

Scheduling

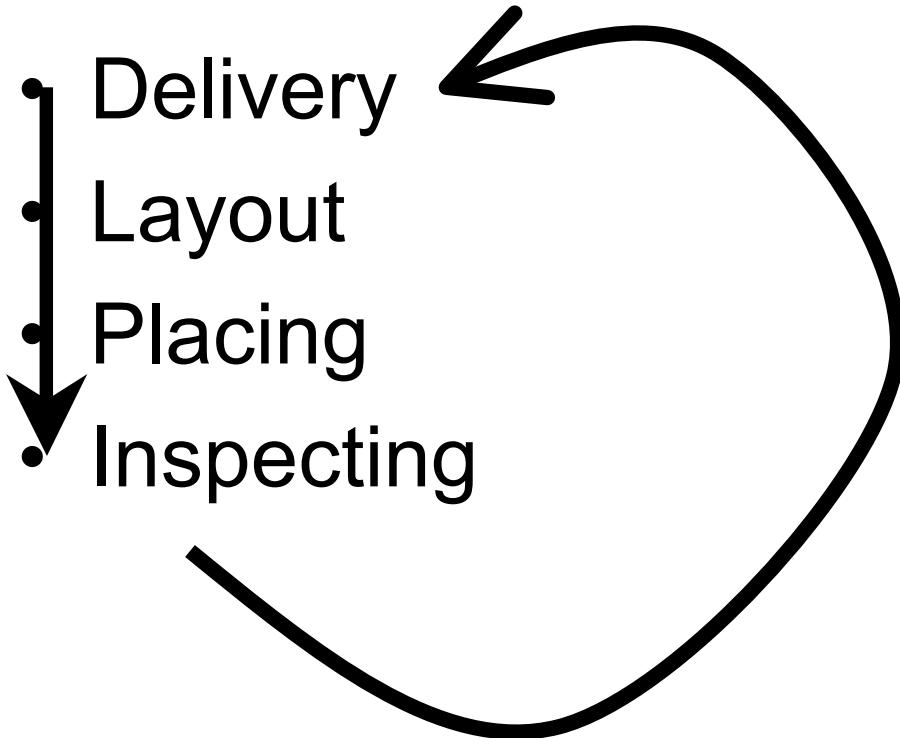
Designing Construction

Everybody schedules

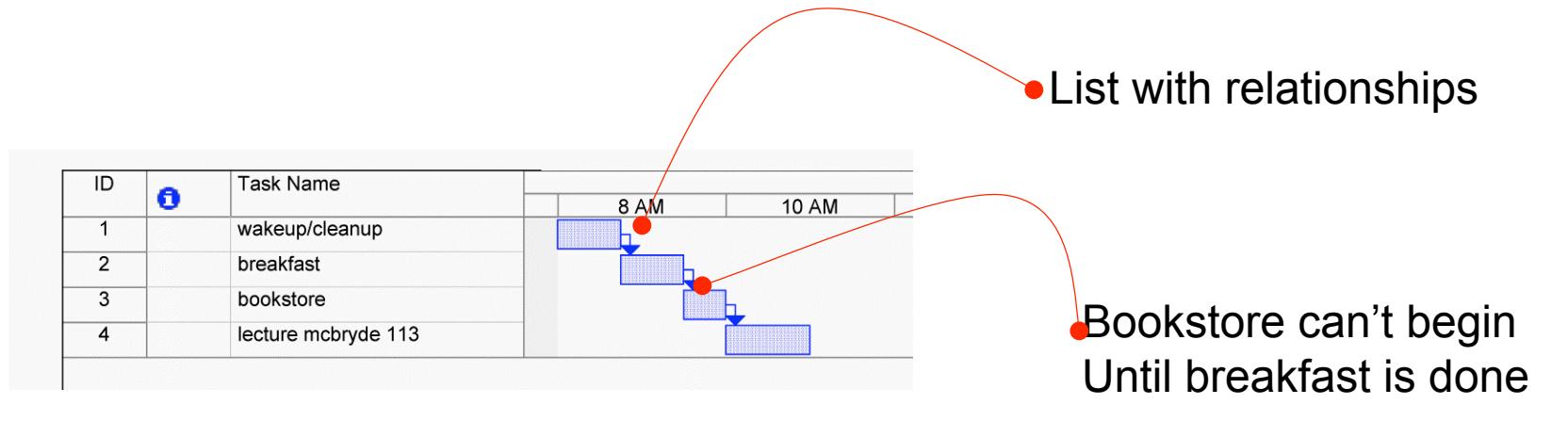
- “To Do” list
- BC1224
 - 7:00 wakeup/cleanup
 - 7:45 breakfast
 - 8:30 bookstore-buy text
 - 9:00 Mcbryde 113 lecture

A way of thinking through construction

- Approvals
- Mobilization
- Delivery
- Layout
- Placing
- Inspecting



Bar (Gantt) chart



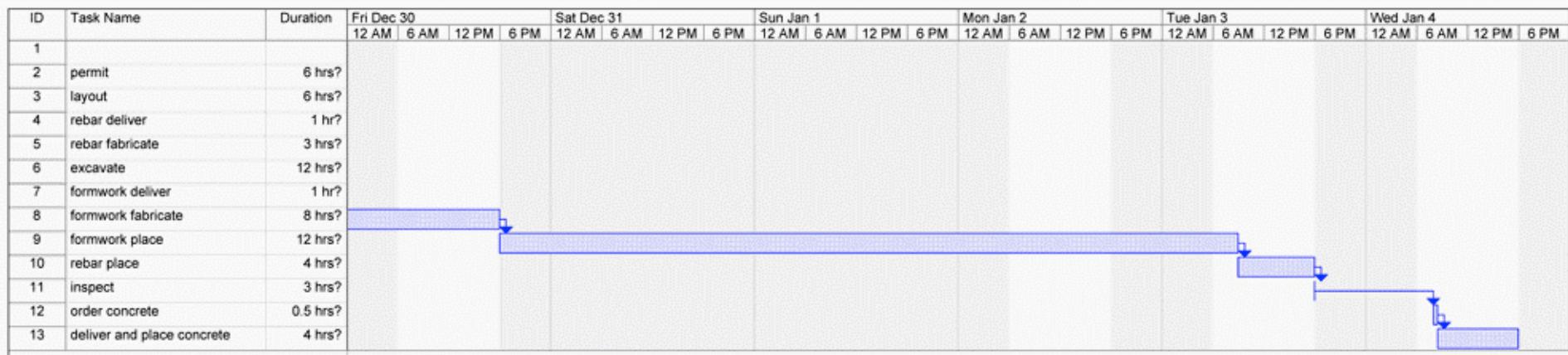
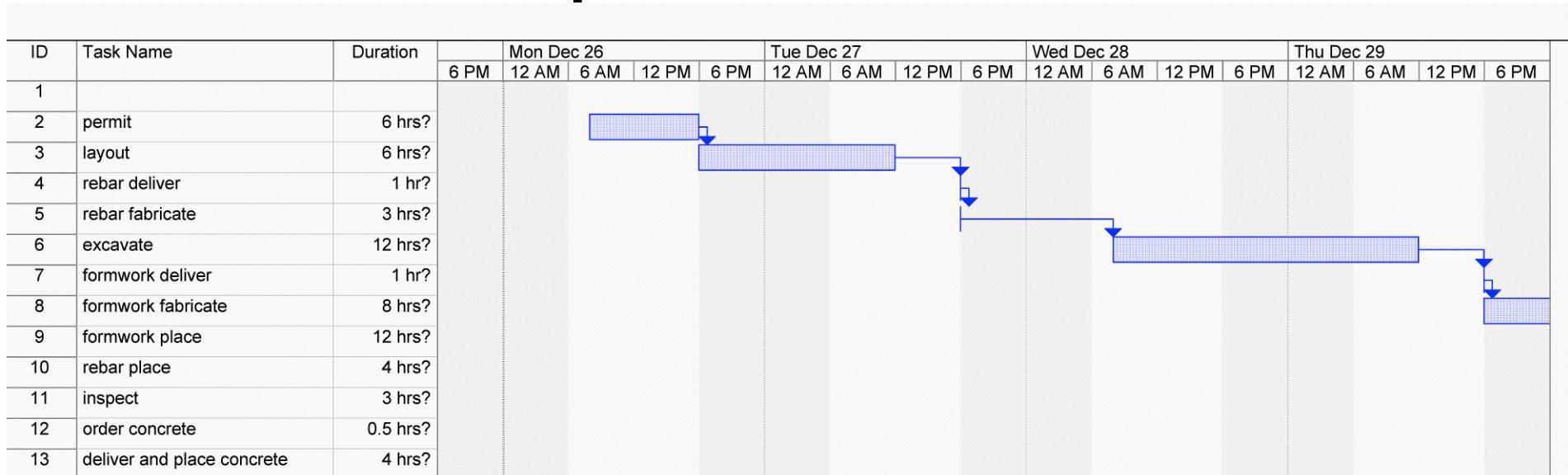
List with relationships

Bookstore can't begin
Until breakfast is done

A ‘finish to start’ relationship

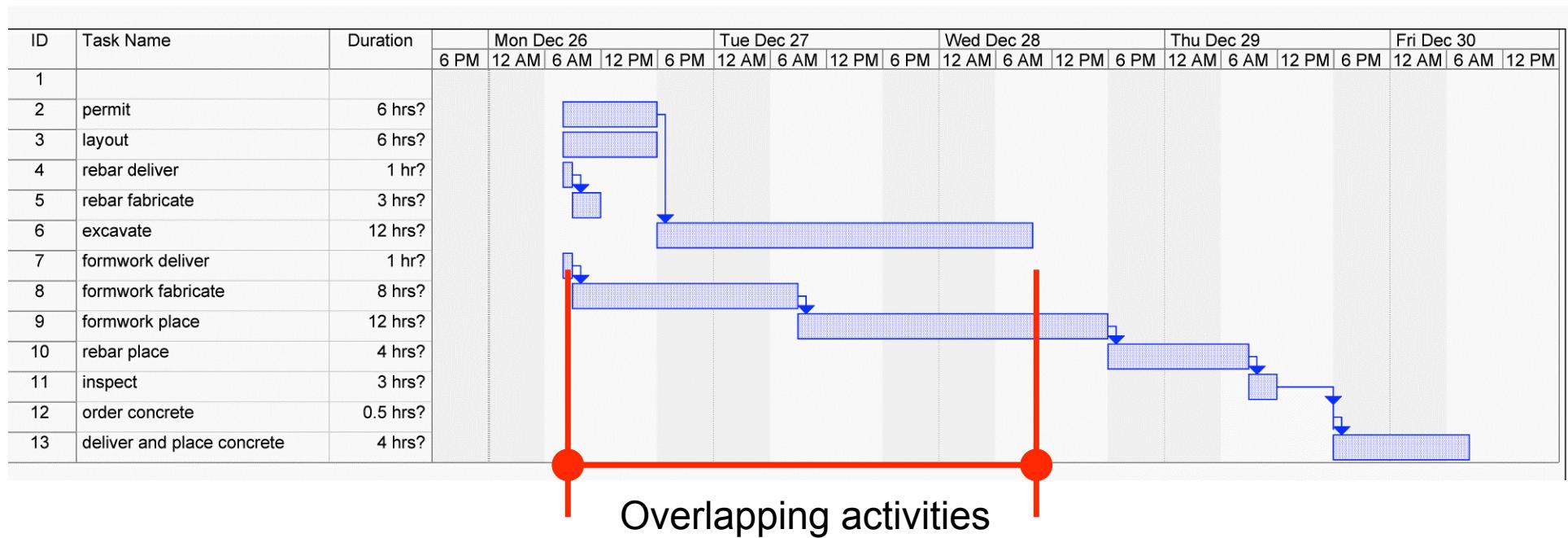
Finish one thing before starting another....in a perfect world

In a perfect world...



...There is enough time to finish one thing before starting another

Our world...why you get the big money



3 days faster

Thinking through...the key to managed overlap

- Knowledge of systems and processes
 - Sizes, weights of materials
 - Sizes, weights of equipment/tools/staging
 - Necessity for heavy lift or high lift equip
 - Power, water needs
 - By-products of processes
 - Dust
 - Water
 - Noise
 - Waste
 - Safety risks – chemical/particle/fall/drop/power

Sub-perform & Self-perform

- Sub perform: subcontractors are hired (bid or negotiated) to conduct some or all of the work for the contracting party
- Self perform: the contracting party has their own labor, equipment to perform the work of the contract.

Bidding and Scheduling

- Most bids don't
 - Describe durations
 - Describe crew size or daily production rates
 - Describe what shared infrastructure is needed
 - Assume they have to compete for workspace, material storage space, electricity, water
 - When a sub loses productivity – the job loses

So how do I schedule before I have subcontractors?

- Many negotiated and some bid projects require some type of rough scheduling to have confidence the work can be done in the time contracted.
- A rough schedule, based on past performance records or production rates listed in estimating guides can help.

How do they get these numbers

1000	Double tees, floor members		C-11	20	3.600	Ea.	2,125	134	72.50	2,331.50
1100	Lightweight, 20" x 8' wide, 45' span			18	4		2,300	149	80.50	2,529.50
1150	24" x 8' wide, 50' span			16	4.500		3,875	168	90.50	4,133.50
1200	32" x 10' wide, 60' span									
1250	Standard weight, 12" x 8' wide, 20' span			22	3.273		790	122	65.50	977.50
1300	16" x 8' wide, 25' span			20	3.600		1,050	134	72.50	1,256.50
1350	18" x 8' wide, 30' span	CN		20	3.600		1,350	134	72.50	1,556.50
1400	20" x 8' wide, 45' span			18	4		1,500	149	80.50	1,729.50
1450	24" x 8' wide, 50' span			16	4.500		1,950	168	90.50	2,208.50
1500	32" x 10' wide, 60' span			14	5.143		3,575	191	103	3,869
2000	Roof members									
2050	Lightweight, 20" x 8' wide, 40' span		C-11	20	3.600	Ea.	1,775	134	72.50	1,981.50
2100	24" x 8' wide, 50' span			18	4		2,375	149	80.50	2,604.50
2150	32" x 10' wide, 60' span			16	4.500		3,925	168	90.50	4,183.50
2200	Standard weight, 12" x 8' wide, 30' span			22	3.273		1,200	122	65.50	1,387.50
2250	16" x 8' wide, 30' span			20	3.600		1,250	134	72.50	1,456.50
2300	18" x 8' wide, 30' span			20	3.600		1,400	134	72.50	1,606.50
2350	20" x 8' wide, 40' span			18	4		1,425	149	80.50	1,654.50
2400	24" x 8' wide, 50' span			16	4.500		1,900	168	90.50	2,158.50
2450	32" x 10' wide, 60' span			14	5.143		3,325	191	103	3,619
03450 Plant-Precast Architectural Concrete										
850	0011	WALL PANELS	R03450 -010							
0050		Uninsulated 4" thick, smooth gray								
0150		Low rise, 4' x 8' x 4" thick		C-11	320	.225	S.F.	10.45	8.40	4.52
0200		8' x 8' x 4" thick			576	.125		10.35	4.65	2.51
0250		8' x 16' x 4" thick			1,024	.070		10.25	2.62	1.41
0400		8' x 8', 4" thick, smooth gray			576	.125		10.35	4.65	2.51
0500		Exposed aggregate			576	.125		13.20	4.65	2.51
0600		High rise, 4' x 8' x 4" thick			288	.250		10.45	9.30	5

- 16 tees /day
- 4.5 hours per tee
- ???

Productivity

- 9 crew (union shop)

Crew C-11	Hr.	Daily	Hr.	Daily	Bare Costs	Incl. O&P
1 Struc. Steel Foreman	\$40.15	\$321.20	\$71.85	\$574.80	\$37.23	\$64.53
6 Struc. Steel Workers	38.15	1831.20	68.25	3276.00		
1 Equip. Oper. (crane)	35.90	287.20	54.10	432.80		
1 Equip. Oper. Oiler	30.10	240.80	45.35	362.80		
1 Truck Crane, 150 Ton		1445.00		1589.50	20.07	22.08
72 L.H., Daily Totals		\$4125.40		\$6235.90	\$57.30	\$86.61

4.5 hours is total labor hours for 1 tee

- 16 tees /day
- 4.5 hours per tee
- 9 crew
- 4.5 hours is 270 minutes
- 270/9 is 30 minutes per tee...everybody gets paid whether they are busy the full 30 minutes or not.
- 8 hour day, 2 tees/hour = 16 tees per day

List work sequences

- How much detail?
- Context driven: rough estimate of time for use by a general contracting bidder might just schedule the major work elements broken down into building parts, like the estimate is structured.

Assumed

Estimating structure

- Mobilization
- Layout
- Foundation excavation
- Rough grade
- Foundation – form reinforce pour strip
- First floor walls
- Roof structure
- Roof enclosure
- Windows and Doors
- Mechanical, Electrical Systems
- Partitions and finishes
- Final grade parking landscape
- Closeout

Rough time estimate

- Durations from previous projects with similar size, complexity, site.

Task Name	Duration	Start	Apr 4, '06					Apr 11, '06					Apr 18, '06						
			T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T
Mobilization	24 hrs?	Wed 4/5/06																	
Layout	8 hrs?	Wed 4/5/06																	
Foundation excavation	28 hrs?	Wed 4/5/06																	
Rough grade	48 hrs?	Wed 4/5/06																	
Foundation – form reinforce poi	80 hrs?	Wed 4/5/06																	
First floor walls	45 hrs?	Wed 4/5/06																	
Roof structure	18 hrs?	Wed 4/5/06																	
Roof enclosure	12 hrs?	Wed 4/5/06																	
Windows and Doors	18 hrs?	Wed 4/5/06																	
Mechanical, Electrical Systems	88 hrs?	Wed 4/5/06																	
Partitions and finishes	58 hrs?	Wed 4/5/06																	
Final grade parking landscape	88 hrs?	Wed 4/5/06																	
Closeout	38 hrs?	Wed 4/5/06																	

- Tasks not sequenced yet

Sequencing

- Which activities must wait for another activity to conclude? (finish to start) **FS**
- Which activities can be concurrent? (start to start) **SS**
- Which activities must finish at the same time? (finish to finish) **FF**
- Which activities must begin before the activity can complete? (start to finish) **SF**

Can we complete this in 90 days?

Task Name	Duration	Apr 4, '06							Apr 11, '06							Apr 18, '06							Apr 25, '06							May 2, '	
		T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W
Mobilization	24 hrs?																														
Layout	8 hrs?																														
Foundation excavation	28 hrs?																														
Rough grade	48 hrs?																														
Foundation – form reinforce poi	80 hrs?																														
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Roof structure	18 hrs?																														
Roof enclosure	12 hrs?																														
Windows and Doors	18 hrs?																														
Partitions and finishes	58 hrs?																														
Mechanical, Electrical Systems	88 hrs?																														
Final grade parking landscape	88 hrs?																														
Closeout	38 hrs?																														

Low Cost or Low Time?

- If the bid form disclosed a bonus for early completion, we could calculate the advantage of paying two crews to produce the concrete work in less time.
- Conversely, if the bid form revealed we could be penalized for each day past the completion time, we could evaluate if we'd have a net savings by reducing crew size and paying the penalty. (usually liquidating damages clauses are calculated to be significant disincentives)

Time Is Money
Based on a 9% Annual Interest Rate

Amount	Work Minute	Work Hour	Work Day	Week	Month	Year
\$50,000,000	\$36.06	\$2,163.46	\$17,308	\$86,538	\$375,000	\$4,500,000
30,000,000	21.63	1,298.08	10,385	51,923	225,000	2,700,000
20,000,000	14.42	865.38	6,923	34,615	150,000	1,800,000
10,000,000	7.21	432.69	3,462	17,308	75,000	900,000
6,000,000	4.33	259.62	2,077	10,385	45,000	540,000
5,000,000	3.61	216.35	1,731	8,654	37,500	450,000
4,000,000	2.88	173.08	1,385	6,923	30,000	360,000
2,000,000	1.44	86.54	692	3,462	15,000	180,000
1,000,000	0.72	43.27	346	1,731	7,500	90,000
800,000	0.58	34.62	277	1,385	6,000	72,000
600,000	0.43	25.96	208	1,038	4,500	54,000
500,000	0.36	21.63	173	865	3,750	45,000
300,000	0.22	12.98	104	519	2,250	27,000
150,000	0.11	6.49	52	260	1,125	13,500
100,000	0.07	4.33	35	173	750	9,000
75,000	0.05	3.25	26	130	563	6,750

Changing roles

- The rough estimate gave us confidence that the project could be completed either on time or just ahead of time. Let's say we won that bid, now it's time to build.
- The schedule now becomes a management tool.

PERT

- A key development in project management came in the mid 1950's with the Navy's development of the Project Evaluation and Review Technique (PERT)
- This technique developed a network flowchart using 3 time estimates, an optimistic time, most likely time and pessimistic time durations.

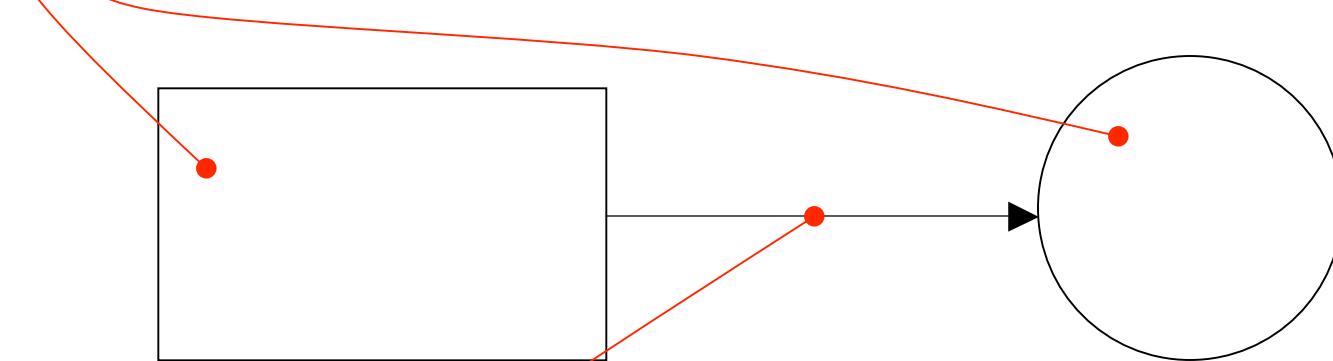
CPM Critical Path Method

- About the same time, Dupont and Remington Rand Corporations were jointly developing a method to manage plant overhaul, maintenance and construction projects.
- It developed a flowchart of activities, a logic diagram showing the logical order of activities, each with a single duration. If one fell behind, the others would automatically update to indicate new start dates.

Before and after

- In CPM diagrams, there are two graphic elements:

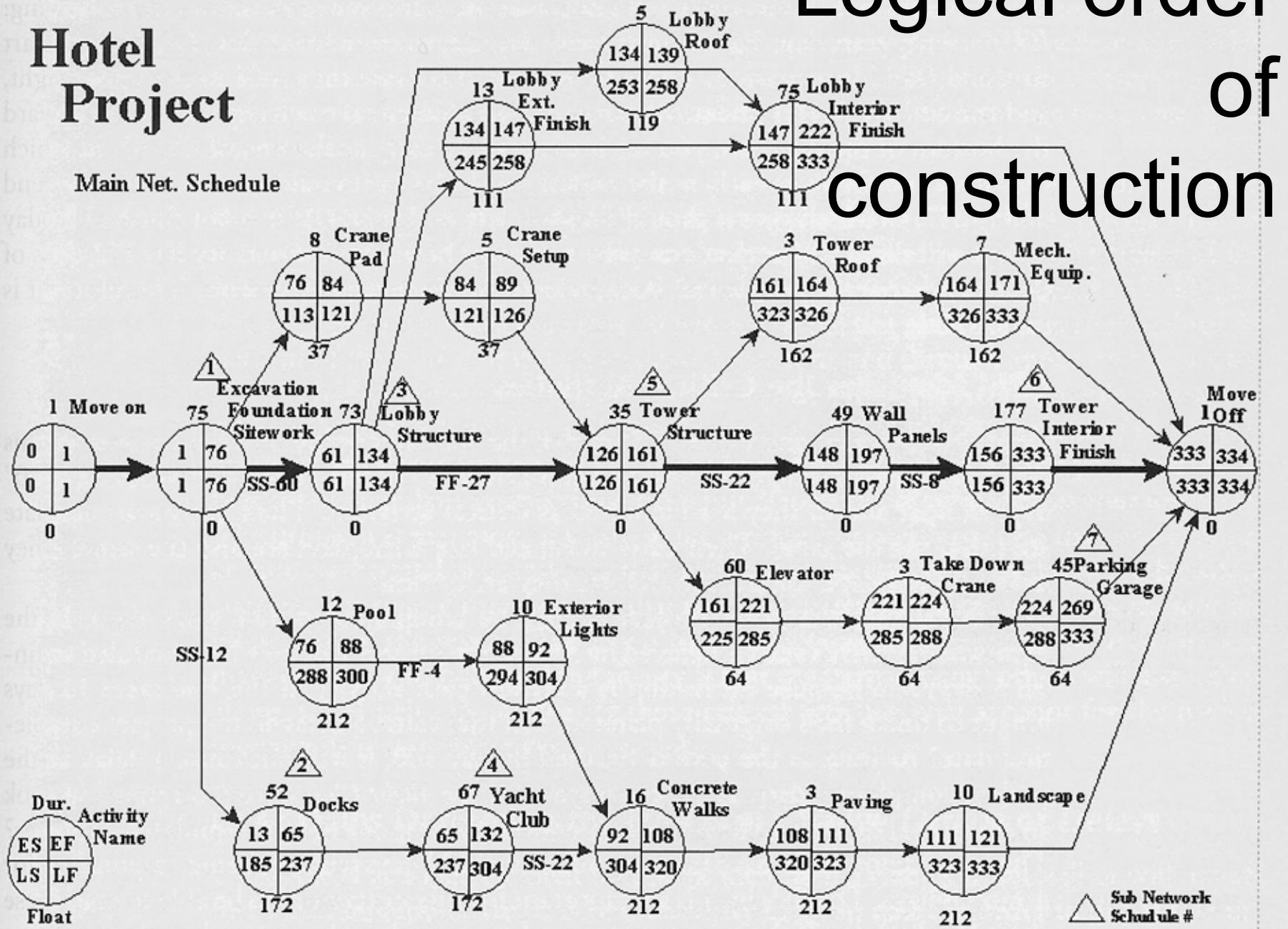
• The “node” which could be rectangular, circular or a parallelogram



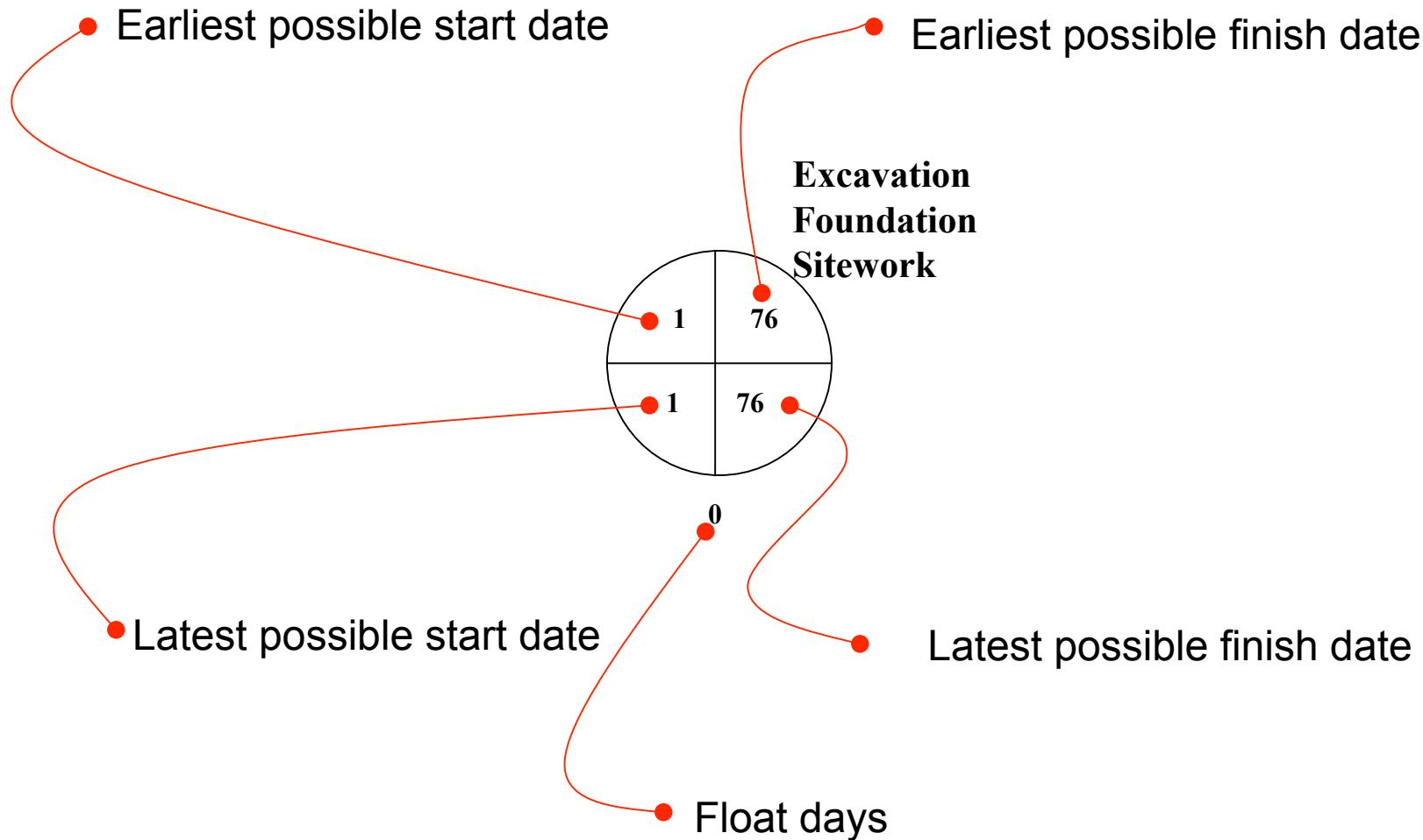
• And the arrow. Most scheduling programs today assume the activity happens in the node, not in the arrow. This is also referred to as AON and is the common nomenclature for logic models constructed using the Precedence Diagram Method (PDM)

Hotel Project

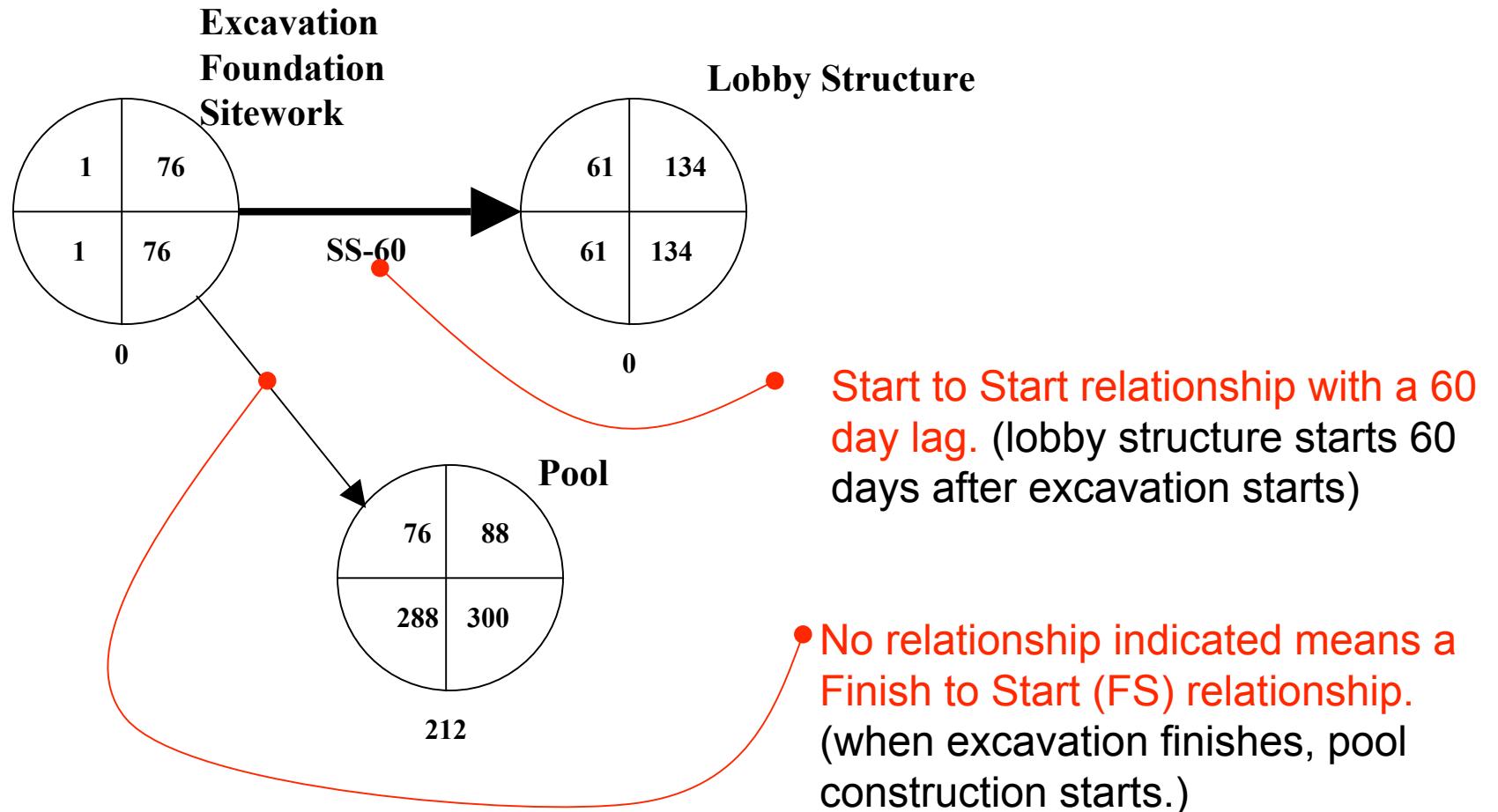
Main Net. Schedule



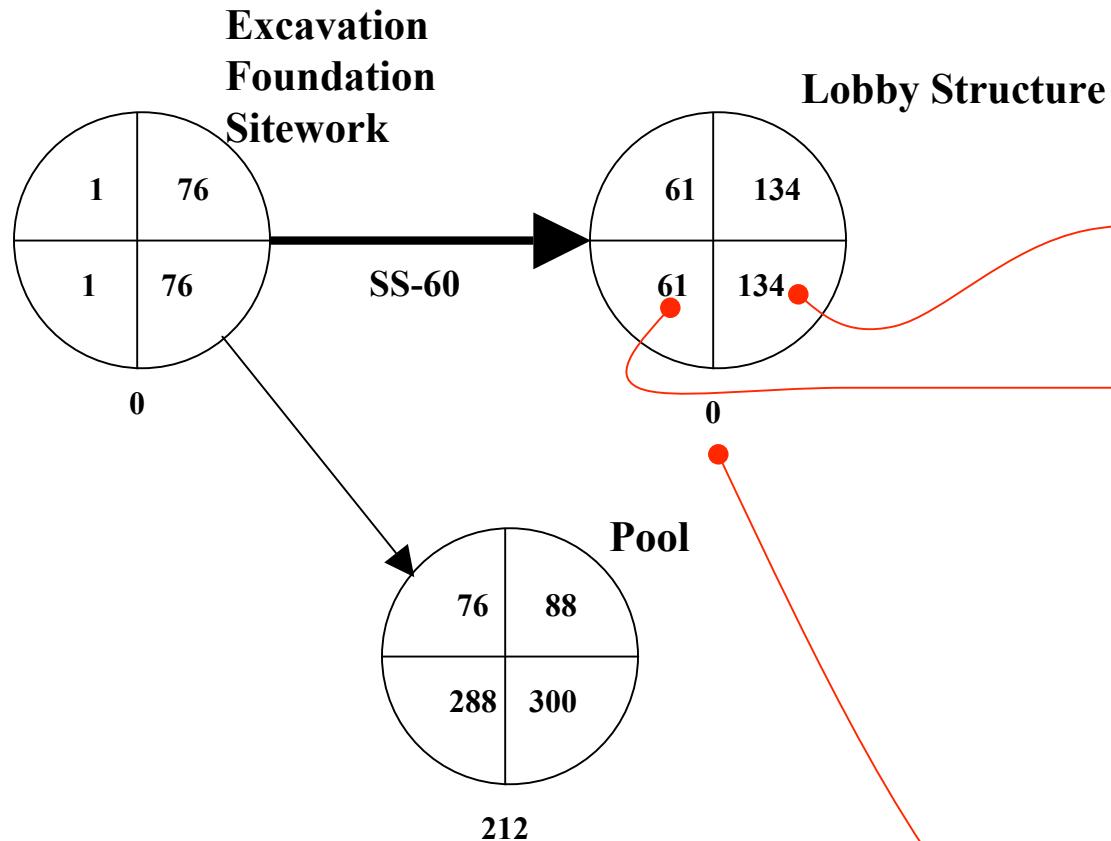
Decoding the critical path 1



Decoding the critical path 2



Decoding the critical path 3



The lobby structure **MUST** be completed by day **134** and **MUST** be started by day **61** and or the project will fall behind schedule making this a **CRITICAL** activity.

Another indication of a **CRITICAL** activity is the **0** days of float time.

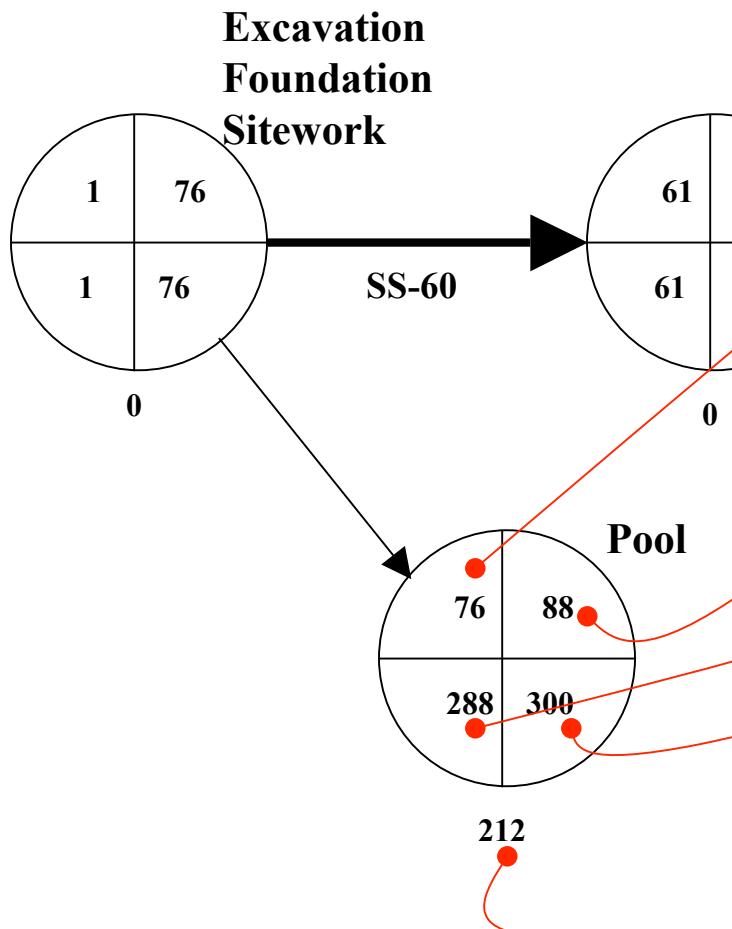
Decoding

the critical path 4

The Pool structure could start as early as day 76, be done as early as day 88 or

Start as late as day 288 and be completed as late as day 300

So the pool has a 212 day cushion of time between its earliest and latest completion dates. 212 days of “float”



$$300 - 88 = 212$$

Durations

- One way to calculate the duration of a task is to accept the daily production rates from the estimating guides, divide the quantity of work required for the task by the daily production rate and you'll know how many days it will take to complete the task

				C-11	20	3.600	Ea.
1000	Double tees, floor members						
1100	Lightweight, 20" x 8' wide, 45' span						
1150	24" x 8' wide, 50' span				18	4	
1200	32" x 10' wide, 60' span				16	4.500	
1250	Standard weight, 12" x 8' wide, 20' span				22	3.273	
1300	16" x 8' wide, 25' span				20	3.600	
1350	18" x 8' wide, 30' span	CN			20	3.600	
1400	20" x 8' wide, 45' span				18	4	
1450	24" x 8' wide, 50' span				16	4.500	
1500	32" x 10' wide, 60' span				14	5.143	
2000	Roof members						
2050	Lightweight, 20" x 8' wide, 40' span			C-11	20	3.600	Ea.
2100	24" x 8' wide, 50' span				18	4	
2150	32" x 10' wide, 60' span				16	4.500	
2200	Standard weight, 12" x 8' wide, 30' span				22	3.273	
2250	16" x 8' wide, 30' span				20	3.600	
2300	18" x 8' wide, 30' span				20	3.600	
2350	20" x 8' wide, 40' span				18	4	
2400	24" x 8' wide, 50' span				16	4.500	
2450	32" x 10' wide, 60' span				14	5.143	
03450 Plant-Precast Architectural Concrete							
850	0011	WALL PANELS	R03450 -010				
	0050	Uninsulated 4" thick, smooth gray					
0150	Low rise, 4' x 8' x 4" thick			C-11	320	.225	S.F.
0200	8' x 8' x 4" thick				576	.125	
0250	8' x 16' x 4" thick				1,024	.070	
0400	8' x 8', 4" thick, smooth gray				576	.125	
0500	Exposed aggregate				576	.125	
0600	High rise, 4' x 8' x 4" thick				288	.250	

Duration 2

- This table says crew C-11 can set 16 24" deep tees per day.
- If the total number of tees we have in the project is 320, we should be done setting the tees in 20 days

1000	Double tees, floor members				
1100	Lightweight, 20" x 8' wide, 45' span	C-11	20	3.600	Ea.
1150	24" x 8' wide, 50' span		18	4	
1200	32" x 10' wide, 60' span		16	4.500	
1250	Standard weight, 12" x 8' wide, 20' span		22	3.273	
1300	16" x 8' wide, 25' span		20	3.600	
1350	18" x 8' wide, 30' span	CN	20	3.600	
1400	20" x 8' wide, 45' span		18	4	
1450	24" x 8' wide, 50' span		16	4.500	
1500	32" x 10' wide, 60' span		14	5.143	
2000	Roof members				
2050	Lightweight, 20" x 8' wide, 40' span	C-11	20	3.600	Ea.
2100	24" x 8' wide, 50' span		18	4	
2150	32" x 10' wide, 60' span		16	4.500	
2200	Standard weight, 12" x 8' wide, 30' span		22	3.273	
2250	16" x 8' wide, 30' span		20	3.600	
2300	18" x 8' wide, 30' span		20	3.600	
2250	20" x 8' wide, 40' span		18	4	
2400	24" x 8' wide, 50' span		16	4.500	
2450	32" x 10' wide, 60' span		14	5.143	

03450 | Plant-Precast Architectural Concrete

850	0011	WALL PANELS	R03450 -010			
	0050	Uninsulated 4" thick, smooth gray				
	0150	Low rise, 4' x 8' x 4" thick	C-11	320	.225	S.F.
	0200	8' x 8' x 4" thick		576	.125	
	0250	8' x 16' x 4" thick		1,024	.070	
	0400	8' x 8', 4" thick, smooth gray		576	.125	
	0500	Exposed aggregate		576	.125	
	0600	High rise, 4' x 8' x 4" thick		288	.250	

So a task duration could be calculated by dividing the quantity of work required for the project by the quantity of work the crew produces in one day.....so 514 If of formwork could be produced in .611 days or just under 5 hours.

Always check your results...think about it... and when it
doesn't make sense...

Your task, email to me before the start of next weeks lab (individual assignment)

- 1. Calculate the duration for each part of the estimate
- 2. Using copy and paste, put each item in order according to what you'd do first, second... to build this building