CEMT5232:
Construction Planning and Control

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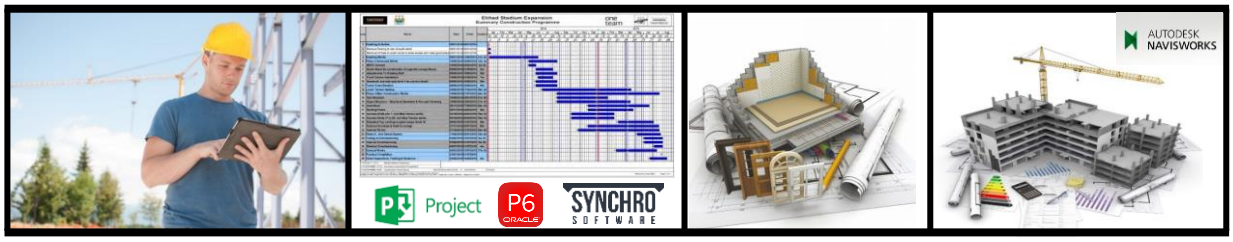
Construction Planning
Cost Estimating

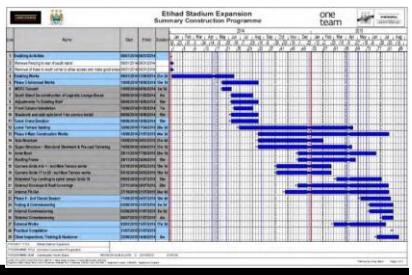


Planning: How?

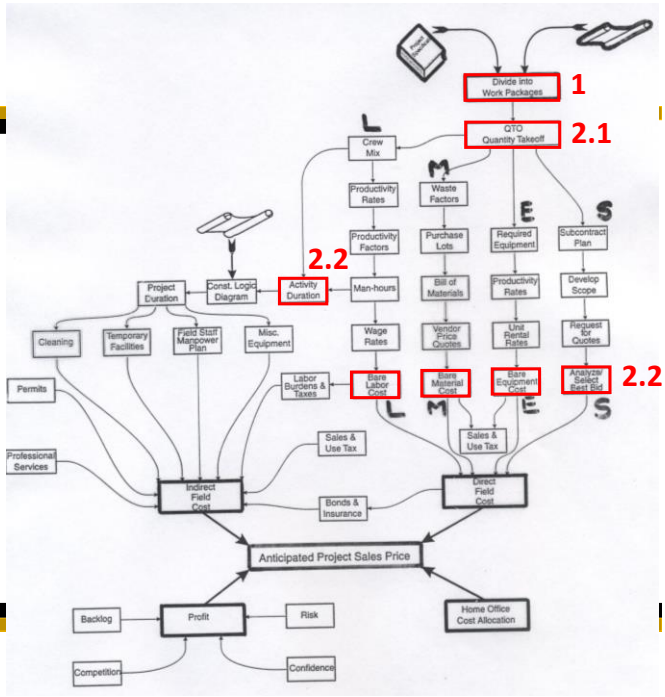
Planning Determines:
1) What must be done?
2) How it is to be performed?
3) What sequential order it will follow?

Planning Requires (skills):
1) Ability to visualize discrete work elements.
2) Establishing interdependencies.
3) Knowledge of construction methods.

Planning Steps:
1) Generate WBS & Activity List.
2) Estimate Activity Duration/Cost.
3) Determine job logic (relationships among activities).
4) Draw graphical presentation in a network.

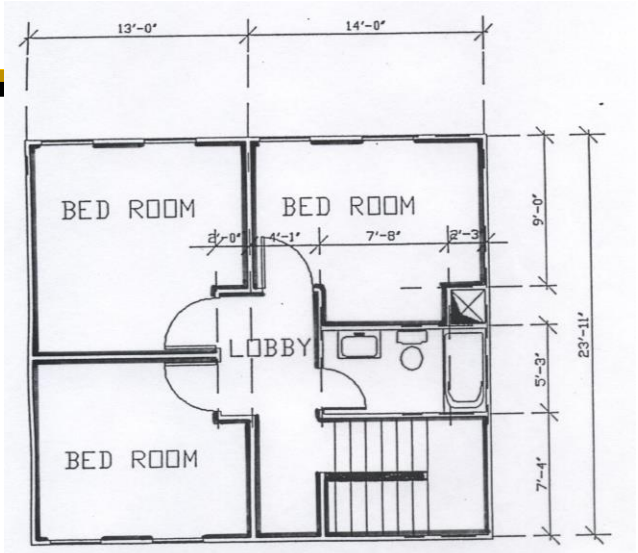


Construction Planning & Cost Estimating

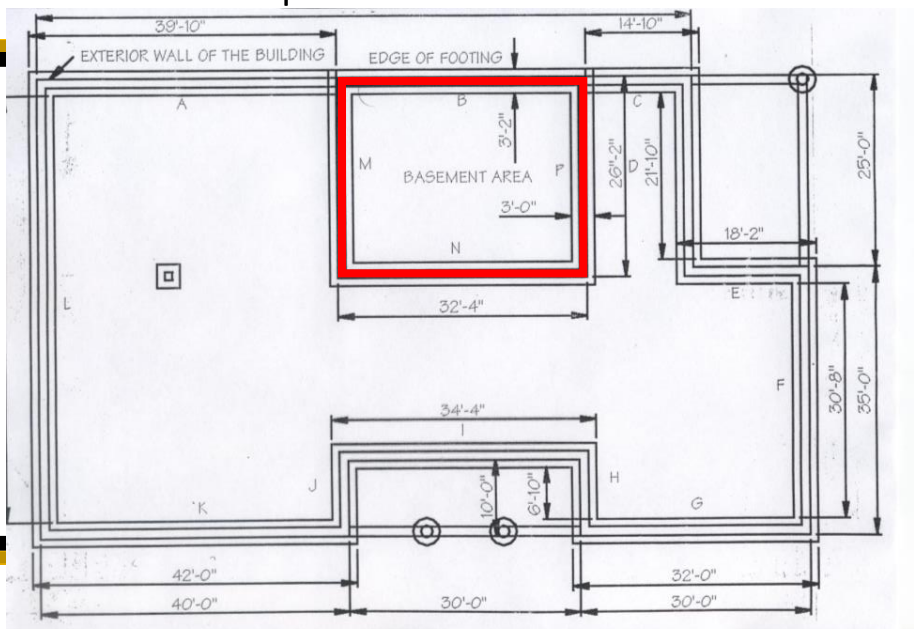


Quantity Take-Off (QTO)

- **QTO:** development of quantities of work in appropriate units (e.g. ft., SF/ft^2, CY, SFCA) for each work package from detailed drawings & specifications.
- How to calculate the quantity of work for the painting activity in this floor plan?



Basement Excavation Example



Basement Excavation Example

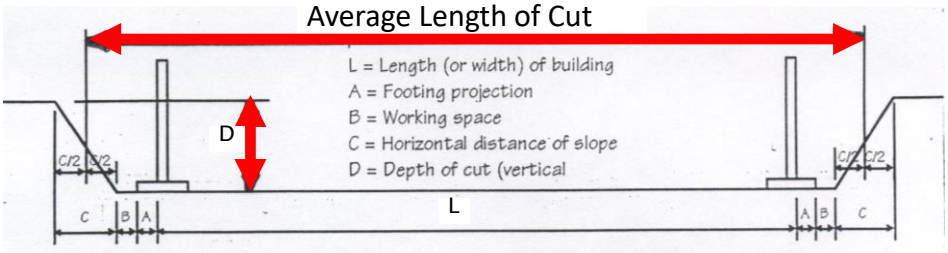
Volume = Average Width x Average Length x Depth

Factors Affecting Average Width/Length:

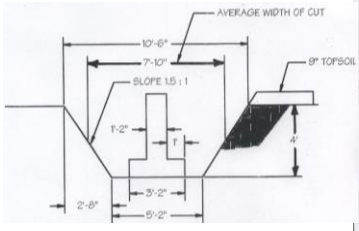
A) Footing Projection.

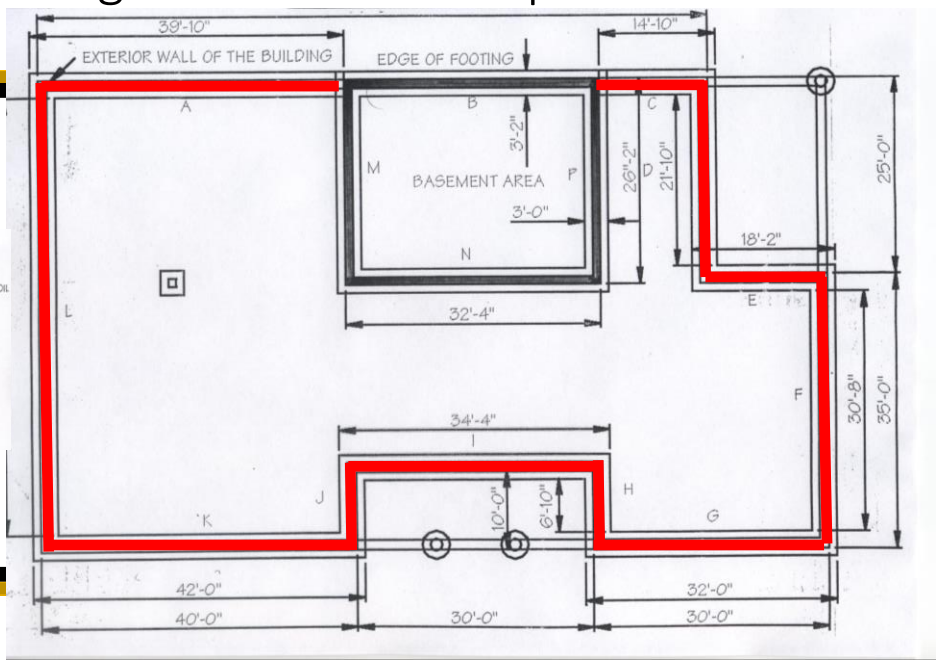
B) Work space beyond footing edge (1 – 2 feet).

C) Horizontal distance of side slopes.



Continuous Footing Excavation Example





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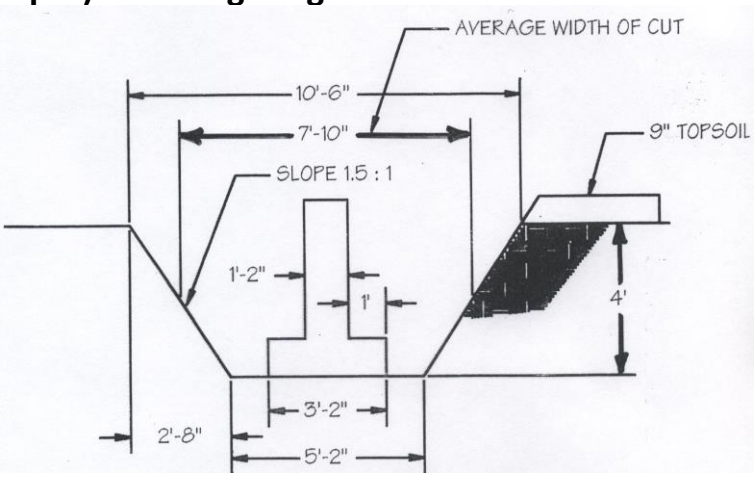
Continuous Footing Excavation Example

Volume = Area of Cut x Footing Length

= (Average Width x Depth) x Footing Length



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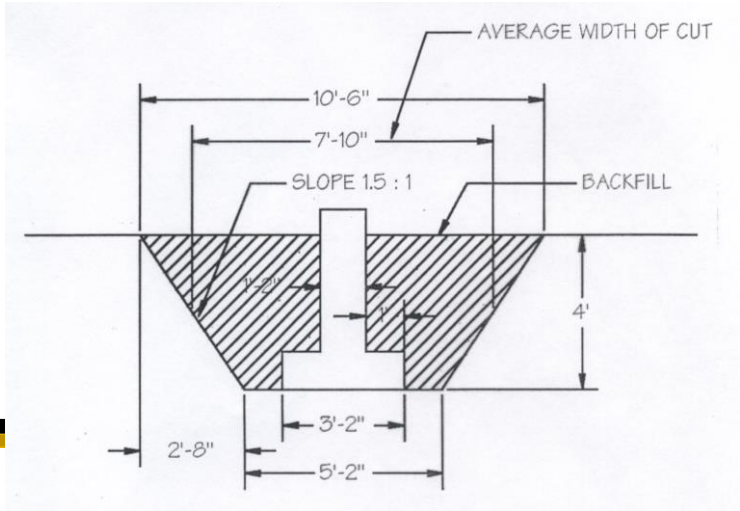
Wall Backfilling Example

Volume = Excavation Volume - Wall Volume



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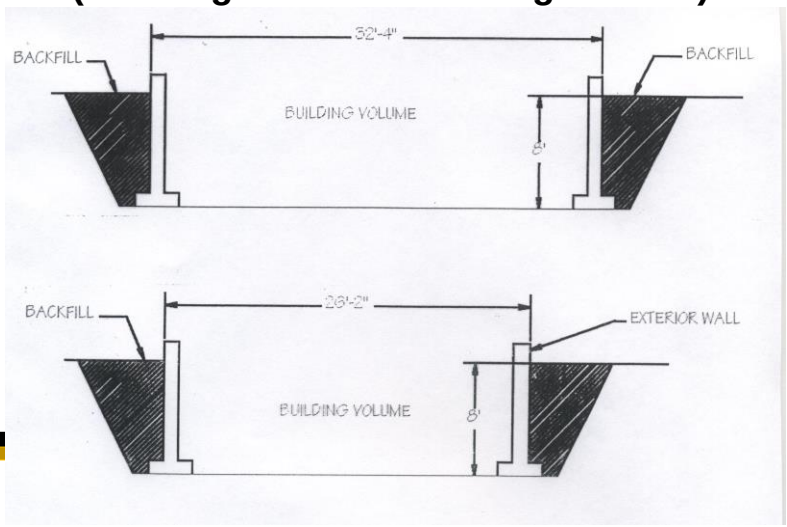
Basement Backfilling Example

Volume = Excavation Volume – (Building Volume + Footing Volume)



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Quantity Take-Off (QTO)

Common Sources of Errors in QTO:

1) Arithmetic: errors in addition, subtraction etc.

2) Transposition: errors in copying or transferring figures, dimensions, etc.

3) Errors of omissions.

4) Scaling drawings rather than indicated dimensions.

5) Unrealistic waste factors.

Detailed Cost Estimating

Steps:

1) Identify all direct cost activities (WBS).

2) Perform quantity takeoff for each activity.

3) Estimate direct cost of each activity.

4) Calculate total direct cost of all activities.

5) Estimate total project indirect cost.

6) Estimate project markup.

7) Total project bid = direct cost + indirect cost + markup

Construction Direct Cost

Direct Cost: can be directly assigned to a specific activity & it includes:

(1) Labor Cost

(2) Equipment Cost

(3) Material Cost

(4) Subcontractor Cost.

Indirect Costs: are costs that cannot be assigned directly to specific construction activities.

RECAP SHEET

Job: Highway Bridge — Bid Date: April 25, 19--

Item No.	Bid Item	Unit	Estimated Quantity	Labor Cost	Equipment Cost	Material Cost	Subcontract Cost	Direct Cost
1	Excavation, unclassified	cy	1,667	$1,805.00	$619.00	$0.00	$0.00	$2,424.00
2	Excavation, structural	cy	120	$2,067.00	$390.00	$0.00	$0.00	$2,457.00
3	Backfill, compacted	cy	340	$2,219.00	$469.00	$0.00	$0.00	$2,688.00
4	Piling, steel	lf	2,240	$10,956.00	$11,184.00	$30,690.00	$0.00	$52,830.00
5	Concrete, footings	cy	120	$2,313.00	$580.00	$6,560.00	$0.00	$9,453.00
6	Concrete, abutments	cy	280	$23,948.00	$6,022.00	$16,747.00	$0.00	$46,717.00
7	Concrete, deck slab, 10 in	sy	200	$8,086.00	$1,043.00	$4,603.00	$0.00	$13,732.00
8	Steel, reinforcing	lb	90,000	$0.00	$0.00	$0.00	$40,275.00	$40,275.00
9	Steel, structural	lb	65,500	$2,474.00	$1,728.00	$27,052.00	$0.00	$31,254.00
10	Bearing plates	lb	3,200	$1,105.00	$432.00	$2,140.00	$0.00	$3,677.00
11	Guardrail	lf	120	$1,207.00	$432.00	$3,848.00	$0.00	$5,487.00
12	Paint	ls	job	$0.00	$0.00	$0.00	$5,820.00	$5,820.00
			Totals	$56,180.00	$22,899.00	$91,640.00	$46,095.00	$216,814.00
						Job overhead		$41,223.00
								$258,037.00
						Small tools (5% of labor)		$2,809.00
								$260,846.00
						Tax 3%		$7,825.38
								$268,671.38
						Markup 15%		$40,300.71
								$308,972.09
						Bonds		$3,752.16
						Total Project Bid		$312,724.24

Construction Labor Cost

Labor Cost includes:

1) Basic Wages: hourly rates used by payroll.

2) Fringe Benefits: contributions paid by employer for health insurance, vacations, pensions, etc.

3) Workers' Compensation: insurance that is based on payroll & it can be included in labor cost or in project indirect cost.

4) Wage Premiums: extra money paid for overtime work (for example 150% of basic wage to 200%).

RSMeans

③ Overtime (Div. 010-064)

One way to improve the completion date of a project or eliminate negative float from a schedule, is to compress activity duration times. This can be achieved by increasing the crew size or working overtime with the proposed crew.

To determine the costs of working overtime to compress activity duration times, consider the following examples. Below is an overtime efficiency and cost chart based on a five, six, or seven day week with an eight through twelve hour day. Payroll percentage increases for time and one half and double time are shown for the various working days.

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

Calculating Labor Cost

For a construction crew that includes N laborers:

1) Estimate A: daily labor cost

A ($/day) = Σ (hourly rate x 8 man hours/day)

2) Estimate P: crew daily output (units/day)

3) Estimate B: unit labor cost

B ($/unit) = A ($/day) / P (units/day)

4) Estimate L: Labor direct cost

L ($) = B ($/unit) x quantity of work (units)

Calculating Labor Cost: Example

- **Example:** Estimate the labor cost for the formwork of a continuous wall footing that has a quantity of 500 square foot of contact area (SFCA). The activity is constructed by crew C1 that has a daily output of 485 SFCA/day, and consists of: 3 carpenters @ $21.60/hr & 1 building laborer @ $17.15/hr.

Solution:

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

= (3 x 21.6 + 17.15) x 8 = $655.6/day

Unit Labor Cost (B) = (A)/(P)

= $655.6/day / 485 SFCA/day = $1.35/SFCA

Total Labor Cost (L) = (B) x quantity of work

= $1.35/SFCA x 500 SFCA = $676

Calculating Labor Cost: Example

Crew C-1

Crew C-1	Bare Costs Hr.	Bare Costs Daily	Including Subs O & P Hr.	Including Subs O & P Daily	Cost Per Man-hour Bare Costs	Cost Per Man-hour Incl. O&P
3 Carpenters	$21.60	$518.40	$32.80	$787.20	$20.48	$31.11
1 Building Laborer	17.15	137.20	26.05	208.40		
Power Tools		23.40		25.75	.73	.80
32 M.H., Daily Totals		$679.00		$1021.35	$21.21	$31.91

A

A (Daily Labor Cost) = 518.4 +137.20 = $655.6/day
P (Daily Output) = 485 SFCA/day

B (Labor Unit Cost) = A/P = 655/485 =$1.35/SFCA

B

P

		031 | Concrete Formwork									
		031 100 | Struct C.I.P. Formwork	CREW	DAILY OUTPUT	MAN-HOURS	UNIT	BARE COSTS MAT.	BARE COSTS LABOR	BARE COSTS EQUIP.	BARE COSTS TOTAL	TOTAL INCL O&P
154	0100	3 use	C-2	200	.240	SFCA	.64	5.10	.16	5.90	8.60
	0150	4 use	"	205	.234		.55	4.96	.15	5.66	8.30
158	0010	FORMS IN PLACE, FOOTINGS Continuous wall, 1 use	C-1	375	.085		.95	1.75	.06	2.76	3.77
	0050	2 use		440	.072		.55	1.49			
	0100	3 use		470	.068		.42				
	0150	4 use		485	.066		.35	1.35	.05	1.75	2.50
		Dowel supports for footings or beams, 1 use			.064	L.F.	.56		.05	1.92	2.66

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Construction Equipment Cost

Types of Construction Equipment:

1) Major Equipment: earthmoving machines, concrete plants, etc.

2) Minor Equipment: power tools, water hose, extension cords, etc.

Equipment Cost includes:

1) Ownership Expenses:

1.1) Rent

1.2) Lease

1.3) Buy

2) Operating & Maintenance Expenses:

2.1) Fuel & oil.

2.2) Repairs & parts.

2.3) Periodic maintenance.

2.4) Tire replacement.

Calculating Equipment Cost

For a construction crew:

1) Estimate A: daily equipment cost (combined ownership & operating expenses)

A ($/day) = Σ (hourly rate x 8 hours/day) **$23.40/day**

2) Estimate P: crew daily output (units/day) **485 units/day**

3) Estimate B: unit equipment cost **23.40/485=$0.05/unit**

B ($/unit) = A ($/day) / P (units/day)

4) Estimate E: Equipment direct cost

E ($) = B ($/unit) x quantity of work (units)

Crew C-1

Crew No.	Bare Costs		Incl. Subs O & P		Cost Per Man-hour	
Crew C-1	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
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Calculating Equipment Cost

Crew C-1

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Power Tools		23.40	A	25.75	.73	.80
32 M.H., Daily Totals		$679.00		$1021.35	$21.21	$31.91

A (Daily Labor Cost) = $23.4/day

P (Daily Output) = 485 SFCA/day

B (Equipment Unit Cost) = A/P = 23.4/485 =$0.05/SFCA

031 | Concrete Formwork

031 100 | Struct C.I.P. Formwork

			CREW	DAILY OUTPUT	MAN-HOURS	UNIT	BARE COSTS MAT.	BARE COSTS LABOR	BARE COSTS EQUIP.	BARE COSTS TOTAL	TOTAL INCL O&P
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	0050	2 use		440	.072		.55	1.49	.05	2.09	2.93
	0100	3 use		470	.068		.42	1.39	.05	1.86	2.62
	0150	4 use		485	.066		.35	1.35	.05	1.75	2.50
	0500	Dowel supports for footings or beams, 1 use		550	.064	L.F.	.56	1.31	.05	1.92	2.66

Material Cost

For each activity:

1) The contractor solicits & receives price quotations for Material unit cost (e.g. $/CY for ready-mix concrete) that includes delivery to site.

2) Estimate percentage of material wastage (W%) & identify the Bill of Materials.

3) Material Cost = Material unit cost x Quantity x (1 + W)

Note: Sales tax on material can be included in project indirect cost, instead of material cost.

Subcontractor Cost

- **Subcontractor Cost:** A prime contractor often subcontracts portions of the project to specialty subcontractors. In the cost estimate, the cost of subcontracted activities are input as a lump sum.

Construction Direct Cost

Direct Cost: can be directly assigned to a specific activity & it includes:

(1) Labor Cost

(2) Equipment Cost

(3) Material Cost

(4) Subcontractor Cost.

RECAP SHEET

Job: Highway Bridge

Bid Date: April 25, 19--

Item No.	Bid Item	Unit	Estimated Quantity	Labor Cost	Equipment Cost	Material Cost	Subcontract Cost	Direct Cost
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3	Backfill, compacted	cy	340	$2,219.00	$469.00	$0.00	$0.00	$2,688.00
4	Piling, steel	lf	2,240	$10,956.00	$11,184.00	$30,690.00	$0.00	$52,830.00
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								$268,671.38
						Markup 15%		$40,300.71
								$308,972.09
						Bonds		$3,752.16
						Total Project Bid		$312,724.24

Construction Indirect Cost

Indirect Costs: are costs that cannot be assigned directly to specific construction activities & it represents around 30% of project direct cost. It includes:

1) Workers' compensation.

2) Main office expenses.

3) Temporary offices and field office expenses

4) Field supervision.

5) Tools & minor equipment.

6) Performance & payment bonds.

7) Taxes.

8) Insurance.

Construction Indirect Cost

General Conditions | **R10.0-100** | **Overhead**

Table 10.0-101 General Contractor's Overhead

The table below shows a contractor's overhead as a percentage of direct cost in two ways. The figures on the right are for the overhead, markup based on both material and labor. The figures on the left are based on the entire overhead applied only to the labor. This figure would be used if the owner supplied the materials or if a contract is for labor only.

Items of General Contractor's Indirect Costs	% of Direct Costs	
	As a Markup of Labor Only	As a Markup of Both Material and Labor
Field Supervision	6.0%	3.2%
Main Office Expense (see details below)	14.7	7.7
Tools and Minor Equipment	1.0	0.5
Workers' Compensation & Employers' Liability. See Table 10.2-201	19.8	10.4
Field Office, Sheds, Photos, Etc.	1.5	0.8
Performance and Payment Bond, 0.5% to 0.9%. See Table 10.1-302	0.7	0.4
Unemployment Tax See R010-100 (Combined Federal and State)	7.3	3.8
Social Security and Medicare (7.65% of first $60,600)	7.7	4.0
Sales Tax – add if applicable 38/80 x % as markup of total direct costs including both material and labor. See R10.2-400		
Sub Total	58.7%	30.8%
*Builder's Risk Insurance ranges from .141% to .586%. See Table 10.1-301	0.3	0.3
*Public Liability Insurance	1.5	1.5
Grand Total	60.5%	32.6%

*Paid by Owner or Contractor

Main Office Costs

Main Office Expenses: Average 7.7% of total direct cost (range 2-20%) & it includes:

1) Managers & estimators salaries.
2) Profit sharing, pension & bonus plans.
3) Estimating & project management (non-salaries).
4) Insurance.

Table 10.0-102 Main Office Expense

A General Contractor's main office expense consists of many items not detailed in the front portion of the book. The percentage of main office expense declines with increased annual volume of the contractor. Typical main office expense ranges from 2% to 20% with the median about 7.2% of total volume. This equals about 7.7% of direct costs. The following are approximate percentages of total overhead for different items usually included in a General Contractor's main office overhead. With different accounting procedures, these percentages may vary.

Item	Typical Range	Average
Managers', clerical and estimators' salaries	40% to 55%	48%
Profit sharing, pension and bonus plans	2 to 20	12
Insurance	5 to 8	6
Estimating and project management (not including salaries)	5 to 9	7
Legal, accounting and data processing	0.5 to 5	3
Automobile and light truck expense	2 to 8	5
*Depreciation of overhead capital expenditures	2 to 6	4
Maintenance of office equipment	0.1 to 1.5	1
Office rental	3 to 5	4
*Utilities including phone and light	1 to 3	2
Miscellaneous	5 to 15	8
Total		100%

Construction Markup

Markup: is a margin that is added to cover profit (% of estimated project cost). Some contractors consider markup to include also contingency & office overhead.

Contingency: an allowance that covers the risk of unforeseen costs. Contingency should not include costs for scope changes.

Range Estimating: is used to evaluate the contingencies or uncertainty in cost estimating by utilizing the fundamentals of statistics & probability.

Total (Direct and Indirect) Cost

Indirect Costs: are costs that cannot be assigned directly to specific construction activities & it represents 30% of project direct cost.

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11	Guardrail	lf	120	$1,207.00	$432.00	$3,848.00	$0.00	$5,487.00
12	Paint	ls	job	$0.00	$0.00	$0.00	$5,820.00	$5,820.00
			Totals	$56,180.00	$22,899.00	$91,640.00	$46,095.00	$216,814.00
						Job overhead		$41,223.00
								$258,037.00
						Small tools (5% of labor)		$2,809.00
								$260,846.00
						Tax	3%	$7,825.38
								$268,671.38
						Markup	15%	$40,300.71
								$308,972.09
						Bonds		$3,752.16
						Total Project Bid		$312,724.24

Next Class

Planning Steps (Cont'd)