PLANNING – PART 1 – NETWORK DIAGRAMS

How to prepare a winning bid? If you win, How to meet project objectives?

IF YOU FAIL TO PLAN . . . YOU PLAN TO FAIL

CONCEPT	DESIGN	BIDDING		CONSTRUCTION	O & M
Owner, CM	A/E, CM, Owner	Bidders	Owner, GM	Contractor	O & M Staff
- Need - Feasibility - Project Definition Owner Approval	- Conceptual Design - Owner Approval - Soil Reports - Preliminary Design - Detailed Design - Quantities Work Documents - Select Project Contract Strategy	Prepare Bid Proposal + Baselines - Collect data (site, quantities, specs, resources, tasks, etc) - Planning - Time & Cost Estimation - Scheduling - Resource Management Adjustments for Resource Constraints & Deadline - Bidding Strategy & Markup Estimation - Cash flow analysis - Submit Bid	- Evaluate Bids and Select General Contractor	- Start Construction - Detailed planning, estimating & resource management - Schedule Updating - Progress Evaluation - Time, Cost, & Quality Control - Commissioning	- O & M - Demolition at end of service life

Planning = Solving a Puzzle

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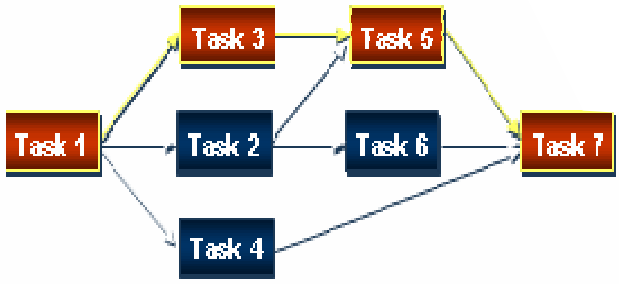


Two steps:

(1) Find all the Pieces
(2) Arrange them in a logical order

Detailed Steps:

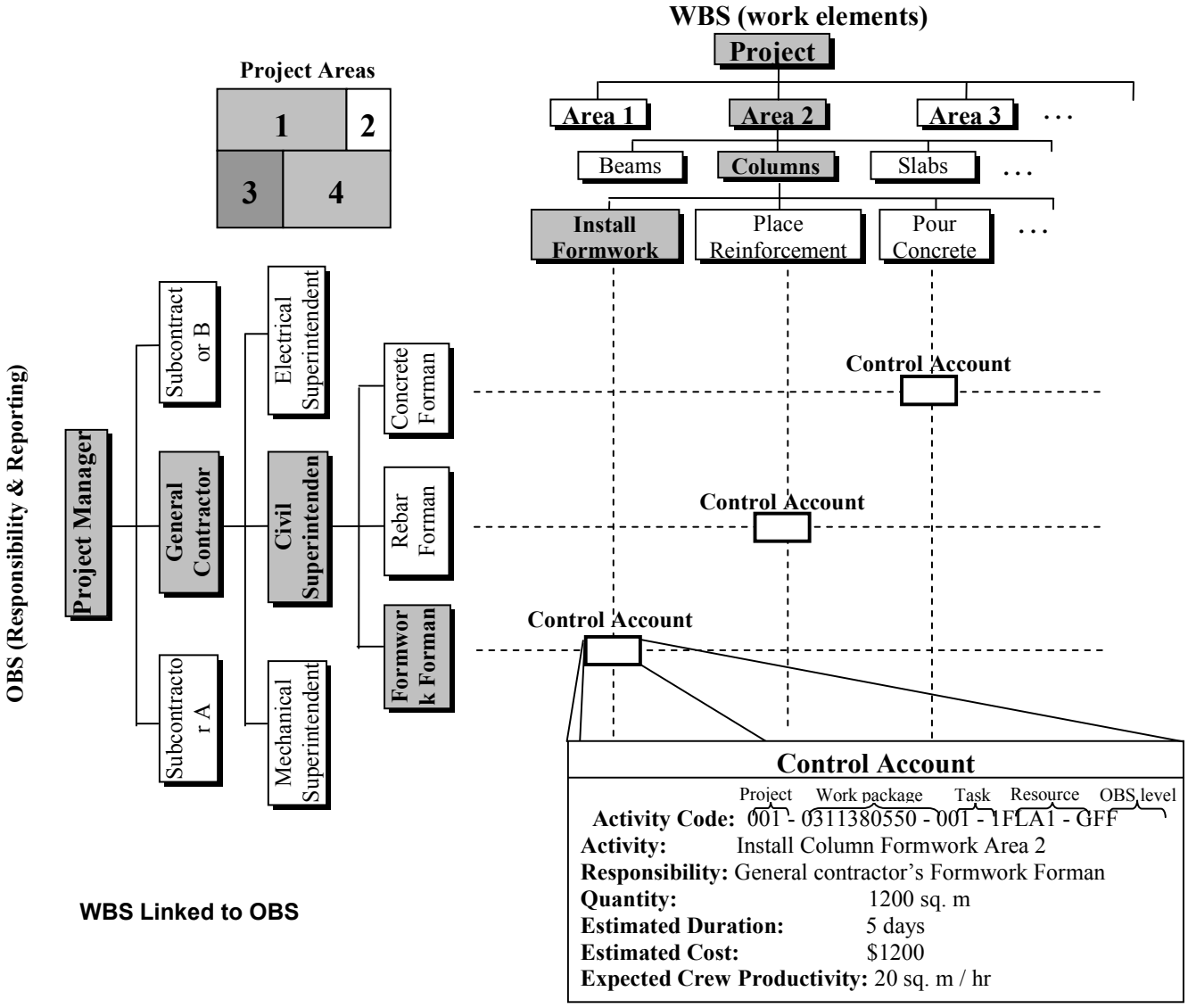
1. **Work Breakdown Structure (WBS) linked to OBS**

- Production activities: excavation, formwork, concreting, and so on. Each having costs, duration, etc.
- Procurement activities: materials and manufactured equipment needed for any production activities.
- Management decision activities: such as vacations, special delays, approvals, etc.
- Hammock activities: dependent on other ones. Example is dewatering, which is required as long as subsurface work is being carried out.
- Dummy activities: activities needed for presentation purposes to maintain logical relationships.

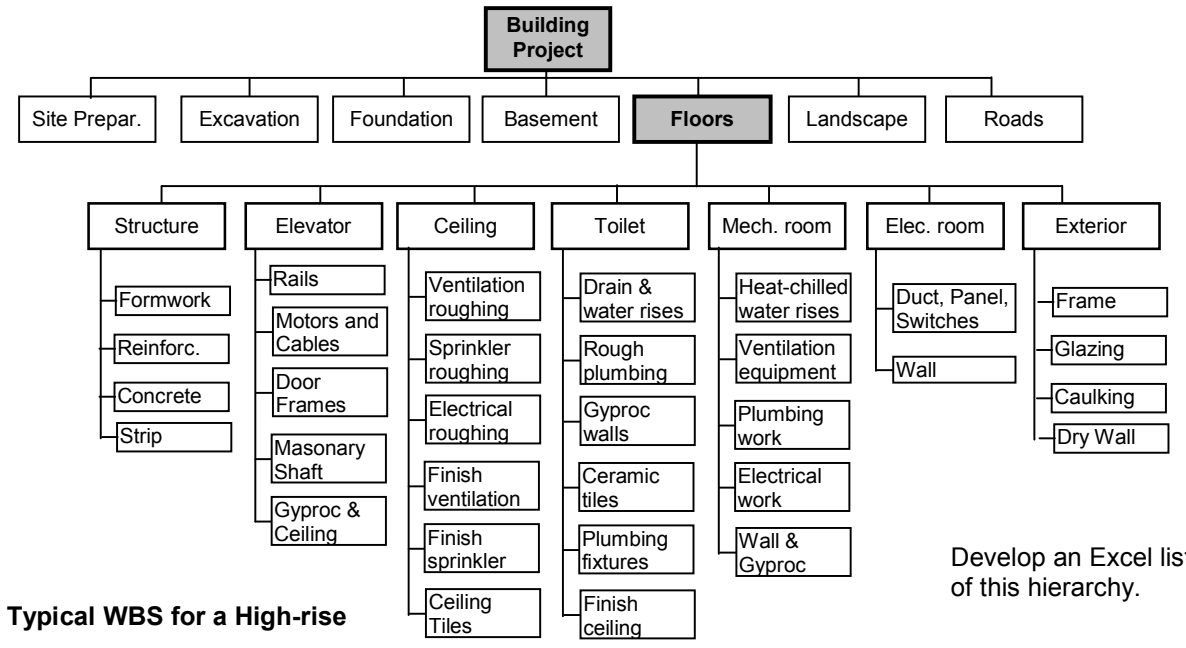
Published Lists: The **MasterFormat** list developed by the Construction Specifications Institute – 16 divisions – is a good checklist for project activities.

Division 1: General Requirements	Division 9: Finishes
Division 2: Site Work	Division 10: Specialties
Division 3: Concrete	Division 11: Equipment
Division 4: Masonry	Division 12: Furnishings
Division 5: Metals	Division 13: Special Construction
Division 6: Wood and Plastics	Division 14: Conveying Systems
Division 7: Thermal Moisture Protection	Division 15: Mechanical
Division 8: Doors and Windows	Division 16: Electrical

The Main Divisions in the MasterFormat list for Building Projects



WBS Linked to OBS



Typical WBS for a High-rise

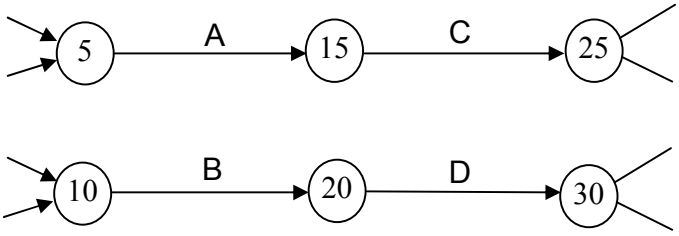
Develop an Excel list of this hierarchy.

2. Activity Logical Relationships and Network Diagram

Jigsaw puzzle - Brainstorming
Which activities are parallel? Which activities must precede? Which activities must succeed?
Remove redundant relations and produce a table of activities and IPAs.
Check if start & finish activities are required and calculate Sequence Steps.

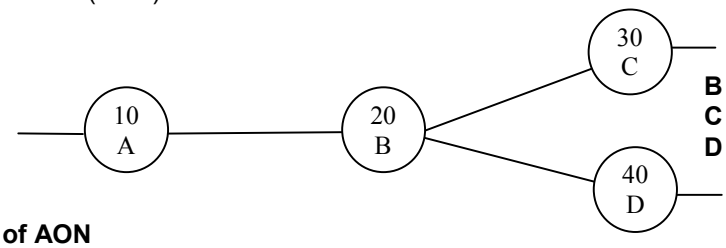
Types of Networks:

Activity on Arrow (AOA) - We may need to add **dummy** activities to preserve logical relations



C depends on A & B
D depends on B only

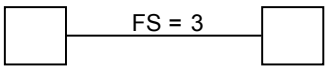
Activity on Node (AON)

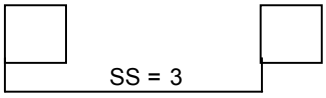


B depends on A
C depends on B
D depends on B

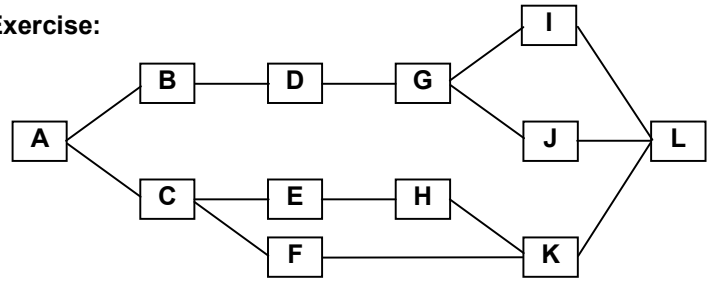
Benefits of AON

- Does not need dummy activities.
- The sequence step calculation also made the AON to look more organized and clearer to read.
- The technique is also well suited to computer implementation.
- Has a major advantage in terms of the types of logical relationships it allows (Finish-to-Start, Start-to-Start, Start-to-Finish, and Finish-to-Finish).





Exercise:



No.	Activity	Predecessors			Successors		
		P1	P2	P3	S1	S2	S3
1	**A**	---	---	---	---	---	---
2	**B**	---	---	---	---	---	---
3	**C**	---	---	---	---	---	---
4	**D**	---	---	---	---	---	---
5	**E**	---	---	---	---	---	---
6	**F**	---	---	---	---	---	---
7	**G**	---	---	---	---	---	---
8	**H**	---	---	---	---	---	---
9	**I**	---	---	---	---	---	---
10	**J**	---	---	---	---	---	---
11	**K**	---	---	---	---	---	---
12	**L**	---	---	---	---	---	---

Example:

Initial Activity List for Example Project

Activity	Description
A	Site clearing
B	Removal of Trees
C	General Excavation
D	Grading general area
E	Excavation for utility trenches
F	Placing formwork and reinforcement for concrete
G	Installing sewer lines
H	Pouring concrete

Refined Activity List

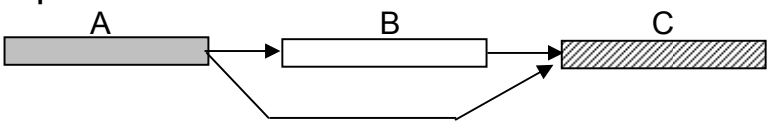
Activity	Description	
A	Site clearing	Production activities
B	Removal of Trees	
C	Excavation	
D	Grading	
E	Excavation for utility trenches	
F	Placing formwork and reinforcement for concrete	
G	Installing sewer lines	
H	Pouring concrete	
J	**Obtain formwork and reinforcing steel**	Material Procurement activities
K	**Obtain sewer lines**	
L	**Obtain concrete**	Labor procurement activity
M	**Steelworker availability**	

Additional activities: J, K, L, M

Initial Relationships

Activity	Description	Depends Upon
A	Site clearing	-----
B	Removal of Trees	-----
C	Excavation	A
D	Grading	A, B, C
E	Excavation for utility trenches	A, B, C
F	Placing formwork and reinforcement for concrete	B, C, J, M
G	Installing sewer lines	B, C, D, E, K
H	Pouring concrete	D, E, F, G, L
J	Obtain formwork and reinforcing steel	-----
K	Obtain sewer lines	-----
L	Obtain concrete	-----
M	Steelworker availability	-----

Redundant Relationships



Which relationship is redundant?

Removing Redundant Relationships

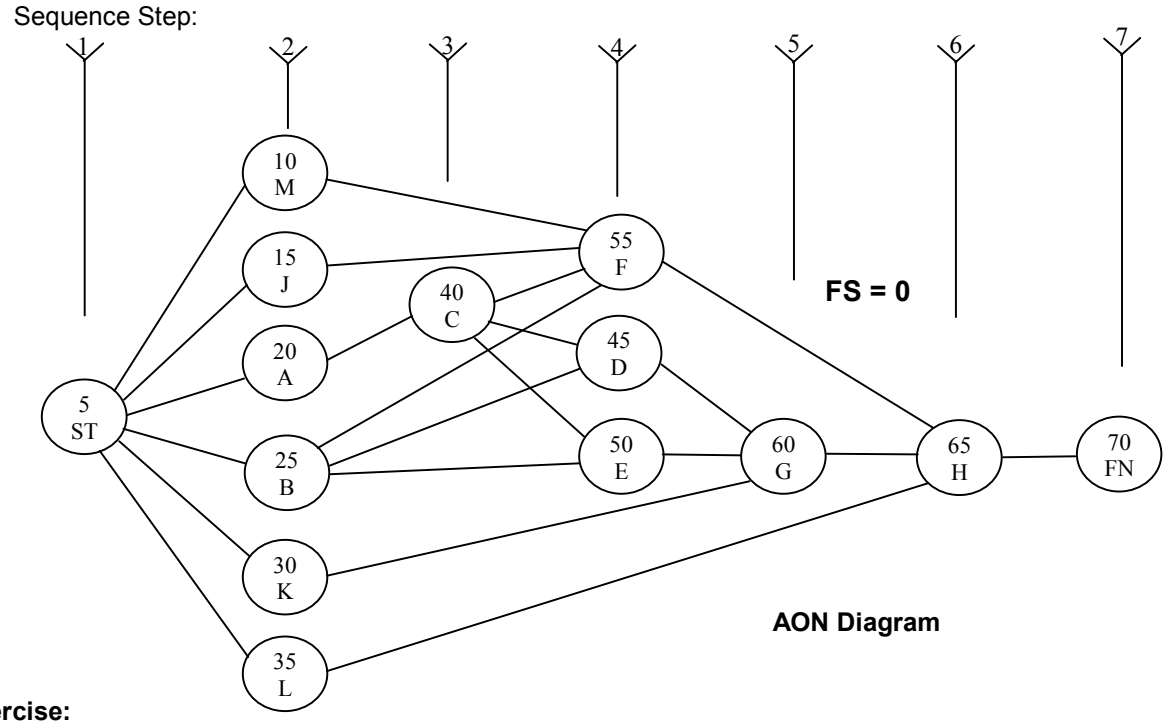
Activity	Description	IPAs
A	Site clearing	-----
B	Removal of Trees	-----
C	Excavation	**A**
D	Grading	**B, C**
E	Excavation for utility trenches	**B, C**
F	Placing formwork and reinforcement for concrete	**B, C, J, M**
G	Installing sewer lines	**D, E, K**
H	Pouring concrete	**F, G, L**
J	Obtain formwork and reinforcing steel	-----
K	Obtain sewer lines	-----
L	Obtain concrete	-----
M	Steelworker availability	-----

Adding Start and Finish Activities

Activity	Description	IPAs
ST	**Start Activity**	-----
A	Site clearing	**ST**
B	Removal of Trees	**ST**
C	Excavation	A
D	Grading	B, C
E	Excavation for utility trenches	B, C
F	Placing formwork and reinforcement for concrete	B, C, J, M
G	Installing sewer lines	D, E, K
H	Pouring concrete	F, G, L
J	Obtain formwork and reinforcing steel	**ST**
K	Obtain sewer lines	**ST**
L	Obtain concrete	**ST**
M	Steelworker availability	**ST**
FN	**Finish Activity**	**H**

Determining the Sequence Steps for AON

Activity	IPAs	Sequence Step (SS)	
		Cycle 1	Cycle 2
ST	-----	SS(ST) = 1	1
A	ST	SS(ST) + 1 = 2	2
B	ST		2
C	A		3
H	F, G, L		6
D	B, C		4
E	B, C		4
F	B, C, J, M		4
G	D, E, K		5
J	ST		2
K	ST		2
L	ST		2
M	ST		2
FN	H		7



AON Diagram

Exercise:

Activity	IPAs	SS	SS
A	----	-------	-------
B	A	-------	-------
C	A	-------	-------
D	A	-------	-------
E	B	-------	-------
F	D	-------	-------
G	B	-------	-------
J	G, H, I	-------	-------
H	C, E	-------	-------
I	F	-------	-------

1		2		3		4		5		6	

Case Study Project

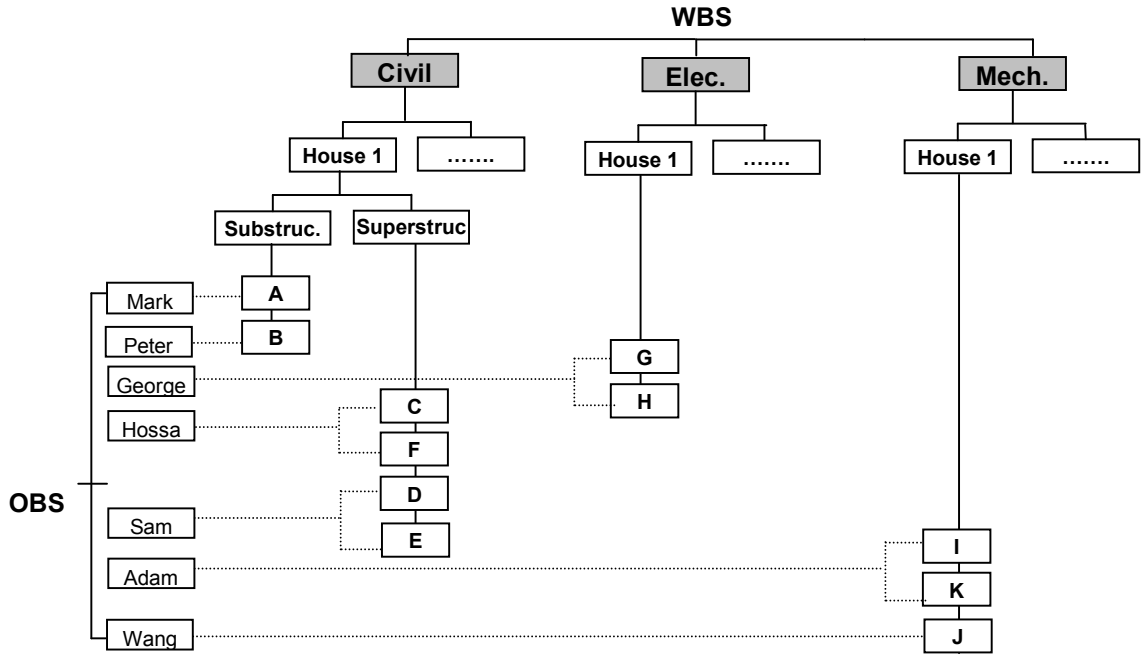
- 11 work packages (activities) are involved: A ,B ,C ,D ,E ,F ,G ,H ,I ,J ,and K;
- Civil activities are A and B (Substructure); and C, D, E, and F (Superstructure);
- Electrical activities are: G (Interior work) and H (Exterior work); and
- Mechanical activities are: I (HVAC), J (Elevator), and K (Plumbing).

Supervision personnel:

- Substructure is supervised by Mark (activity A) and Peter (activity B);
- Superstructure is supervised by Hossam (activities C and F) and Sam (D and E);
- All Electrical work is supervised by George; and
- Adam is responsible for all HVAC and Plumbing work, while Wang is responsible for the elevator work.

From the project information, the WBS and its link to the OBS is shown below. A simple Excel list that shows all the information is also shown.

WBS and OBS



An Excel List of WBS & OBS

	A	B	C	D	E	F	G
1	Item	Desc.	WBS1	WBS2	WBS3	OBS	COST
2	1	A	Civil	House1	Substruct.	Mark	1000
3	2	B	Civil	House1	Substruct.	Peter	1000
4	3	C	Civil	House1	Superstruct.	Hosam	1000
5	4	D	Civil	House1	Superstruct.	Sam	1000
6	5	E	Civil	House1	Superstruct.	Sam	1000
7	6	F	Civil	House1	Superstruct.	Hosam	1000
8	7	G	Electrical	House1	Interior	George	1000
9	8	H	Electrical	House1	Exterior	George	1000
10	9	I	Mechanical	House1	HVAC	Adam	1000
11	10	J	Mechanical	House1	Elevator	Wang	1000
12	11	K	Mechanical	House1	Plumbing	Adam	1000

Notice the arrangement of the data in columns: 3 levels of WBS and one level of OBS

Page Fields

	I	J
15	WBS1	Civil
16	WBS2	House1
17	WBS3	Superstruct.
18	OBS	Sam
20	Sum of COST	
21	Desc.	Total
22	D	1000
23	E	1000
24	Grand Total	2000

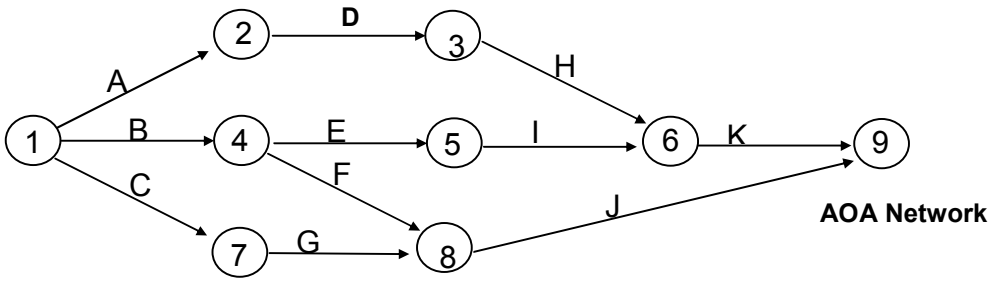
Logical relationships:

- Activities E and F follow activity B;
- Activity C precedes activity G;
- Activity I follows the completion of activity E;
- The predecessors to activity K are activities H and I;
- Activity D follows activity A and precedes activity H; and
- Activity J is preceded by activities F and G.
- From the planning information available to us, we can form the relationship table and the network diagrams as shown below.

Activity Dependency Table and Sequence Step Calculation.

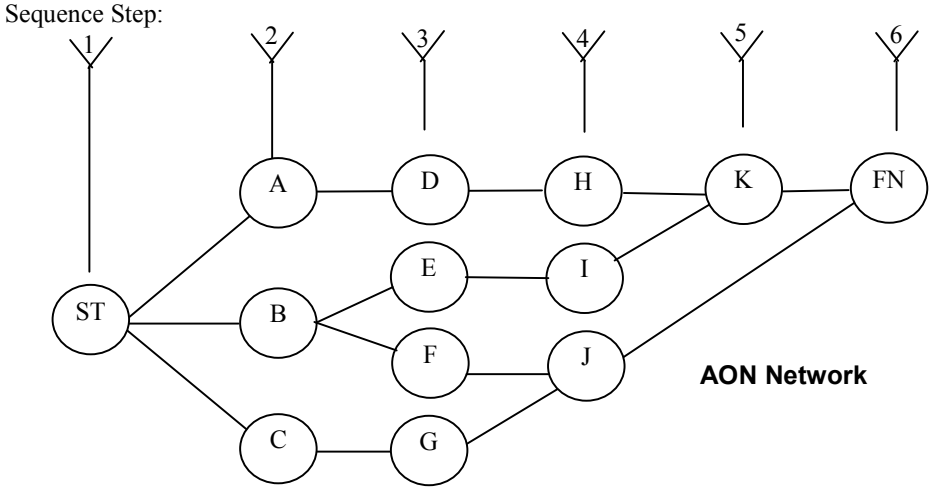
Activity	IPAs	Sequence Step (SS) Cycle 1
ST	---	
A	ST	
B	ST	
C	ST	
D	A	
E	B	
F	B	
G	C	
H	D	
I	E	
J	F, G	
K	H, I	
FN	J, K	

Note: a Start (ST) and a Finish (FN) activities have been added.



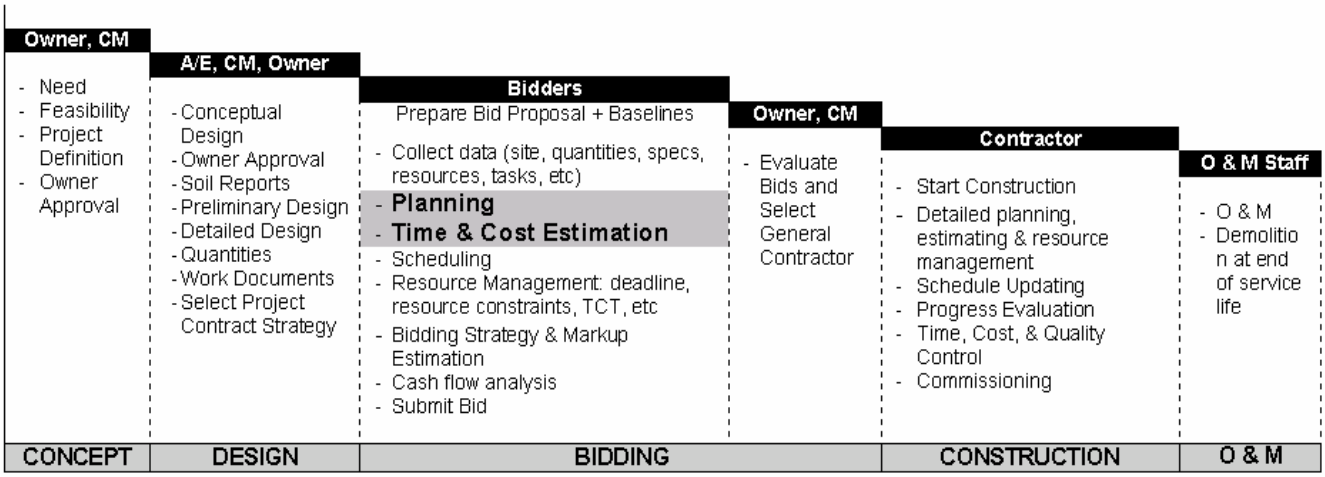
AOA Network

Sequence Step:

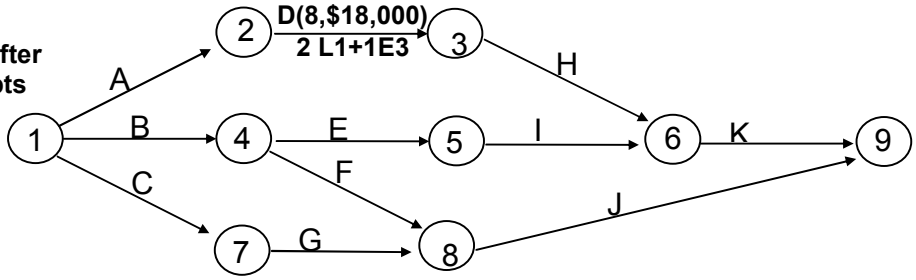


AON Network

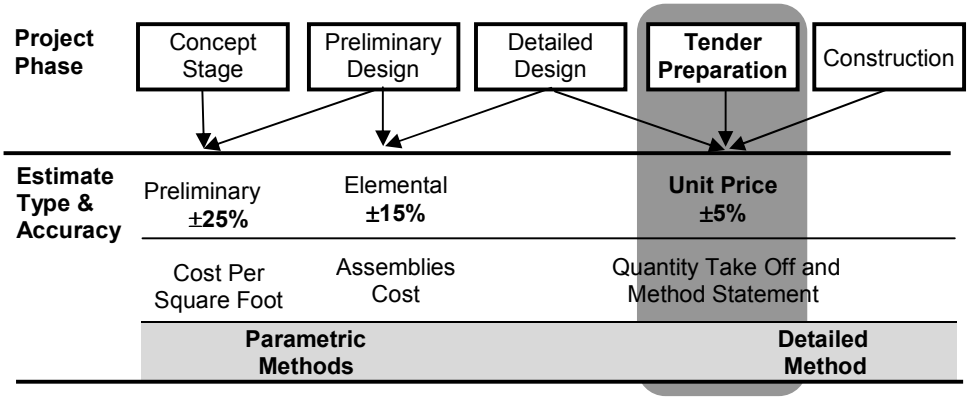
TIME & COST ESTIMATION



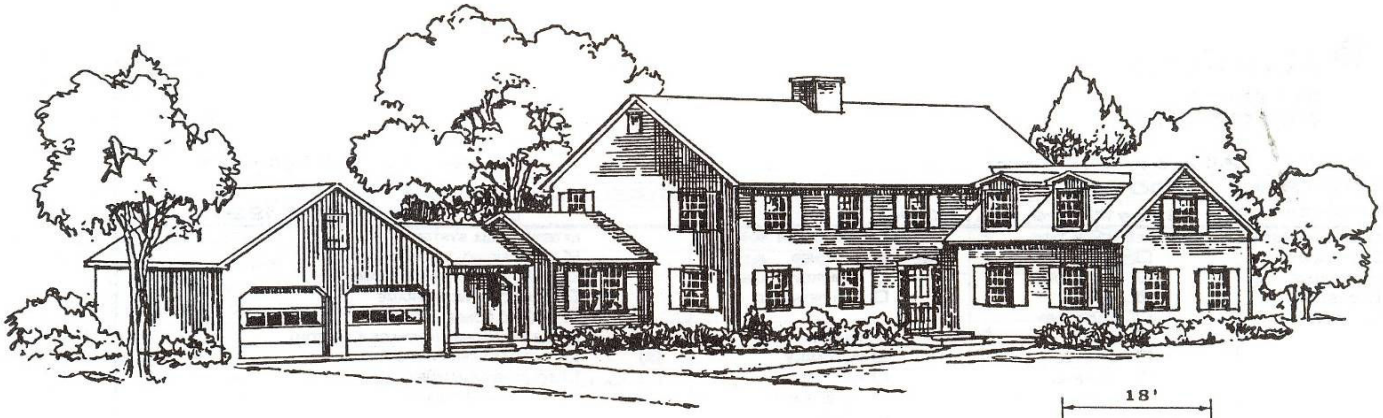
Expected Result of this chapter after applying Cost Estimation Concepts



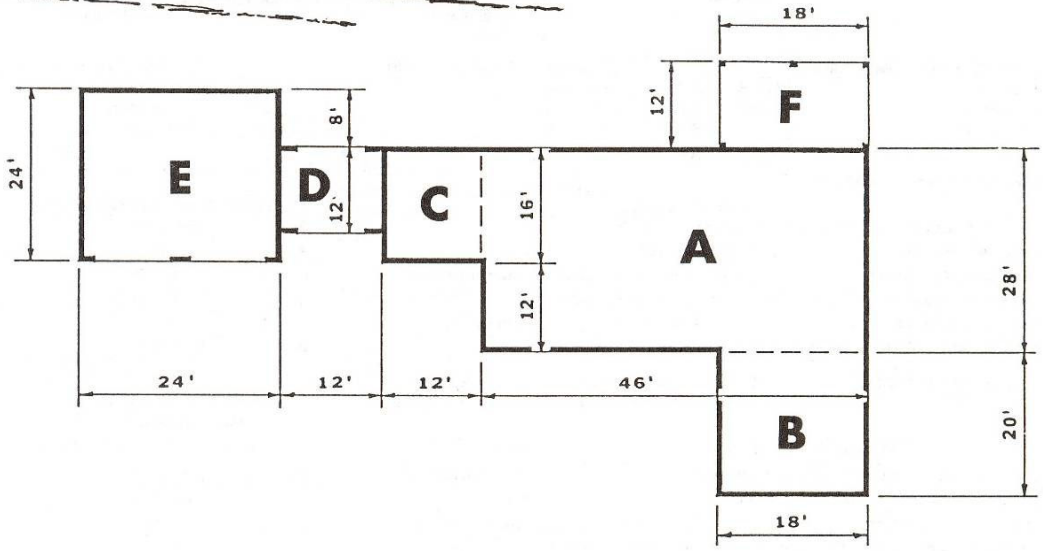
Estimating: Types and Challenges



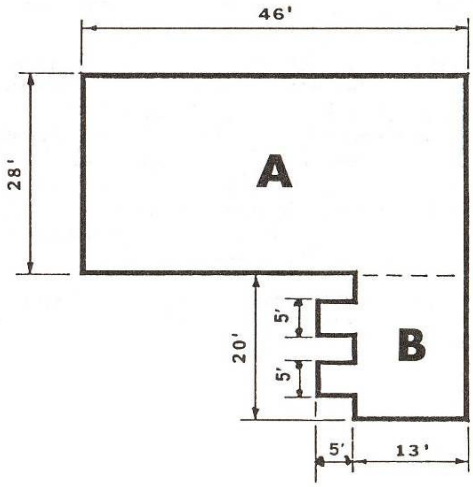
Preliminary Estimate: Residential - RS Means Square Foot Costs



First Floor Plan



Second Floor Plan



A = Main House
B = 1 1/2 Story Wing
C = 1 Story Wing
D = Breezeway
E = Garage
F = Open Covered Porch

Means Forms

RESIDENTIAL
COST ESTIMATE

OWNER'S NAME: Albert Westenberg
APPRAISER: Nicole Wojtowicz
RESIDENCE ADDRESS: 300 Sygiel Road
PROJECT: # 55
CITY, STATE, ZIP CODE: Three Rivers, MA 01080
DATE: January 2, 1997

CLASS OF CONSTRUCTION
- ☐ ECONOMY
- ☑ AVERAGE
- ☐ CUSTOM
- ☐ LUXURY

RESIDENCE TYPE
- ☐ 1 STORY
- ☐ 1-1/2 STORY
- ☑ 2 STORY
- ☐ 2-1/2 STORY
- ☐ 3 STORY
- ☐ BI-LEVEL
- ☐ TRI-LEVEL

CONFIGURATION
- ☑ DETACHED
- ☐ TOWN/ROW HOUSE
- ☐ SEMI-DETACHED

OCCUPANCY
- ☑ ONE FAMILY
- ☐ TWO FAMILY
- ☐ THREE FAMILY
- ☐ OTHER

EXTERIOR WALL SYSTEM
- ☑ WOOD SIDING - WOOD FRAME
- ☐ BRICK VENEER - WOOD FRAME
- ☐ STUCCO ON WOOD FRAME
- ☐ PAINTED CONCRETE BLOCK
- ☐ SOLID MASONRY (AVERAGE & CUSTOM)
- ☐ STONE VENEER - WOOD FRAME
- ☐ SOLID BRICK (LUXURY)
- ☐ SOLID STONE (LUXURY)

* LIVING AREA (Main Building)		
First Level	1288	S.F.
Second level	1288	S.F.
Third Level		S.F.
Total	2576	S.F.

* LIVING AREA (~~Wing~~ or Ell) (B)		
First Level	360	S.F.
Second level	310	S.F.
Third Level		S.F.
Total	670	S.F.

* LIVING AREA (WING or ~~ELL~~) (C)		
First Level	192	S.F.
Second level		S.F.
Third Level		S.F.
Total	192	S.F.

* Basement Area is not part of living area.

MAIN BUILDING	COSTS PER S.F. LIVING AREA
Cost per Square Foot of Living Area, from Page 30	$ 58.30
Basement Addition: % Finished, 100 % Unfinished	+ 3.35
Roof Cover Adjustment: Cedar Shake Type, Page 30 (Add or Deduct)	(+) 1.05
Central Air Conditioning: ☐ Separate Ducts ☑ Heating Ducts, Page 30	+ 1.30
Heating System Adjustment: Type, Page (Add or Deduct)	( ) —
Main Building: Adjusted Cost per S.F. of Living Area	$ 64.00

MAIN BUILDING TOTAL COST: $ 64.00 /S.F. (Cost per S.F. Living Area) x 2,576 S.F. (Living Area) x 1 (Town/Row House Multiplier (Use 1 for Detached)) = $ 164,864 TOTAL COST

~~WING~~ OR ELL (B) 1-1/2 STORY	COSTS PER S.F. LIVING AREA
Cost per Square Foot of Living Area, from Page 37 (Wood Siding)	$ 51.65
Basement Addition: 100 % Finished, % Unfinished	+ 14.45
Roof Cover Adjustment: Type, Page (Add or Deduct)	( ) —
Central Air Conditioning: ☐ Separate Ducts ☑ Heating Ducts, Page 29	+ 1.65
Heating System Adjustment: Type, Page (Add or Deduct)	( ) —
Wing or Ell (B) : Adjusted Cost per S.F. of Living Area	$ 67.75

WING OR ELL (B) TOTAL COST: $ 67.75 /S.F. (Cost per S.F. Living Area) x 670 S.F. (Living Area) x = $ 45,393 TOTAL COST

WING OR ELL (C) 1 STORY	COSTS PER S.F. LIVING AREA
Cost per Square Foot of Living Area, from Page 37 (Wood Siding)	$ 77.30
Basement Addition: % Finished, % Unfinished	+ —
Roof Cover Adjustment: Type, Page (Add or Deduct)	( ) —
Central Air Conditioning: ☐ Separate Ducts ☐ Heating Ducts, Page	+ —
Heating System Adjustment: Type, Page (Add or Deduct)	( ) —
Wing or Ell ( ): Adjusted Cost per S.F. of Living Area	$ 77.30

WING OR ~~ELL~~ (C) TOTAL COST: $ 77.30 /S.F. (Cost per S.F. Living Area) x 192 S.F. (Living Area) x = $ 14,842 TOTAL COST

TOTAL THIS PAGE: 225,099

Page 1 of 2

Means Forms

RESIDENTIAL
COST ESTIMATE

	QUANTITY	UNIT COST	
Total Page 1			$ 225,099
Additional Bathrooms: 2 Full 1 Half 2@3,528 1@2,173			9,229
Finished Attic: N/A Ft. x Ft.	S.F.		+
Breezeway: ☑ Open ☐ Enclosed 12 Ft. x 12 Ft.	144 S.F.	13.85	+ 1,994
Covered Porch: ☑ Open ☐ Enclosed 18 Ft. x 12 Ft.	216 S.F.	20.80	+ 4,493
Fireplace: ☑ Interior Chimney ☐ Exterior Chimney ☑ No. of Flues (2) ☑ Additional Fireplaces 1 - 2nd Story			+ 6,050
Appliances:			+ —
Kitchen Cabinets Adjustments: (±)			—
☑ Garage ☐ Carport: 2 Car(s) Description Wood, Attached (±)			9,831
Miscellaneous:			+

ADJUSTED TOTAL BUILDING COST $ 256,696

REPLACEMENT COST		
ADJUSTED TOTAL BUILDING COST	$	256,696
Site Improvements		
(A) Paving & Sidewalks	$	
(B) Landscaping	$	
(C) Fences	$	
(D) Swimming Pools	$	
(E) Miscellaneous	$	
TOTAL	$	256,696
Location Factor	x	1.07
Location Replacement Cost	$	274,665
Depreciation -10 %	- $	27,466
LOCAL DEPRECIATED COST	$	247,199

INSURANCE COST		
ADJUSTED TOTAL BUILDING COST	$	
Insurance Exclusions		
(A) Footings, Site work, Underground Piping	- $	
(B) Architects Fees	- $	
Total Building Cost Less Exclusion	$	
Location Factor	x	
LOCAL INSURABLE REPLACEMENT COST	$	

RESIDENTIAL | Average | 2 Story

- **Simple design from standard plans**
- **Single family — 1 full bath, 1 kitchen**
- **No basement**
- **Asphalt shingles on roof**
- **Hot air heat**
- **Drywall interior finishes**
- **Materials and workmanship are average**
- **Detail specifications on p. 27**

Note: The illustration shown may contain some optional components (for example: garages and/or fireplaces) whose costs are shown in the modifications, adjustments, & alternatives below or at the end of the square foot section.

Base cost per square foot of living area

Exterior Wall	Living Area 1000	1200	1400	1600	1800	2000	2200	2600	3000	3400	3800
Wood Siding - Wood Frame	82.40	74.15	70.95	68.80	65.95	63.55	61.95	58.30	54.80	53.45	51.90
Brick Veneer - Wood Frame	87.90	79.25	75.70	73.30	70.25	67.65	65.85	61.80	58.10	56.60	54.85
Stucco on Wood Frame	82.85	74.55	71.35	69.15	66.35	63.90	62.25	58.60	55.10	53.75	52.15
Solid Masonry	96.35	87.10	83.05	80.30	76.85	74.00	71.85	67.30	63.15	61.35	59.40
Finished Basement, **Add**	11.70	11.30	10.90	10.70	10.40	10.25	10.05	9.70	9.45	9.30	9.15
Unfinished Basement, **Add**	4.70	4.40	4.15	4.00	3.85	3.70	3.60	3.35	3.20	3.10	3.00

Modifications

Add to the total cost

Upgrade Kitchen Cabinets	$ + 1969
Solid Surface Countertops	+ 798
Full Bath - including plumbing, wall and floor finishes	+ 3528
Half Bath - including plumbing, wall and floor finishes	+ 2173
One Car Attached Garage	+ 6927
One Car Detached Garage	+ 7430
Fireplace & Chimney	+ 3590

Adjustments

For multi family - add to total cost

Additional Kitchen	$ + 3709
Additional Bath	+ 3528
Additional Entry & Exit	+ 969
Separate Heating	+ 1165
Separate Electric	+ 1184

For Townhouse/Rowhouse - Multiply cost per square foot by

Inner Unit	.90
End Unit	.95

Alternatives

Add to or deduct from the cost per square foot of living area

Cedar Shake Roof	$+ 1.05
Clay Tile Roof	+ 2.20
Slate Roof	+ 3.65
Upgrade Walls to Skim Coat Plaster	+ .29
Upgrade Ceilings to Textured Finish	+ .41
Air Conditioning (in heating ductwork)	+ 1.30

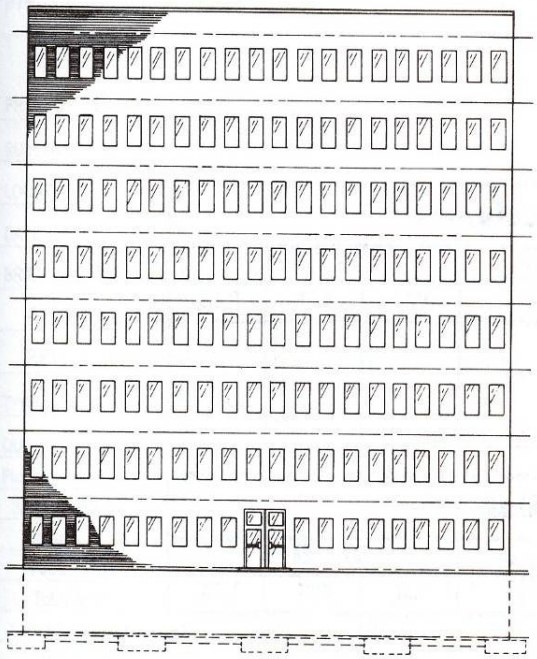
Additional upgrades or components

Using Published Data for Elemental Estimating

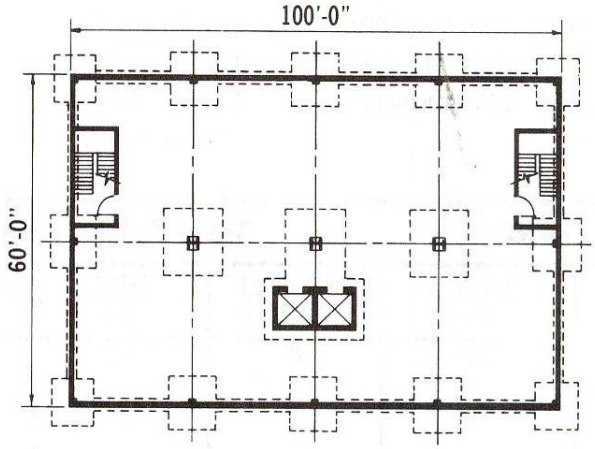
RS Means Assemblies Estimate

Example

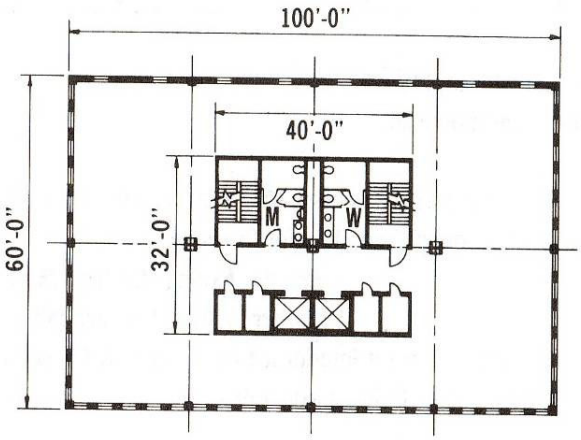
Front Elevation



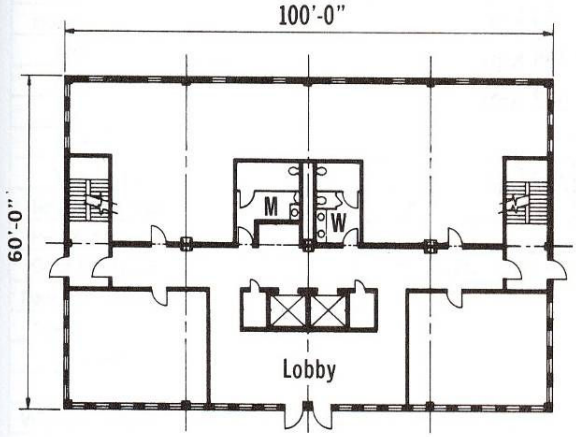
Basement Plan



Typical Floor Plan



Ground Floor Plan



Means Forms

PROJECT	Office Building	TOTAL AREA	54,000 S.F.
LOCATION		TOTAL VOLUME	648,000 C.F.
ARCHITECT		COST PER S.F.	
OWNER		COST PER C.F.	

ASSEMBLY NUMBER		QTY.	UNIT	TOTAL COST UNIT	TOTAL COST TOTAL	COST PER S.F.
1.0	**Foundations**					
1.1-120-7900	Corner Footings 8'-6" SQ. x 27"	4	Ea.	1170	4,680	
-8010	Exterior 9'-6" SQ. x 30"	8	↓	1560	12,480	
-8300	Interior ↓ 12" SQ.	3	↓	2825	8,475	
1.1-140-2700	Strip ↓ 2' Wide x 1' Thick					
	320 L.F. [(4 x 8.5) + (8 x 9.5)] =	210	L.F.	25.25	5,303	
1.1-210-7262	Foundation Wall 12' High, 1' Thick	↓	↓	142.50	29,925	
1.1-292-2800	Foundation Waterproofing	↓	↓	11.57	2,430	
1.9-100-3440	Building Excavation + Backfill	6000	S.F.	3.91	23,460	
-3500	(Interpolated ; 12' Between					
-4620	8' and 16' ; 6,000 Between					
-4680	4,000 and 10,000 S.F.)					
	Total				86,753	1.61

NO.	DESCRIPTION	SUBTOTAL COST	COST/S.F.	%
1.0	Foundation	86,753	1.61	
2.0	Substructure	18,300	.34	
3.0	Superstructure	723,764	13.40	
4.0	Exterior Closure	652,477	12.08	
5.0	Roofing	18,255	.34	
6.0	Interior Construction	535,862	9.92	
7.0	Conveying	249,360	4.62	
8.0	Mechanical System	794,812	14.72	
9.0	Electrical	543,575	10.07	
10.0	General Conditions			
11.0	Special Construction	8,280	.15	
12.0	Site Work			
	Building Subtotal	3,631,438		$ 3,631,438
Sales Tax	N/A % x Subtotal $	N/A /2		$
General Conditions (%)	5 % x Subtotal $	3,631,438 =	181,572	
			General Conditions	$ 181,572
			Subtotal "A"	$ 3,813,010
Overhead	7 % x Subtotal "A"	$ 3,813,010		$ 266,911
			Subtotal "B"	$ 4,079,921
Profit	3 % x Subtotal "B"	$ 4,079,921		$ 122,398
			Subtotal "C"	$ 4,202,319
Location Factor	N/A % x Subtotal "C"	$ N/A		
			Adjusted Building Cost	$ 4,202,319
Architect's Fee	6.5 % x Adjusted Building Cost	4,202,319 =		$ 273,151
Contingency	N/A % x Adjusted Building Cost	N/A =		$
			Total Cost	4,475,470
Square Foot Cost	$ 4,475,470 / 54,000 S.F.	82.88 $/S.F.		

If spread footing & column sizes are unknown, develop approximate loads as follows. Enter tables with these loads to determine costs.

Superimposed Load Ranges

Apartments & Residential Structures	65	to	75 psf
Assembly Areas & Retail Stores	110	to	125 psf
Commercial & Manufacturing	150	to	250 psf
Offices	75	to	100 psf

Approximate loads/S.F. for roof & floors.

Roof. Assume 40 psf superimposed load.

Steel joists, beams & deck.

Table 3.7-420—Line 3900

3.7-420	Steel Joists, Beams, & Deck on Columns							
	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	DEPTH (IN.)	TOTAL LOAD (P.S.F.)	COLUMN ADD	COST PER S.F.		
						MAT.	INST.	TOTAL
3500	25x30	20	22	40		2.61	.99	3.60
3600					columns	.52	.17	.69
3900		40	25	60		3.16	1.17	4.33
4000					columns	.62	.21	.83

3.5-540	Composite Beams, Deck & Slab							
	BAY SIZE (FT.)	SUPERIMPOSED LOAD (P.S.F.)	SLAB THICKNESS (IN.)	TOTAL DEPTH (FT. - IN.)	TOTAL LOAD (P.S.F.)	COST PER S.F.		
						MAT.	INST.	TOTAL
3400	25x30	40	5-1/2	1 - 11-1/2	83	5.80	3.65	9.45
3600		75	5-1/2	1 - 11-1/2	119	6.25	3.69	9.94
3900		125	5-1/2	1 - 11-1/2	170	7.20	4.16	11.36
4000		200	6-1/4	2 - 6-1/4	252	8.65	4.71	13.36

Floors—Total load, 119 psf.

Interior foundation load.

Roof

[(25′ × 30′ × 60 psf) + 8 floors × (25′ × 30′ × 119 psf)] × 1/1000 lb./Kip = 759 Kips

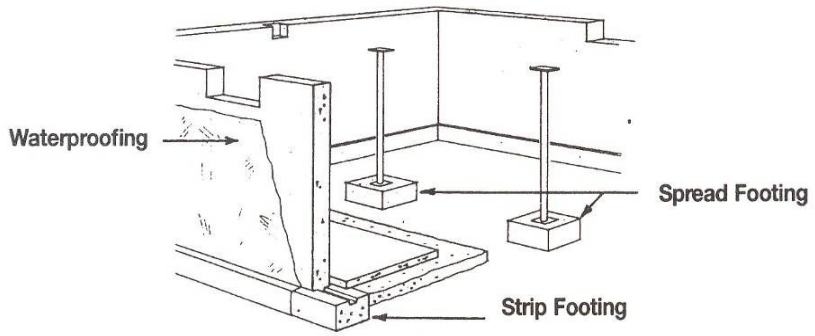
Approximate Footing Loads, Interior footing = 759 Kips

Exterior footing (1/2 bay) 759 k × .6 = 455 Kips

Corner footing (1/4 bay) 759 k × .45 = 342 Kips

[Factors to convert Interior load to Exterior & Corner loads]

Approximate average Column load 759 k/2 = 379 Kips

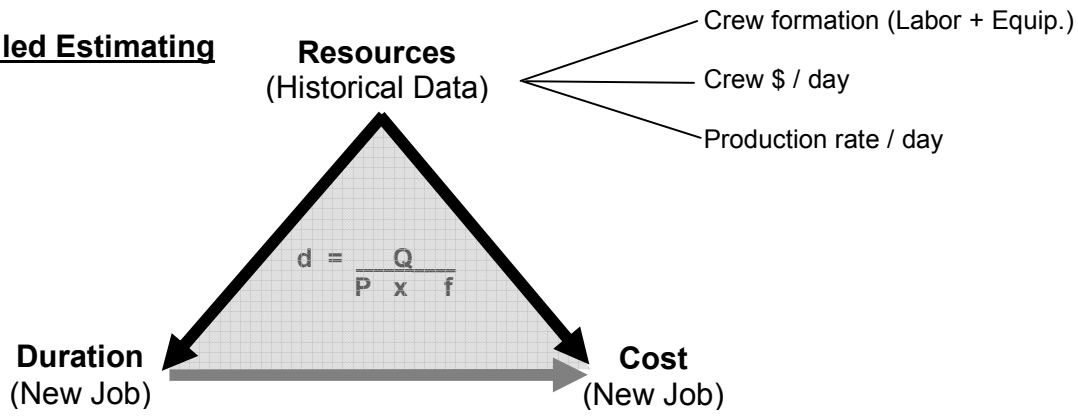


1.1-120	Spread Footings	COST EACH		
		MAT.	INST.	TOTAL
7090	Spread footings, 3000 psi concrete, chute delivered			
7100	Load 25K, soil capacity 3 KSF, 3'-0" sq. x 12" deep	42	73.50	115.50
7150	Load 50K, soil capacity 3 KSF, 4'-6" sq. x 12" deep	83.50	128	211.50
7200	Load 50K, soil capacity 6 KSF, 3'-0" sq. x 12" deep	42	73.50	115.50
7250	Load 75K, soil capacity 3 KSF, 5'-6" sq. x 13" deep	128	181	309
7300	Load 75K, soil capacity 6 KSF, 4'-0" sq. x 12" deep	69	109	178
7350	Load 100K, soil capacity 3 KSF, 6'-0" sq. x 14" deep	160	216	376
7410	Load 100K, soil capacity 6 KSF, 4'-6" sq. x 15" deep	102	150	252
7450	Load 125K, soil capacity 3 KSF, 7'-0" sq. x 17" deep	250	310	560
7500	Load 125K, soil capacity 6 KSF, 5'-0" sq. x 16" deep	130	180	310
7550	Load 150K, soil capacity 3 KSF 7'-6" sq. x 18" deep	299	365	664
7610	Load 150K, soil capacity 6 KSF, 5'-6" sq. x 18" deep	171	227	398
7650	Load 200K, soil capacity 3 KSF, 8'-6" sq. x 20" deep	420	485	905
7700	Load 200K, soil capacity 6 KSF, 6'-0" sq. x 20" deep	221	280	501
7750	Load 300K, soil capacity 3 KSF, 10'-6" sq. x 25" deep	755	785	1,540
7810	Load 300K, soil capacity 6 KSF, 7'-6" sq. x 25" deep	410	470	880
7850	Load 400K, soil capacity 3 KSF, 12'-6" sq. x 28" deep	1,175	1,150	2,325
7900	Load 400K, soil capacity 6 KSF, 8'-6" sq. x 27" deep	560	610	1,170
8010	Load 500K, soil capacity 6 KSF, 9'-6" sq. x 30" deep	760	800	1,560
8100	Load 600K, soil capacity 6 KSF, 10'-6" sq. x 33" deep	1,025	1,025	2,050
8200	Load 700K, soil capacity 6 KSF, 11'-6" sq. x 36" deep	1,300	1,275	2,575
8300	Load 800K, soil capacity 6 KSF, 12'-0" sq. x 37" deep	1,450	1,375	2,825
8400	Load 900K, soil capacity 6 KSF, 13'-0" sq. x 39" deep	1,775	1,650	3,425
8500	Load 1000K, soil capacity 6 KSF, 13'-6" sq. x 41" deep	2,000	1,850	3,850

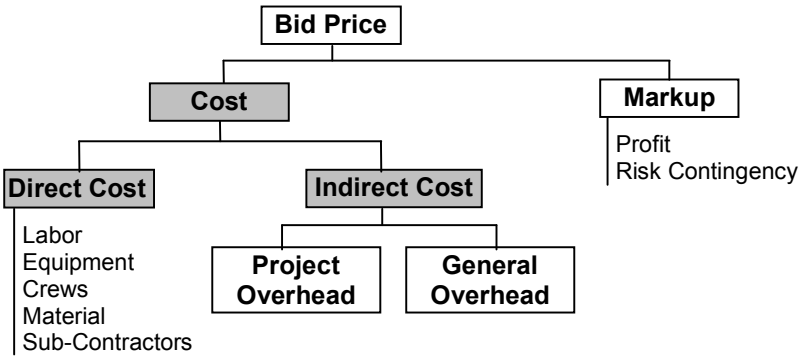
1.1-140	Strip Footings	COST PER L.F.		
		MAT.	INST.	TOTAL
2100	Strip footing, load 2.6KLF, soil capacity 3KSF, 16"wide x 8"deep plain	5.20	9	14.20
2300	Load 3.9 KLF, soil capacity, 3 KSF, 24"wide x 8"deep, plain	6.20	9.95	16.15
2500	Load 5.1KLF, soil capacity 3 KSF, 24"wide x 12"deep, reinf.	10.15	15.10	25.25
2700	Load 11.1KLF, soil capacity 6 KSF, 24"wide x 12"deep, reinf.	10.15	15.10	25.25
2900	Load 6.8 KLF, soil capacity 3 KSF, 32"wide x 12"deep, reinf.	12.05	16.50	28.55
3100	Load 14.8 KLF, soil capacity 6 KSF, 32"wide x 12"deep, reinf.	12.05	16.50	28.55
3300	Load 9.3 KLF, soil capacity 3 KSF, 40"wide x 12"deep, reinf.	13.85	17.90	31.75
3500	Load 18.4 KLF, soil capacity 6 KSF, 40"wide x 12"deep, reinf.	13.95	18.05	32
4500	Load 10KLF, soil capacity 3 KSF, 48"wide x 16"deep, reinf.	18.95	22	40.95
4700	Load 22KLF, soil capacity 6 KSF, 48"wide, 16"deep, reinf.	19.35	22.50	41.85
5700	Load 15KLF, soil capacity 3 KSF, 72"wide x 20"deep, reinf.	31.50	31.50	63
5900	Load 33KLF, soil capacity 6 KSF, 72"wide x 20"deep, reinf.	33.50	33.50	67

c) **Activity Detailed Estimating**

Basics



Bid Components



Determine your bid prices for the following project. Total indirect cost = $100,000; and markup = 10%.

Activity	Quantity	Unit	Direct Cost	Indirect Cost	Unit Price	Bid Price	Unbalanced Bid
Excavation	50,000	m3	$500,000				
Concrete Work	2,000	m3	$200,000				
Steel Work	---	LS	$300,000				
					Total Bid =		

Example 1:

Activity: **D**
Work Crew: **CR-06 (2L1 + 1E3)**
Crew daily production: **175 units/day**
Crew daily cost: **$1,800 / day**.
Needed material / day: **4.5 units of M1 ($100/unit)**.
Day: **8 hours**.

In a new bid, calculate the time and cost it takes the crew to finish **1,400 units**. Also, calculate the unit cost.

Duration = = 8 days

Crew Cost = = $14,400

Total Cost = $14,400 + = $18,000

Unit Cost = = $12.86 /unit

Example 2:

The resources used by a concreting subcontractor are:

Labor:

Code	Description	Rate/hr
L1	General Laborer	15
L4	Concrete Worker	25

Equipment:

Code	Description	Rent $/h	Oper. $/hr
E2	Crane & Bucket	40	10
E14	Pump & Tool	15	5

Crews:

Code	Description	Composition
C16	Concrete Crew	2L1 + 3L4 + 1E2 + 2E14

Materials:

Code	Description	Unit	Cost/Unit
M12	Ready-mixed concrete	Cu ft	17

Methods of Construction:

Code	Description	Unit	Resources	Production/d	Notes
Md4	Concreting by Pump - 8 hrs/day	Cuft	1 **C16** + **M12**	100	Normal Hours
Md6	Concreting by Pump - 14 hrs/day	Cuft	1 **C16** + **M12**	**?**	6 overtime hours/d

Normal **day is 8 hours**. Labor **overtime rate = 1.5 x normal rate**. During an overtime hour, the **crew production = 90% of regular production**.

The subcontractor is currently preparing an estimate for a **new concreting job** in which he has to **pour 500 cubic feet (Cuft)** of concrete.

a) Estimating Direct Cost and Duration:

Method Md4: **Normal Work:** During the **8 hours** work, crew produces **100 Cuft/day**.

Duration (days) = = **5 days**

Total Cost ($) = Duration (days) x Cost per day

= 5 days × (daily cost of crew C16 + cost of 100 M12 material)

= 5 days ×

2L1 x $15 x 8 = $240
3L4 x $25 x 8 = $600
1E2 x ($40+$10) x 8 = $400
2E14 x ($15+$5) x 8 = $320 + 100 x $17

= 5 x ($1560 + $1,700) = **$16,300**

Method Md6: **Overtime Work:** **14-hour day** (6 overtime hours).

Production per day = = 167.5 Cuft/day

Then, Duration (days) = = **3 days**

Total Cost ($) = Duration (days) x Cost per day

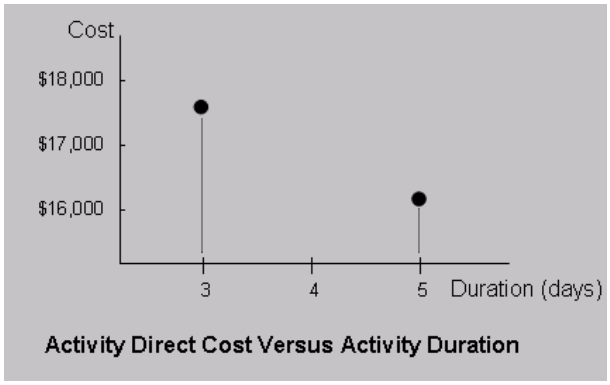
= 3 days × (daily cost of crew C16 + cost of 167.5 M12 material)

= 3 days ×

2L1 x $15 (8 + 1.5 x 6)= $510
3L4 x $25 (8 + 1.5 x 6)= $1275
1E2 x ($40+$10) x 14 = $700
2E14 x ($15+$5) x 14 = $560 + 167.5 x $17

= 3 x ($3,045 + $2,847.5) = **$17,677.5**

b) Cost and Time Relationship:



Activity Direct Cost Versus Activity Duration

General Estimating Equation:

$$\text{Duration} = \frac{\text{Quantity}}{\text{Production rate} \times f}$$

f = Productivity factor (0 – 1.0), **depends on**:

- Local weather conditions;
- Learning curve;
- Labor Unrest;
- Crew absenteeism;
- Economic activity (recession vs. boom);
- Space congestion;
- Regulatory rules and cultural habits;
- Design changes and rework;
- Overtime; and
- Uncertainty (owner attitude, project location, etc).

Using published cost data for detailed estimating - R.S. Means:

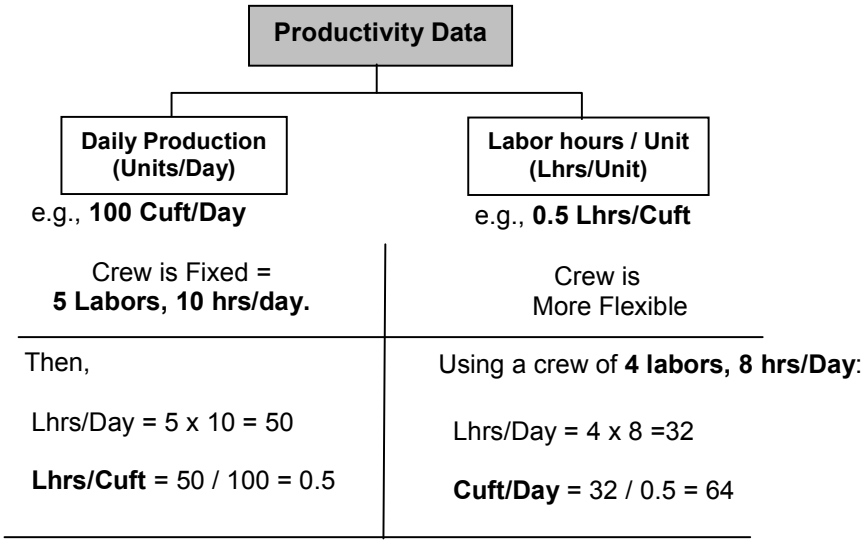
022 | Earthwork

022 200 | Excav./Backfill/Compact.

			CREW	DAILY OUTPUT	LABOR HOURS	UNIT	1998 BARE COSTS MAT.	LABOR	EQUIP.	TOTAL	TOTAL INCL O&P	
242	3040	Clay	B-10W	294	.041	m3		1.03	1.41	2.44	3.13	242
	3200	45 m haul, sand & gravel		237	.051			1.28	1.75	3.03	3.88	
	3220	Common earth		206	0.058			1.47	2.01	3.48	4.47	
	3240	Clay		130	0.092			2.33	3.18	5.51	7.10	
	3300	90 m haul, sand & gravel		107	.112			2.83	3.87	6.70	8.6	
	3320	Common earth		91.75	.131			303.	4.51	7.81	10	
	3340	Clay		76.46	.157			3.96	5.40	9..36	12.05	
	4000	149 KW, 15 m haul, sand & gravel	B-10B	1,070	.011			.28	.78	1.06	1.29	
	4020	Common earth		940	.013			.32	.89	1.21	1.46	
	4040	Clay		589	.020			.51	1.41	1.92	2.34	
246	0010	**EXCAVATION, BULK, SCRAPERS** R022 -240										246
	0100	Elevating scraper 8.4 m3, sand & gravel 450 m haul	B-33F	528	.027	m3		.68	1.79	2.47	3.01	
	0150	900 m haul		466	.030			.77	2.03	2.80	3.42	
	0200	1500 m haul		386	.036			.93	2.46	3.39	4.12	
	0300	Common earth		459	.031			.78	2.06	2.84	3.47	
	0350	900 m haul		405	.035			.88	2.34	3.22	3.93	
	0400	1500 m haul		336	.042			1.07	2.82	3.89	4.73	
	0500	Clay, 450 m haul		287	.049			1.25	3.30	4.55	5.55	
	0550	900 m haul		252	.056			1.42	3.76	5.18	6.30	
	0600	1500 m haul		210	.067			1.71	4.51	6.22	7.55	
	1000	Self propelled scraper, 10.7 m3 ¼ push dozer, sand										
	1050	And gravel, 450 m haul	B-33D	703	.020	m3		.51	2.64	3.15	3.68	

Important: See the Reference Section for critical supporting data – Reference Nos., Crews & City Cost Indexes

Code for Material & Supporting Info. **Crew Code** **Crew Production Rate/day** **Labor hrs/ Unit** **Detailed Unit Costs**



Using published cost data for detailed estimating

095 Acoustical Treatment & Wood Flooring

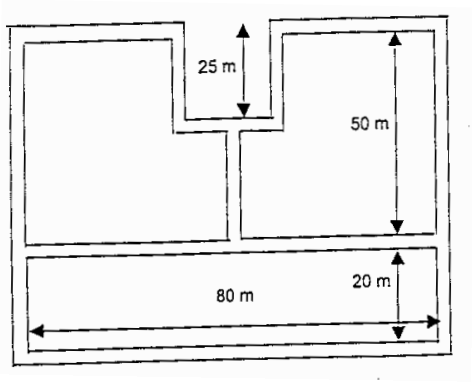
	095 800 | Wood Comp. Flooring		CREW	DAILY OUTPUT	LABOR HOURS	UNIT	BARE COSTS MAT.	BARE COSTS LABOR	BARE COSTS EQUIP.	BARE COSTS TOTAL	TOTAL INCL O&P
801		**WOOD COMPOSITION**									
	0100	Gym floors 57 mm x 175 mm x 10 mm, on 51 mm grout setting bed	D-7	13.94	1.148	m2	48.5	27	-----	75.5	93.50

The details of the crew D-7 are:

Crew no.	Bare costs		Incl. Subs O&P		Cost per labor-hour	
Crew D-7	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Tile Layer	$26.10	$208.80	$38.60	$308.80	$23.55	$34.83
1 Tile Layer Helper	$21.00	168.00	31.05	248.40		
16 L.H., Daily Totals		$376.80		$557.20	$23.55	$34.83

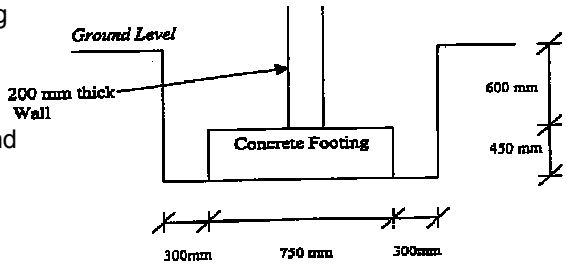
Example on Detailed Estimating

A foundations subcontractor has been asked to place foundation on a flat site (shown) for a building according to the provided cross-section. The tasks are: excavating trench, placing forms on the trench sides, and then concreting the foundation. The foundation wall is not included in the scope of work.



The subcontractor intends to do the work as follows:

- The Excavation crew works 8 hours per day and uses a 0.29m3 tractor/backhoe;
- The Formwork crew works 8 hours per day, while the Concreting crew works 9 hours;
- The Formwork material can be used for two uses;
- Concrete production is 4.5 m3 per hour;
- The Concrete supplier's quote is $20,000 (includes material); and
- RS Means data for the related activities are as follows:



022 200 | Excav./Backfill/Compact.		CREW	DAILY OUTPUT	MAN-HOURS	UNIT	BARE COSTS MAT.	BARE COSTS LABOR	BARE COSTS EQUIP.	BARE COSTS TOTAL	TOTAL INCL O&P
0010	EXCAVATING, TRENCH or continuous footing, common earth									
0020	No sheeting or dewatering included									
0050	0.3 m to 1.2 m deep, 0.29 m³ tractor loader/backhoe	B-11C	115	.139	m³		3.02	1.74	4.76	6.60
0060	0.38 m³ tractor loader/backhoe	B-11M	153	.105			2.27	1.79	4.06	5.50
0090	1.2 m to 2 m deep, 0.38 m³ tractor loader/backhoe	"	153	.105			2.27	1.79	4.06	5.50
0100	0.48 m³ hydraulic backhoe	B-12Q	191	.084			1.93	1.98	3.91	5.15
031 | Concrete Formwork										
0010	FORMS IN PLACE, FOOTINGS Continuous wall, 1 use R031-050	C-1	34.84	.919	m²CA	12.80	21	.79	34.59	48
0050	2 use		40.88	.783		7	17.70	.67	25.37	36.50
0100	3 use		43.66	.733		5.15	16.55	.63	22.33	32.50
0150	4 use		45.06	.710		4.09	16.05	.61	20.75	30.50
0500	Dowel supports for footings or beams, 1 use		152	.211	m	1.74	4.76	.18	6.68	9.65
1000	Integral starter wall, to 100 mm high, 1 use		122	.262		3.38	5.95	.23	9.56	13.35

Requirements:
Manually confirm the calculations in the following table.

Activity	Quantity	Duration	Bare Cost
Trench Excavation	650 m3	6	$3,094
Footing formwork	411 m2CA	10	$10,427
Concrete	154 m3	4	$20,000

Cost Estimation Software Systems.

Computer Software	Description
Win Est.	Building construction estimator assigns WBS tags to each item.
Success	Cost estimation, cost management with a link to scheduling software.
Design 4/Cost	Preliminary estimate based on square foot system.
Micro fusion for windows	An advanced integrated planning, estimating, proposal preparation and performance management system.
Timberline	A cost estimating software with modules for CAD and scheduling
G2 Estimator	Cost estimation based on previous experience
Best estimate	Cost estimation software.

Many other systems

Another Example on Detailed Estimating Using EasyPlan

A General Contractor has the following resources stored in the company's resource list.

Labor:

Code	Basic $/hr
L1	25
L2	25
L3	25
L4	25
L5	25

Equipment:

Code	Basic $/hr
E1	50
E2	50
E3	50
E4	50
E5	50

Crews:

Code	Composition
CR1	L1+L2
CR2	L3+E1
CR3	L4+2L2+E2
CR4	L4+3L2+E3
CR5	L5+2L2
CR6	L3+E4+L2
CR7	L4+E4+L2
CR8	E5+3L2
CR9	L4+2L2+E2
CR11	E4+2L3
CR12	4L2+E3

Subs:

Code
As Needed

New Bid:

The contractor is preparing a bid for the installation of a mobile house. Activities and estimates are:

No.	Activity	Depend on	Estimate 1	Estimate 2	Estimate 3
1	**Site Layout**	-----	CR1, 8 hrs Q= 1, Prod.= 0.5 *	CR1, 12 hrs Q= 1, Prod.= 0.5	Subcontractor S1 1 day, $1,200
2	**Excavation**	1	CR2, 8 hrs Q= 600, Prod.= 100	CR2, 12 hrs Q= 600, Prod.= 100	Subcontractor S2 3 days, $5,350
3	**Forms**	2	CR3, 8 hrs Q= 300, Prod.= 100	CR3, 12 hrs Q= 300, Prod.= 100	Subcontractor S3 1 day, $4,500
4	**Concrete**	3	CR1, 8 hrs Q= 300, Prod.= 150	CR1, 12 hrs Q= 300, Prod.= 150	Subcontractor S4 1 day, $3,500
5	**Rough Plumbing**	1	CR5, 8 hrs Q=3000, Prod.= 1000	CR5, 12 hrs Q=3000, Prod.= 1000	Subcontractor S5 2 days, $3,000
6	**Place Blocks**	5	CR6, 8 hrs Q= 200, Prod.= 50	CR6, 12 hrs Q= 200, Prod.= 50	Subcontractor S6 2 days, $5,000
7	**Rough Elec.**	5	CR7, 8 hrs Q= 300, Prod.= 75	CR7, 12 hrs Q= 300, Prod.= 75	Subcontractor S7 2 days, $5,200
8	**Place Home**	6	CR8, 8 hrs Q= 1, Prod.= 0.5	CR8, 12 hrs Q= 1, Prod.= 0.5	Subcontractor S8 1 day, $2,800
9	**Remove forms**	4	CR9, 8 hrs Q= 300, Prod.= 75	CR9, 12 hrs Q= 300, Prod.= 75	Subcontractor S9 2 days, $6,909
10	**Cure Concrete**	4	Subcontractor S10: 7 days and $1400		
11	**Hookup finish**	7, 8	CR11, 8 hrs Q= 30, Prod.= 10	CR11, 12 hrs Q= 30, Prod.= 10	
12	**Cleanup**	9, 10, 11	CR12, 8 hrs Q= 1, Prod.= 0.25	CR12, 12 hrs Q= 1, Prod.= 0.25	Subcontractor S12 2 days, $7,000

Notes: * Q = Quantity of work; Prod. = Regular production rate in an 8-hr day.
- Seasonal productivity factors for all activities are: Winter (0.7), Spring (1.0), & Fall (0.85).

Project Constraints:

Start date = June 1, 04; Markup = 5%;
Resource Limit is 4 L2; Retainage = 10%;
Reporting period = every 7 days;
Interest / period = 1%; Mobilization = 0%;
Indirect costs = $300/day; Suppliers' credit = 20%;
Penalty =$10,000/day; Incentive =$2,000/day; &

Deadline = 90% of project duration when all activities use their first estimate (rounded up).

Requirements:

In EasyPlan, use the "**Auto-Estimate**" option in the activities sheet to estimate activities' costs. Determine an optimum plan that meets the contractor's constraints. Check your solution (**Pr8**).

Compare project cost and time for three project start-date possibilities: Feb. 1, 2004, June 1, 2004, or Oct. 1, 2004. Comment on the results.