Project Management Phase

FEASIBILITY

DESIGN
PLANNING

DEVELOPMENT

CLOSEOUT

OPERATIONS

Fin.&Eval.
Risk
Organization
Estimating
Planning
Different types of estimates are required as a project evolves

- **Conceptual & Preliminary Estimates**
  - Prepared early in the project prior to engineering design completion (e.g., to tell Owner whether the contemplated project scope is feasible)
  - Incorporate new information from design to obtain an updated estimate of the project

- **Detailed Estimates**
  - Prepared from completed plans and specifications

- **Definitive Estimates**
  - Forecast the project cost within allowable limits from a combination of conceptual and detailed information often including partial contract and other procurement awards

Source: Barrie & Paulson, 1992
Design & Estimating Process

- Feasibility
- Conceptual design
- Detailed design
- Pre-bid
- Construction
- Conceptual & Preliminary Estimates
- Definitive Estimates
- Detailed Estimates
Outline

- Conceptual & Preliminary Estimates
  - Cost indices
  - Cost capacity factor
  - Parameter Cost
- Detailed Estimates
  - Estimates
  - Cost classification
  - Calculation
Conceptual and Preliminary Estimates

- Decide Feasibility
- Great Variability According to Type
- Categories:
  - Time-referenced Cost Indices
  - Cost-capacity Factors
  - Parameter Costs
Outline

- Conceptual & Preliminary Estimates
  - Cost indices
    - Cost capacity factor
    - Parameter Cost
- Detailed Estimates
  - Estimates
  - Cost classification
  - Calculation
Cost Indices

- Show changes of costs over time by upgrading the cost of similar facilities from the past to the present

Cost indices show the changes of a certain facility’s costs over time
Year 1913 = 100, …Year 2007 = 4432

If Facility A is similar to my ‘wish’ facility and I know the value of Facility A at 1913, I can assume my ‘wish’ facility’s value at 2007.

Source: http://www.enr.com/features/conEco/
Cost Indices

- Show changes of costs over time by upgrading the cost of similar facilities from the past to the present
- Used to determine the general construction costs of structures
- Published periodically by Engineering News Record (ENR) and other publications

ENR’s Building Cost Index (BCI): Changes of facility’s costs over time

- Facility’s components are:
  - 1,088 Board Feet of Lumber (2x4, 20-city Average)
    - 1 Board Feet = 1’ x 1’ x 1” = 144 in³
      - (e.g., 2x4 - 10 ft long contains [(2x4)x10] x 12] = 960 in³ → 6.67 board feet)
  - 2500 Pounds of Structural-Steel Shapes (20-city Average, Base Mill Price before 1996, Fabricated after 1996)
  - 1.128 Tons of Portland Cement (Bulk, 20-city Average)
  - 66.38 Hours of Skilled Labor (20-City Average of Bricklayers, Carpenters, and Structural Ironworkers)

Source: http://www.enr.com/features/conEco/
# Building Cost Index Data (1990–Date)

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Source: http://www.enr.com/features/conEco/

Base: 1913=100
# Building Cost Index Data (Prior to 1990)

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Source: http://www.enr.com/features/conEco/
Example:

Warehouse Estimate: Assume you have an estimate to a similar warehouse located nearby and completed in 1993 for a cost of $4,200,000. We are planning to build a new warehouse in Feb. of 2007. The Building Cost Index from ENR for 1993, relative to the base date of 1913, was 2996% and Building Cost Index from ENR for Feb. 2007 is 4432%. What is the estimated project cost if you establish the estimate using Building Cost Index from ENR?

Adapted from: Barrie & Paulson, 1992
What Information Do We Need?

- Current Building Cost Index (Feb. 2007) = 4432
- Building Cost Index for Year 1993 = 2996
- Similar Facility’s Cost at Year 1993 = $4,200,000

We Convert From One Base Period to Another

- $2996 : $4,200,000 = 4432 : $X$
- $X = (4432/2996) * $4,200,000 = $6,213,084$

Adapted from: Barrie & Paulson, 1992
Cost Indices Component Calculations

- **ENR’s Construction Cost Index:**
  - Used when labor costs are a high proportion of total cost
  - Components:
    - 1,088 Board Feet of Lumber (2x4, 20-city Average)
      - 1 Board Foot = 1’ x 1’ x 1” = 144 in³
    - 1.128 Tons of Portland Cement (Bulk, 20-city Average)
    - 200 Hours of Common Labor (20-city Average)
Cost Indices Use and Accuracy

- Accuracies Within 20% to 30% of Actual Costs
- Negligible Time and Effort
- Valuable for Preliminary Planning
Cost Indices - Limitations

- Problems could arise if the proportions of the input components (e.g., lumber) in a building type cost index do not reflect the resources used on the project in question
  - E.g., about 40% of the costs in a petrochemical project is in piping (pipe and pipe fitters)

- Problems could arise if the project on which the Index is based has very little in common with the project under consideration

- Some types of indices do not consider factors such as: productivity, changes in technology, and competitiveness of contractors

Adapted from: Barrie & Paulson, 1992
Outline

- Conceptual & Preliminary Estimates
  - Cost indices
  - Cost capacity factor
  - Parameter Cost

- Detailed Estimates
  - Estimates
  - Cost classification
  - Calculation
Cost-Capacity Factor

- Apply to changes in size, scope, or capacity of projects of similar types
- Reflect the nonlinear increase in cost with size (economies of scale, learning curves)

\[ C_2 = C_1 \left( \frac{Q_2}{Q_1} \right)^x \]

Where

- \( C_2 \) = estimated cost of the new facility w/capacity \( Q_2 \)
- \( C_1 \) = known cost of facility of capacity \( Q_1 \)
- \( x \) = the cost-capacity factor for this type of work
Cost-Capacity Factor

- Q is a parameter that reasonably reflects the size of the facility (e.g., barrels per day produced by a refinery, tons of steel per day produced by a steel mill, gross floor area for a warehouse)

- X is an empirically derived factor based on well-documented historical records for a variety of different types of projects
Example Revisit:

- Warehouse Estimate: Assume you have an estimate to a similar warehouse located nearby and completed in 1993 for a cost of $4,200,000. We are planning to build a new warehouse in Feb. of 2007. The ENR index for 1993, relative to the base date of 1913, was 2996% and the ENR index for 2007 is 4432%.

- Consider the cost-capacity factor $x = 0.8$ for a warehouse.
- The above warehouse has a usable area of 120,000 square feet.
- The prospective owner for the new warehouse wants a structure with a usable area of 150,000 square feet.
Cost-Capacity Factor Example

- What Information Do We Need?
  - \( \frac{Q_2}{Q_1} = \frac{150,000}{120,000} = 1.25 \)
  - Cost-capacity factor \( x = 0.8 \)
  - Known cost = $4,200,000

- \( C_2 = $4,200,000 \times (1.25)^{0.8} = $5,020,851 \)

- A 25% more capacity implies only 20% more costs
Combine Cost Indices & Cost Capacity Factors to take into account changes in both time & capacity

\[ C_2 = C_1 \left( \frac{I_b}{I_a} \right) \left( \frac{Q_2}{Q_1} \right)^x \]

- Where
  - \( I_b \) = Index number “Now” or present time.
  - \( I_a \) = Index number at that time

Source: Barrie & Paulson, 1992
Example Revisit:

- Warehouse Estimate: Assume you have an estimate to a similar warehouse located nearby and completed in 1993 for a cost of $4,200,000. We are planning to build a new warehouse in Feb. of 2007. The ENR index for 1993, relative to the base date of 1913, was 2996% and the ENR index for 2007 is 4432%.

- Consider the cost-capacity factor $x = 0.8$ for a warehouse.
- The above warehouse has a usable area of 120,000 square feet.
- The prospective owner for the new warehouse wants a structure with a usable area of 150,000 square feet.
Cost Indices & Cost-Capacity Factor Example

- \( C_2 = 4,200,000 \times \left( \frac{4432}{2996} \right) \times \left( \frac{150,000}{120,000} \right)^{0.8} = $7,188,731 \)
Outline

- Conceptual Estimates
  - Cost indices
  - Cost capacity factor
  - Parameter Cost

- Detailed Estimates
  - Estimates
  - Cost classification
  - Calculation
Commonly used in building construction
ENR “Quarterly Cost Roundup”
R.S. Means “Means Square Foot Costs”
Parameter Costs Characteristics

- Relates all costs of a project to just a few physical measures, or “Parameters”, that reflect the size or scope of the project.
  - E.g., warehouse - the “Parameter” would be “Gross Enclosed Floor Area”
    - all costs represented by $X/\text{S.F.} \rightarrow \text{total cost} = X \times \text{the project’s gross enclosed floor area (S.F.)}

- With good historical records on comparable structures, parameter costing can give reasonable levels of accuracy for preliminary estimates.
Means Square Foot Cost

- Costs per Square Foot
- Type of Facility (total 23,000 S.F apartment with 3 stories)

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<th>Commercial/Industrial/Institutional</th>
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<tbody>
<tr>
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<td>2. Apartment, 1-3 Story</td>
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Story Height = 10’ and No Basement

Source: RS Means, Square Foot Costs Data, 2006
What is the Cost for an apartment building (7 Story) if the perimeter of the building is 502 L.F. and the story height is 11’-4”? Assume that the apartment building has decorative concrete block on the east, west & south walls. The north walls external finish is brick with concrete block backup. The area of each floor of the apartment building 11,460 S.F. The basement floor area s 4,200 S.F. Please use the Means Square Foot Cost to obtain an estimate. The building frame is steel. The apartment building is located in Atlantic City, New Jersey, Zip Code 07410.
Characteristics of the Apartment Building

- 60’ x 191’ = 11,460 S.F./Floor
- 2 * [191’ + 60’] = 502 L.F. Perimeter
- 7 Floors

Exterior Walls:
- North wall: Face brick w/ concrete block backup
- East, West & South walls: Decorative Concrete Block

- Story Height: 11’-4”
- Basement Area: 4,200 S.F
- Steel Frame
- Located in Atlantic City, New Jersey, Zip Code 07410

Coefficients are determined from Model Number M.020 for Apartment, 4-7 Story type (Refer to RS Means (2006) - Square Foot Costs, page 80)

Source: RS Means, Square Foot Costs Data, 2006
### Parameter Cost Example

Choose type

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#### Costs per square foot of floor area

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**For Basement**, add $27.30 per square foot of basement area

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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 $54.35 to $157.75 per S.F.

Source: RS Means, Square Foot Costs Data, 2006

Figure by MIT OCW.
## Parameter Cost Example

### Costs per square foot of floor area

<table>
<thead>
<tr>
<th>Exterior Wall</th>
<th>S.F. Area</th>
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<tbody>
<tr>
<td></td>
<td>L.F. Perimeter</td>
<td>366</td>
<td>400</td>
<td>433</td>
<td>466</td>
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<tr>
<td>Perimeter Adj., Add or Deduct</td>
<td>Per 100 L.F.</td>
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</table>

**For Basement**, add $27.30 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 $54.35 to $157.75 per S.F.*

---

Figure by MIT OCW.  
Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- What should be adjusted when the cost is to be established by using the Means Square Foot Cost Method?

  - Exterior Wall Variation
  - Perimeter Adjustment
  - Story Height Adjustment
  - Basement Addition
  - Location Modifier

Source: RS Means, Square Foot Costs Data, 2006
### Commercial/Industrial/Institutional

<table>
<thead>
<tr>
<th>M.020</th>
<th>Apartment, 4-7 Story</th>
</tr>
</thead>
</table>

### Costs per square foot of floor area

<table>
<thead>
<tr>
<th>Exterior Wall</th>
<th>S.F. Area</th>
<th>40000</th>
<th>45000</th>
<th>50000</th>
<th>55000</th>
<th>60000</th>
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Figure by MIT OCW.

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- Basic SF Cost in R.S. Means for S.F Area=80000, L.F Perimeter = 530, Story Height = 10’ & No Basement
  - $128.35/SF when exterior walls are Brick w/ Concrete Block Backup (North)
  - $122.25/SF when exterior walls are Decorative Concrete Block (East, West, south)

- North wall makes up:
  - \[\frac{191’}{502’} \times 100 = 38.04\% \text{ of total building perimeter}\]

- East, West & South walls make up:
  - \[\frac{(191’+2\times60’)}{502’} \times 100 = 61.96\% \text{ of total building perimeter}\]

- Exterior Wall Variation
  - \[\$128.35 \times 38.04\% + \$122.25 \times 61.96\% = \$124.6/\text{S.F.}\]

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- What should be adjusted when the cost is to be established by using the Means Square Foot Cost Method?
  - Exterior Wall Variation
  - Perimeter Adjustment
  - Story Height Adjustment
  - Basement Addition
  - Location Modifier

Source: RS Means, Square Foot Costs Data, 2006
### Parameter Cost Example

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**For Basement**, add $27.30 per square foot of basement area

Figure by MIT OCW.

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- Exterior Wall Variation:
  - \[ (128.35 \times 38.04\% ) + (122.25 \times 61.96\% ) = 124.6/\text{S.F.} \]

- Perimeter Adjustment:
  - Apartment building perimeter is 28 L.F (530 - 502) less than the M.020 model building in RS Means
  - Perimeter adjustment factor: $2.65 per 100 L.F
  - \[ 124.6 - ( (2.65/100\ \text{L.F} \times 28\ \text{L.F}) = 123.9/\text{S.F} \]

- Height Adjustment:
  - Apartment building story height is 1’ 4” (11’ 4”-10’) more than the M.020 model building in RS Means
  - Height adjustment factor: $1.20 per ft
  - \[ 123.9 + (1.20 \times 1.3) = 125.5/\text{S.F} \]
  - Apartment Building initial total cost: \[ 125.5 \times 80,220 \text{ S.F} = 10,067,610 \]

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- What should be adjusted when the cost is to be established by using the Means Square Foot Cost Method?
  - Exterior Wall Variation
  - Perimeter Adjustment
  - Story Height Adjustment
  - Basement Addition
  - Location Modifier

Source: RS Means, Square Foot Costs Data, 2006
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 $54.33 to $157.75 per S.F.
Parameter Cost Example

- Apartment Building initial total cost: $125.5 \times 80,220 \text{ S.F} = $10,067,610
- Basement Addition:
  - Apartment building has 4,200 \text{ S.F} basement
  - Basement Addition Factor: $27.30 \text{ per S.F of basement area}
  - Basement added cost: $10,067,610 + $27.30 \times 4,200 \text{ S.F} = $10,182,270

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- What should be adjusted when the cost is to be established by using the Means Square Foot Cost Method?
  - Exterior Wall Variation
  - Perimeter Adjustment
  - Story Height Adjustment
  - Basement Addition
  - Location Modifier

Source: RS Means, Square Foot Costs Data, 2006
## Parameter Cost Example

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<th>Commercial</th>
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<td>Jersey City</td>
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</tbody>
</table>

Figure by MIT OCW.

Source: RS Means, Square Foot Costs Data, 2006
Parameter Cost Example

- Basement Addition:
  - $10,182,270

- Location Modifier for Residential Bldg: 1.13 (Refer to RS Means (2006) - Square Foot Costs, page 455)

  - **Apartment building modified total cost: $10,182,270 * 1.13 = $11,505,965**

Source: RS Means, Square Foot Costs Data, 2006
What is the Cost for an apartment building (7 Story) if the perimeter of the building is 502 L.F. and the story height is 11’-4”? Assume that the apartment building has decorative concrete block on the east, west & south walls. The north walls external finish is brick with concrete block backup. The area of each floor of the apartment building 11,460 S.F. The basement floor area is 4,200 S.F. Please use the Means Square Foot Cost to obtain an estimate. The building frame is steel with an observed age of 20 years. The apartment building is located in Atlantic City, New Jersey, Zip Code 07410.
Parameter Cost Example

- What should be adjusted when the cost is to be established by using the Means Square Foot Cost Method?
  - Exterior Wall Variation
  - Perimeter Adjustment
  - Story Height Adjustment
  - Basement Addition
  - Location Modifier
  - Depreciation Adjustment

Source: RS Means, Square Foot Costs Data, 2006
### Depreciation Table

**Commercial/Industrial/Institutional**

<table>
<thead>
<tr>
<th>Observed Age (Years)</th>
<th>Frame</th>
<th>Masonry on Wood</th>
<th>Masonry on Masonry or Steel</th>
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</thead>
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<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
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</tbody>
</table>

*Figure by MIT OCW.*

**Source:** RS Means, *Square Foot Costs Data*, 2006.
Location Modifier for Residential Building

$ 11,505,965

Depreciation Adjustment for steel frame building with 20 year observed age: 20 % (Refer to RS Means (2006) - Square Foot Costs, page 228)

Depreciation Amount: 0.2 * $ 11,505,965 = $ 2,301,193

Total Existing Building Cost: $ 11,505,965 - $ 2,301,193 = $9,204,772

Source: RS Means, Square Foot Costs Data, 2006
Outline

✓ Conceptual Estimates
  ✓ Cost indices
  ✓ Cost capacity factor
  ✓ Parameter Cost

➤ Detailed Estimates
  ➤ Estimates
    ▪ Cost classification
    ▪ Calculation
Different types of estimates are required as a project evolves

- Conceptual & Preliminary Estimates
  - Prepared early in the project prior to engineering design completion (to tell Owner whether the contemplated project scope is feasible)
  - Incorporate new information from design to obtain an updated estimate of the project

- Detailed Estimates
  - Prepared from completed plans and specifications

- Definitive Estimates
  - Forecast the project cost within allowable limits from a combination of conceptual and detailed information often including partial contract and other procurement awards

Source: Barrie & Paulson, 1992
Design & Estimating Process

Feasibility → Conceptual design → Detailed design → Pre-bid → Construction

Conceptual & Preliminary Estimates → Definitive Estimates → Detailed Estimates
Important General Lesson

- Precision in detailed estimates does not mean accuracy!
  - More an art than a science
    - Detailed quantitative estimates possible – but ignore important qualitative factors
    - Have differing ranges of uncertainties
  - Actual costs depend on systemic complexity
    - Two types of complexity at issue
      - Detail complexity (myriad components required)
      - System complexity (dynamic interactions, etc.)

- Always consider:
  - What are assumptions behind the estimate?
  - What factors are being ignored?
  - How might these factors change the estimate?
After most or all of the detail design work is complete, approximate estimates are refined using detailed estimates

- Engineer’s Detailed Estimates
- Bid Detailed Estimates
Design & Estimating Process

- Feasibility
- Conceptual design
- Detailed design
- Pre-bid
- Construction

Conceptual & Preliminary Estimates
- Definitive Estimates
- Detailed Estimates
- Engineer’s
Engineer’s Detailed Estimates

- Part of actual bid documents
- Who? - owner, consultant, CM, or design-build team
- Use unit prices databases
  - Estimate = $\sum [\text{Quantity}] \times [\text{Unit Prices}]$
  - RS Means or other sources
  - Unit prices as result of average industry standards
Engineer’s Detailed Estimates

- Part of actual bid documents

- Who? – owner, consultant, or CM

- Use unit prices databases
  - Estimate = \( \Sigma \text{[Quantity]} \times \text{[Unit Prices]} \)
  - RS Means or other sources
  - Unit prices as result of average industry standards

- No lump-sum subcontract quotations

- May be simplified number of line items (e.g., mark-up: not detailed)
Engineer’s Breakdown - Example

- Building
  - Foundations
    - Piles
    - Concrete foundations
  - Steel erection
    - Structural steel
      - Columns
      - Beams
    - Detail steel
    - Concrete decks
    - Stairs
Design & Estimating Process

Feasibility → Conceptual design → Detailed design → Pre-bid → Construction

Conceptual & Preliminary Estimates → Definitive Estimates → Detailed Estimates → Engineer’s Bid
Bid Detailed Estimates

- Contractor’s estimate low enough to obtain the work, yet high enough to make profit
- Who? – contractor
- More detail depending upon the contractor’s own procedures
- Overall unit prices (past) → detailed categories (present)
- Often relies on
  - Historical productivity data for company
  - Intuition on speed of movement
  - Quantity takeoff for most important items
  - Subcontractor bids
    - Sometimes less detailed than engineer’s estimates - subcontractors from 30% to 80% of the project
Bid Breakdown – Example

- **Building (Bid estimates)**
  - Piles (material take-off)
  - Concrete subcontract (lump-sum)
  - Steel erection subcontract (lump-sum)

- **Building (Engineer’s estimates)**
  - Foundations
    - Piles
  - Concrete foundations
  - Steel erection
    - Structural steel
      - Columns
      - Beams
    - Detail steel
    - Concrete decks
    - Stairs
Is estimating a streamlined process?

A look at bids received for a typical project in a competitive area will sometimes show more than 50% difference between the low and the high bidders.
Estimation Levels - Revisit

Different types of estimates are required as a project evolves

- Conceptual & Preliminary Estimates
  - Prepared early in the project prior to engineering design completion (to tell Owner whether the contemplated project scope is feasible)
  - Incorporate new information from design to obtain an updated estimate of the project

- Detailed Estimates
  - Prepared from completed plans and specifications

- Definitive Estimates
  - Forecast the project cost within allowable limits from a combination of conceptual and detailed information often including partial contract and other procurement awards

Source: Barrie & Paulson, 1992
Design & Estimating Process

- Feasibility
- Conceptual design
- Detailed design
- Pre-bid
- Construction

- Conceptual & Preliminary Estimates
- Definitive Estimates
- Detailed Estimates
Definitive Estimates

- There comes a time when a definitive estimate can be prepared that will forecast the final project cost with little margin for error...

- This error can be minimized through the proper addition of an evaluated contingency

- Engineer’s estimates can complete this process

- The proper time to classify an estimate as ‘definitive’ will vary according to the characteristics of the project. For example:
  - Traditional
  - Unit-price
  - Professional CM
  - Design-Build
Definitive Estimates:
Traditional & Unit Price

- **DBB definitive estimate**

  Start | Preliminary design | Detailed design | Contract

- **Unit Price definitive estimate**

  Start | Preliminary design | Detailed design | Contract
Definitive Estimates: CM & Design-Build

- CM definitive estimate
  - Start
  - Preliminary design
  - Detailed design
  - Contract

- Design-Build definitive estimate
  - Start
  - Preliminary design
  - Contract
  - Detailed design
Outline

☑ Conceptual Estimates
  ☑ Cost indices
  ☑ Cost capacity factor
  ☑ Parameter Cost

▪ Detailed Estimates
  ☑ Estimates
  ➢ Cost classification

▪ Calculation
Cost Classification

- **Direct Cost**
  - Labor Cost
    - Direct Labor
    - Indirect Labor
  - Material Cost
  - Equipment Cost
  - Subcontractor Price

- **Indirect Cost (i.e., Job Overhead)**
  - Project Overhead

- **Markup**
  - General Overhead
  - Profit
  - Contingency

Source: Shtub et al., 1994
Cost Classification - Direct Cost

- **Labor Cost**
  - **Direct Labor Cost**
    - Difficult to evaluate precisely but all effort is done to get an accurate estimate as possible
    - Greatest amount of uncertainty in project estimation
  - **Indirect Labor Cost**
    - Costs that are additional to the basic hourly rates (e.g., tax, insurance, fringe benefits)
    - Substantial in amount: add 25 to 50 percent to direct labor costs
    - Commonly used approach adds indirect labor costs as a percentage to the total direct labor costs or for each major work category

- **Material Cost**
  - All materials that are utilized in the finished structure.

- **Equipment Cost**
  - Costs Includes: ownership, lease or rental expenses, and operating costs

- **Subcontractor Price**
  - Includes quotations from all subcontractors working on the project
  - Quotations submitted by the subcontractor usually require extensive review by the general contractor’s estimator to determine what they include & do not include

Source: Clough et al., 2005; Barrie & Paulson, 1992
Cost Classification – Indirect Cost

- **Project Overhead (i.e., Job Overhead)**
  - Costs that do not pertain directly to any given construction work
  - Generally constitutes 5-15 percent of the total project cost
  - Costs computed by listing & evaluating each item of overhead individually
  - Examples of typical items included:

Source: Clough et al., 2005
Cost Classification – Markup

- **Markup**
  - Added at the close of the estimating process
  - Varies between 5 to 20 percent of the job cost
  - Reflects the contractor’s appraisal of the probability of being the lowest bidder for the project & the chances of making a reasonable profit
  - Factors considered when deciding on a job markup include: project size & complexity, provisions of the contract documents, difficulties inherent in the work, identities of the owner & architect/engineer

- **Include allowance for:**
  - **General Overhead or Office Overhead**
    - Includes costs that are incurred to support the overall company construction program
    - Normally included in the bid as a percentage of the total estimated job cost
    - Examples of general business expenses include: office rent, office insurance, heat, electricity, office supplies, furniture, telephone & internet, legal expenses, donations, advertising, travel, association dues, and the salaries of executives & office employees

- **Profit**
- **Contingency**

Source: Clough et al., 2005
Bid Estimates = Direct Cost + Overhead + Markup (including Firm Overhead)

Cost Classification (Example)

Recap Sheet For Unit Price Bid

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Bid Item</th>
<th>Unit</th>
<th>Estimated Quantity</th>
<th>Labor Cost</th>
<th>Equipment Cost</th>
<th>Material Cost</th>
<th>Subcontract Cost</th>
<th>Direct Cost</th>
<th>Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Clearing</td>
<td>l.s.</td>
<td>Job</td>
<td>$5,139</td>
<td>$11,097</td>
<td>-</td>
<td>-</td>
<td>$16,236</td>
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<td>-</td>
<td>-</td>
<td>$250,830</td>
<td>$311,029.20</td>
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<tr>
<td>4</td>
<td>Base Course</td>
<td>ton</td>
<td>79,500</td>
<td>$352,670</td>
<td>$651,995</td>
<td>$159,479</td>
<td>-</td>
<td>$1,164,144</td>
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<tr>
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<td>$1,035</td>
<td>$1,304</td>
<td>$2,208</td>
<td>-</td>
<td>$4,547</td>
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<td>$5,439</td>
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<td>-</td>
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<td>-</td>
<td>-</td>
<td>$255,957</td>
<td>$255,957</td>
<td>$317,386.68</td>
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<td>-</td>
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<td>$56,680.40</td>
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<td>$205,790.40</td>
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</table>

Totals $3,067,430 $1,416,887 $2,373,185 $337,295 $7,194,797 $8,921,548

Job Overhead $272,091
Markup, 15% $7,466,888 $1,120,033
Bond $8,586,921 $71,815
Sales Tax $8,658,736 $259,762
Total Project Bid $8,918,498

Factor = $8,921,548 / $7,194,797 = 1.240

Figure by MIT OCW.

Source: Clough et al., 2005
Cost Classification (Example)

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<td>$205,790</td>
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<tr>
<td>Totals</td>
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<td></td>
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<td>$1,416,887</td>
<td>$7,977</td>
<td>$2,233,185</td>
<td>$7,194,797</td>
<td>$8,921,548</td>
<td>$8,921,548</td>
</tr>
</tbody>
</table>

Job Overhead = $1,209
Markup, 15% = $1,813
Bond = $8,586
Sales Tax = $8,658
Total Project Bid = $8,918

Bid Estimates = Direct Cost + Overhead + Markup (including Firm Overhead)

Source: Clough et al., 2005
Outline

- Conceptual Estimates
  - Cost indices
  - Cost capacity factor
  - Parameter Cost

- Detailed Estimates
  - Estimates
  - Cost classification
  - Calculation
Detailed Estimates - Methodology

- **Stage 1: Quantity takeoff**
  - Decomposition into items, measurement of quantities
  - Challenges: tremendous detail complexity

- **Stage 2: Direct Cost contribution**
  - \( \Sigma [\text{Quantity}] \times [\text{Unit Price}] \)
  - Challenge: determination unit price (based on historical data)

- **Example:**

<table>
<thead>
<tr>
<th>Item</th>
<th>unit</th>
<th>quantity</th>
<th>Unit price</th>
<th>Price</th>
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<tbody>
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<td>0.60</td>
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</tr>
</tbody>
</table>
Labor Costs

- Categorized Bid Estimate (not overall unit prices)
- Basic Unit Labor Cost = P / LP ($/unit)
  - P = Price of all money elements ($/hours)
  - LP = Labor Productivity (units/hour)
- Total Labor Cost = Q * P/LP
  - Q = Total quantity of work
- Estimation of labor costs particularly tricky
  - Prices: In United States, highly detail intensive
  - Productivity: Many qualitative components
Components
- Wages (varies by area, seniority, …)
- Insurance (varies w/contractor record, work type)
- Social security benefits
- Fringe benefits (health…)
- Wage premiums (e.g., overtime, shift-work differentials, hazardous work)
Labor Cost - Productivity

- **Difficult but critical**
  - High importance of qualitative factors (environment, morale, fatigue, learning, etc)
  - The primary means by which to control labor costs $P / LP$ ($/unit$)

- **Historical data available**
  - Firm updated database
  - Department of Labor, professional organizations, state governments
Productivity Considerations

- Considerations
  - Location of jobsite (local skill base, jurisdiction rules – hiring & firing)
  - Learning curves
  - Work schedule (overtime, shift work)
  - Weather
  - Environment
    - Location on jobsite, noise, proximity to materials
  - Management style (e.g., incentive)
  - Worksite rules
Learning Curves

Particularly useful for repetitive works

Figure by MIT OCW.
Productivity Effects of Overtime

Figure by MIT OCW.
Concluding Remarks

- Functions of Estimating
  - Could Assess cost of construction from the conceptual design phase (Owner, Designer & Sometimes Contractor). Feedback to
    - Conceptual Design for Alternative Architecture
    - Feasibility of the Project
    - Project / Company Alignment of Objectives, Constraints, Strategic Goals and Policies
  - Provide the basis for bidding & contracting (Contractor)
  - Provide a baseline for cost control and post project evaluation (Owner & Contractor)
Concluding Remarks

In Converting an Estimate to a Control Budget, Consider:

- The organization and categorization of costs suitable for preparing an estimate are often not compatible with realistic field cost control (e.g., might be convenient for the owner).

- Estimates necessarily deal in averages, whereas tighter standards are sometimes desirable for control purposes.