Material Take-off

Week 3
CEE4333

Agenda
- Earthwork / Excavation
- Concrete foundation wall

Continuous Operation

Dump Site

Cycle Time

Excavation Site

Production Rate (CY/hr)

Excavator / Loader
118 horsepower 710G,
22.5 ft depth reach,
John Deere

Dump trucks: Volume CY
Haul distance

Empty back
1. Efficiency
2. Unit costs: Operator, Equipment,
3. Indirect costs

Fresno Scraper (1883)

Scrapers:
Loading, Hauling and Distributing

Draglines:
Good for excavating waterway channels

Earthwork: Cut and Fill

- Division 2 CSI Format
- Volume of displaced soil
  \[ \frac{[c - f] a}{4 \times 27} \text{ CY (cubic yards)} \]
  \(c\) = cut in feet \(f\) = fill in feet \(a\) = area (sq. ft)
- Shrinkage and swell values:
  \(L = (1 + \frac{S_w}{100})B\)
  \(C = (1 - \frac{S_s}{100})B\) (Eqns 7.1,2)
  \(S_w\): % swell, \(S_s\): % shrinkage (Table 7.1)
  \(L\): volume of loose soil
  \(C\): volume of compacted soil
  \(B\): volume of undisturbed soil

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Excavating Basements and Structural Foundations

- Called mass excavations
- Angle of repose and working space driven by safety considerations
- \[ V = \left[ (F + 2W + D \tan \alpha) \frac{D}{(L)} \right] / 27 \]
- \( V \) = undisturbed volume in CY
- \( L \) = Linear foot of footing

Division 3: Concrete

- Grade beam footings
- Basement walls for buildings
- Retaining walls
- Vertical walls for water reservoirs

Contd.

- Concrete volume estimation:
  \[ \text{Volume in CY} = \left( \frac{X \text{ area in sq ft.}(\text{length in ft})(\text{waste factor})}{27} \right) \]
- Concrete aggregate estimation (use this table and table 10.10 in text book):

<table>
<thead>
<tr>
<th>Concrete Mixes to Volume</th>
<th>Sand of Cement</th>
<th>Fine Aggregate (%)</th>
<th>Course Aggregate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.09</td>
<td>0.78</td>
<td>0.75</td>
</tr>
<tr>
<td>1.2</td>
<td>0.81</td>
<td>0.54</td>
<td>0.65</td>
</tr>
<tr>
<td>1.3</td>
<td>0.73</td>
<td>0.38</td>
<td>0.70</td>
</tr>
<tr>
<td>1.4</td>
<td>0.69</td>
<td>0.33</td>
<td>0.74</td>
</tr>
</tbody>
</table>

Contd.

Amounts of aggregate and sacks of cement required to produce 1 CY of concrete

Contd.

- Estimating Reinforcing steel (use following table and table 10.6 in text book)

<table>
<thead>
<tr>
<th>Bar Number</th>
<th>Bar Diameter (mm)</th>
<th>Weight (lbs/ft)</th>
<th>Minimum Overlap Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1</td>
<td>0.107</td>
<td>1 - 2'</td>
</tr>
<tr>
<td>2</td>
<td>0.9</td>
<td>0.076</td>
<td>1 - 2'</td>
</tr>
<tr>
<td>3</td>
<td>0.8</td>
<td>0.060</td>
<td>1 - 2'</td>
</tr>
<tr>
<td>4</td>
<td>0.75</td>
<td>0.045</td>
<td>1 - 2'</td>
</tr>
<tr>
<td>5</td>
<td>0.6</td>
<td>0.030</td>
<td>1 - 2'</td>
</tr>
<tr>
<td>6</td>
<td>0.5</td>
<td>0.030</td>
<td>2 - 4'</td>
</tr>
<tr>
<td>7</td>
<td>0.4</td>
<td>0.030</td>
<td>2 - 4'</td>
</tr>
<tr>
<td>8</td>
<td>0.3</td>
<td>0.030</td>
<td>2 - 4'</td>
</tr>
<tr>
<td>9</td>
<td>0.24</td>
<td>0.030</td>
<td>2 - 4'</td>
</tr>
<tr>
<td>10</td>
<td>0.25</td>
<td>0.030</td>
<td>2 - 4'</td>
</tr>
</tbody>
</table>

Contd.

- Estimating reinforcing steel;
  - Estimated by the pound/ton
  - Minimum overlapping distance: guarantees structural integrity in reinforced concrete structures when splicing is used
  - Adjustment: Add 10% for wastage due to overlapping and cut related wastage
Formwork

- Talk about bf
- About studs
- About nails
- Each formula
- Then go on to the problem

Formwork

- Not included in drawings: Temporary, therefore reuse wherever possible
  - Complicated formwork: multiple reuse (steel, aluminum)
  - Typically 2-4 uses (lumber, plywood, plyform)
- Functionality: To support the pressure imposed by fresh concrete
  - Pressure (rate of filling, temperature of concrete)
  - See table for Pressure
  - Allows decision on formwork design

<table>
<thead>
<tr>
<th>Filling Rate (Foot/Min)</th>
<th>Concrete Temperature (°F)</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>250</td>
<td>220</td>
<td>200</td>
<td>180</td>
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<tr>
<td>2</td>
<td>320</td>
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<td>200</td>
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<td>3</td>
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<td>180</td>
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<td>4</td>
<td>320</td>
<td>250</td>
<td>220</td>
<td>200</td>
<td>180</td>
<td>160</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>320</td>
<td>250</td>
<td>220</td>
<td>200</td>
<td>180</td>
<td>160</td>
<td>140</td>
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Maximum pressure exerted on forms by fresh concrete in lb/SF for concrete weighing 150lb/CF

Pressure exerted by alt. Conc = (P)/(Wa)/150
P: Pressure exerted by 150lb/CF conc.
Wa: Weight of the alternative concrete in lb/CF

Plywood, Plyform
- Comes in sheets 4’ wide x 8’, 10’, 12’ long
- Use available dimensions or incur wastage

Lumber
- Measured and priced in board feet (bf) [foot board measure]
- Lumber sawed lengthwise at the mill and finished: usually there is a loss in size
- Thus 2 x 4 (nominal size) is 1.5” thick and 3.5” wide (actual size)
- S4S: Surfaced on all 4 Sides

Calculating Foot Board Measure

- 1 bf (board foot) is lumber with dimension:
  - 1 bf = (1” thick x 1’ wide) x 1’ long = 1/12 CF
  - A 2’ thick x 4’ wide lumber = 8/12 bf/ft = 0.67bf/ft
  - A 2’ thick x 8’ wide lumber = 16/12 bf/ft = 1.33bf/ft
- If we need 120 linear ft of 2 x 4 studs:
  - (2’/12)’ x 4’ x 120 = 80bf
Estimating Foundation Walls

- WL: Wall Length
- WH: Wall Height
- W: Waste Factor
- HS: Horizontal Spacing
- VS: Vertical Spacing
- #L: Number of Layers
- #U: Number of uses of Lumber

The Account

- Horizontal Reinforcement:
  \[ \text{lf} = \frac{\text{WL} \cdot (\frac{\text{WH}}{\text{VS}})}{(\text{#L} \cdot \text{W})} \]

- Vertical Reinforcement:
  \[ \text{lf} = \frac{\text{WH} \cdot (\frac{\text{WL}}{\text{HS}})}{(\text{#L} \cdot \text{W})} \]

- Formwork:
  - Amount of plywood: \( \frac{\text{WL} \cdot (\text{WH}) \cdot 2 \cdot \text{W}}{(\text{#U})} \) sf
  - Studs: \( \frac{\text{WH} \cdot (\text{WL}) \cdot 2 \cdot \text{W}}{(\text{#U})} \) if
  - Wales: \( \frac{\text{WL} \cdot (\text{WH}) \cdot 2 \cdot \text{W}}{(\text{#U})} \) if
  - Sills: \( \frac{(\text{WL}) \cdot 4 \cdot \text{W}}{(\text{#U})} \) if
  - Braces: \( \frac{(\text{lf} \text{ of Wales}) \cdot (\text{#U})}{4} \) / (Tie Spacing)
  - Nails: \( \frac{(10 \text{ lb} / 1000 \text{ fbm}) \cdot (\text{total fbm}) \cdot (\text{#U})}{} \)
  - Ties: \( \frac{(\text{lf} \text{ of Wales}) \cdot (\text{#U})}{4} \) / (Tie Spacing)

The Method

- Calculate Undisturbed Volume of earth to be removed: Factor in swellage
- Calculate amount of earth to be disposed
- Estimate concrete
  - Use information about mixture to estimate coarse, fine and sacks of cement
  - Estimate reinforcing (in tonnage)
- Estimate formwork
  - What is the concrete pressure temp. being used?
  - Decide on spacing for studs, wales and ties
  - Convert total linear footage of lumber to bfm

A contractor is estimating the amount of soil to be removed in order to build the 4 feet base footings and the 1-foot thick foundation walls for an office building. According to the structural design, the footing will reside 6 feet underground with a height of 1 foot. Geotechnical tests show that the soil is made up of clay. The contractor estimates that it is necessary to allocate 2 feet for working space on both sides of the footings to set up the formwork for the foundation walls. The plans call for 700 LF of foundation walls.

How much earth will the contractor have to remove and handle?

The Denver School Board is working on its budget for the year 2008. One of the capital expenditures projected for the year is the construction of a new High School to satisfy increased demand. The plan calls for a facility with a capacity of 800 students to be built in a piece of land already owned by the City. Estimate the cost of the new building and recommend to the School Board the amount they should budget for the project.

Basic Unit Cost:

- Given the average cost per pupil in 2005 in the US for a High School was $16,872. (2005) = 7518.28
- Inflation = 3%
- Design fees for school buildings between $10 million and $50 million = 6%