Material Take-off

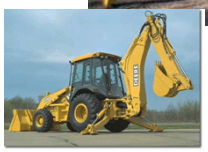
Week 3

CEE4333

Agenda

- Earthwork / Excavation
- Concrete foundation wall

Continuous Operation



Dump Site

Dump trucks *Volume CY*

Haul distance

Excavation Site

Cycle Time

Production Rate

(CY/hr)

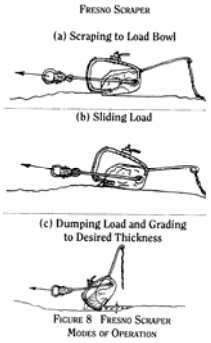
Empty back

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

Excavator / Loader

118 horsepower 710G,
22.5 ft depth reach,
John Deere

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
  = [(c - f) a]/(4*27) CY (cubic yards)
  c = cut in feet *f* = fill in feet *a* = area (sq. ft)
- Shrinkage and swell values:

$L = (1 + S_w/100)B$

$C = (1 - S_h/100)B$ (Eqns 7.1,2)

S_w: % swell, S_h: % shrinkage (Table 7.1)

L: volume of loose soil

C: volume of compacted soil

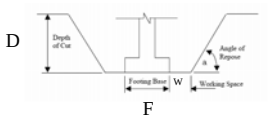
B: volume of undisturbed soil

Excavating Basements and Structural Foundations

- Called mass excavations
- Angle of repose and working space driven by safety considerations
- V = [(F +2W+ D/tan α) (D) (L)]/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

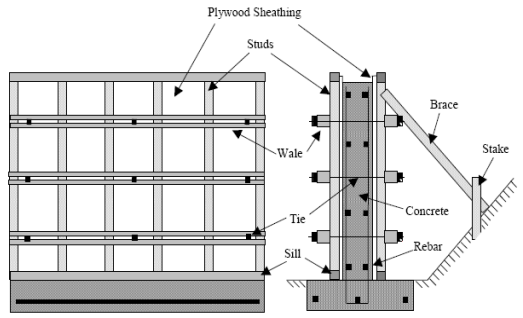


Figure 10.2 in Text book

Contd.

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

Concrete Mixture by Volume	Sacks of Cement	Fine Aggregate (CY)	Coarse Aggregate (CY)
1:1:1.75	10.00	0.37	0.63
1:2:2.25	7.75	0.56	0.65
1:2.25:3	6.25	0.52	0.70
1:3:4	5.00	0.56	0.74

Source: 1998 R.S. Means Building Construction Cost Data

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

Contd.

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

Bar Number	Bar Diameter (in)	Weight (lb/LF)	Minimum Overlap Recommended
2	1/4	0.167	1' - 0"
3	3/8	0.376	1' - 0"
4	1/2	0.668	1' - 0"
5	5/8	1.043	1' - 3"
6	3/4	1.502	1' - 6"
7	7/8	2.044	1' - 9"
8	1.0	2.670	2' - 0"
9	1.128	3.400	2' - 4"
10	1.270	4.303	2' - 7"
11	1.410	5.513	2'- 10"

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

Filling Rate (Feet/Hr)	Concrete Temperature (F)					
	50	60	70	80	90	100
1	330	300	279	262	250	240
2	510	450	409	375	350	330
3	690	600	536	487	450	420
4	870	750	664	600	550	510
5	1,050	900	793	712	650	600
6	1,230	1,050	921	825	750	690
7	1,410	1,200	1,050	933	850	780
8	1,466	1,246	1,090	972	877	808
9	1,522	1,293	1,130	1,007	912	836
10	1,578	1,340	1,170	1,042	943	864

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

	Maximum Concrete Pressure (lb/SF)							
	350	450	550	650	750	850	950	1250
Maximum Spacing of Studs for Safe Value of Sheathing(in)								
1" sheathing	26	23	21	19	18	17	15	14
2" sheathing	45	40	36	33	31	29	28	24
Maximum Spacing of Wales for Safe Value of Studs (in)								
2x4 studs, 1" sheathing	29	27	26	25	24	23	23	21
4x4 studs, 1" sheathing	45	42	40	38	37	35	35	33
2x6 studs, 2" sheathing	35	33	31	30	29	27	27	25
3x6 studs, 2" sheathing	45	43	41	39	37	36	35	33
Maximum Spacing of Ties for Safe Value of Wales (in)								
Double 2x4 wale, 2 x 4 stud	39	36	33	31	29	28	27	24
Double 2x4 wale, 4 x 4 stud	34	31	29	27	26	24	24	21
Double 2x6 wale, 2 x 6 stud	49	45	41	39	37	35	34	31
Double 2x6 wale, 3 x 6 stud	50	45	41	38	37	35	34	31

Form design information

Formwork

- 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:
  - (WL)[(WH)/(VS)](#L)(W) (linear feet: lf)
- Vertical Reinforcement:
  - (WH)[(WL)/(HS)](#L)(W) (linear feet: lf)
- Formwork:
  - Amount of plywood: (WL)(WH)(2)(W)/(#U) sf
  - Studs: (WH)[(WL)/(HS)](2)(W)/(#U) lf
  - Wales: (WL)[(WH)/(VS)](2)(W)/(#U) lf
  - Sills: (WL)(4)(W)/(#U) lf
  - Braces: [(WL)/(HS)][(WH)/(#U)](W) lf
  - Nails: (10lb/1000 fbm)(total fbm)(#U)
  - Ties: [(lf of Wales)(#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?

How much earth will the contractor have to dispose of assuming that the excavation will be backfilled to the original level?

Estimate the amounts of materials required to build the foundation wall.

Concrete will be produced on site following a 1:2:2.25 mixture by volume.

The wall reinforcement consists of horizontal and vertical steel bars.

The horizontal reinforcement is made up of #4 bars spaced at 10” from one another at both sides of the wall.

The vertical reinforcement is made up of U-shaped #3 bars located every 2 feet along the wall.

Finally, the 170 lb/CF concrete will be poured at a rate of 4 feet/hour. The concrete temperature is expected to be 70F.

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. I(2005) = 7518.28

Inflation = 3%

Design fees for school buildings between $10 million and $50 million = 6%