CVE 4070

Construction Engineering
Construction Estimating
Prof. Ralph V. Locurcio, PE
Registration info for Spring

- CVE 4074/5074 – see CRN 18654/18555
- Leading Construction Operations
- Syllabus:
  1- Personal Leadership- your leadership style
  2- Organizational Leadership- corporate style
  3- Team Leadership- leading a team
  4- Includes professional communications
  5- Includes segment on ethics
# Part III – Advanced CM tools

<table>
<thead>
<tr>
<th>Date</th>
<th>Week</th>
<th>Topic</th>
<th>Additional Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/28</td>
<td>21</td>
<td>Risk Management</td>
<td>Kerzner Ch-17</td>
</tr>
<tr>
<td>11/2</td>
<td>22</td>
<td>Construction Estimating;</td>
<td>Kerzner Ch-14 &amp; Handout</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>HW#7-Pyramid Estimate Handout</strong></td>
<td></td>
</tr>
<tr>
<td>11/4</td>
<td>23</td>
<td>Value Engineering &amp; Risk Management</td>
<td>Kerzner Ch-14 &amp; 17</td>
</tr>
<tr>
<td>11/9</td>
<td>24</td>
<td>Project Closeout &amp; Pyramid Estimate</td>
<td><strong>Pyramid Estimate Due</strong></td>
</tr>
<tr>
<td>11/11</td>
<td>25</td>
<td>Construction Law &amp; Legal Issues</td>
<td>Handout</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>HW#8-Ethics Handout</strong></td>
<td></td>
</tr>
<tr>
<td>11/16</td>
<td>26</td>
<td>Construction Leadership &amp; Ethics</td>
<td><strong>Ethics Paper Due;</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Study Guide</td>
<td>Kerzner Ch 8.5</td>
</tr>
<tr>
<td>11/18</td>
<td>27</td>
<td><strong>Test-3 &amp; Critique</strong></td>
<td><strong>Notebook turn-in</strong></td>
</tr>
</tbody>
</table>
Pyramid Estimate - due Nov 9

☐ Prep an estimate of cost of pyramid
  ➢ Read notes carefully
  ➢ Spread sheet format in Excel
  ➢ One price = what is your bid amount?
  ➢ Include labor, materials & support costs

☐ Graded exercise

☐ Questions?
Ethics Paper – due Nov 16

☐ NSPE Rules of Professional Conduct
  ➢ Read all rules
  ➢ Summarize each of the obligations in one paragraph

☐ Pick a case study: 1, 7, 58, 59, 60
  ➢ Write a 2-page paper applying NSPE to the issues presented in the case
  ➢ What errors were made, how should the engineer behave in the case
Estimating Construction Work
Estimating is Serious Business!
So pay close attention!
Estimating defined...

- A complex process involving the collection of available information on the scope of a project, the expected resource consumption, and future changes in resource costs.

- This information is synthesized in a visualization of the construction process and translated into an approximation of the final cost.
Components of an estimate...

- Systematic analysis of:
  - Project components
  - Equipment needed
  - Construction methods
  - Temporary work items
  - Support activities
  - Externalities
Qualifications of an estimator...

- Extensive knowledge of:
  - Construction processes & methods
  - Read & interpret construction plans
  - Materials & equipment usage
  - Contracts & work practices
  - Construction documents & details
  - Background business factors; costing
  - Design & code requirements
  - Verbal & written communications
  - Logic, good common sense & judgment
Estimating Process

- Decision to bid
- Form the estimating team
- Estimate work plan
  - Type of estimate
  - Procedures
  - Documentation
- Risk & contingency analysis
- Review & check the estimate
- Finalize the estimate
Estimating is a bit like walking in the dark...

So you have to rely on outside sources of information!
Estimating & Bidding

- Kickoff Meeting
- Work Plan
- Establish Standards
- Update Database

- Prepare Estimate
- Document Estimate
- Review Estimate

- Adjust Estimate?
  - Yes
  - No
    - Submit Bid
      - Project Execution
      - Project Completion
Key Estimating Activities

1. Read the Plans, Specs & Contract
2. Conduct Site Visit
3. Decide Construction Method
4. Prepare Schedule

- Material Take-Offs
- Plan for Equipment
- Plan for Subcontracts

- Estimate Costs
- Analyze Risk Factors

- Determine Contingency

- Finalize Bid
Two broad types of estimates...

- **Conceptual**
  - Used for early decisions & feasibility
  - Rough estimate using minimal data
  - Relies heavily on past data
  - Level of accuracy about 70%

- **Detailed**
  - Used for major decisions; i.e. bids & budgets
  - Based on final design documents
  - Level of accuracy up to 95%
Conceptual Estimates-1

- Based on historical data
- Accuracy = ±30%
- Used for planning purposes when no design exists
- Used to check validity of detailed estimate
- Sometimes called “parametric” estimates
Conceptual estimates-2

- Based on prior experience:
  - Cost per SF or CF... volume
  - Weight check... weight of equipment
  - Cost-capacity factor- ratio of Q/$
  - Comparative cost of structure – $/unit

- Feasibility or budgeting estimates

- Apply time & location adjustments
Comparative cost of structure...

- Basis is cost per unit based on past experience with similar units.
  - Compare structures of like construction, (e.g. school: steel, concrete, quality, local labor, weather)
  - Develop cost per unit, e.g. Unit A - existing
    $/pupil = A Cost/A pupils = $1,000,000 / 100
    = $10,000 / pupil
  - Apply to new construction: Unit B
    B Cost = B pupils \times A Cost / pupil
    B Cost = 200 \times $10,000 = $2,000,000
Examples:

- Schools: $/pupil
- Bridges: $/feet of span
- Stadium: $/seat
- Hospital: $/beds
- Offices: $/ft²
- Warehouses: $/ft³
Variations of comparative cost...

- Floor area... cost/ft\(^2\) ... but
  - Total horizontal area... all floors equal
  - Finished floor area... $ based on type finish

- Building volume... cost/ft\(^3\)
  - Cubic foot of volume... floor height varies

- Plant cost ratio...
  - Process plant ratio
  - Differentiates machine ft\(^2\) from admin ft\(^2\)
Cost of equipment method...

- Assumes cost of equipment is dominant factor in plant cost
- Estimate based on % of cost allocated to equipment relative to total cost of facility
- Estimated cost is proportional to known cost
Plant Cost Ratio Method

Methods:
- Panel... hist data on “typical” panels
- Bay... hist data on “typical” bays
- Plant component... equip cost + other

\[ TPC = \frac{ET}{1-PT} \]

Where ET = equip total
And PT = sum of % all other costs)

\[ TPC = \frac{500,000}{0.70} = 714,285 \]
Panel or Bay Method...

Total Cost = (Bay1sf x $80) + (Bay2sf x $345) + (Bay3sf x $45) + (Bay4sf x $55)
Volume Method...

Total Cost = (Bay1cf x $8) + (Bay2cf x $12) + (Bay3cf x $4) + (Bay4cf x $6)
Time & Location adjustments...

- Cost indexing
  - Based on similar “group” of key items
  - Compare “group” over time or location
  - Final cost based on ratio x calculated cost:
    
    Time Adj = Est. Cost = $500,000 = 1.00/.96 x $500,000 = $520,000
    
    Loc Adj = Est. Cost = $520,000 = 1.00/1.25 x $520,000 = $416,000
Cost forecasting...

“The future ain’t what it used to be”...
Projecting Cost...

- Need to project costs to mid-point of the construction year for budgeting = average cost of construction

- Generally average past 2-5 years cost data & project forward = 3-5% per year

- So... for forecasting 2 years ahead @3%...
  
  $416,000 \times 1.03 = $428,480

  $428,480 \times 1.03 = $441,334

  Not... $416,000 \times 1.06 = $440,960... short $374
Detailed estimates...

- Based on three primary factors:

  A. Scope... quantities

  B. Constructability... methods

  C. Risk... externalities
A. Scope factors...

- Technology in project - complexity
- Milestone deadlines for work - timing
- Material & equipment - availability
- Staffing needed – skill & availability
- Contract terms – allocation of risk
- Amount of competition - markets
B. Constructability factors...

- Construction quality – skill required
- Allowable tolerances – productivity
- Complexity of design – learning curve
- Flexibility of methods – special terms
C. Risk factors...

- Unspecified material or workmanship
- Differing site conditions
- Error in bidding
- Changes in cost over time
- Subcontractor error or failures
- Weather & environmental issues
- Strikes & labor issues
- Utilities & support issues
Accuracy increases over time...
Estimating process...

1. Determine project characteristics: **Scope, Constructability, Risk**
2. Examine the project design & site
3. Structure the estimate
4. Determine elements of cost
5. Calculate estimate
Examine Project Design...

- Technical specifications
- Referenced standards
- Project drawings
- Testing and performance
- Special methods or procedures
- Physical elements & site characteristics
- Errors & omissions
Structure the estimate...

- Structure often follows specification template
- Ensure nothing left out
- Need a plan for completing the project
- Logical flow of resources & materials
- Productivity factors
Determine elements of cost...

- **Labor**: craft & skill resources; sub-contractors; union labor; wage rates; training; “effective” labor rates; productivity factors (weather, complexity, experience, management)
- **Material**: price, shipping, availability, storage, relation to specifications
- **Equipment**: purchase vs. lease, single use, down time, cost of maintenance
- **Capital**: interest rates, payment flow, retainage
- **Time**: overhead costs, required completion date,
Calculate the estimate...

- **Material take-off from plans**
  1. Quantities of all construction materials
  2. Compare with specifications

- **Labor cost for construction or installation**
  1. Effective labor rates
  2. Team composition & duration

- **Construction equipment schedule**
  1. On hand vs. lease or purchase
  2. Time on job

- **Follow elements of cost**
  1. Ensure all items are covered
Detailed estimate take-off...

1. Foundation
2. Exterior Walls
3. Interior Walls
4. Windows
5. Downpours
6. Roof
7. Exterior Finish
8. Labor
9. OH & Profit
Cost of materials (including taxes):

<table>
<thead>
<tr>
<th>Item</th>
<th>L</th>
<th>H</th>
<th>Quant</th>
<th>Unit $</th>
<th>Tot 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>8” Block wall @ $16.96/SF</td>
<td>8</td>
<td>8</td>
<td>64</td>
<td>$16.96</td>
<td>$1,085.44</td>
</tr>
<tr>
<td>3-1/2” Interior wall @ $6.24/SF</td>
<td>8</td>
<td>8</td>
<td>64</td>
<td>$6.24</td>
<td>$399.36</td>
</tr>
<tr>
<td>3-1/2” Interior bearing wall @ $8.48/SF</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$8.48</td>
<td>$0.00</td>
</tr>
<tr>
<td>5-1/2” Plumbing wall @ $8.48/SF</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>$8.48</td>
<td>$0.00</td>
</tr>
<tr>
<td>Foundation @ $12.92/LF</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>$12.92</td>
<td>$103.36</td>
</tr>
<tr>
<td>W7 Window @ $125.00 ea</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>$125.00</td>
<td>$125.00</td>
</tr>
<tr>
<td>Downpours @ $88.00 ea</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>$88.00</td>
<td>$176.00</td>
</tr>
<tr>
<td>Exterior finish @ $8.00/SF</td>
<td>8</td>
<td>8</td>
<td>64</td>
<td>$8.00</td>
<td>$512.00</td>
</tr>
<tr>
<td>Roof @ $15.00/SF</td>
<td>4</td>
<td>30</td>
<td>120</td>
<td>$15.00</td>
<td>$1,800.00</td>
</tr>
</tbody>
</table>

Subtotal 1: $4,201.16
Labor @ 2x materials: $8,402.32
Subtotal 2: $12,603.48
Add OH @ 5%: $13,233.65
Add Profit @ 5%: $13,895.34
Grand total: $13,895.34
SF check @ $60/SF: $14,400.00

Labor (includes benefits): assume labor = 2x cost of materials
Extras: Add 5% overhead and 5% profit
Show your calculations (continue on reverse):

Price of change: $13,604.28
Approximate SF price: $14,400.00
if you get the estimate wrong...

And this is what happens....

The Boss....

And You....

if you get the estimate wrong...
Using the data below create a construction cost estimate for the pyramid using MS Excel.

Note (1) - L = number of laborers; L assumes 100% work; so you must consider productivity; 
- Prod = effective work rate; applies only to laborers;
- Super = ratio of supervisors/laborers;
- Mgt = ratio of managers/laborers;
- Use decimal quantities for Excel formulas.

Note (2) - Determine stone quantities from Pyramid text handout

Note (3) - Placement of stone includes cost of equipment & animals

<table>
<thead>
<tr>
<th>Labor Activities</th>
<th>Const Time</th>
<th>Laborers (Note1)</th>
<th>Labor Rate ($/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>S/U L/day Prod</td>
<td>Super Mgt Labor</td>
</tr>
<tr>
<td>Planning</td>
<td>550</td>
<td>S 50 0.7 1/10</td>
<td>$4 $16 $40</td>
</tr>
<tr>
<td>Master Plan</td>
<td>400</td>
<td>S 50 0.7 1/10</td>
<td>$4 $16 $40</td>
</tr>
<tr>
<td>Site Selection</td>
<td>500</td>
<td>S 50 0.6 1/10</td>
<td>$4 $16 $40</td>
</tr>
<tr>
<td>Build Camp</td>
<td>200</td>
<td>U 500 0.8 1/50</td>
<td>$4 $11 $25</td>
</tr>
<tr>
<td>Demob Camp</td>
<td>150</td>
<td>U 250 0.8 1/50</td>
<td>$4 $11 $25</td>
</tr>
<tr>
<td>Hire Workforce</td>
<td>1800</td>
<td>S 50 0.8 1/10</td>
<td>$5 $15 $40</td>
</tr>
</tbody>
</table>
Cost Parameters...

1. Cost of Labor =
   a. Skilled
   b. Unskilled
   c. Managers

2. Cost of Stone Materials
   a. Core stones – cutting
   b. Core stones - placing
   c. Trim stones – cutting
   d. Trim stones - placing

3. Cost of Support Functions
   a. Unskilled worker support
   b. Skilled worker support
   c. Managers are considered skilled
Productivity Calculations

Worker productivity = 70% ... accounts for breaks, sick time, etc.

Therefore... full time labor = #days required per task / .70

Example... Task 23 requires 450 days @ 70% efficiency

Therefore... You need 450 man days / .70 = 643 mandays

Because: \[
\frac{450}{70\%} = \frac{X}{100\%} \quad \text{so} \quad X = \frac{450 \times 1.00}{.70} = 643 \text{ mandays}
\]

Not: \[
450 \times 1.3 = 585 \text{ mandays}
\]
<table>
<thead>
<tr>
<th>Item no.</th>
<th>Description</th>
<th>Calculations</th>
<th>Number of units</th>
<th>Unit cost</th>
<th>Material cost</th>
<th>Equipment cost</th>
<th>Labor cost</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2350-0</td>
<td>Furnish and drive 200 creosote-treated piles. Drive piles to full penetration into normal soil. Piles size: 50 ft length, 14-in. butt, 6-in. tip</td>
<td>200 ft × 50 ft = 10,000 lin ft</td>
<td>20,000 ft</td>
<td>$4.20/lin ft</td>
<td>$43,050</td>
<td></td>
<td></td>
<td>$43,050</td>
</tr>
<tr>
<td>10</td>
<td>Materials</td>
<td>205 ft × 50 ft = 10,250 lin ft</td>
<td>10,250 ft</td>
<td>$4.20/lin ft</td>
<td>$43,050</td>
<td></td>
<td></td>
<td>$43,050</td>
</tr>
<tr>
<td>20</td>
<td>Equipment</td>
<td>Moving to and from the job lump sum</td>
<td></td>
<td></td>
<td>$7,000</td>
<td>$11,600</td>
<td></td>
<td>$18,600</td>
</tr>
<tr>
<td></td>
<td>Crane, 12-ton</td>
<td>80 hr</td>
<td>$15/ hr</td>
<td>$11,600</td>
<td></td>
<td></td>
<td></td>
<td>$11,600</td>
</tr>
<tr>
<td></td>
<td>Hammer, single-acting, 15,000 foot pound</td>
<td>80 hr</td>
<td>$9/ hr</td>
<td>$1,200</td>
<td>$720</td>
<td></td>
<td></td>
<td>$2,900</td>
</tr>
<tr>
<td></td>
<td>Air compressor equipment</td>
<td>80 hr</td>
<td>$5/ hr</td>
<td></td>
<td>$400</td>
<td></td>
<td></td>
<td>$400</td>
</tr>
<tr>
<td></td>
<td>Leads and sundry equipment</td>
<td>80 hr</td>
<td>$5/ hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$400</td>
</tr>
<tr>
<td>30</td>
<td>Labor</td>
<td>(add 16 hr to set up and take down equipment)</td>
<td>80 hr + 16 = 96 hr</td>
<td>96 hr</td>
<td>$25/ hr</td>
<td>$2,400</td>
<td>$2,400</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Foreman</td>
<td>96 hr</td>
<td>96 hr</td>
<td>$18/ hr</td>
<td>$1,728</td>
<td></td>
<td></td>
<td>$1,728</td>
</tr>
<tr>
<td>34</td>
<td>Crane operator</td>
<td>96 hr</td>
<td>96 hr</td>
<td>$14/ hr</td>
<td>$1,344</td>
<td>$2,680</td>
<td>$2,680</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Laborer (1 total)</td>
<td>96 hr</td>
<td>96 hr</td>
<td>$12/ hr</td>
<td>$2,304</td>
<td>$3,804</td>
<td>$3,804</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Workers on hammer (2 total)</td>
<td>96 hr × 2 = 192 hr</td>
<td>192 hr</td>
<td>$15/ hr</td>
<td>$3,408</td>
<td>$3,408</td>
<td></td>
<td>$3,408</td>
</tr>
<tr>
<td>39</td>
<td>Helpers (2 total)</td>
<td>96 hr × 2 = 192 hr</td>
<td>192 hr</td>
<td>$12/ hr</td>
<td>$3,408</td>
<td>$3,408</td>
<td></td>
<td>$3,408</td>
</tr>
<tr>
<td>40</td>
<td>Subtotal direct costs</td>
<td></td>
<td></td>
<td>$43,050</td>
<td>$20,920</td>
<td>$10,656</td>
<td></td>
<td>$74,626</td>
</tr>
<tr>
<td>-50</td>
<td>Indirect costs</td>
<td></td>
<td></td>
<td></td>
<td>$2,052</td>
<td>$431</td>
<td></td>
<td>$2,483</td>
</tr>
<tr>
<td>-51</td>
<td>Material taxes</td>
<td></td>
<td></td>
<td></td>
<td>$2,052</td>
<td>$431</td>
<td></td>
<td>$2,483</td>
</tr>
<tr>
<td>-511</td>
<td>State sales tax</td>
<td>5% × $43,050</td>
<td></td>
<td></td>
<td>$2,153</td>
<td></td>
<td></td>
<td>$2,153</td>
</tr>
<tr>
<td>-512</td>
<td>County sales tax</td>
<td>1% × $43,050</td>
<td></td>
<td></td>
<td>$430</td>
<td></td>
<td></td>
<td>$430</td>
</tr>
<tr>
<td>-520</td>
<td>Labor taxes</td>
<td></td>
<td></td>
<td></td>
<td>$815</td>
<td></td>
<td></td>
<td>$815</td>
</tr>
<tr>
<td>-521</td>
<td>FICA (social security tax)</td>
<td>7.65% × $10,656</td>
<td></td>
<td></td>
<td>$815</td>
<td></td>
<td></td>
<td>$815</td>
</tr>
<tr>
<td>-523</td>
<td>Unemployment tax</td>
<td>3% × $10,656</td>
<td></td>
<td></td>
<td>$320</td>
<td></td>
<td></td>
<td>$320</td>
</tr>
<tr>
<td>-530</td>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
<td>$998</td>
<td></td>
<td></td>
<td>$998</td>
</tr>
<tr>
<td>-531</td>
<td>Workman's compensation insurance</td>
<td>9% × $10,656</td>
<td></td>
<td></td>
<td>$998</td>
<td></td>
<td></td>
<td>$998</td>
</tr>
<tr>
<td>-532</td>
<td>Contractor's liability insurance</td>
<td>4% × $10,656</td>
<td></td>
<td></td>
<td>$436</td>
<td></td>
<td></td>
<td>$436</td>
</tr>
<tr>
<td>-540</td>
<td>Overhead</td>
<td></td>
<td></td>
<td></td>
<td>$5,970</td>
<td></td>
<td></td>
<td>$5,970</td>
</tr>
<tr>
<td>-541</td>
<td>Job overhead</td>
<td>5% × $74,626</td>
<td></td>
<td></td>
<td>$3,731</td>
<td></td>
<td></td>
<td>$3,731</td>
</tr>
<tr>
<td>-542</td>
<td>Office overhead</td>
<td>2% × $74,626</td>
<td></td>
<td></td>
<td>$1,493</td>
<td></td>
<td></td>
<td>$1,493</td>
</tr>
<tr>
<td>-60</td>
<td>Subtotal indirect costs</td>
<td></td>
<td></td>
<td></td>
<td>$11,651</td>
<td></td>
<td></td>
<td>$11,651</td>
</tr>
<tr>
<td>-70</td>
<td>Total direct and indirect costs</td>
<td></td>
<td></td>
<td></td>
<td>$96,277</td>
<td></td>
<td></td>
<td>$96,277</td>
</tr>
<tr>
<td>-80</td>
<td>Add-ons</td>
<td></td>
<td></td>
<td></td>
<td>$4,314</td>
<td>$8,626</td>
<td></td>
<td>$12,942</td>
</tr>
<tr>
<td>-811</td>
<td>Contingency</td>
<td>5% × $86,277</td>
<td></td>
<td></td>
<td>$4,314</td>
<td></td>
<td></td>
<td>$4,314</td>
</tr>
<tr>
<td>-812</td>
<td>Profit</td>
<td>10% × $86,277</td>
<td></td>
<td></td>
<td>$8,626</td>
<td></td>
<td></td>
<td>$8,626</td>
</tr>
<tr>
<td></td>
<td>Subtotal of add-ons</td>
<td></td>
<td></td>
<td></td>
<td>$12,942</td>
<td></td>
<td></td>
<td>$12,942</td>
</tr>
<tr>
<td>-90</td>
<td>Performance bond</td>
<td>1% × ($86,277 + $12,942)</td>
<td></td>
<td></td>
<td>$922</td>
<td></td>
<td></td>
<td>$922</td>
</tr>
<tr>
<td>-91</td>
<td>Total cost, amount of bid</td>
<td>$86,277 + $12,942 + $922</td>
<td></td>
<td></td>
<td>$100,141</td>
<td></td>
<td></td>
<td>$100,141</td>
</tr>
<tr>
<td>-92</td>
<td>Cost per lin ft</td>
<td>$100,141/10,000 lin ft</td>
<td></td>
<td></td>
<td>$10.01 per lin ft</td>
<td></td>
<td></td>
<td>$10.01 per lin ft</td>
</tr>
</tbody>
</table>
So are there any questions???
OK, then, class dismissed !!!