافسة شديدة بين المصانع المحلية البالغ عددها 11 مصنعا، موضحا أن استهلاك المملكة من مادة الحديد سنويا يصل إلى نحو 400 ألف طن.

ولفت إلى أن الطلب على مادة الحديد بالسوق المحلية منخفض بشكل كبير بفعل أجواء فصل الشتاء، حيث تتوقف حركة البناء بشكل ملحوظ، متوقعا أن ترتفع وتيرته خلال الفترة المقبلة بعد تخفيف إجراءات كورونا الجديدة والبدء بتنفيذ مشروعات حكومية.

--(بترا)

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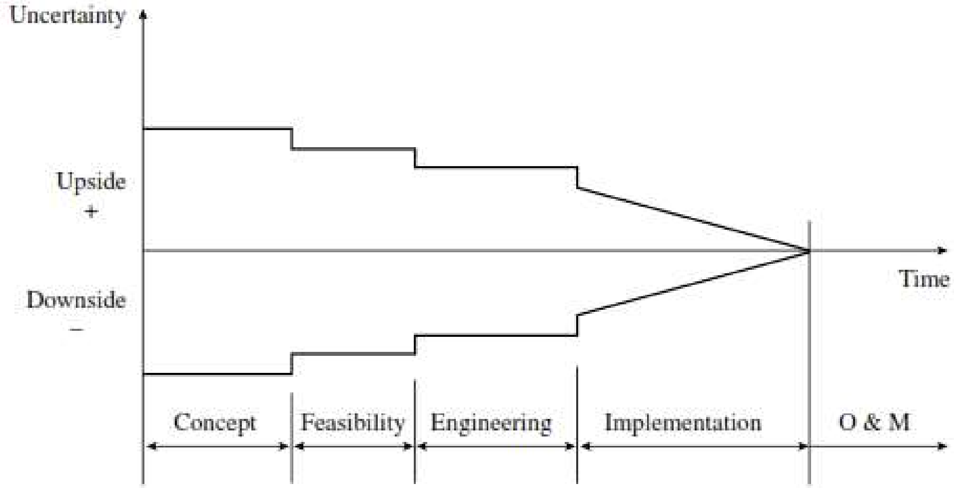
811

- Examples of positive risks (opportunities) in construction
  - Actual cost lower than planned
  - Incentive fee if work finished earlier
  - Providing better quality than planned
  - Equipment lasted longer than expected

812

• Project risk exposure



813

Contingencies

- On virtually every construction project, some items are left out or not foreseen when the estimates are prepared
- In some cases, the items left out could not have been anticipated at the time of estimating
- Should a contingency amount be included? That is, should a sum of money (or percentage) be added to the bid for items overlooked or left out?
- This money would provide a fund from which the items could be purchased

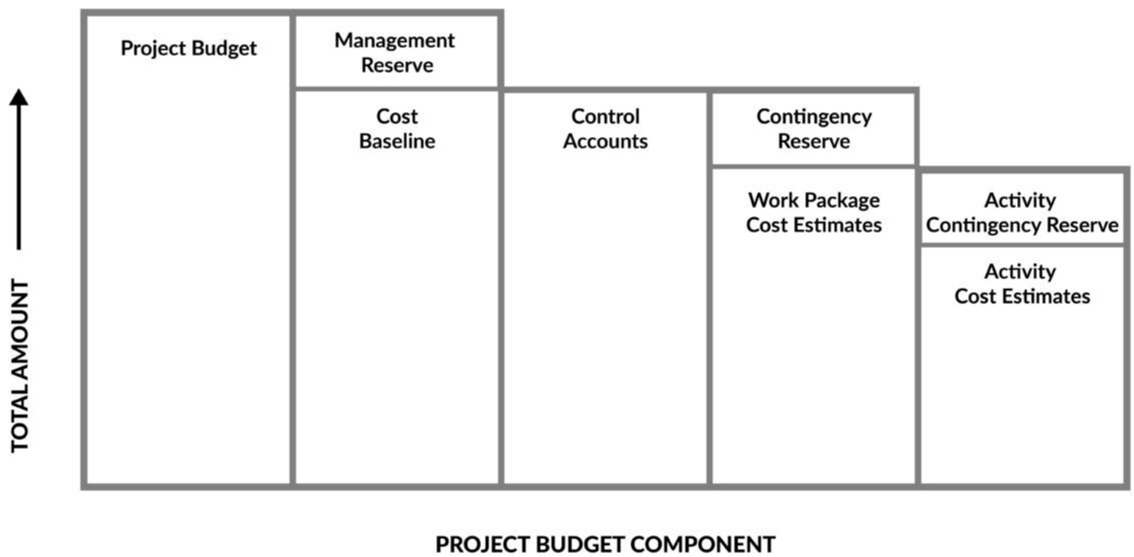
814

- If an accurate estimate is not made, an estimator never knows how much to allow for these forgotten items
- Contingencies are often an excuse for using poor estimating practices
- The most rational use for contingencies is for price escalation
- Changes to project scope should not be included in contingencies

815

- Contingency reserve
  - Included in the cost and schedule baseline of the project
  - Could be included in specific item (activity level)
  - Could be included in direct cost estimation: material, labor, equipment, and subcontract costs
- Management reserve
  - Allowance for future events that are impossible to predict
  - Utilization requires change to cost baseline
  - Project level

816



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Assigning Contingency

- Applying a percentage
  - Contingency may be assigned based on personal past experience
  - A percentage is applied to the major cost items to derive the total contingency
  - Some organizations use standard percentages for contingencies based on the class of estimate. Typically, the percentage used is based on the level of scope definition or on the stage of project development

818

- Expected net risk
  - The estimator may determine contingency based on expected maximum risk and likelihood
  - The first step involves determining the maximum possible risk for each element, recognizing that it is unlikely that all the risk will occur for all elements
  - The next step involves assessing the percentage probability that this risk will occur

819

- Expected net risk
  - The expected net risk then becomes a product of the maximum risk times the probability
  - The sum of all the expected net risks provides the total maximum risk contingency required ($112)

Element	Base estimate	Max. cost	Max. risk	% probability	Expected net risk
#1	$400	$500	$100	30%	$ 30
#2	$ 80	$120	$ 40	80%	$ 32
#3	$100	$200	$100	50%	$50
Total	$580	$820	$240		$112

820

Example

- Find the expected net risk for a project with a cost estimate of $800,000
- Risk analysis
  1. 10% probability of a delay in receiving material with a cost of $100,000
  2. 20% probability that steel reinforcement will be $40,000 cheaper than expected
  3. 25% probability of a design error causing $50,000 of rework
  4. 7% probability that the work may be finished earlier than expected, resulting in receiving $18,000 incentive fee

821

Risk	Probability (%)	Impact ($)	Expected net risk ($)
1	10%	$100,000	$10,000
2	20%	$40,000	+$8,000
3	25%	$50,000	$12,500
4	7%	$18,000	+$1,260
		Total	$13,240

822

- What is the expected project cost?
  - \$800,000 + \$13,240 = \$813,240
- What is the estimated project cost without the risk analysis?
  - \$800,000
- What is the best case scenario for the project cost estimate?
  - \$800,000 - \$40,000 - \$18,000 = \$742,000
- What is the worst case scenario for the project cost estimate?
  - \$800,000 + \$100,000 + \$50,000 = \$950,000

823

- Simulation
  - A formal risk analysis for determining contingency is usually based on simulation
  - A simulation of probabilistic assessment of critical risk elements can be performed to match the desired confidence level
  - Monte Carlo simulation software packages are useful tools for performing simulation
  - A knowledge of statistical modeling and probability theory are required to use these tools properly

824

Sensitivity Analysis

- The contingency added to an estimate includes the combined impact of all risk elements
- A sensitivity analysis can be performed to illustrate how a specific risk element can impact the total estimate
- The sensitivity analysis evaluates the impact of only one risk element at a time

825

- A sample sensitivity analysis for a $3M base estimate

- Base estimate summary ($M)

Equipment cost	$1.2	
Material cost	$0.6	
Labor cost	$1	← (= $50/h x 20,000 h)
Subcontractor cost	$0.2	
Total base estimate	$3	

826

- A sample sensitivity analysis for a $3M base estimate

Risk element	% change from estimate	New base estimate ($M)
Labor rate ($50/h)	0	3
Labor rate	+10 (55/h,+$100,000)	3.1
Labor rate	-5 (47.5/h,-$50,000)	2.95
Total work hours (20,000h)	0	3
Total work hours	+15 (23,000h, +$150,000)	3.15
Total work hours	-7 (18,600h, -$70,000)	2.93
Equipment ($1.2)	0	3
Equipment	+5 (+$60,000)	3.06
Equipment	-5 (-$60,000)	2.94

827

Decision Tree Analysis

- One of the tools of risk analysis
- A diagram that describes a decision under consideration and the implications of choosing one or another of the available alternatives
- Incorporates the probabilities of risks and costs or rewards of each logical path of events and the future decisions
- Solving the decision tree indicates which decision yields the greatest expected monetary value (EMV) when all uncertain costs and rewards are quantified

828

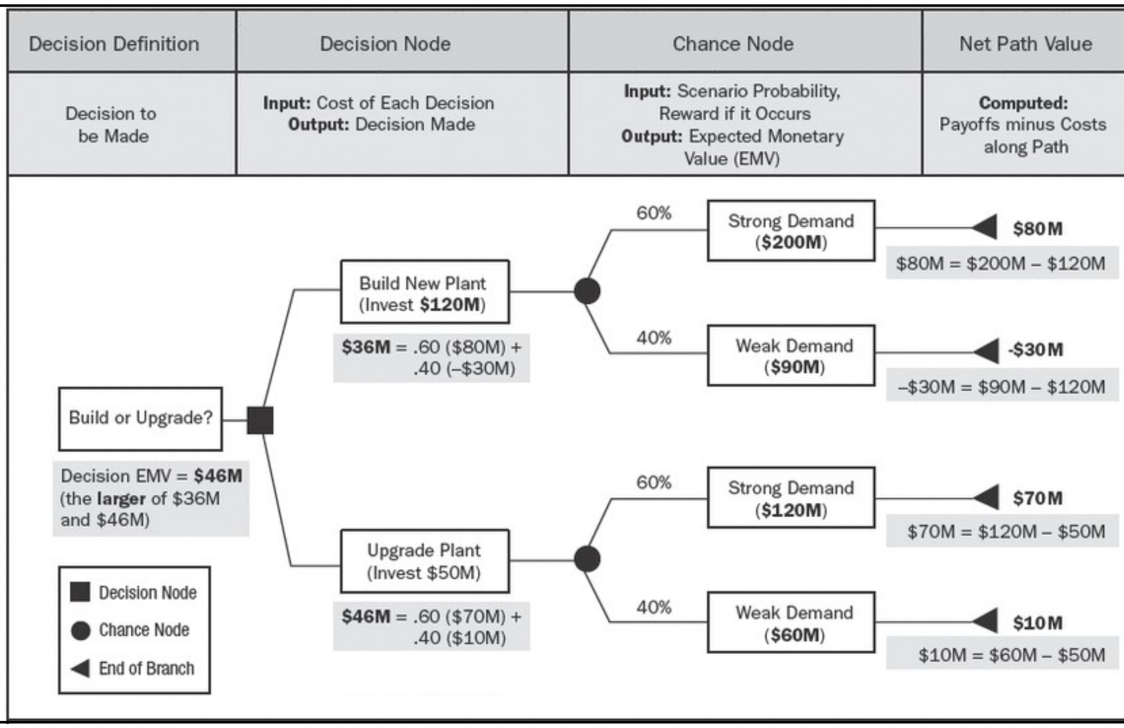
Example

- A decision is being made whether to invest \$120M to build a new plant or to instead invest only \$50M to upgrade the existing plant
- For each decision, the demand which is uncertain must be accounted for
- A strong demand leads to \$200M revenue with the new plant but only \$120M for the upgraded plant
- The lower revenue for the upgraded plant is due to lower capacity compared to new plant capacity

829

- A weak demand leads to \$90M revenue with the new plant but only \$60M for the upgraded plant
- Probability of the strong demand is 60%

830



831

- The upgraded plant has a higher EMV of $46M which is also the EMV of the overall decision
- This choice represents the lowest risk, avoiding the worst case possible outcome of a loss of $30M

832

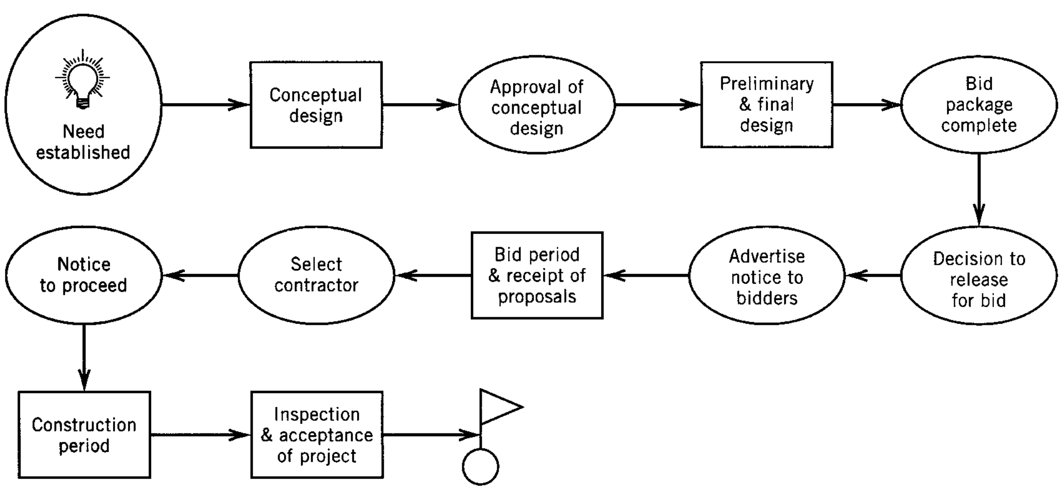
Construction Cost Analysis & Estimating – 110401543

Bidding Procedures & Documents

Dr. Mohammad Almashaqbeh
Department of Civil Engineering
Hashemite University

833

- Project development cycle



834

Notice to Bidders/Invitation to Bid

- The document announcing to prospective bidders that design documents are available for consideration and that the owner is ready to receive bids (Advertisement for bids)
- The job is advertised to those contractors who are capable of completing the work at a reasonable price (qualified bidders)
- In private construction, owners may choose to
  - Negotiate with a contractor of choice
  - Announce the job to bid on an invitation basis
  - Utilize competitive bidding open to anyone who wants to bid

835

- A notice to bidders can be posted electronically, in a newspaper, or sent by mail/email to all prospective bidders
- The notice to bidders contains information regarding
  - General type and size of the project
  - Location and extent of the work
  - Availability of plans and specifications for review
  - Time, place, and date of the bid opening

836

NOTICE TO BIDDERS
FOR
CONSTRUCTING SEWERAGE SYSTEM IMPROVEMENTS
CONTRACT "B"
CENTRAL STATE HOSPITAL
FOR THE
GEORGIA BUILDING AUTHORITY (HOSPITAL)
STATE CAPITOL—ATLANTA, GEORGIA

Sealed proposals will be received for Constructing Sewerage System Improvements, Contract "B," for the Georgia Building Authority (Hospital), State Capitol, Atlanta, Georgia, at Room 315, State Health Building, 47 Trinity Avenue, S.W., Atlanta, Georgia, until 2:00 P.M., E.S.T., February, 18 __, at which time and place they will be publicly opened and read. Bidding information on equipment in Section No. 10 shall be submitted on or before February 4 __.

Work to Be Done: The work to be done consists of furnishing all materials, equipment, and labor and constructing:

Division One. Approximately 12,400 L.F. 36″ Sewer Pipe, 5,650 L.F. 30″ Sewer Pipe, 7,300 L.F. 24″ Sewer Pipe, 1,160 L.F. 15″ Sewer Pipe, 3,170 L.F. 12″ Sewer Pipe, 300 L.F. 8″ Sewer Pipe, 418 L.F. 36″ C.I. Pipe Sewer, 324 L.F. 30″ C.I. Pipe Sewer, 1,150 L.F. 30″ C.I. Force Main, 333 L.F. 24″ C.I. Force Main, 686 L.F. 24″ C.I. Pipe Sewer, and all other appurtenances for sewers.
Division Two. One Sewage Pumping Station—"Main Pump Station."
Division Three. One Sewage Pumping Station—"Fishing Creek Pump Station."
Division Four. One Sewage Pumping Station—"Camp Creek Pump Station."

Bids may be made on any or all Divisions, any of which may be awarded individually or in any combination.

837

اعلان طرح العطاء
رقم (T2020/12SH)

تعلن شركة مناجم الفوسفات الاردنية المساهمة العامة المحدودة عن طرح العطاء رقم (T2020/12SH) مشروع انشاء خط مياه جديد لابار الجفر واعادة تأهيل الخط القائم ومحطة الضخ وخزان المياه الخرساني القائم

ترغب شركة الفوسفات الاردنية المساهمة العامة بانشاء خط مياه جديد لابار الجفر واعادة تأهيل الخط القائم ومحطة الضخ وخزان المياه الخرساني القائم في منجم الشيدية، فعلى الراغبين بالمشاركة بهذا العطاء من المقاولين المصنفين درجة اولى في (مجال/اختصاص) المياه والصرف الصحي، على ان يكون لديهم خبرة كافية في تنفيذ اعمال خطوط نقل المياه (**Ductile iron**) بأقطار لا تقل عن ٦٠سم ومحطات الضخ واعمال الحماية من المطرقة المائىة، ارسال الوثائق المطلوبة لادارة التزويد والمشتريات/دائرة المشتريات المحلية على البريد الالكتروني
(**m.abuhawileh@jpmc.com.jo**)

علما بأن الوثائق المطلوبة (صورة عن شهادة التصنيف المطلوب سارية المفعول وصورة عن السجل التجاري وصورة عن رخصة المهن سارية المفعول) يتم بعدها تزويدكم برقم الحساب البنكي الخاص بالشركة لايداع ثمن نسخة وثائق العطاء والبالغة ١٠٠٠ دينار (الف دينار) غير مستردة ثمن للنسخة الواحدة وارسال صورة من سند الايداع على البريد الالكتروني، يتم بعدها مراجعة مكاتب شركة الفوسفات الاردنية في الشميساني بجانب وزارة الصناعة والتجارة للحصول على نسخة من وثائق العطاء.

للاستفسار عن اية معلومات اضافية يرجى الاتصال على الرقم ٠٧٩١٦٩٦٣٦١

علما بأن اخر موعد لبيع نسخ العطاء الساعة الثانية عشرة من ظهر يوم الخميس الموافق ٢٠٢٠/١١/١٩ واخر موعد لاستلام عروض العطاء اعلاه الساعة الثانية عشرة من ظهر يوم الاثنين الموافق ٢٠٢٠/١٢/٢١.

المهندس عبدالوهاب الرواد/ الرئيس التنفيذي

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الجامعة الهاشمية

العطاء رقم (٢٠١٩/٥٣) الخاص بانشاء محطتي محروقات على ارض الجامعة الهاشمية

ترغب الجامعة الهاشمية بانشاء محطة وقود عدد (٢) اثنين مع مرافقهما باعتماد نظام (تصميم، انشاء، تشغيل، نقل (D.B.O.T) وعلى النحو التالي:

المحطة الاولى : تقع على قطعة الارض رقم (١) حوض رقم (٤) من اراضي المشيدة الواقعة على الطريق العام (عمان – بغداد) (طريق خو – المنطقة الحرة)

المحطة الثانية : تقع على قطعة الارض رقم (١٣) حوض رقم (٤) من اراضي المشيدة الواقعة غرب الطريق الدولي (عمان – دمشق) المجاور لاسكانات المدينة التدريبية (الجيش العربي) وذلك حسب الاسس التالية:

انشاء محطتي وقود بمرافقهما حسب المواصفات والمقاييس العامة المعمول بها بوزارة الطاقة والثروة المعدنية الاردنية وتشمل اعمال البنية التحتية المتكاملة من ساحات وتجهيزات مدنية وكهروميكانيكية

ب. يقوم المستثمر او من يمثله من جهة استشارية وبالتنسيق مع المالك باعداد التصاميم والمخططات المعمارية والانشائية والكهربائية والميكانيكية وغيرها للبناء المشار اليه في (اولا) ويتحمل كافة النفقات المترتبة على ذلك.

ج- ان يكون المتقدم للعطاء قادرا على التمويل والانشاء ومن ثم التشغيل لمدة (زمنية معينة يحددها في عرضه) ومن بعد انقضاء مدة التشغيل يقوم بارجاع المنشأة والمرافق الى الجامعة وذلك حسب الاتفاقية التي يتم اعدادها من قبل الجامعة

د- يجب ان يتضمن العرض المعلومات التالية:

نبذة عن خبرة المستثمر

العرض الفني شاملا وصفا للمحطة المراد انشاؤها ومرافقها مع تحديد المدة الزمنية اللازمة لتنفيذها وبدء التشغيل طريق التمويل ومدته

مساحة الارض المطلوبة للاستثمار والمدة الزمنية للتشغيل وبدل الايجار السنوي المقترح دفعه للجامعة.

هـ- يحق للجامعة اختيار العرض الذي تراه مناسبا

فعلى الراغبين في الاشتراك في هذا العطاء مراعاة ما يلي:

اولا : أ- مراجعة مدير مكتب العطاءات المركزية في الجامعة / الزرقاء لاستلام المواصفات والوثائق الخاصة بالعطاء.

آخر موعد لبيع نسخ المناقصة حتى الساعة (١٠) من صباح يوم الاربعاء الموافق ٢٠١٩/١٠/١٦

تم تحديد موعد زيارة ميدانية لكافة المناقصين المشاركين بالعطاء وذلك يوم الخميس الموافق ٢٠١٩/١٠/١٧ الساعة (١٠) العاشرة صباحا والتجمع في مكتب العطاءات المركزية في الجامعة.

آخر موعد لقبول الاستفسارات من المناقصين المشاركين بالعطاء حول العطاء حتى الساعة (١٢) الثانية عشرة من ظهر يوم الاحد الموافق ٢٠١٩/١٠/٢٠ ولن يتم قبول اية استفسارات تصل بعد هذا الموعد

موعد الرد على الاستفسارات سيكون يوم الاثنين الموافق ٢٠١٩/١٠/٢١

تودع العروض في صندوق العطاءات لدى مكتب العطاءات المركزية في الجامعة الهاشمية في موعد اقصاه الساعة (١١) الحادية عشرة من صباح يوم الاحد الموافق ٢٠١٩/١٠/٢٧

ج- ثمن بيع نسخة دعوة العطاء (مجانا)

ثانيا : يقدم العروض على ثلاث نسخ (اصلية + صورتين) وتوضع في مغلف منفصل ويكتب على كل مغلف اسم المتعهد وعنوانه واسم العطاء ورقمه ومحتويات المغلف ويرفق العرض ايضا على (قرص مرن) في مغلف مغلق

ثالثا : يرفق بالعروض كفالة مالية او شيك مصدق او ايصال ايداع مبلغ نقدي في حساب الجامعة الهاشمية في البنك العربي تأمينا لدخول العطاء بقيمة مقطوعة مقدارها (١٠٠٠٠) عشرة الاف دينار لصالح الجامعة الهاشمية وتوضع في مغلف منفصل

رابعا : توضع المغلفات في مغلف واحد مختوم يكتب عليه اسم المتعهد وعنوانه ورقم العطاء ويودع في صندوق العطاءات في مكتب العطاءات المركزية في الجامعة الهاشمية / الزرقاء في موعد اقصاه الساعة الحادية عشرة من صباح يوم الاحد الموافق ٢٠١٩/١٠/٢٧م

خامسا : اجور الاعلان على من يحال عليه / عليهم العطاء مهما تكرر

سادسا : للراغبين بالاطلاع على مواصفات العطاء يمكنهم الحصول عليها من خلال صفحة مكتب العطاءات المركزية على الانترنت: http://hu.edu.jo/tenders

هاتف : ٠٥٣٩٠٣٣٣٣ فرعي ٤٧٤٣ فاكس ٠٥٣٨٢٦٨١٧

سابعا : سوف يهمل كل عرض غير مستوف لهذه الشروط

رئيس لجنة العطاءات المركزية

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وتستمر المسيرة

وزارة الأشغال العامة والإسكان

الرقم ش/ ٢٠٢١/١٧ ٢٠٨٤

التاريخ ٢٠٢١-٠١-٢٥

الموافق

مناقصة محلية

إعلان طرح

العطاء المحلي رقم (ش/٢٠٢١/١٧)

صادر عن وزارة الأشغال العامة والإسكان

الخاص بمشروع إنشاء مبنى مركز شباب بدر/منطقة بدر/محافظة العاصمة

الجهة المستفيدة وزارة الشباب

يدعى المقاولون الأردنيون المصنفون لدى دائرة العطاءات الحكومية بموجب شهادة تصنيف سارية المفعول صادرة عن الدائرة في مجال الابنية اختصاص إنشاء الأبنية بالفئة الرابعة أو الثالثة، الراغبون بالمشاركة في هذا العطاء مراجعة مديرية العطاءات المحلية اعتباراً من يوم الثلاثاء الموافق ٢٠٢١/٠١/٢٦ ووفقاً لما يلي: -

١- وصف العمل: إنشاء مركزمبنى شباب بدر /محافظة العاصمة، وحسب ما هو وارد في وثائق الشراء.

٢- ثمن نسخة المناقصة (٢٠٠) مئتي دينارا غير مسترده ، وعلى المقاولين تقديم صورة مصدقة عن شهادة التصنيف سارية المفعول لدى شراء وثائق الشراء، علماً أن أجور نشر الإعلان على من يرسو عليه العطاء.

٣- أخر موعد لبيع نسخ المناقصة هو الساعة الثانية عشرة والنصف ظهراً ليوم الاثنين الموافق ٢٠٢١/٠٢/٨، علماً ان صندوق المقبوضات في الوزارة يغلق الساعة الثانية عشرة والنصف ظهراً يوميا.

٤- تم تحديد موعد زيارة ميدانية لكافة الشركات المشاركة في العطاء وذلك يوم الثلاثاء الموافق ٢٠٢١/٠٢/٩ الساعة العاشرة صباحاً ويتم التجمع في مديرية دراسات الابنية وبالتنسيق مع هاتف خلوي رقم (٠٧٩٦٦٥٦٩٦٩).

٥- آخر موعد لقبول طلب التوضيح حول وثائق الشراء هو نهاية الدوام الرسمي ليوم الاربعاء الموافق ٢٠٢٠/٠٢/١٠ ولن يتم قبول اية استيضاحات تصل بعد هذا التاريخ على ان تقدم الإستيضاحات لديوان مديرية العطاءات المحلية الطابق الأرضي في وزارة الاشغال العامة والاسكان /الدوار الثامن.

٦- تحتفظ لجنة الشراء المحلية لنفسها الحق في رفض كل العروض المقدمة إليها أو إلغاء إجراءات المناقصة وفقاً لأحكام القانون.

٧- يقدم تأمين دخول العطاء (الكفالة البنكية) بمغلف منفصل حسب المتطلبات التالية:

- رقم العطاء: (ش/٢٠٢١/١٧).
- إسم العطاء: إنشاء مبنى مركز شباب بدر/ منطقة بدر/محافظة العاصمة .
- تأمين دخول العطاء (الكفالة البنكية) باسم: معالي وزير الأشغال العامة والإسكان بالإضافة لوظيفته.
- مدة سريان تأمين دخول العطاء (الكفالة البنكية): تسعون يوماً من تاريخ إيداع العروض.
- قيمة تأمين دخول العطاء (الكفالة البنكية): (٧٠٠٠) سبعة آلاف ديناراً.
- اسم المناقص كما هو وارد في شهادة التصنيف.
- أن يكون تأمين الدخول (الكفالة البنكية) مطابقة للنموذج المعتمد وسوف يتم رفض أي عطاء غير مرفق بتأمين دخول المناقصة.

المملكة الأردنية الهاشمية

mpwh@mpw

وتستمر المسيرة 1921 100 2021

وزارة الأشغال العامة والإسكان

دائرة العطاءات الحكومية

الرقم ع-7-1/ 453

التاريخ 2022\2\10

الموافق

مناقصة دولية

إعـلان طـرح

العطاء المركزي رقم (2022/17)

الخاص باستكمال أعمال العطاء المركزي (2018/53) الخاص بإنشاء طريق معبر الكرامة /الركبان/الحدلات الحدودي

الجهة المستفيدة: وزارة الأشغال العامة والإسكان

يدعى المقاولون الأردنيّون المصنفون لدى دائرة العطاءات الحكومية في مجال الطرق اختصاص إنشاء وصيانة الطرق بالفئة الاولى بموجب شهادة تصنيف سارية المفعول بالإئتلاف مع المقاولين السعوديين المصنفين في مجال الطرق بالفئة الأولى أو الثانية أو الثالثة.

- يسمح بالائتلاف بين مناقصين اثنين فقط (أردني وسعودي) كحد أقصى لتحقيق شروط دعوة العطاء ولا يسمح لأي مناقص المشاركة في اكثر من إئتلاف .
- على المناقص تقديم وثيقة ائتلاف مبدئية عند إيداع العروض ويتم تصديقها أصولياً للائتلاف الفائز قبل إحالة العطاء.
- لا يسمح التقدم لهذا العطاء بشكل منفرد.
- على المناقصين الراغبين في الإشتراك في هذه الدعوة مراجعة دائرة العطاءات الحكومية في وزارة الأشغال العامة والإسكان / عمان / الأردن اعتباراً من يوم الأحد الموافق 2022/2/20 او سحب الدعوة من خلال نظام الشراء الإلكتروني الأردني (**JONEPS**).
- رقم دعوة العطاء حسب نظام الشراء الإلكتروني الأردني (**JONEPS**)(2022000072-00).

1. <u>وصف العمل:</u>

يتضمن العمل استكمال إنشاء طريق يصل بين مركز حدود الكرامة الحدودي ومنطقة الركبان بطول 83 كم تقريباً وبعرض 5 م بمستوى طريق ثانوي، كما يشمل العمل إنشاء عبارات انبوبية لتصريف مياه الأودية وكما هو مبين في وثائق الشراء.

2. ثمن نسخة وثائق الشراء الواحدة (800) دينار أردني غير مستردة وعلى المقاولين تقديم صورة مصدقة عن شهادة التصنيف السارية المفعول لدى شرائهم وثائق الشراء ويتم دفع ثمن نسخة وثيقة الشراء من خلال تطبيق **eFAWTEERcom** او من خلال تطبيقات البنوك للدفع الإلكتروني أو من خلال صندوق دائرة العطاءات الحكومية.

3. آخر موعد لبيع نسخ وثائق الشراء هو الساعة الثالثة مساءً ليوم الأحد الموافق 2022/3/6 .

المملكة الأردنية الهاشمية

هاتف: ١٤- ٥٨٥٨٣١١ ص.ب ١٢٢٠ الرمز البريدي ١١١١٨ فاكسيملي: ٥٨٥٧٥٨٣ - ٥٨٥٧٦٣٩

Tel.: 5858311 - 14 P.O.Box 1220 Post Code 11118 Facsmile 5857583 - 5857639 E-mail : gtd@gtd.gov.jo

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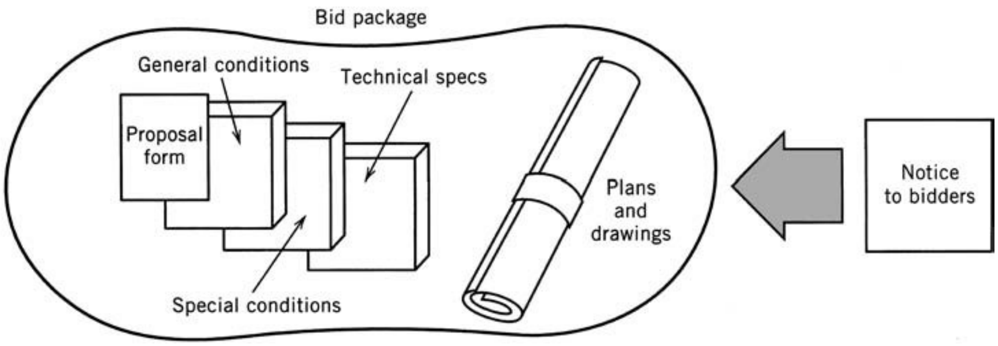
Bid Package

- The documents that are available to the contractor to make a decision to bid or not to bid are those in the bid package



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- A bid package prepared by the design professional consists of
  - Plans and technical specifications
  - Proposal form
  - General conditions that cover procedures common to all construction contracts
  - Special conditions which pertain to procedures to be used that are unique to a given project

842

- The proposal form, when completed and submitted by the contractor, indicates the contractor’s desire to perform the work and the price to construct the project
- The proposal form when completed and submitted establishes intent on the part of the contractor to enter into a contract to complete the work specified at the price indicated in the proposal

843

- It is an offer and by itself is not a formal contract
- If, however, the owner responds by awarding the contract based on the proposal, an acceptance of the offer results and a contractual relationship is established

PROPOSAL

TO THE GEORGIA BUILDING AUTHORITY (HOSPITAL)
STATE CAPITOL
ATLANTA, GEORGIA

Submitted: ____(date)____, 2XXX

The undersigned, as Bidder, hereby declares that the only person or persons interested in the Proposal as principal or principals is or are named herein and that no other person than herein mentioned has any interest in this Proposal or in the Contract to be entered into; that this Proposal is made without connection with any other person, company, or parties making a bid or Proposal; and that it is in all respects fair and in good faith without collusion or fraud.

The Bidder further declares that he has examined the site of the work and informed himself fully in regard to all conditions pertaining to the place where the work is to be done; that he has examined the plans and specifications for the work and contractual documents relative thereto, and has read all Special Provisions and General Conditions furnished prior to the opening of bids; and that he has satisfied himself relative to the work to be performed.

The Bidder proposes and agrees, if this Proposal is accepted, to contract with the Georgia Building Authority (Hospital), Atlanta, Georgia, in the form of contract specified, to furnish all necessary material, equipment, machinery, tools, apparatus, means of transportation, and labor, and to finish the construction of the work in complete accordance with the shown, noted, described, and reasonable intended requirements of the plans and specifications and contract documents to the full and entire satisfaction of the Authority with a definite understanding that no money will be allowed for extra work except as set forth in the attached General Conditions and Contract Documents, for the following prices:

CAMP CREEK PUMP STATION

Section 1: Unit Price Work

(For part payment—except rock excavation—by unit prices, to establish price for variation in quantities. Include balance of quantities for these items—except rock excavation—in lump sum bid for Section 2.)

Item Number	Quantity	Unit	Description	Unit Price	Total Amount
1.	550	cubic yard (cu yd)	Rock excavation (for structures and pipes only)	$____	$____
2.	50	linear foot (lin ft)	8″ C.I. force main	$____	$____
3.	20	cubic yard (cu yd)	Trench excavation for pipes	$____	$____
4.	200	square yard (sq yd)	Paving	$____	$____

Subtotal, Section 1, Item Nos. 1 to 4, Inclusive ________

________ Dollars ($________)

844

- The prices at which the work will be constructed can be stated either as lump-sum or as unit-price figures

Section 1: Unit Price Work

(For part payment—except rock excavation—by unit prices, to establish price for variation in quantities. Include balance of quantities for these items—except rock excavation—in lump sum bid for Section 2.)

Item Number	Quantity	Unit	Description	Unit Price	Total Amount
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4.	200	square yard (sq yd)	Paving	$______	$______

Subtotal, Section 1, Item Nos. 1 to 4, Inclusive ________________

________________ Dollars ($____________)

Section 2: Lump Sum Work

Item No.	Description		Total Amount
5.	Excavation and Fill		
	(a) Access Roadway	$______	
	(b) Structure Excavation and Backfill	$______	
	(c) Finish Grading	$______	
	Total for Item No. 5		$______
6.	Paving		
	(a) Access Roadway	$______	
	(b) Station Area	$______	
	Total for Item No. 6		$______
7.	Concrete Work		$______

845

- In the proposal form, the contract duration can sometimes be specified
- In many instances, the project duration in working or calendar days is specified in the special conditions portion of the bid package
- For example, a proposal form can indicate that the contractor is to begin work within 10 calendar days after receipt of written notice of award of contract
- Award of contract is usually communicated to the contractor in the form of a notice to proceed

846

General Conditions

- Certain conditions or requirements regarding how a contract is to be administered and the relationships between the parties involved are often the same for all contracts
- An organization that enters into a large number of contracts each year normally evolves a standard set of conditions that establishes these procedures and applies them to all construction contracts
- This set of provisions is normally referred to as the general conditions

- Large government contracting organizations have a standard set of general provisions
- Topics typically addressed in general conditions:

1. Definitions
2. Preliminary matters
3. Contract documents
4. Bonds and insurance
5. Contractor's responsibilities
6. Owner's responsibilities
7. Engineer's responsibilities
8. Changes in the work
9. Change of contract price
10. Change of contract times
11. Tests and inspections
12. Payments to contractor and completion
13. Suspension of work and termination
14. Dispute resolution

- The rights and responsibilities of the primary contractual parties in any construction contract are defined in the general conditions
- Sections pertaining to the (a) owner, (b) architect (or A/E), (c) contractor, and (d) subcontractors are typically found in the general conditions
- Each of the provisions of a standard set of general conditions has legal implications, and the wording cannot be changed without careful consideration

849

Supplementary/Special Conditions

- Those aspects of the contractual relationship that are unique to a given project are given in the supplementary conditions
- Typical provisions included in the supplementary conditions
  - Duration of the project
  - Additional instructions regarding commencement of work
  - Owner-procured materials
  - Mandatory wage rates characteristic of the local area
  - Format required for project progress reporting (e.g., a network schedule)
  - Amount of liquidated damages (reimbursement for damages suffered by the owner because of contractor's failure to fulfill contractual obligations)

850

- Two types of items contained in supplementary conditions
  - Modifications to the basic articles of the general condition in the form of additions, deletions, or substitutions
  - Additional articles of a contractual-legal nature that may be desirable or necessary for a particular project
- Because some of the provisions are extensions or interpretations of the general conditions, some of the major paragraph titles are similar to those used in the general conditions

851

- Special conditions for a channel improvement project

PART II
SPECIAL CONDITIONS
INDEX

Paragraph No.	Title	Page No.
SC-1.	Commencement, Prosection, and Completion of Work	SC-1
SC-2.	Liquidated Damages	SC-1
SC-3.	Contract Drawings, Maps, and Specifications	SC-1
SC-4.	Construction Drawings	SC-4
SC-5.	Physical Data	SC-5
SC-6.	Rates of Wages	SC-6
SC-7.	Variations in Estimated Quantities	SC-6
SC-8.	Government-Furnished Property	SC-7
SC-9.	Water	SC-7
SC-10.	Electricity	SC-7
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SC-13.	Damage to Work	SC-8
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SC-17.	Performance of Work by Contractor	SC-12
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SC-22.	Work Areas	SC-14
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SC-29.	Protection of Constructed Facilities	SC-16
SC-30.	Protection of Utilities	SC-16
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SC-33.	Requirements of Pennsylvania Railroad Company and Westinghouse Electric Corp. Pertaining to Construction Work Within the Limits of Railroad Right-of-Way and Westinghouse Electric Corp. Property	SC-16 SC-17
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SC-35.	Watchmen and Danger Signs	SC-19
SC-36.	Sequence of Operations	SC-20
SC-37.	Acceptance of Work	SC-21
SC-38.	Insurance Policies to be Furnished to the Government	SC-22
SC-39.	Payment	SC-22

852

Technical Specifications

- The contract documents must convey the requirements of the project to potential bidders and establish a legally precise picture of the technical aspects of the work to be performed
- This is accomplished visually through the use of drawings
- A verbal description of the technical requirements is established in the technical specifications

853

- These provisions pertain in large part to the establishment of quality levels
- Standards of workmanship and material standards are defined in the specifications
- For materials and equipment, this is often done by citing a specific brand name and model number as the desired item for installation

854

- Often the quality required will be established by reference to an accepted practice or quality specification
  - The American Concrete Institute (ACI)
  - The American Welding Society (AWS)
  - The American Association of State Highway and Transportation Officials (AASHTO)
  - The American Society for Testing and Materials (ASTM)
  - Government agencies publish recognized specifications and guides

855

Typical references to structural inspection and testing standards

American Concrete Institute

211.1-91 Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete (Reapproved 2009)

211.2-98 Standard Practice for Selecting Proportions for Structural Lightweight Concrete (Reapproved 2004)

214R-02 Evaluation of Strength Test Results of Concrete

301-05 Specifications for Structural Concrete

318-08 Building Code Requirements for Structural Concrete and Commentary

421.2R-07 Seismic Design of Punching Shear Reinforcement in Flat Plates

ITG-7-09 Specification for Tolerances for Precast Concrete

SP-211 Large-Scale Structural Testing

ACI 305.1-06—Specification for Hot Weather Concreting

ACI 306.1-90 Standard Specification for Cold Weather Concreting (Reapproved 2002)

ACI 530/530.1—Building Code Requirements & Specifications for Masonry Structures, 2005

American Society for Testing and Materials

A185/A185M-07 Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete

A934/A934M-07 Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

C270-08a Standard Specification for Mortar for Unit Masonry

C55-09 Standard Specification for Concrete Building Brick

C109/C109M-08 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars

C1116/C1116M-09 Standard Specification for Fiber-Reinforced Concrete

C1329-05 Standard Specification for Mortar Cement

C140-09 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

American Society of Civil Engineers

ASCE/SEI 7-05 Minimum Design Loads for Buildings and Other Structures

Building Seismic Safety Council

NEHRP Recommended Provisions and Commentary for Seismic Regulations for New Buildings and Other Structures. 2003 Edition

National Ready Mix Concrete Association

Concrete Plant Standards of Concrete Plant Manufacturers Bureau (15th Revision, 2007)

Truck Mixer, Agitator and Front Discharge Concrete Carrier (15th Revision, 2001)

Concrete Reinforcing Steel Institute Reinforcement

Reinforcement, Anchorages and Splices, 5th Edition 2008

856

- The organization of the technical specifications section usually follows the sequence of construction
- Specifications regarding concrete placement precede those pertaining to mechanical installation
- A typical index of specifications for a heavy construction project might appear as follows
  1. Clearing and grubbing
  2. Removal of existing structures
  3. Excavation and fill

857

4. Sheet steel piling
5. Stone protection
6. Concrete
7. Miscellaneous items of work
8. Metal work fabrication
9. Water supply facilities
10. Painting
11. Seeding

858

Addenda

- Addenda
  - Any changes in detail, additions, corrections, and contract conditions
  - Changes arise before bids are opened
  - These changes are intended to become part of the bid package and the basis for bidding are incorporated into the bid package through addenda

859

- An addendum becomes part of the contract documents and provides the vehicle for the owner (or the owner's representative) to modify the scope and detail of a contract before it is finalized
- It is important therefore that addenda details be rapidly communicated to all potential bidders prior to bid submission

860

Addendum vs. Change Order

- After a contract has been signed
  - Future changes in the scope or details of a contract may form the basis for a new financial relationship between contracting parties
  - The original contract, in such cases, can no longer be accepted as forming the basis for a full description of the project
  - Such changes are referred to as change orders

861

The Estimate and the Decision to Bid

- After investigating the plans and specifications, the contractor must make a major decision as to whether or not to bid the job
- Since the estimate is the basis for determining the bid price of a project, it is important that the estimate be carefully prepared
- Once quantities are established, estimators who have access to pricing information use these quantities and their knowledge of construction methods and productivities to establish estimates of the direct costs of performing each construction task

862

- Indirect costs that cannot be assigned directly to a particular physical piece of the project are added to the totaled project direct costs
- Finally, the bid price is established by adding the overhead costs, allowances for contingencies, and a suitable profit margin

863

- Example of building construction project bid summary using the CSI organization of work

Item	Division	Material	Labor	Subcontract	Total
1	**General requirement**	$ 16,435.00	$ 36,355.00	$ 4,882.00	$ 57.672.00
2	**Site-work**	15,070.00	20,123.00	146,186.00	181,389.00
3	**Concrete**	97,176.00	51,524.00	0.00	148,700.00
4	**Masonry**	0.00	0.00	212,724.00	212,724.00
5	**Metals**	212,724.00	59,321.00	0.00	272,045.00
6	**Woods and plastics**	38,753.00	10,496.00	4,908.00	54,157.00
7	**Thermal and moisture**	0.00	0.00	138,072.00	138,072.00
8	**Doors and windows**	36,821.00	32,115.00	0.00	68,936.00
9	**Finishes**	172,587.00	187,922.00	0.00	360,509.00
10	**Specialties**	15,748.00	11,104.00	9,525.00	36,377.00
11	**Equipment**	0.00	0.00	45,729.00	45,729.00
12	**Furnishings**	0.00	0.00	0.00	0.00
13	**Special construction**	0.00	0.00	0.00	0.00
14	**Conveying systems**	0.00	0.00	0.00	0.00
15	**Mechanical**	0.00	0.00	641,673.00	641,673.00
16	**Electrical**	0.00	0.00	354,661.00	354,661.00
	Total direct costs	$605,314.00	$408,960.00	$1,558,360.00	$2,572,644.00
	Material tax (5%)	30,266.00			2,602,910.00
	Labor tax (18%)		73,613.00		2,676,523.00
	Contingency (2%)			53,530.00	2,730,053.00
	Bonds/Insurance			34,091.00	2,764,144.00
	Profit (10%)			276,414.00	3,040,558.00
				Bid price =	$3,040,558.00

864

Construction Cost Analysis & Estimating – 110401543

Cash Flow

Dr. Mohammad Almashaqbeh
Department of Civil Engineering
Hashemite University

865

- There are two primary threats to a construction company's financial future
  - Lack of profitability
  - Insufficient cash
- Insufficient cash is where the company lacks sufficient funds to pay the bills that are due
- A company may be profitable and still fail because it lacks sufficient cash

866

- The cash generated by a project is equal to the cash receipts less the cash disbursements
- If the cash disbursements are less than the cash receipts for a project, the project will be generating cash for use by the company on
  - Other projects
  - To cover general overhead
  - Provide a profit to the owners
- When a project is generating cash the cash flow will be positive

867

- If the cash disbursements exceed the cash receipts on a project, the company will need to supply cash to fund the project and the cash flow will be negative
- Most construction projects require the investment of cash at the beginning of the project and, if they are profitable, generate cash near the end of the project
- The construction company's needs for cash stem from the company's need to pay bills before receiving payment from the owner for the work associated with these bills

868

- A lack of sufficient cash hurts a construction company in many ways
- First, when a company cannot pay its bills on time because of a lack of cash, the company may have to pay late charges, pay higher prices, or may have to prepay for materials and subcontractor services
- When the company pays late charges and higher prices, this reduces a company's profits and reduces a company's ability to compete based on price
- When a company has to prepay for materials and services due to lack of cash, this increases its need for cash and further aggravates the problem

869

- Second, the amount of cash a construction company has greatly affects the amount of work the company can perform
- This can be in the form of limits placed on a company from the bonding and insurance carriers or because the company cannot acquire the necessary materials and subcontractor services necessary to complete the project because it lacks the cash necessary to obtain credit
- If the lack of cash is great enough, an otherwise profitable company may be forced into bankruptcy

870

- For construction projects where a construction company receives monthly progress payments the cash flow from the project has three unique characteristics
- First, the cash receipts for the project usually occur only once during each month
- As a result, there is a single point in time during the month when the cash a construction company has invested in the project rapidly decreases, which coincides with the receipt of the payment from the owner

871

- Second, a construction company can often defer paying some of the costs associated with the construction on these types of projects until it receives payment from the owner
- As a result, much of the payment from the owner is immediately paid out to suppliers and subcontractors
- In effect, some of the cash associated with these projects quickly passes from the project's owner through the construction company's banking accounts to the suppliers and subcontractors

872

- Third, the owner holds back part of the payments due to the construction company in the form of retention, which is held until the project is completed
- At the completion of the project, the owner pays the construction company the retention
- Retention on a project can often exceed the expected profits on a project

873

- To determine the needed cash for a project we need to look at the timing of the cash flows for the project
- Specifically, the cash flows associated with the payments from the owner versus the payment of the construction bills
- One of the biggest factors in determining the cash needs for a project is the schedule of payments from the owner
- A construction company will need more cash to complete a project when the owner pays the monthly bill 60 days after receipt of the bill than it would need if the owner paid the monthly bill 15 days after receipt
- Often the final payment has a different payment schedule than the progress payments

874

- Another big factor in determining the cash needs for a construction project is retention
- Retention is often held by the owner to ensure that a construction company completes a project
- Most commonly, retention is expressed as a percentage of the cost of the work billed to the owner
- Common retention rates include 5 and 10%
- In some cases, the owner may hold retention only on the first half of the contract

875

- For example, the owner may hold 10% retention until the contract is 50% complete, at which time no additional retention is withheld
- In this example, at the completion of the project the owner would be holding retention equal to 5% of the contract amount
- The retention is often paid to the construction company at the time of the final payment although it may be paid at a later date
- When negotiating a construction contract, the contractor should negotiate the retention terms as well as the contract price

876

- One of the greatest needs for cash on a project comes from labor performed by the company on the project
- Often, labor for a project is paid weekly or every two weeks
- When paying weekly, the construction company pays for the labor performed for the previous week during the current week
- For a construction company that bills the owner on a monthly basis this means that the company will pay up to four weeks of labor before it can bill the owner for the labor and then the construction company has to wait for the owner to pay the bill

877

- If the owner pays one month after the bill is received, the construction company will need enough cash to cover two months of labor
- If the payment schedule for the owner is increased to 45 days, the contractor will be funding two and a half months of payroll
- Conversely, if the payment terms are reduced to 15 days the contractor will reduce funding needs to one and a half months of payroll

878

- Because retention cannot be held from employees' wages, the construction company also must have sufficient cash to cover the retention held on wages
- One way a construction company may reduce the cash required to cover labor costs is to subcontract the labor out, thereby utilizing the subcontractor's cash rather than its own

879

Example

- Payroll due to the employees on a project is $10,594 for the week of May 12 through 18
- The employees will be paid on May 21
- The construction company can bill the owner for this labor on May 31 and will be paid for the labor on June 25
- How long must the construction company fund the labor?

- The company must fund the $10,594 of labor from May 21 to June 25 or for 35 days

880

- Another need for cash comes from the use of materials on the project
- The payment terms with material suppliers vary from company to company
- Material suppliers often require that they be paid without taking into account whether the construction company has received payment from the owner
- Commonly, suppliers require that they be paid 10, 15, or 30 days after issuing the bill
- How often the supplier bills the construction company has a great effect on the cash needs of the construction company

881

- For example, a project where the owner pays the monthly bills within 15 days of receipt and the suppliers bill monthly
- Just in time for the construction company to submit the monthly bill to the owner
- The suppliers allow the construction company 30 days to pay the bill, the construction company would not need cash to pay the supplier’s bills
- This is because the construction company receives payment from the owner before it has to pay the suppliers

882

- If the supplier on the same project bills on a weekly basis, the construction company would need cash to cover the bills received during the first part of the monthly billing period
- Bills received after the middle of the month will not require funding by the construction company

883

- When dealing with large purchases or when the construction company is one of the supplier’s largest customers, the construction company may be able to negotiate for the supplier to be paid when the owner pays the construction company
- Like subcontracting, this allows the construction company to use the supplier’s cash rather than its own

884

- Most often material suppliers will not allow retention to be held from their payments, leaving the construction company to supply the cash needed to cover retention on the materials
- Some suppliers offer discounts for early payment

885

Example

- A $5,000 material bill for lumber is received on May 7 and is due 30 days from its billing date of May 1
- An $800 material bill for lumber is received on May 27 and is due 30 days from its billing date of May 23
- The construction company can bill the owner for these material bills on May 31 and will be paid on June 15
- How long must the construction company fund the costs of these material bills?

886

- The $5,000 bill must be paid by May 31
- Therefore, the company must fund the bill from May 31 to June 15 or for 15 days
- The $800 bill must be paid by June 22, after the construction company receives payment from the owner for this bill
- Therefore, it will not need to fund the payment of this bill

887

- Additional cash may be needed to pay for materials because the point in time when the materials become a billable item to the construction company may be different than the point in time when the materials become a billable item to the project's owner
- Materials may become a billable item to the construction company when it orders the materials or when the materials are delivered to the project
- The same materials may become a billable item to the project's owner when they are ordered, delivered, or incorporated into the construction project

888

- For example, a supplier of custom-built materials may require that the construction company place a deposit on or prepayment for the materials before fabrication begins
- However, the project's owner may require that the materials be incorporated into the project before the construction company can bill the owner for the materials
- This would require the construction company to fund the cash paid to the supplier from the time the order was placed until after the materials were incorporated into the project

889

- When dealing with expensive mechanical and electrical equipment, a large sum of cash could be tied up for many months
- Similarly, when a project's owner does not pay for materials until they are incorporated into the construction, additional cash is required when materials are delivered to the site before the work crews are ready to incorporate them into the project
- When calculating the needed cash for a project, the construction manager should understand when it is allowed to bill the project's owner for materials used in the construction project

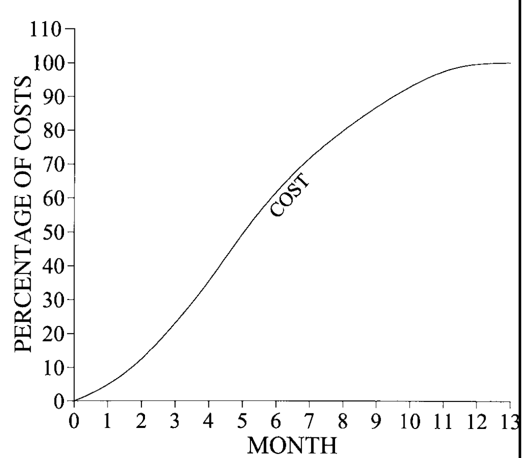
890

- There are four steps a construction manager must follow when developing a cash flow for a construction project

1. The manager must prepare a cost-loaded schedule for the project
    - The rate of progress on a project usually starts out slowly, picks up speed through the middle of the project, and slows down as the project nears completion
    - Commonly, the rate of progress at the end of the project is slower than at the beginning of the project

891

- Cost-loaded schedule for a typical project
- The graph is based on the cost of the work performed
- The months shown on the x axis of the graph represent the end of the months
- This cost curve is often referred to as the S curve

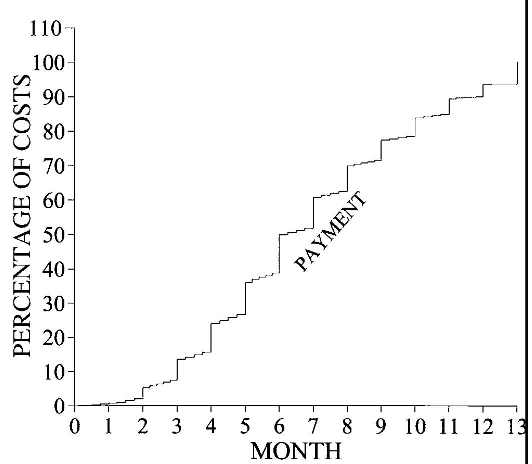


892

2. The manager must determine when the construction company will pay for the items in the cost-loaded schedule
   - To do this, the costs on the cost-loaded schedule must be grouped based on their payment terms
   - For example, labor costs that will be paid during the week following the week the costs were incurred need to be separated from the costs that will be paid when payment is received from the project's owner
   - Additionally, costs that will be paid in full need to be separated from those costs that retention can be withheld from until the completion of the project, usually subcontractor costs

893

- The payment of costs for a project
- The graph is based on 25% of the costs being materials, 25% being labor, and 50% being subcontractors
- The material bills are paid in full when payment is received from the project's owner
- The labor is paid weekly
- The subcontractors are paid when payment is received, less 10% retention that is withheld until the retention is released by the owner

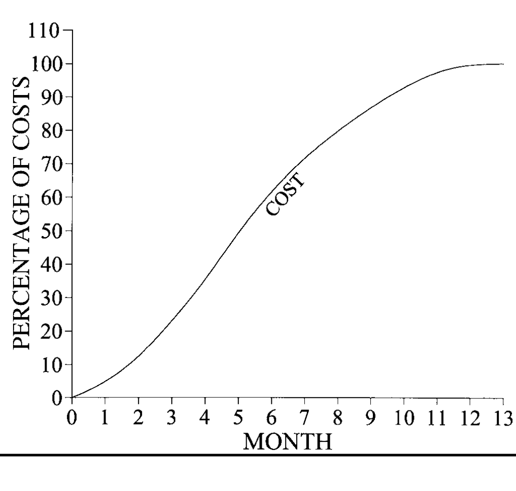


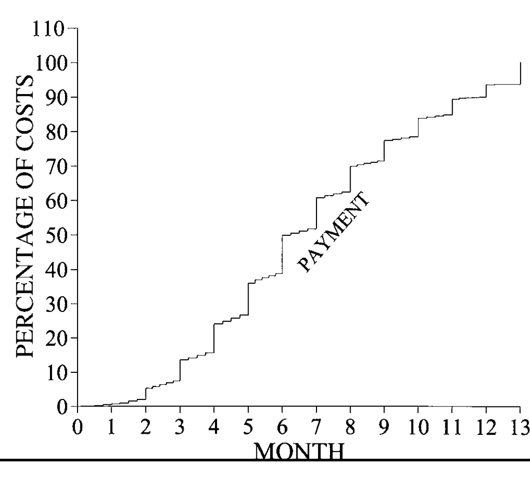
894

3. The manager must determine when payment will be received from the project's owner for the work in the cost-loaded schedule
   - This is done by determining when the costs in the cost-loaded schedule will be billed to the owner and then determining when payment will be received
   - The payments must be reduced by the retention withheld by the project's owner and the release of retention must be included in the cash flows at the end of the project

895

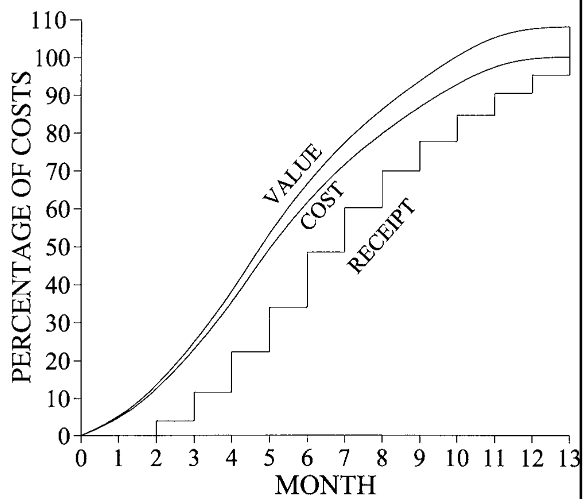
- The costs and payments shown include only the construction costs, while excluding the profit and overhead markup





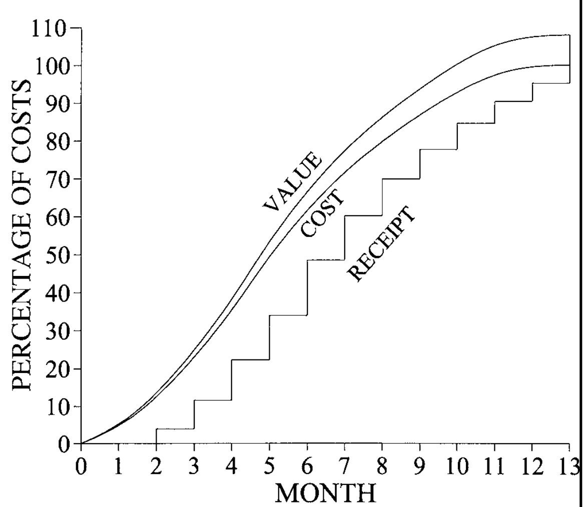
896

- When billing the project's owner the profit and overhead markup is included in the progress payments
- In addition to the cost of the work, the figure shows the value of the work, which includes an 8% profit and overhead markup along with the cash receipts (payments) from the project's owner, both of which are expressed as a percentage of costs



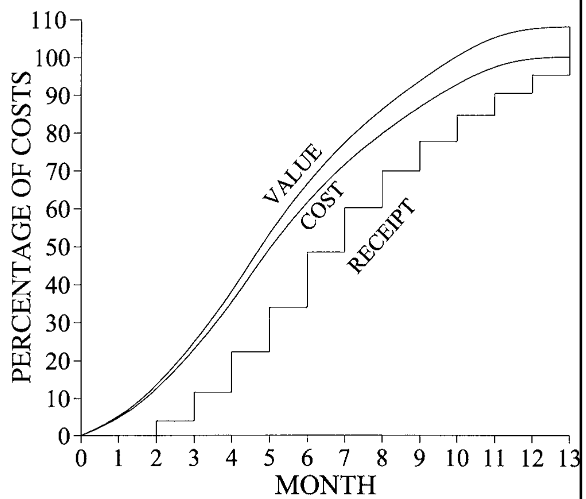
897

- The receipts are based on the owner being billed at the end of the month for the work being performed during the month and the project's owner paying the bills at the end of the following month, while withholding a 10% retention
- In this example, the costs incurred during the first month are billed at the end of the first month and payment is received from the owner for these costs at the end of the second month



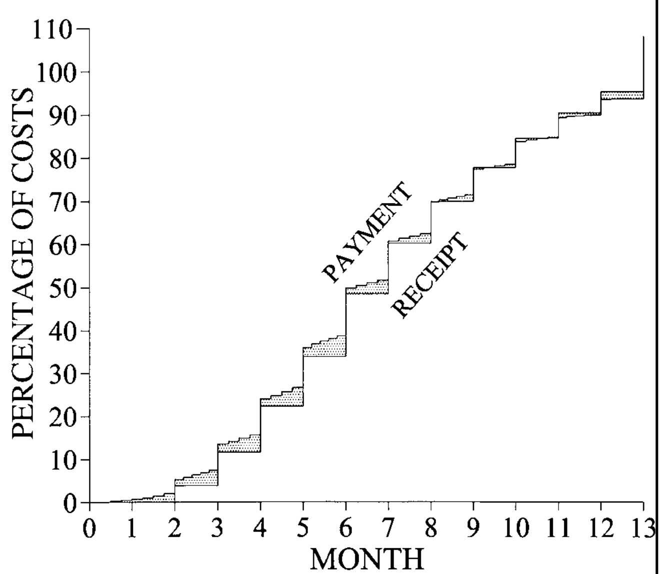
898

- The retention is released at the end of the thirteenth month
- If the project's owner paid the bills 15 days after receipt, the receipt curve would move one-half of a month to the left
- If payments were received 45 days after receipt of the bill, the receipt curve would move one-half of a month to the right



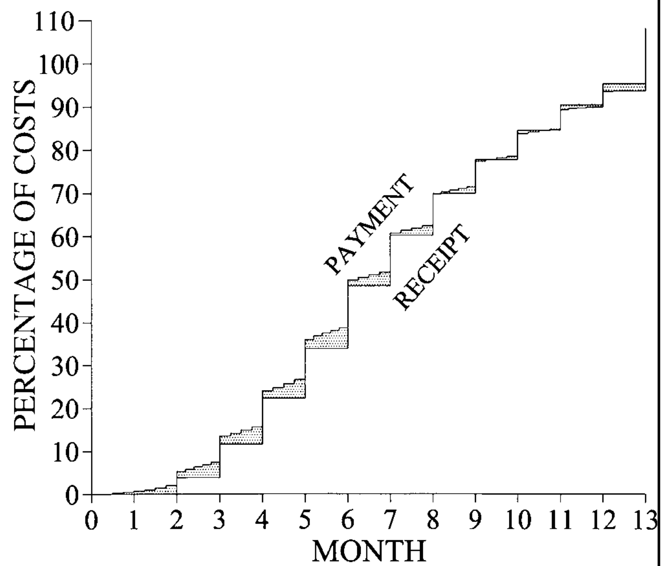
899

4. The manager must determine the difference between the cash inflows to the project (receipts from the owner) and the cash outflows from the project (payment to labor, suppliers, and subcontractors)



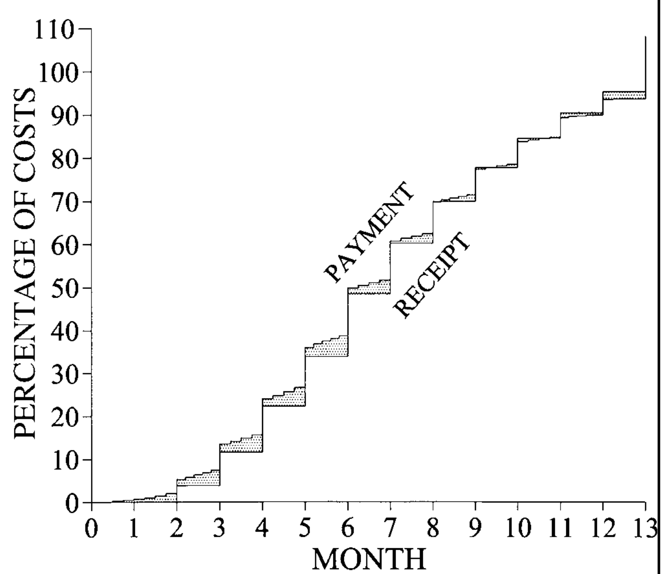
900

- The vertical distance between the payment and receipt lines represents the cash provided by the construction company and is shown as the shaded area in the figure



901

- In this example, the project first experiences a cash surplus during the tenth month—which is eliminated by labor payments during the month—and by the twelfth month a constant cash surplus on the project occurs



902

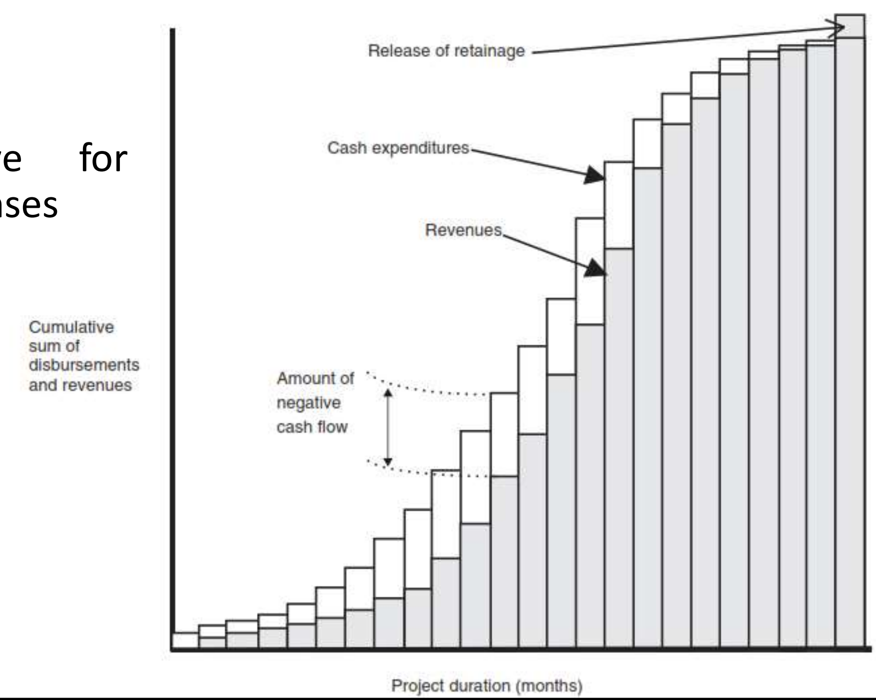
• Sample cost breakdown for an apartment building project

Apartment Building Cost Breakdown

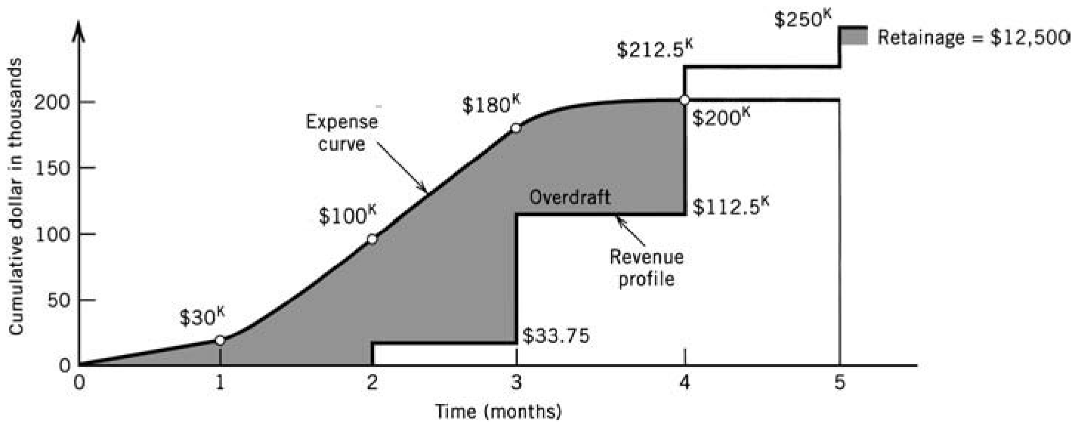
Work Item Description	Percent of Total	Cumulative Amount
Slab (forms, rebar, concrete)	8	8
Plumbing (site and slab)	3	11
1st floor framing (through joists)	10	21
Deck 1st floor	2	23
2nd floor framing (through joists)	10	33
Deck 2nd floor	2	35
3rd floor framing (through joists)	11	46
Roof deck	2	48
Rough plumbing complete (through roof)	4	52
Roofing	3	55
HVAC rough in	4	59
Electrical rough in	4	63
Drywall, tape and float	5	68
Painting	4	72
Cabinets	4	76
Trim carpentry	3	79
Masonry complete	2	81
HVAC final	4	85
Plumbing final	3	88
Electrical final	4	92
Appliances	3	95
Carpet, vinyl flooring, ceramic tile	4	99
Final clean-up	1	100

903

• Cash flow curve for revenues and expenses

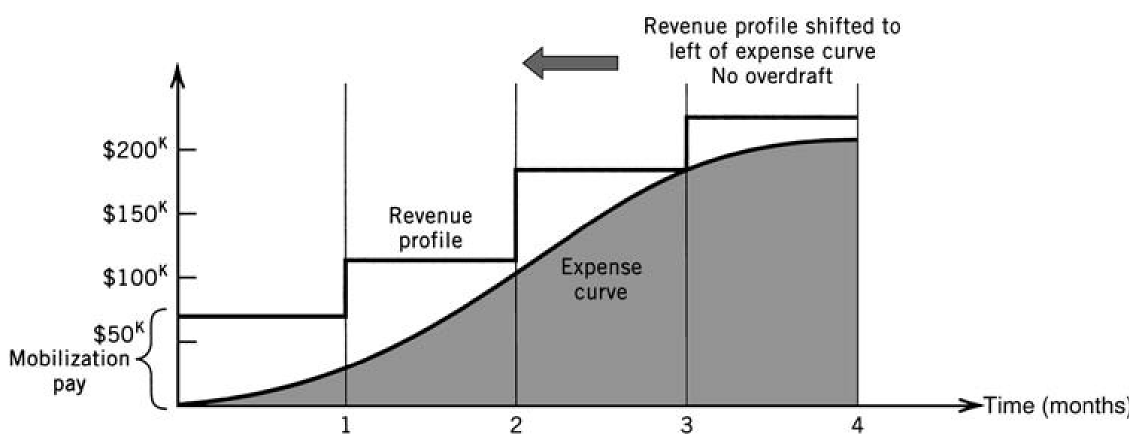


904



905

- Some contractors offset the overdraft borrowing requirement by requesting front/mobilization payment from the owner



906

- The monthly cash flow may be characterized by measuring the monthly cash flows to date at two points in time during the month
- The first point in time is at the end of each month
- This is referred to as the monthly cash flow
- The second point in time is when the project requires the greatest investment of cash during the month, which usually occurs just before the payment is received from the project's owner
- This is referred to as the peak cash flow and represents the most negative cash flow during the month

907

- The monthly cash flow for the project for a specific month (n) equals the cash receipts less the cash disbursements for the month and is calculated as follows
- $\text{Cash Flow}_n = \text{Cash Receipts}_n - \text{Cash Disbursements}_n$
- We could calculate the total cash generated as of the end of a month by adding the monthly cash flow to the total cash generated as of the end of the previous month
- $\text{Cash}_n = \text{Cash}_{n-1} + \text{Cash Flow}_n$

908

- The peak amount of cash required by projects often occurs just prior to receipt of payment from the project's owner
- When calculating the total cash generated just prior to receipt of payment from the project's owner ($Cash_{n'}$), we would add this month's cash flows ($Cash\ Flow_{n'}$) that occur before payment is received from the owner to the total cash generated as of the end of the previous month
- The total cash generated just prior to receipt of payment from the project's owner is calculated as follows
- $Cash_{n'} = Cash_{n-1} + Cash\ Flow_{n'}$

909

Example

- A construction company is negotiating on a construction project with a six-month duration
- On the last day of each month the construction company may bill the owner for the work completed during the month
- The owner pays the monthly bills one month after they are received
- For example, the construction company receives payment for work completed during June on July 31
- The owner also holds 10% retention

910

- Final payment is expected one month after completion of the project and will include payment of the retention
- The construction company pays material suppliers in full when it receives payment from the owner
- The construction company pays subcontractors when it receives payment from the owner but withholds 10% from the subcontractor's payment
- The construction company pays for labor weekly

911

- The projected monthly material, labor, and subcontractor costs, as well as the amount the construction company will bill the project's owner each month, are shown in the table

	Costs			
Month	Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	30,400	34,900	54,700	129,600
2	57,300	48,900	123,800	248,400
3	80,500	73,100	136,400	313,200
4	29,200	34,000	106,800	183,600
5	27,800	26,200	66,000	129,600
6	15,400	11,300	43,300	75,600
Total	240,600	228,400	531,000	1,080,000

912

- Determine the monthly cash flows and the total cash generated by the project at the end of each month and just before each payment is received from the project's owner
- What is the maximum amount of cash invested by the company during the completion of the project?

913

- Because the first payment from the owner is not received until the second month, the first point in time where we calculate the total cash generated by the project is at the end of the first month
- For the first month, the peak cash flow occurs at the end of the month
- Because material suppliers and subcontractors are paid only when the construction company receives payment from the owner, no material or subcontractor payments are made during the first month

914

- Cash $Flow_n$ = Cash $Receipts_n$ – Cash $Disbursements_n$
- Cash $Flow_n$ = Cash $Receipts_n$ – (Material $payments_n$ + Labor $payments_n$ + Subcontractor $payments_n$)
- Cash $Flow_1$ = 0 – (0 + \$34,900 + 0) = - \$34,900
- The total cash generated by the project by the end of the first month: $Cash_1$ = $Cash_0$ + Cash $Flow_1$ = 0 + (- \$34,900) = - \$34,900
- At the end of the first month the construction company will have \$34,900 of cash invested in the project

915

- The next point in time where we need to calculate total cash generated by the project is just before receipt of the first payment from the owner, which occurs at the end of the second month
- No additional payments have been made to suppliers and subcontractors during this part of the month
- The construction company has paid out \$48,900 to cover the cost of the labor performed during the second month
- Cash $Flow_{2'}$ = 0 – (0 + \$48,900 + 0) = - \$48,900

916

- The total cash generated by the project just before the first payment is received from the project's owner: $Cash_{2'}$ = $Cash_1$ + Cash $Flow_{2'}$ = -$34,900 + (-$48,900) = -$83,800
- Just before the construction company receives payment from the owner during the second month, the construction company will have $83,800 of cash invested in the project

917

- At the end of the second month the construction company will have received the first payment from the owner
- The payment will be equal to the work billed at the end of the first month less the 10% retention
- The payment received from the owner during the second month
- Cash $Receipt_n$ = $Bill_{n-1}$ (1 – Retention Rate)
- Cash $Receipt_2$ = $129,600 (0.9) = $116,640

918

- During the month the construction company will have paid out \$30,400 to material suppliers, \$48,900 to cover the cost of the labor, and the first month's subcontractor costs—less the 10% retention
- Subcontractor Payment_2 = \$54,700 (0.9) = \$49,230
- Cash Flow_2 = \$116,640 – (\$30,400 + \$48,900 + \$49,230) = - \$11,890
- The total cash generated by the project by the end of the second month $\text{Cash}_2 = \text{Cash}_1 + \text{Cash Flow}_2$ = -\$34,900 + (-\$11,890) = -\$46,790

919

- The cash flows and the amount of cash needed for the third through the sixth month are calculated in a similar manner

	Monthly Cash Flow (\$)		Cash Generated (\$)	
Month	n'	n	n'	n
1	−34,900	−34,900	−34,900	−34,900
2	−48,900	−11,890	−83,800	−46,790
3	−73,100	−18,260	−119,890	−65,050
4	−34,000	44,620	−99,050	−20,430
5	−26,200	13,720	−46,630	−6,710
6	−11,300	18,140	−18,010	11,430
7	0	68,570	11,430	80,000

920

3^{rd} Month

- Cash $Flow_{3'}$ = 0 – (0 + \$73,100 + 0) = - \$73,100
- $Cash_{3'}$ = $Cash_2$ + Cash $Flow_{3'}$ = -\$46,790 + (-\$73,100) = -\$119,890
- Cash $Receipt_3$ = \$248,400 (0.9) = \$223,560
- Subcontractor $Payment_3$ = \$123,800 (0.9) = \$111,420
- Cash $Flow_3$ = \$223,560 – (\$57,300 + \$73,100 + \$111,420) = - \$18,260
- $Cash_3$ = $Cash_2$ + Cash $Flow_3$ = -\$46,790 + (-\$18,260) = -\$65,050

921

4^{th} Month

- Cash $Flow_{4'}$ = 0 – (0 + \$34,000 + 0) = - \$34,000
- $Cash_{4'}$ = $Cash_3$ + Cash $Flow_{4'}$ = -\$65,050 + (-\$34,000) = -\$99,050
- Cash $Receipt_4$ = \$313,200 (0.9) = \$281,880
- Subcontractor $Payment_4$ = \$136,400 (0.9) = \$122,760
- Cash $Flow_4$ = \$281,880 – (\$80,500 + \$34,000 + \$122,760) = \$44,620
- $Cash_4$ = $Cash_3$ + Cash $Flow_4$ = -\$65,050 + (\$44,620) = -\$20,430

922

5^{th} Month

- Cash $Flow_{5'}$ = 0 – (0 + \$26,200 + 0) = - \$26,200
- $Cash_{5'}$ = $Cash_4$ + Cash $Flow_{5'}$ = -\$20,430 + (-\$26,200) = -\$46,630
- Cash $Receipt_4$ = \$183,600 (0.9) = \$165,240
- Subcontractor $Payment_5$ = \$106,800 (0.9) = \$96,120
- Cash $Flow_5$ = \$165,240 – (\$29,200 + \$26,200 + \$96,120) = \$13,720
- $Cash_5$ = $Cash_4$ + Cash $Flow_5$ = -\$20,430 + (\$13,720) = -\$6,710

923

6^{th} Month

- Cash $Flow_{6'}$ = 0 – (0 + \$11,300 + 0) = - \$11,300
- $Cash_{6'}$ = $Cash_5$ + Cash $Flow_{3'}$ = -\$6,710 + (-\$11,300) = -\$18,010
- Cash $Receipt_6$ = \$129,600 (0.9) = \$116,640
- Subcontractor $Payment_6$ = \$66,000 (0.9) = \$59,400
- Cash $Flow_6$ = \$116,640 – (\$27,800 + \$11,300 + \$59,400) = \$18,140
- $Cash_6$ = $Cash_5$ + Cash $Flow_6$ = -\$6,710 + (\$18,140) = \$11,430

924

- The next point in time where we need to calculate total cash generated by the project is just before receipt of the last payment from the owner, which occurs at the end of the seventh month
- By this time the construction company has not paid any additional costs; therefore, the total cash generated by the project equals the total cash generated by the project at the end of the previous month for a total of $11,430:
- $Cash_{7'} = Cash_6 + Cash\ Flow_{7'} = \$11,430 + 0 = \$11,430$

925

- The payment received from the owner during the seventh month will include the full amount of the bill from the sixth month plus the retention withheld from the previous months
- The retention held during the first six months is as follows
- Retention = $0 + $129,600(0.10) + $248,400(0.10) + $313,200(0.10) + $183,600(0.10) + $129,600(0.10) = $100,440
- The seventh month's payment from the owner is Cash $Receipt_7$ = $100,440 + $75,600 = $176,040

926

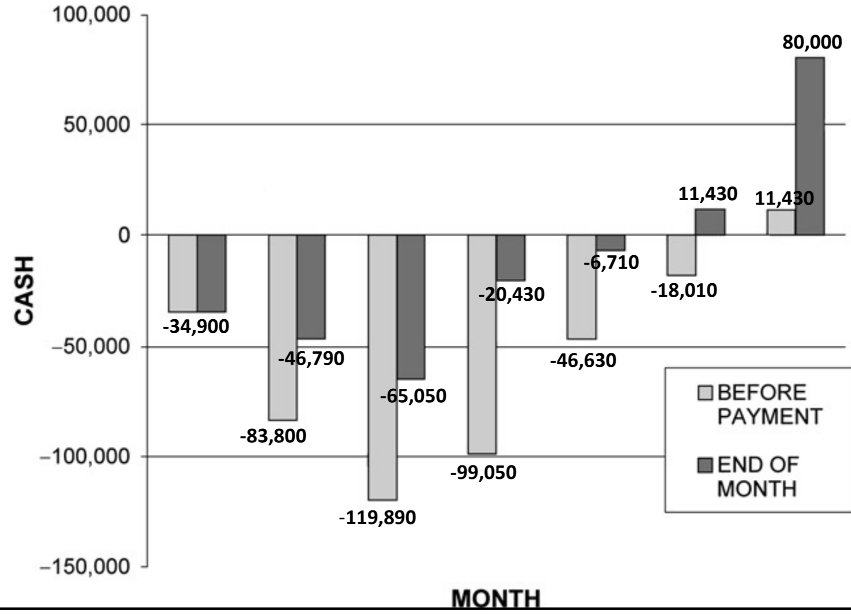
- During the month the construction company will have paid out \$15,400 to material suppliers and will have to pay for the sixth month's subcontractor costs plus all of the retention held during the first six months
- Retention (Subcontractor) = \$0 + \$54,700(0.10) + \$123,800(0.10) + \$136,400(0.10) + \$106,800(0.10) + \$66,000(0.10) = \$48,770
- The seventh month's payment to the subcontractors: Subcontractor Payment_7 = 48,770 + \$43,300 = \$92,070

927

- The cash flow for the seventh month: Cash Flow_7 = \$176,040 - (\$15,400 + \$0 + \$92,070) = \$68,570
- The total cash generated by the project at the end of the seventh month: Cash_7 = Cash_6 + Cash Flow_7 = \$11,430 + \$68,570 = \$80,000
- At this point the project is complete
- At the completion of the project the cash generated by the project should equal the profit and overhead realized on the project, which equals the profit and overhead markup for this example

928

• The cash generated by the project just before payment from the owner and at the end of the month



929

• The maximum amount of cash invested in the project by the construction company occurs in the third month and is $119,890, which is greater than the profit and overhead markup on the project

• For the construction company to complete this project, it would need $119,890 in cash

930

- From the previous example we see that the cash requirements just before payment was received from the project's owner were consistently greater than the cash requirements at the end of the month
- Had we projected the amount of cash needed to complete the project based on the cash needed at the end of the months we would have come up short by as much as $78,620 ($99,050 - $20,430)

931

- In the previous example there were five things that affected the amount of cash needed to complete the project
  - Material payments
  - Labor payments
  - Subcontractor payments
  - Retention held by the owner
  - Profit and overhead markup

932

- Material payments did not affect the project’s cash requirements because the material bills were paid in full when the company received payment from the owner
- Labor payments had a great effect on the project’s cash requirements
- Just before receiving the payment from the owner, the construction company had paid out almost two months of wages

933

- For the labor performed during the first month the construction company will
  - Pay the wages during the first month
  - Bill the owner for the wages at the end of the first month
  - Receive payment from the owner at the end of the second month
- During this time, the owner will have to cover the costs of the wages for the second month

934

- The maximum amount of cash needed to cover the costs of labor during the project occurs in the third month
- At this time the construction company has to cover the second and third month's wages for a total of $122,000 ($48,900 + $73,100)

MONTH	COSTS MATERIALS ($)	LABOR ($)	SUB. ($)	BILL TO OWNER ($)
1	30,400	34,900	54,700	129,600
2	57,300	48,900	123,800	248,400
3	80,500	73,100	136,400	313,200
4	29,200	34,000	106,800	183,600
5	27,800	26,200	66,000	129,600
6	15,400	11,300	43,300	75,600
Total	240,600	228,400	531,000	1,080,000

935

- Subcontractor payments were paid when the company received payment from the owner; however, the payment was reduced by the 10% retention
- As a result, the subcontractors became a source of cash that offsets the cash consumed by retention held by the owners
- By the seventh month, the subcontractors had provided $48,770 of cash to the construction company, which is the amount of retention withheld from the subcontractors during the first six months

936

- Retention is an extensive use of cash
- By the seventh month the owner had withheld $100,400 in retention from the contractor
- Profit and overhead markup was a source of cash
- By the end of the project, it provided the company with $80,000 in cash. However, this cash is needed to cover the costs of the general overhead, provide cash for investment, and provide a profit to the company’s shareholders

937

- In the previous example there are four ways the construction company could reduce the project’s cash requirements

1. First, the construction company could increase its use of subcontractors as a way to reduce the materials and labor that it provides
    - The construction company uses the subcontractor’s cash to cover the cost of labor and increases its cash by withholding retention from the subcontractors on the labor supplied

938

- By having the subcontractors provide materials, the construction company increases its cash by withholding retention from the subcontractors on the materials supplied

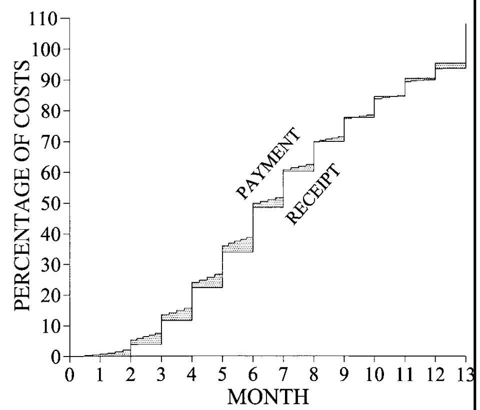
2. Second, the construction company could negotiate a more favorable retention rate
   - The greatest benefit of reducing the retention rate comes when the construction company is providing most of the labor and materials, while minimizing the use of subcontractors

939

- When subcontractors are supplying most of the labor and materials and the construction company is withholding retention on the subcontractors, there is little benefit gained by reducing the retention rate because the construction company passes the lower retention rate on to its subcontractors
- The savings in cash due to the reduced retention rate is offset by a loss of cash being provided by the subcontractors in the form of retention

940

3. Third, the construction company could increase the profit and overhead markup
   - Increasing the profit and overhead markup raises the entire receipt curve
   - This decreases the distance between the payment and receipt curves when the payments (outgoing cash) are greater than the receipts (incoming cash), which reduces the cash needed for the project



941

4. Fourth, the schedule of values can be front loaded by increasing the price charged to the owner for items completed early in the project while decreasing the price of items completed later in the project

	Costs			
Month	Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	30,400	34,900	54,700	129,600
2	57,300	48,900	123,800	248,400
3	80,500	73,100	136,400	313,200
4	29,200	34,000	106,800	183,600
5	27,800	26,200	66,000	129,600
6	15,400	11,300	43,300	75,600
Total	240,600	228,400	531,000	1,080,000

942

- The price increases and decreases are such that the total cost of the project remains unchanged
- Front loading the project raises the early portions of the receipt curve, the portions where a company has the most cash invested in the project, while leaving the later part of the curve unchanged
- This decreases the distance between the payment and receipt curves for the early part of the project, which reduces the amount of cash needed for the project

943

Example

- How would the project's cash requirements change for the construction company in the previous example if it increased the amount of work performed by subcontractors from 53.1% to 74.1% as shown in the table

	Costs			
Month	Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	17,700	19,000	83,300	129,600
2	31,600	26,300	172,100	248,400
3	47,700	40,100	202,200	313,200
4	15,500	17,800	136,700	183,600
5	14,200	14,600	91,200	129,600
6	8,300	6,300	55,400	75,600
Total	135,000	124,100	740,900	1,080,000

944

• Sub. = 53.1%

Month	Costs Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	30,400	34,900	54,700	129,600
2	57,300	48,900	123,800	248,400
3	80,500	73,100	136,400	313,200
4	29,200	34,000	106,800	183,600
5	27,800	26,200	66,000	129,600
6	15,400	11,300	43,300	75,600
Total	240,600	228,400	531,000	1,080,000

• Sub. = 74.1%

Month	Costs Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	17,700	19,000	83,300	129,600
2	31,600	26,300	172,100	248,400
3	47,700	40,100	202,200	313,200
4	15,500	17,800	136,700	183,600
5	14,200	14,600	91,200	129,600
6	8,300	6,300	55,400	75,600
Total	135,000	124,100	740,900	1,080,000

945

• Sub. = 53.1%

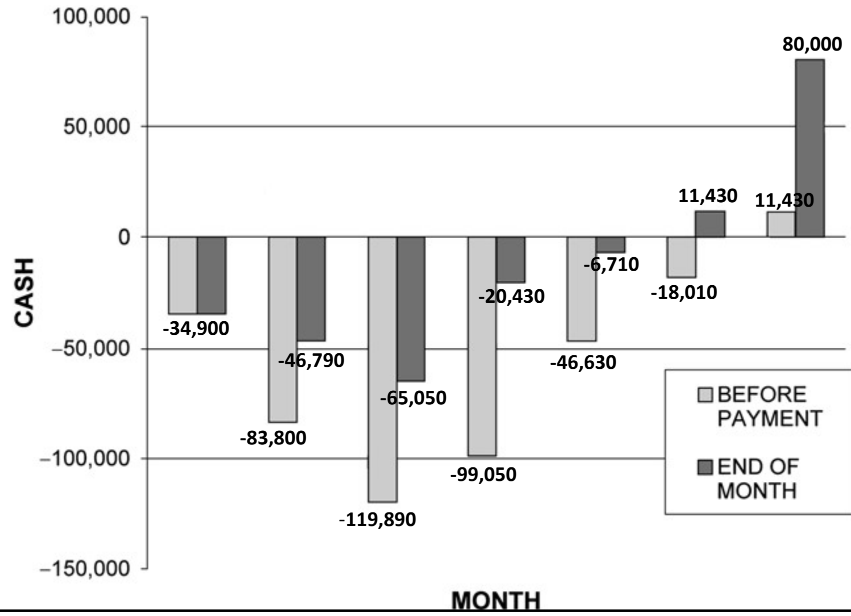
Month	Monthly Cash Flow ($)		Cash Generated ($)	
	n'	n	n'	n
1	−34,900	−34,900	−34,900	−34,900
2	−48,900	−11,890	−83,800	−46,790
3	−73,100	−18,260	−119,890	−65,050
4	−34,000	44,620	−99,050	−20,430
5	−26,200	13,720	−46,630	−6,710
6	−11,300	18,140	−18,010	11,430
7	0	68,570	11,430	80,000

• Sub. = 74.1%

Month	Monthly Cash Flow ($)		Cash Generated ($)	
	n'	n	n'	n
1	−19,000	−19,000	−19,000	−19,000
2	−26,300	−2,330	−45,300	−21,330
3	−40,100	−3,030	−61,430	−24,360
4	−17,800	34,400	−42,160	10,040
5	−14,600	12,110	−4,560	22,150
6	−6,300	14,060	15,850	36,210
7	0	43,790	36,210	80,000

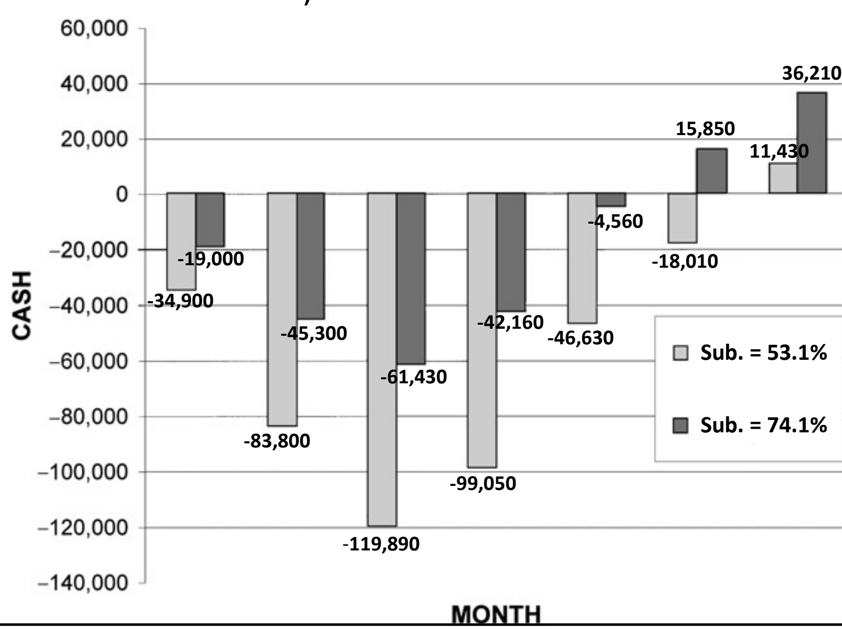
946

• The cash generated by the project just before payment from the owner and at the end of the month (Sub. = 53.1%)



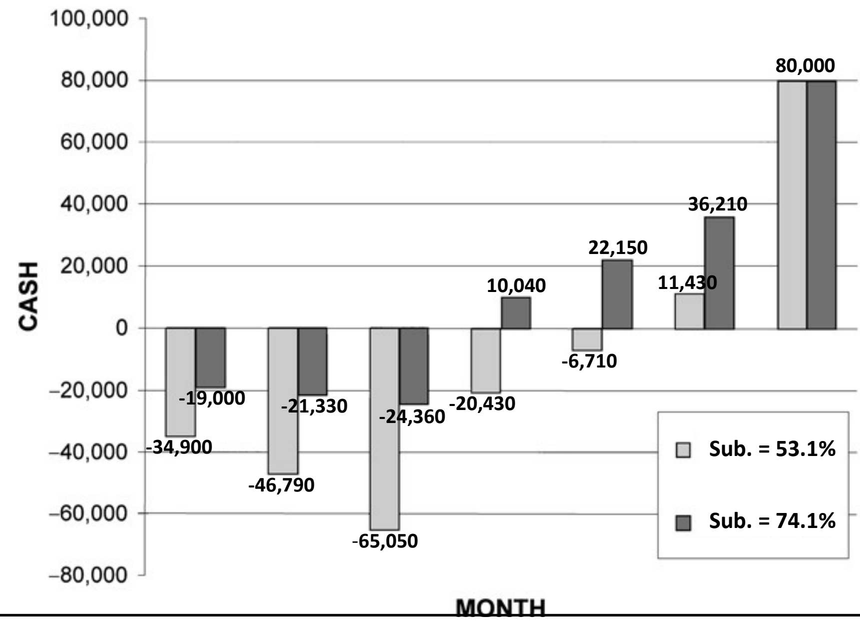
947

• Maximum cash invested in the project each month (just before payment from the owner)



948

• Maximum cash invested in the project at the end of each month



949

• At the completion of the project the cash generated by both examples equals the profit and overhead markup

• The peak amount of cash invested in the project by the construction company occurs in the third month and is \$61,430 (Sub. = 53.1%) compared to \$119,890 (Sub. = 74.1%)

• Sub. = 74.1% required less cash investment and required this investment for a shorter period of time than did Sub. = 53.1%

• This is because the construction company used the subcontractor's cash rather than its own to fund the project

950

- In the previous examples we looked at the amount of cash a construction company needs to complete a project
- In both of these examples the owner of the project received the benefit of using the construction company and its suppliers and subcontractor's cash rather than using their own cash
- The benefit to the project's owner equals the amount of cash provided by the construction company, the labor, the suppliers, and the subcontractors, which equals the cost to the owner for the work performed less the payments received from the owner

951

- The benefit for a specific month is calculated by taking the previous month's benefit and adding this month's costs less this month's receipts
- $Cash_n = Cash_{n-1} + Bills_{n-1} - Receipt_n$
- Like the cash required by the construction company, the benefit to the owner may be measured just before the monthly payment to the construction company is made and at the end of the month

952

Example

- Determine the amount of cash that the construction company and its suppliers and subcontractors are providing to the project owner

Month	Costs: Materials ($)	Labor ($)	Sub. ($)	Bill to Owner ($)
1	30,400	34,900	54,700	129,600
2	57,300	48,900	123,800	248,400
3	80,500	73,100	136,400	313,200
4	29,200	34,000	106,800	183,600
5	27,800	26,200	66,000	129,600
6	15,400	11,300	43,300	75,600
Total	240,600	228,400	531,000	1,080,000

953

- Because the owner does not make a payment during the first month, the first point in time we calculate the benefit is at the end of the first month
- The monthly bill to the owner is $129,600 and the monthly benefit is calculated as follows
- $Cash_n = Cash_{n-1} + Bills_{n-1} - Receipt_n$
- $Cash_1 = 0 + \$129,600 – 0 = \$129,600$
- At the end of the first month the construction company and its suppliers and subcontractors have provided the project's owner with $129,600 in funding for the project

954

- The next point in time we need to calculate the benefit to the owner is just before receipt of the first payment from the owner, which occurs at the end of the second month
- The benefit just before the payment has been received is equal to the cash from the previous month plus the cost of the work completed between the end of the previous month and just before receipt of payment from the owner

955

- The cost of the work completed between the end of the previous month and just before receipt of payment from the owner is approximately equal to the billing to the owner
- The benefit is calculated as follows
- $Cash_{2'}$ = \$129,600 + \$248,400 – 0 = \$378,000

- $Receipt_2$ = \$129,600 (0.9) = \$116,640
- The benefit for the end of the second month is $Cash_2$ = \$129,600 + \$248,400 – \$116,640 = \$261,360

956

- The benefits for the third through seventh months are calculated as follows
- $Cash_{3'}$ = \$261,360 + \$313,200 – 0 = \$574,560
- $Cash_{3}$ = \$261,360 + \$313,200 – \$223,560 = \$351,000
- $Cash_{4'}$ = \$351,360 + \$183,600 – 0 = \$534,600
- $Cash_{4}$ = \$351,360 + \$183,600 – \$281,880 = \$252,720
- $Cash_{5'}$ = \$252,720 + \$129,600 – 0 = \$382,320
- $Cash_{5}$ = \$252,720 + \$129,600 – \$165,240 = \$217,080

957

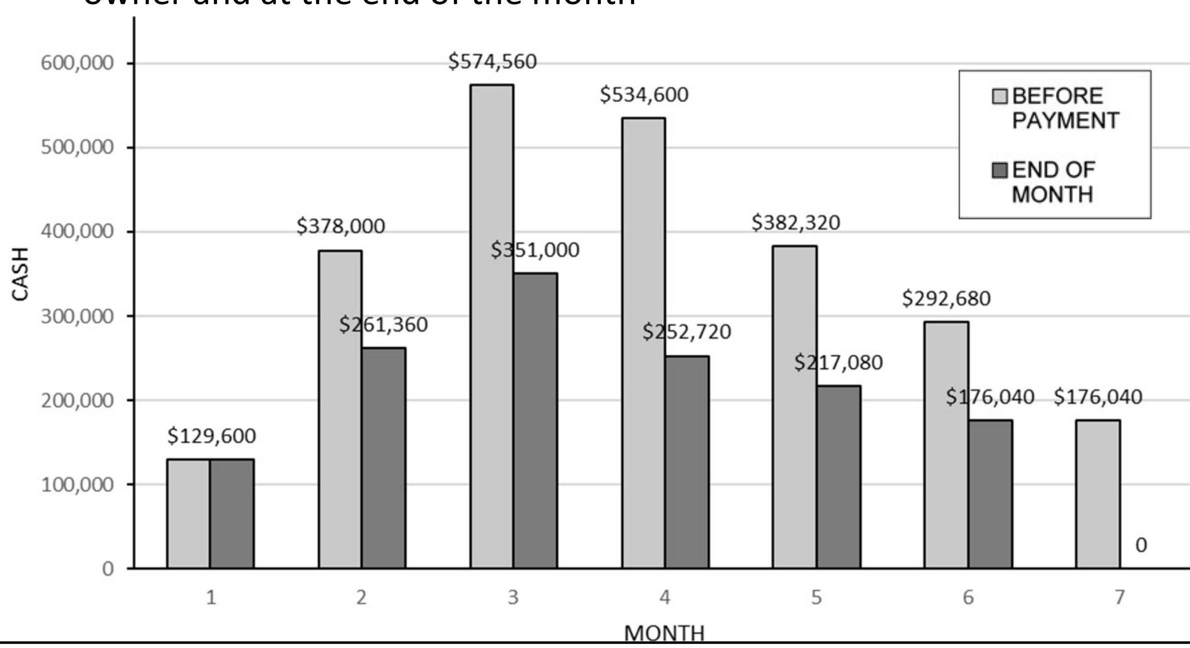
- $Cash_{6'}$ = \$217,080 + \$75,600 – 0 = \$292,680
- $Cash_{6}$ = \$217,080 + \$75,600 – \$116,640 = \$176,040
- $Cash_{7'}$ = \$176,040 + 0 – 0 = \$176,040
- $Cash_{7}$ = \$176,040 + 0 – \$176,040 = 0
- When the owner has paid for the project in full, the benefit provided by the construction company and its suppliers and subcontractors is zero

958

- The maximum benefit provided by the construction company and its suppliers and subcontractors occurs during the third month and has a value in excess of half of the total cost of the project to the owner
- In other words, during the third month the construction company and its suppliers and subcontractors are providing over half of the funds needed to construct the project

959

- The benefit to the project's owner just before payment from the owner and at the end of the month



960

- Sometimes a project will receive progress payment from the project's owner at intervals other than monthly
- For example, a project may receive progress payments at 25, 50, 75, and 100% complete
- The procedures for calculating the project's cash needs are the same as for a project that receives monthly payments, with cash flows being calculated at the end of each month and just before each payment is received

961

Cash Flow for Projects with a Single Payment

- Projects with a single payment differ in three ways from projects where the construction company receives progress payments from the project's owner
- First, because there are no progress payments, the peak amount of cash required is equal to the cash required at the end of the month for all but the last month when the payment is received
- Second, retention is not held because there are no progress payments

962

- Third, the construction company may also be paying some, if not all, of the soft costs
- Soft costs include payments for the following
  - The purchase of the land
  - Engineering and design fees
  - Permitting and other fees charged by government entities
  - Construction interest and loan fees
  - Taxes and insurance

963

Example

- The construction company decides to act as the owner on the project
- The construction company plans to sell the project for $1,350,600 at the end of the seventh month

	Costs		
Month	Materials ($)	Labor ($)	Sub. ($)
1	30,400	34,900	54,700
2	57,300	48,900	123,800
3	80,500	73,100	136,400
4	29,200	34,000	106,800
5	27,800	26,200	66,000
6	15,400	11,300	43,300
Total	240,600	228,400	531,000

964

- In addition to the construction costs the construction company has the following soft costs
  - Land purchase: $200,000
  - Engineering and design fees: $30,000
  - Building permits: $5,600
  - Government fees: $20,000
  - Miscellaneous costs: $15,000
- The soft cost will be paid at the end of month zero

965

- The construction company pays material suppliers in full on the last day of the month following the month the materials were supplied to the project
- For example, materials supplied during the first month will be paid for at the end of the second month
- The subcontractors will be paid on the same schedule as the suppliers; however, the construction company will withhold 10% retention from the subcontractors' payments, which will be paid to the subcontractors at the end of the seventh month

966

- The construction company pays for labor weekly
- Determine the monthly cash flows and total cash generated by the project at the end of each month and just before the payment is received
- What is the maximum amount of cash invested by the company during the completion of the project?

967

- Because only one payment is received for the project, which occurs during the seventh month, we need to calculate only the cash flow and total cash generated at the end of the month for the first six months
- For the seventh month the cash flow and total cash generated will need to be calculated at the point in time just before the project is sold and after the project is sold

968

- Because the first costs occur during month zero, we begin by calculating the cash flow for month zero
- The total cash disbursements for the soft costs are as follows
- Cash Disbursements$_0$ = \$200,000 + \$30,000 + \$5,600 + \$20,000 + \$15,000 = \$270,600
- The cash flow for month zero is calculated as follows
- Cash Flow$_n$ = Cash Receipts$_n$ – Cash Disbursements$_n$
- Cash Flow$_0$ = 0 – \$270,600 = - \$270,600

969

- The total cash generated at the end of month zero is calculated as follows
- Cash$_n$ = Cash$_{n-1}$ + Cash Flow$_n$
- Cash$_0$ = 0 + (- \$270,600) = - \$270,600
- No payments to material suppliers or subcontractors will be made during the first month
- During the first month the construction company will pay \$34,900 for labor

970

- The cash flow for the first month: $\text{Cash Flow}_1 = 0 – \$34,900 = - \$34,900$
- The total cash generated at the end of the first month: $\text{Cash}_1 = - \$270,600 + (- \$34,900) = - \$305,500$
- At the end of the first month the construction company will need to have $305,500 of cash invested in the project

971

- During the second month the construction company will pay out $30,400 to material suppliers and $48,900 to cover the cost of the labor
- The construction company will have to pay for the first month's subcontractor costs, less the 10% retention
- The monthly subcontractor payments are as follows
- $\text{Subcontractor Payment}_2 = \$54,700 (0.9) = \$49,230$
- The cash flow for the second month: $\text{Cash Flow}_2 = 0 – (\$30,400 + \$48,900 + \$49,230) = - \$128,530$
- The total cash generated at the end of the second month: $\text{Cash}_2 = - \$305,500 + (- \$128,530) = - \$434,030$

972

- The cash flow and cash generated for the third through the sixth months are calculated in a similar manner
- Subcontractor $Payment_3$ = \$123,800 (0.9) = \$111,420
- Cash $Flow_3$ = 0 – (\$57,300 + \$73,100 + \$111,420) = -\$241,820
- $Cash_3$ = $Cash_2$ + Cash $Flow_3$ = - \$434,030 + (-\$241,820) = - \$675,850

973

- Subcontractor $Payment_4$ = \$136,400 (0.9) = \$122,760
- Cash $Flow_4$ = 0 – (\$80,500 + \$34,000 + \$122,760) = -\$237,260
- $Cash_4$ = $Cash_3$ + Cash $Flow_4$ = - \$675,850 + (-\$237,260) = -\$913,110
- Subcontractor $Payment_5$ = \$106,800 (0.9) = \$96,120
- Cash $Flow_5$ = 0 – (\$29,200 + \$26,200 + \$96,120) = -\$151,520
- $Cash_5$ = $Cash_4$ + Cash $Flow_5$ = -\$913,110 + (-\$151,520) = -\$1,064,630

974

- Subcontractor $Payment_6$ = \$66,000 (0.9) = \$59,400
- Cash $Flow_6$ = 0 – (\$27,800 + \$11,300 + \$59,400) = -\$98,500
- $Cash_6$ = $Cash_5$ + Cash $Flow_6$ = -\$1,064,630 + (-\$98,500) = -\$1,163,130
- The next point in time when we need to perform our calculation is just before the payment is received for the project
- By this time the construction company has paid no additional costs; therefore, the total cash generated is equal to the total cash generated at the end of the previous month: $Cash_{7'}$ = $Cash_6$ + Cash $Flow_{7'}$ = -\$1,163,130 + 0 = -\$1,163,130

975

- The payment of \$1,350,600 for the project is received at the end of the seventh month
- At the end of the seventh month the construction company will pay out \$15,400 to material suppliers
- The construction company will pay the subcontractors the retention held during the first six months plus the full amount of the work performed by the subcontractors during the sixth month

976

- The retention held during the first six months is as follows
- Retention (Subcontractor) = $0 + $54,700(0.10) + $123,800(0.10) + $136,400(0.10) + $106,800(0.10) + $66,000(0.10) = $48,770
- The seventh month's payment to the subcontractors: Subcontractor Payment_7 = 48,770 + $43,300 = $92,070
- The cash flow for the seventh month Cash Flow_7 = $1,350,600 – ($15,400 + $92,070) = $1,243,130

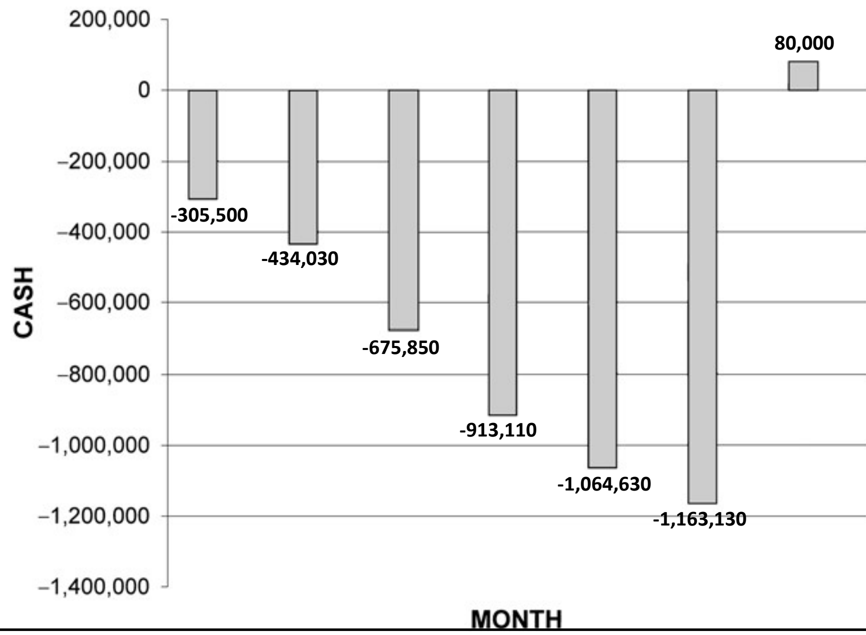
977

- The total cash generated at the end of the seventh month Cash_7 = Cash_6 + Cash Flow_7 = -$1,163,130 + $1,243,130 = $80,000
- At this point the project is complete
- The monthly cash flow and the cash generated at the end of each month are shown in the table

Month	Monthly Cash Flow ($)	Cash Generated ($)
0	−270,600	−270,600
1	−34,900	−305,500
2	−128,530	−434,030
3	−241,820	−675,850
4	−237,260	−913,110
5	−151,520	−1,064,630
6	−98,500	−1,163,130
7′	0	−1,163,130
7	1,243,130	80,000

978

• The cash generated by the project



979

- At the completion of the project the cash generated by the project should equal the profit and overhead realized on the project, which equals the profit and overhead markup
- The maximum amount of cash needed by the construction company occurs just before the payment is received. For the construction company to complete this project, it would need at least $1,163,600 in cash
- The construction company's needs for cash continue to increase throughout the life of the project with the maximum amount of cash required occurring just before the payment for the project is received, in this case when the project is sold

980