King Fahd University of Petroleum & Minerals

College of Environmental Design

Construction Engineering & Management Department

CEM 510

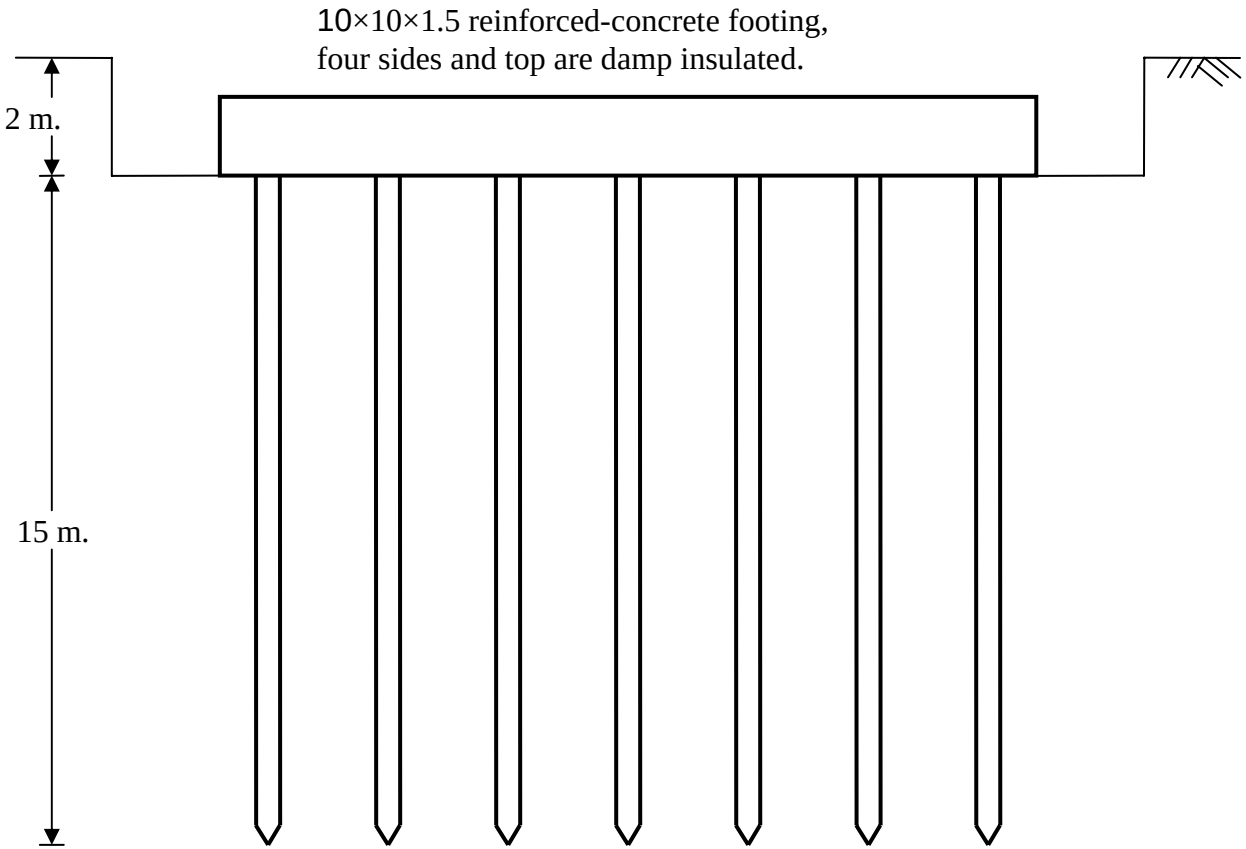
Construction Planning & Scheduling

Fall 2005/2006

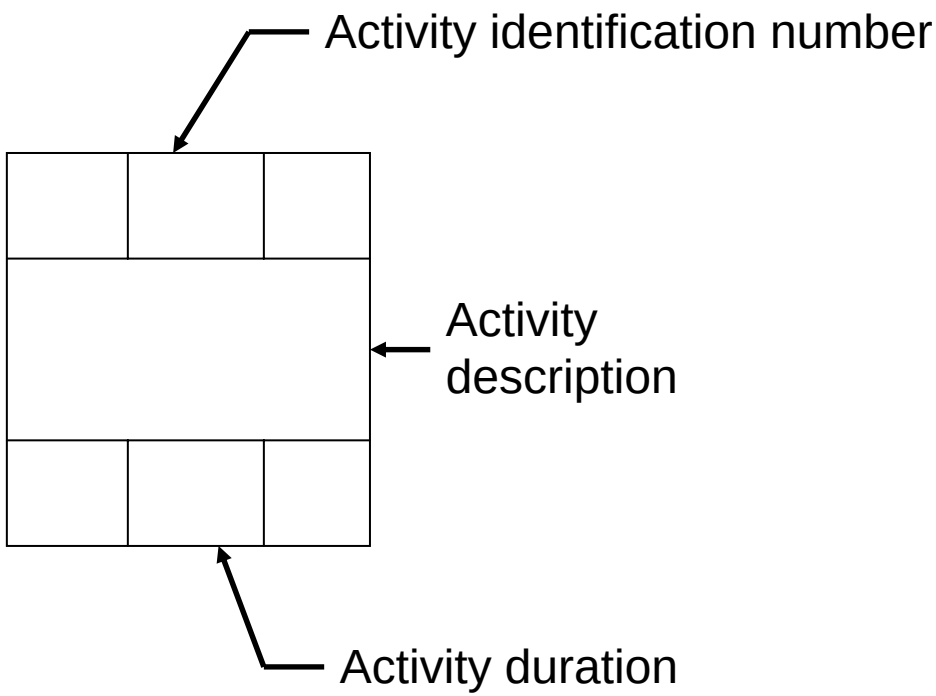
Project Scheduling

Pile-supported RC footing

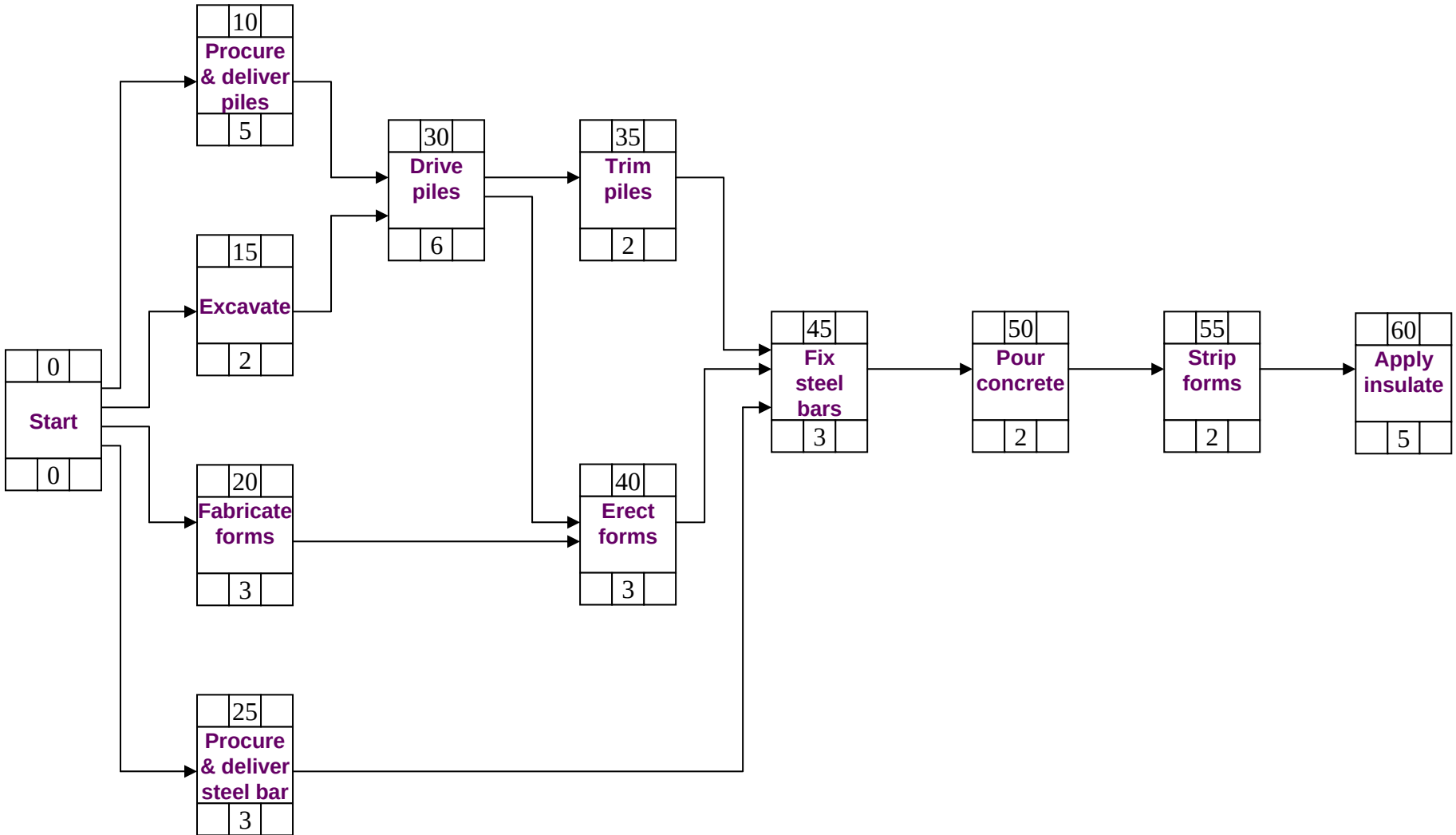
- **Scope of work:**



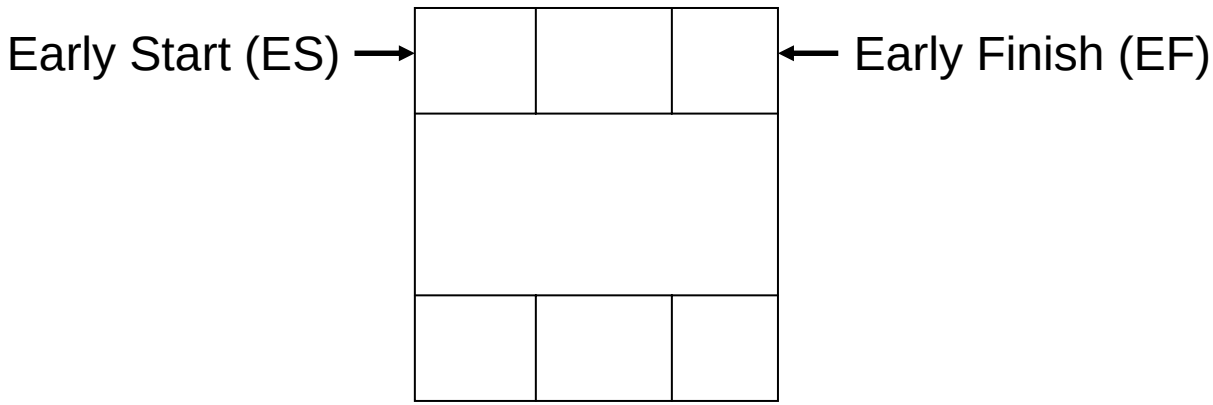
Activity duration



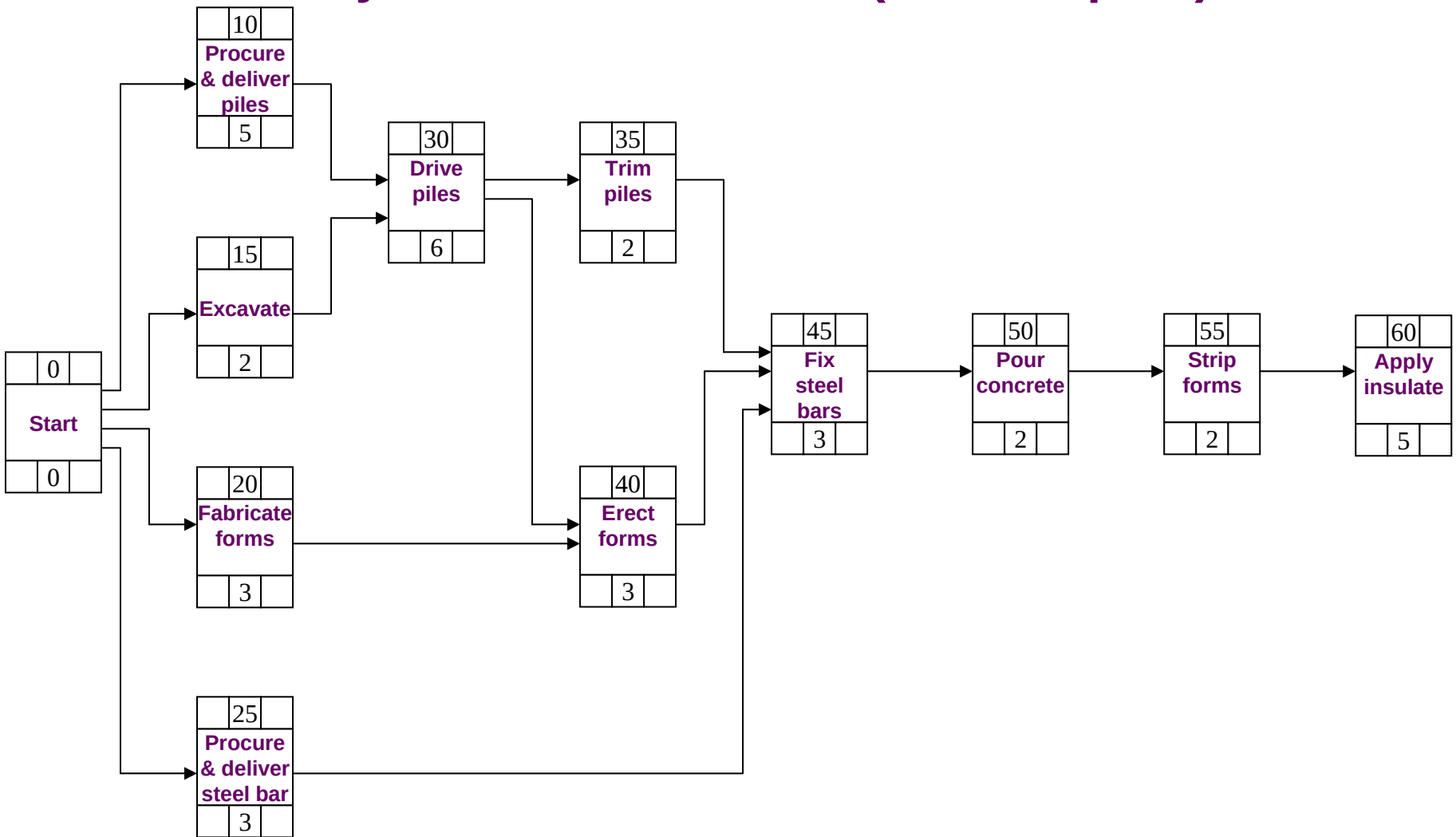
Activities' durations



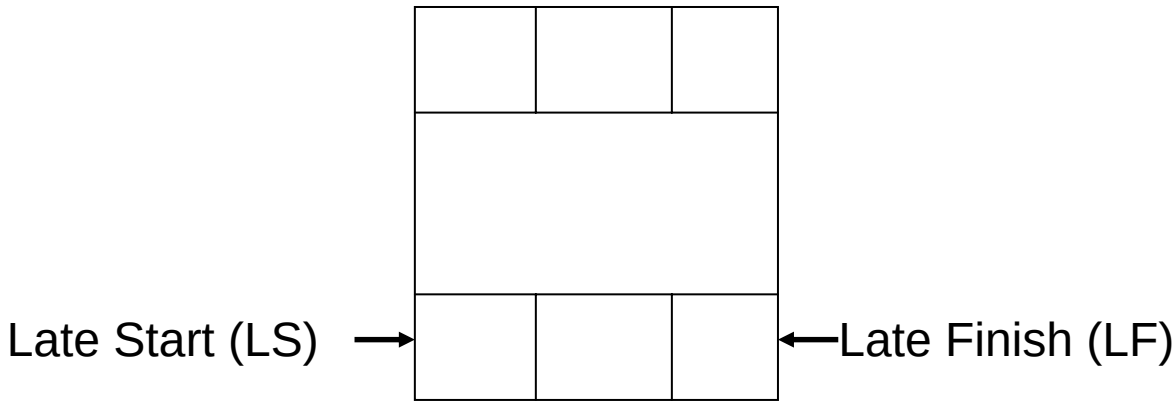
Early times



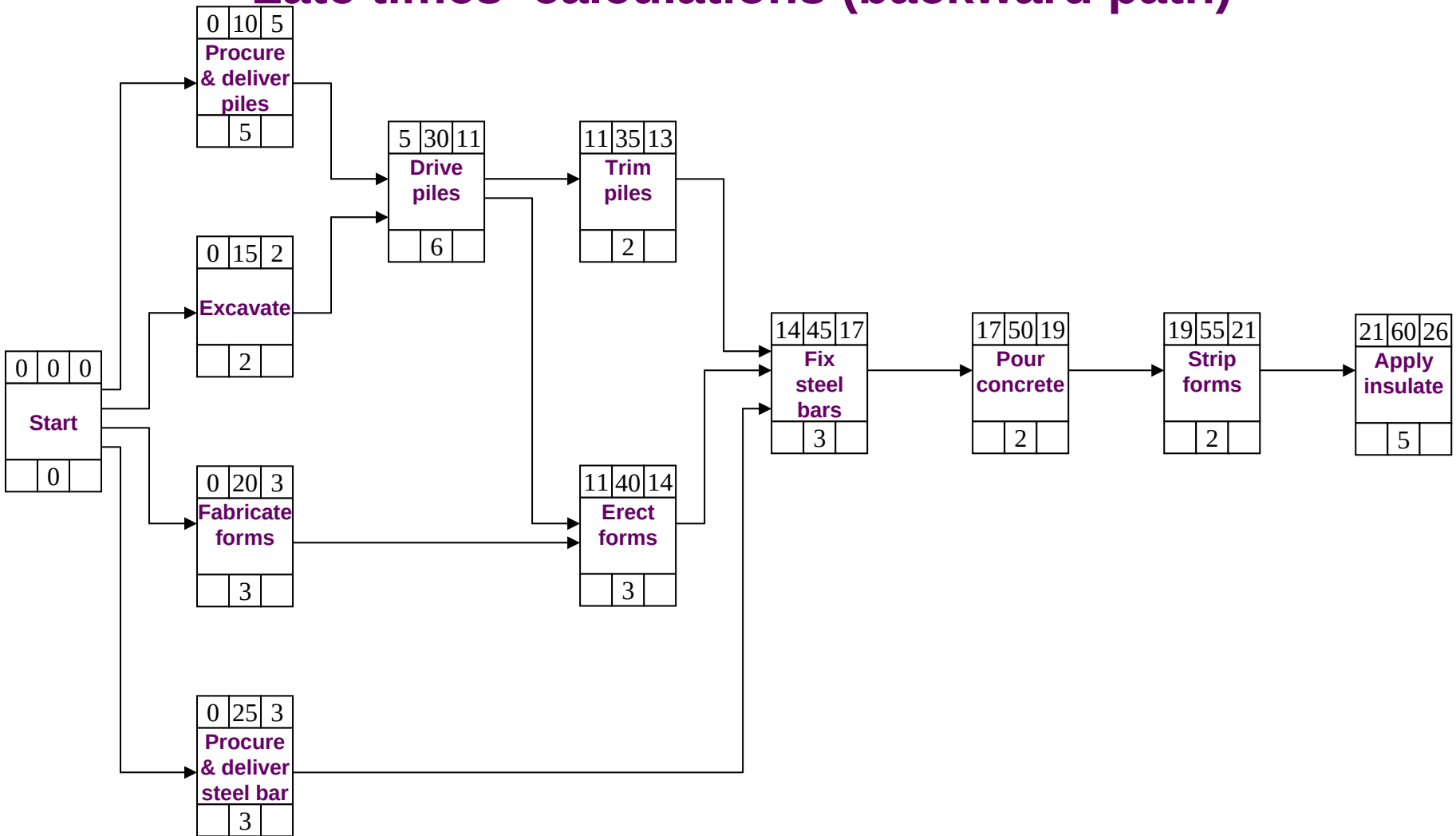
Early times' calculations (forward path)



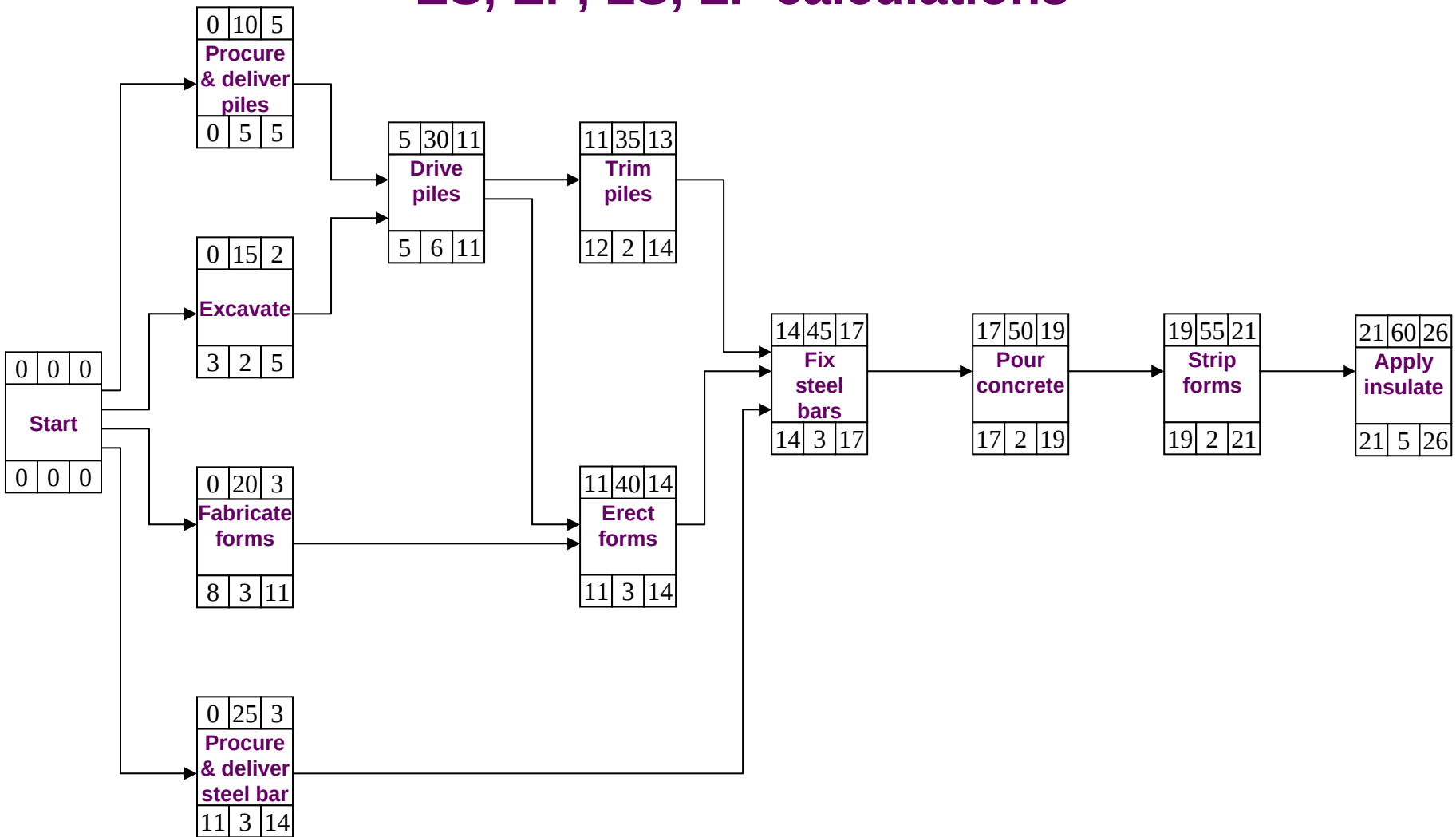
Late times



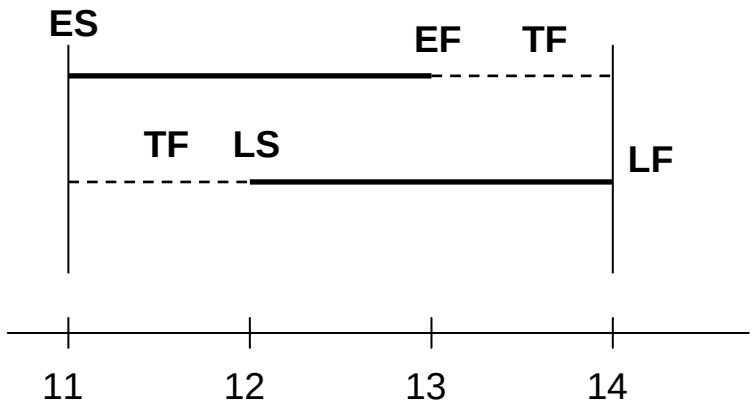
Late times' calculations (backward path)



ES, EF, LS, LF calculations



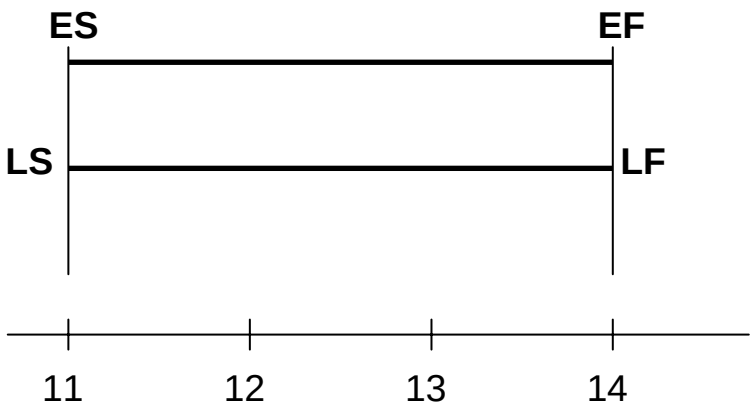
Total Float (TF)



TF= 1

Non-critical activity

11	35	13
Trim piles		
12	2	14



TF= 0

critical activity

11	40	14
Erect forms		
11	3	14

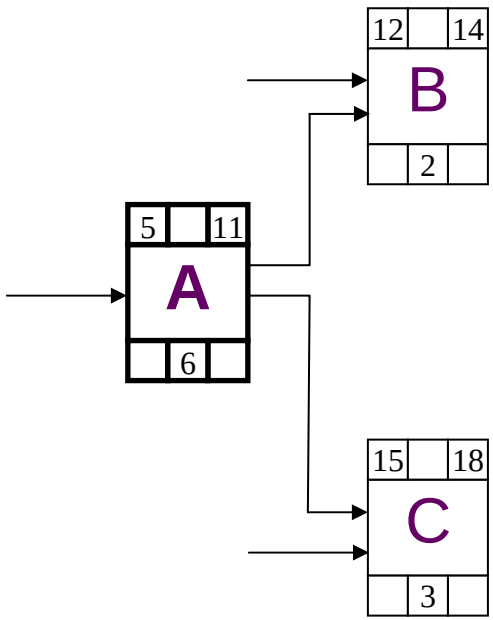
Free Float (FF)

For activity A:

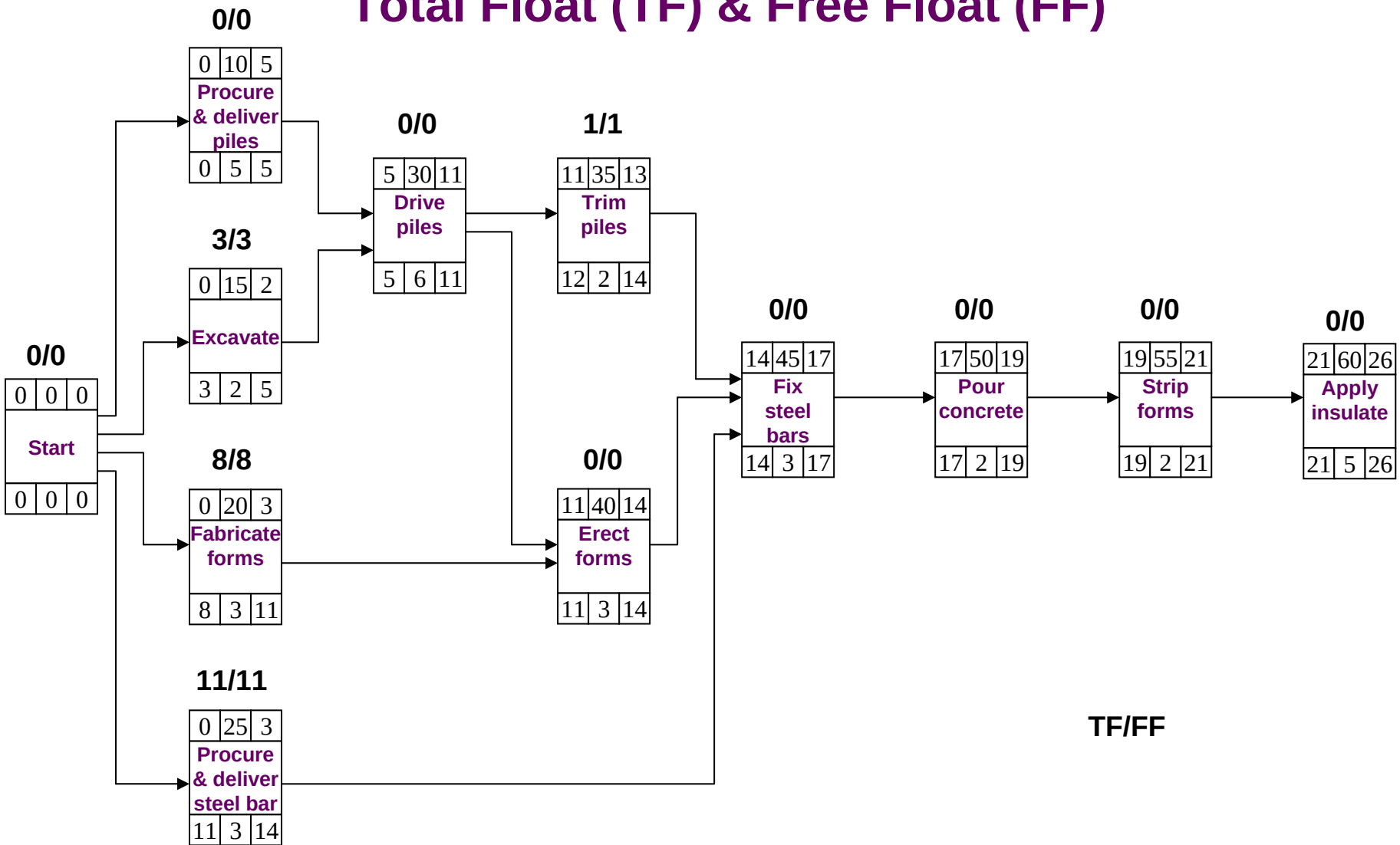
A-B relationship = 12 - 11 = 1

A-C relationship = 15 - 11 = 4

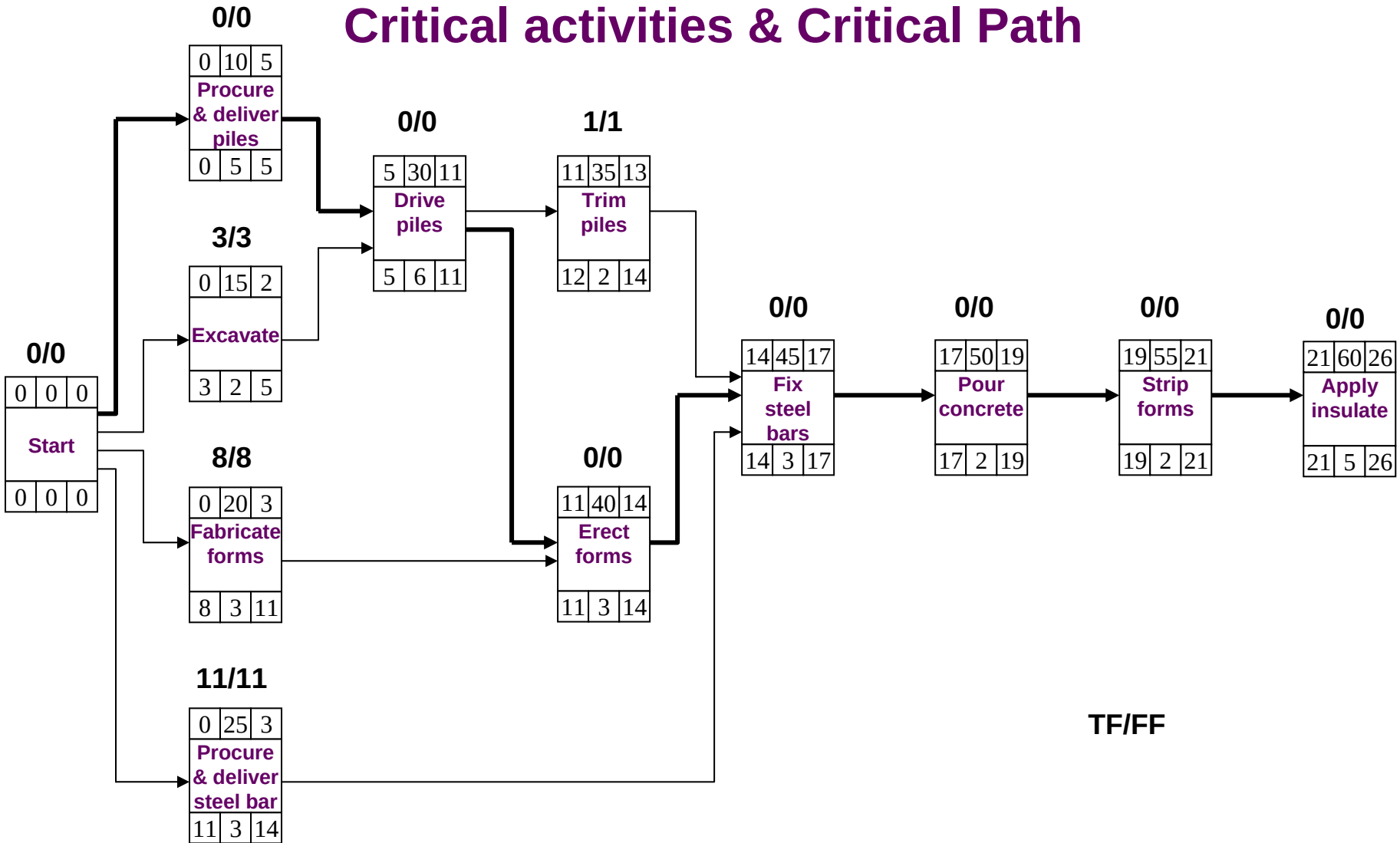
FF of A = least of {1,4} = 1



Total Float (TF) & Free Float (FF)



Critical activities & Critical Path

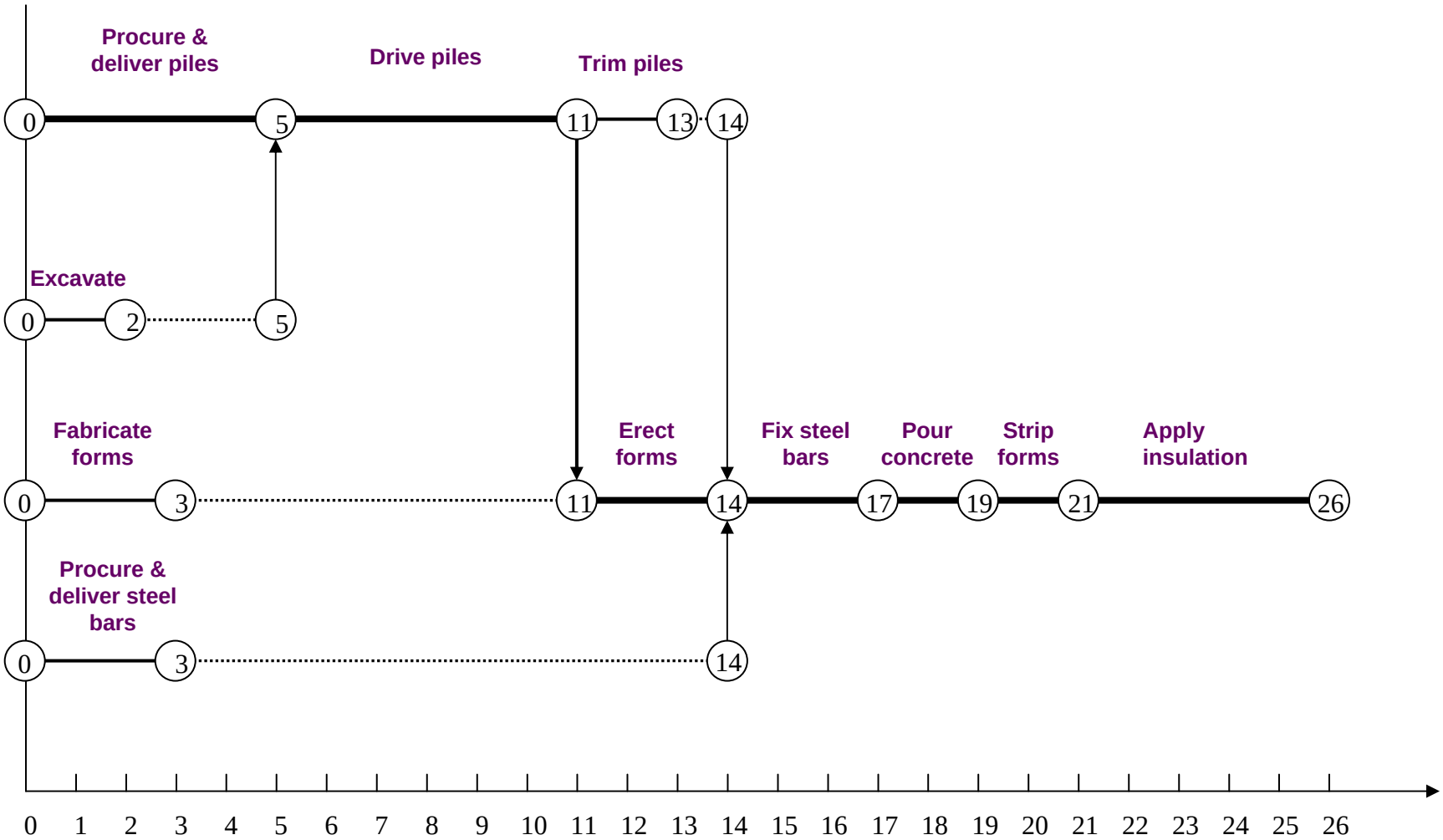


Summary of results

Activity No.	Activity name	ES	EF	LS	LF	TF	FF
1	Excavate	0	2	3	5	3	3
2	Procure & deliver piles*	0	5	0	5	0	0
3	Procure & deliver steel bars	0	3	11	14	11	11
4	Fabricate forms	0	3	8	11	8	8
5	Drive piles*	5	11	5	11	0	0
6	Trim piles	11	13	12	14	1	1
7	Erect forms*	11	14	11	14	0	0
8	Fix steel bars*	14	17	14	17	0	0
9	Pour concrete*	17	19	17	19	0	0
10	Strip forms*	19	21	19	21	0	0
11	Apply insulation*	21	26	21	26	0	0

*** Critical activities**

Time-scaled diagram



Calendar schedule

- **Project starts on June 14.**

June

Fri	Sat	Sun	Mon	Tue	Wed	Thu
		1	2	3	4	5
6	7	8	9	10	11	12
13	14 (1)	15 (2)	16 (3)	17 (4)	18 (5)	19
20	21 (6)	22 (7)	23 (8)	24 (9)	25 (10)	26
27	28 (11)	29 (12)	30 (13)			

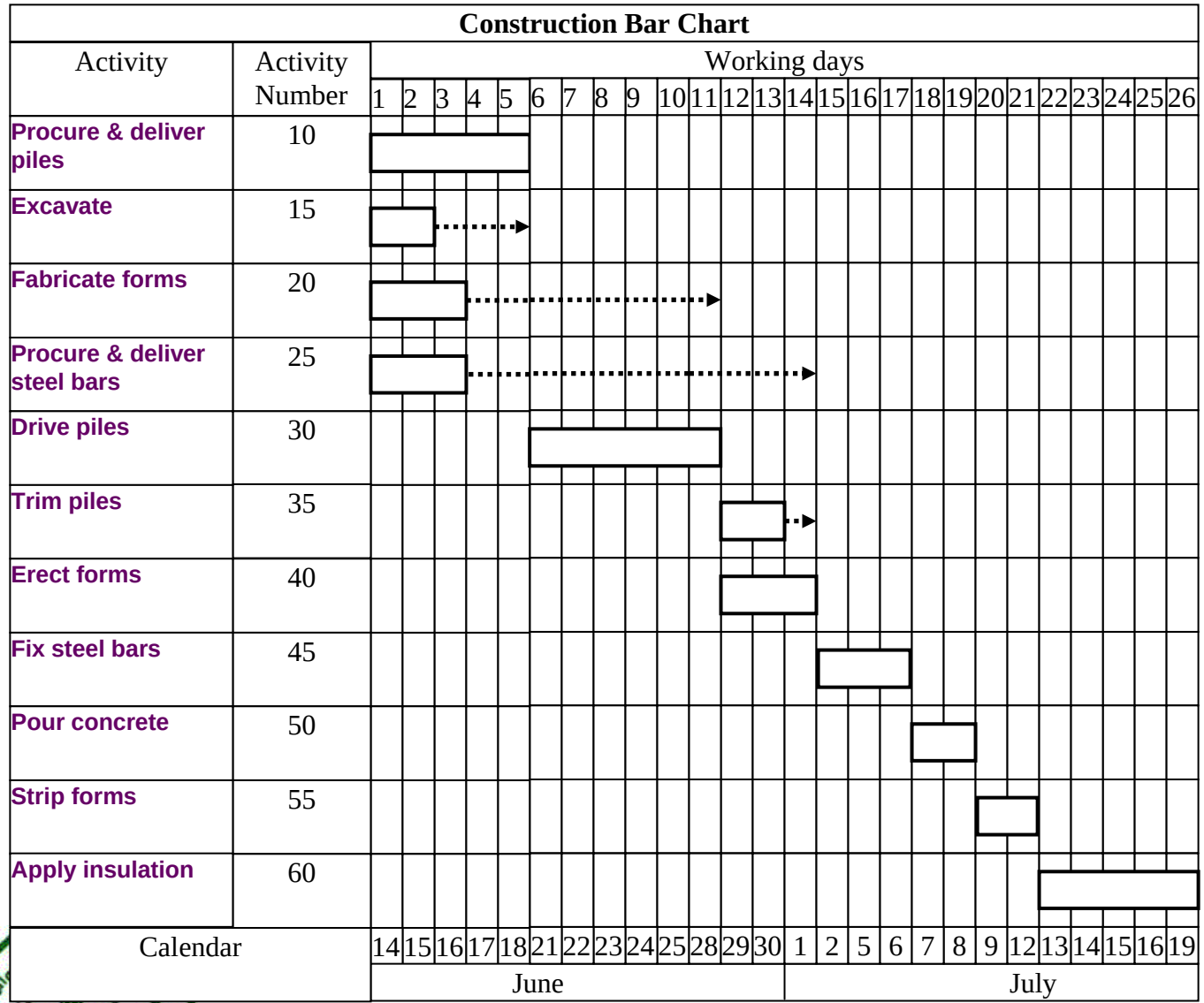
July

Fri	Sat	Sun	Mon	Tue	Wed	Thu
				1 (14)	2 (15)	3 (16)
4	5 (16)	6 (17)	7 (18)	8 (19)	9 (20)	10
11	12 (21)	13 (22)	14 (23)	15 (24)	16 (25)	17
18	19 (26)	20	21	22	23	24
25	26	27	28	29	30	31

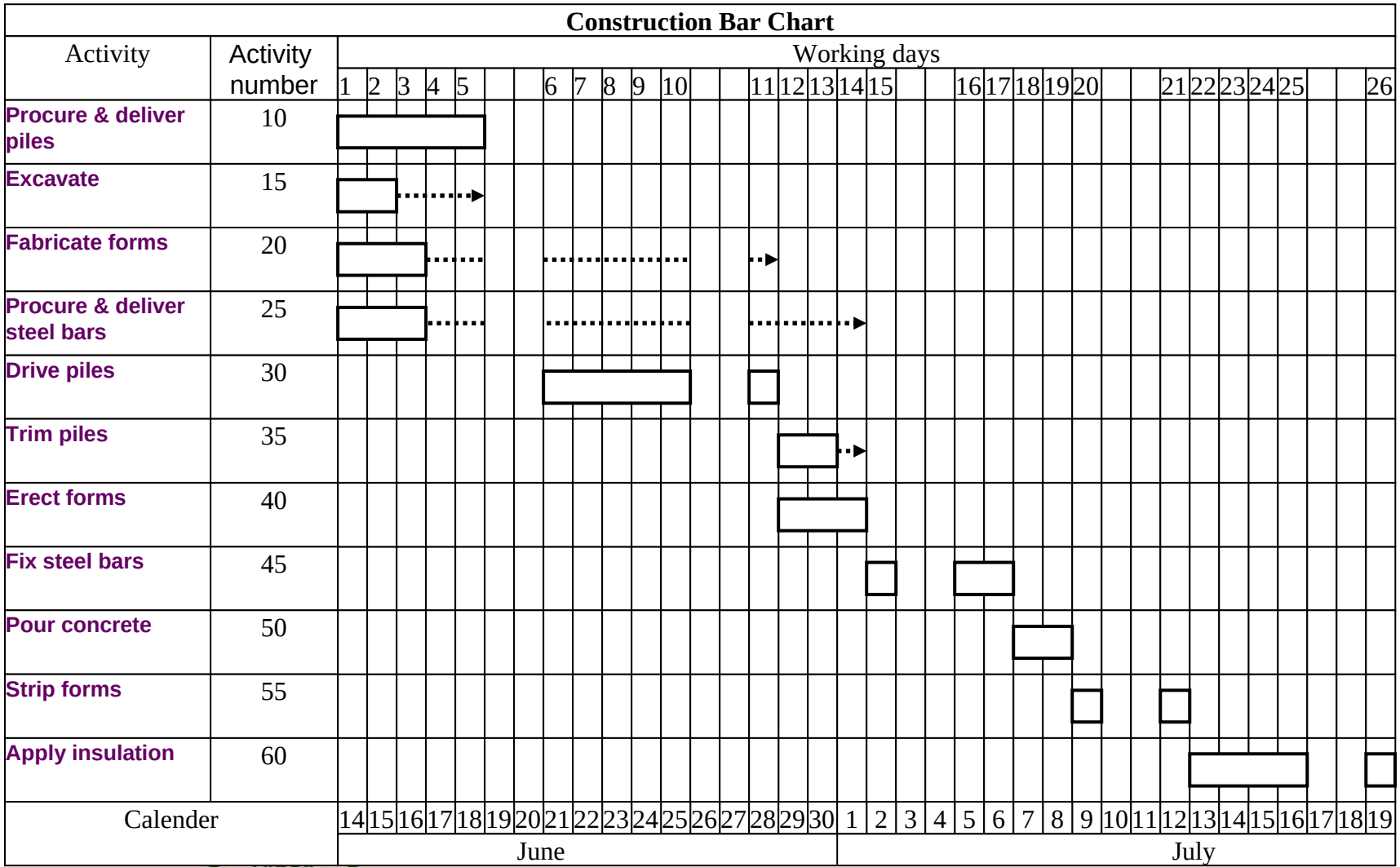
Calendar schedule

Activity No.	Activity name	duration	ES	EF
1	Excavate	2	June 14	June 15
2	Procure & deliver piles*	5	June 14	June 18
3	Procure & deliver steel bars	3	June 14	June 16
4	Fabricate forms	3	June 14	June 16
5	Drive piles*	6	June 21	June 28
6	Trim piles	2	June 29	June 30
7	Erect forms*	3	June 29	July 1
8	Fix steel bars*	3	July 2	July 6
9	Pour concrete*	2	July 7	July 8
10	Strip forms*	2	July 9	July 12
11	Apply insulation*	5	July 13	July 19

Bar chart

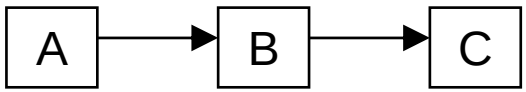

Construction Bar Chart
Activity
Activity Number
Working days
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Procure & deliver piles
10
Excavate
15
Fabricate forms
20
Procure & deliver steel bars
25
Drive piles
30
Trim piles
35
Erect forms
40
Fix steel bars
45
Pour concrete
50
Strip forms
55
Apply insulation
60
Calendar
14 15 16 17 18 21 22 23 24 25 28 29 30 1 2 5 6 7 8 9 12 13 14 15 16 19
June
July

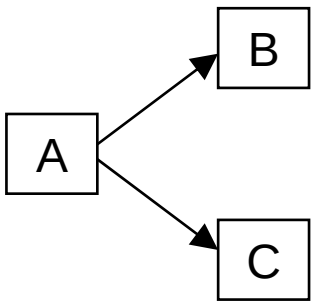
Bar chart

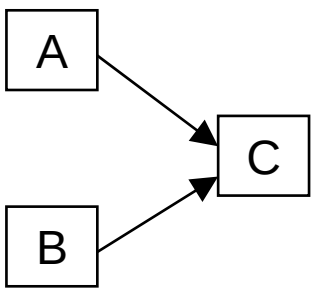

Construction Bar Chart
Activity
Activity number
Working days
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Procure & deliver piles
10
Excavate
15
Fabricate forms
20
Procure & deliver steel bars
25
Drive piles
30
Trim piles
35
Erect forms
40
Fix steel bars
45
Pour concrete
50
Strip forms
55
Apply insulation
60
Calender
14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
June
July

Arrow notation

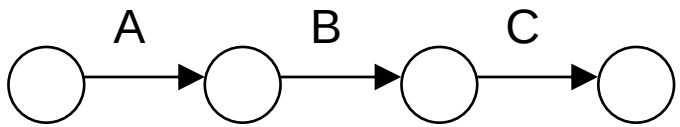
Precedence notation

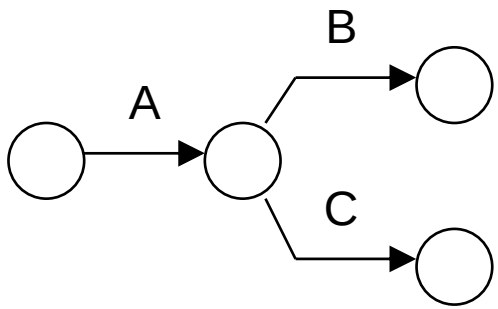


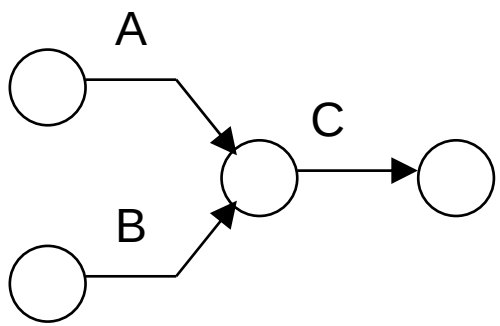




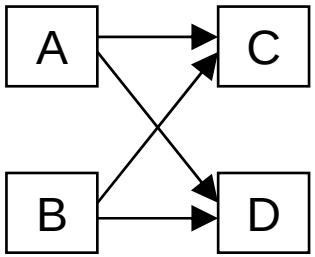
Arrow notation

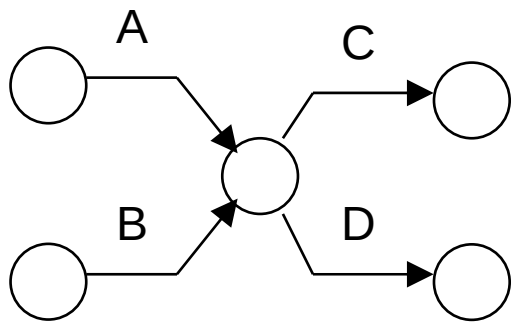


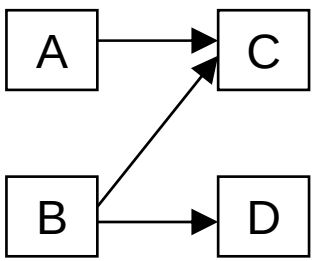


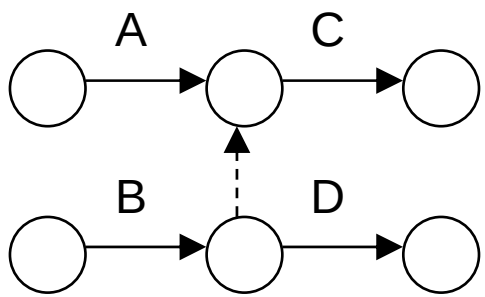


Arrow notation

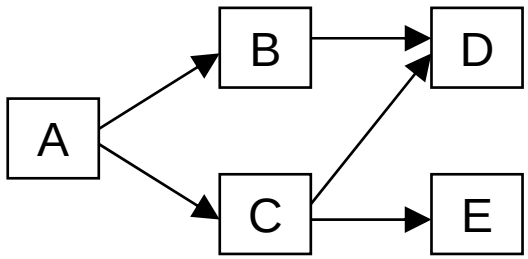


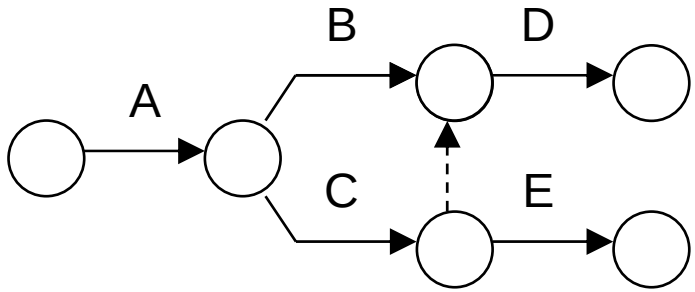


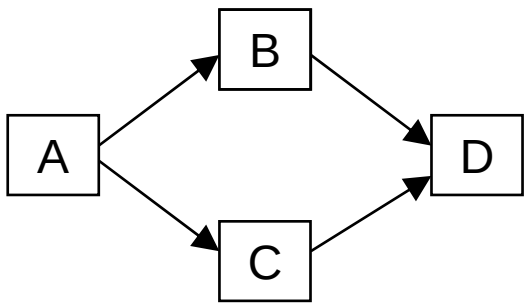


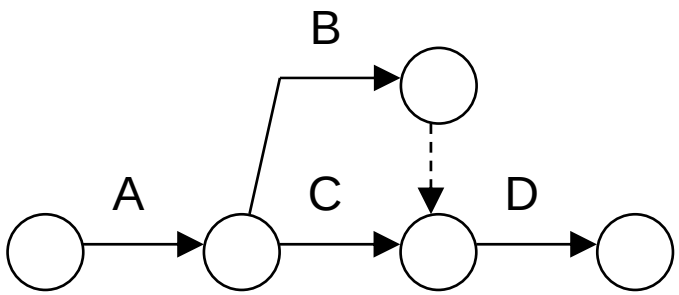


Arrow notation

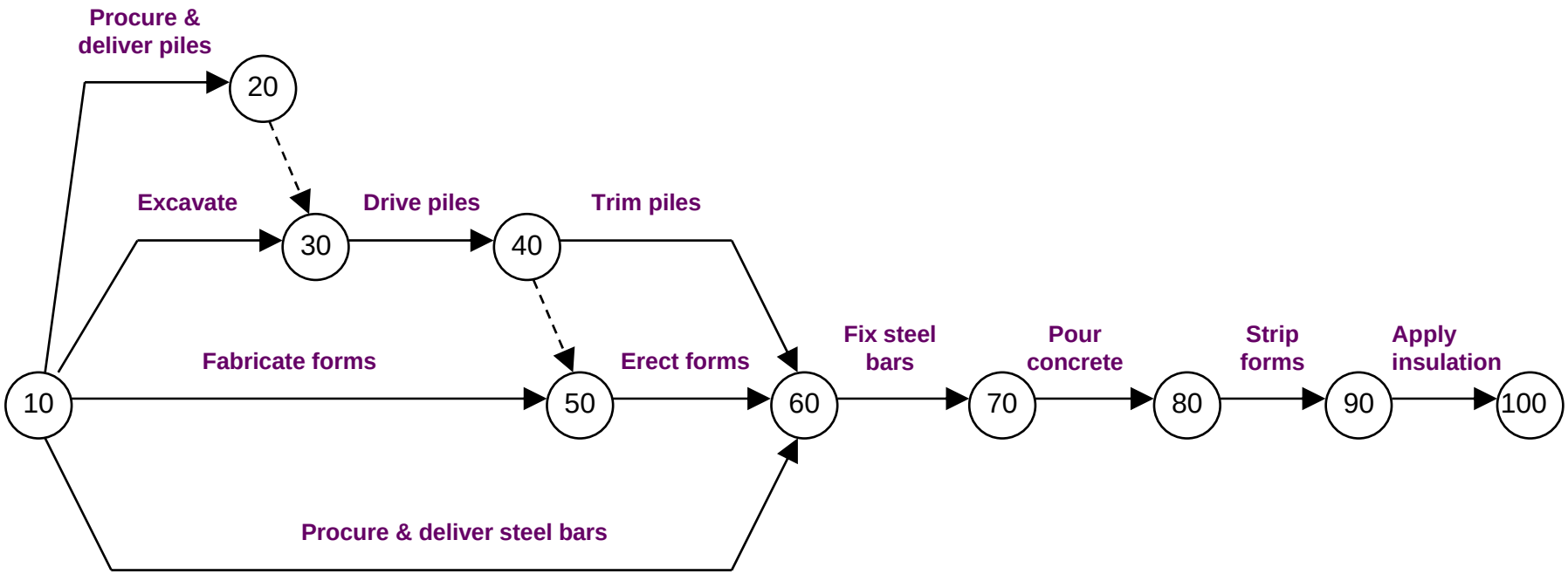




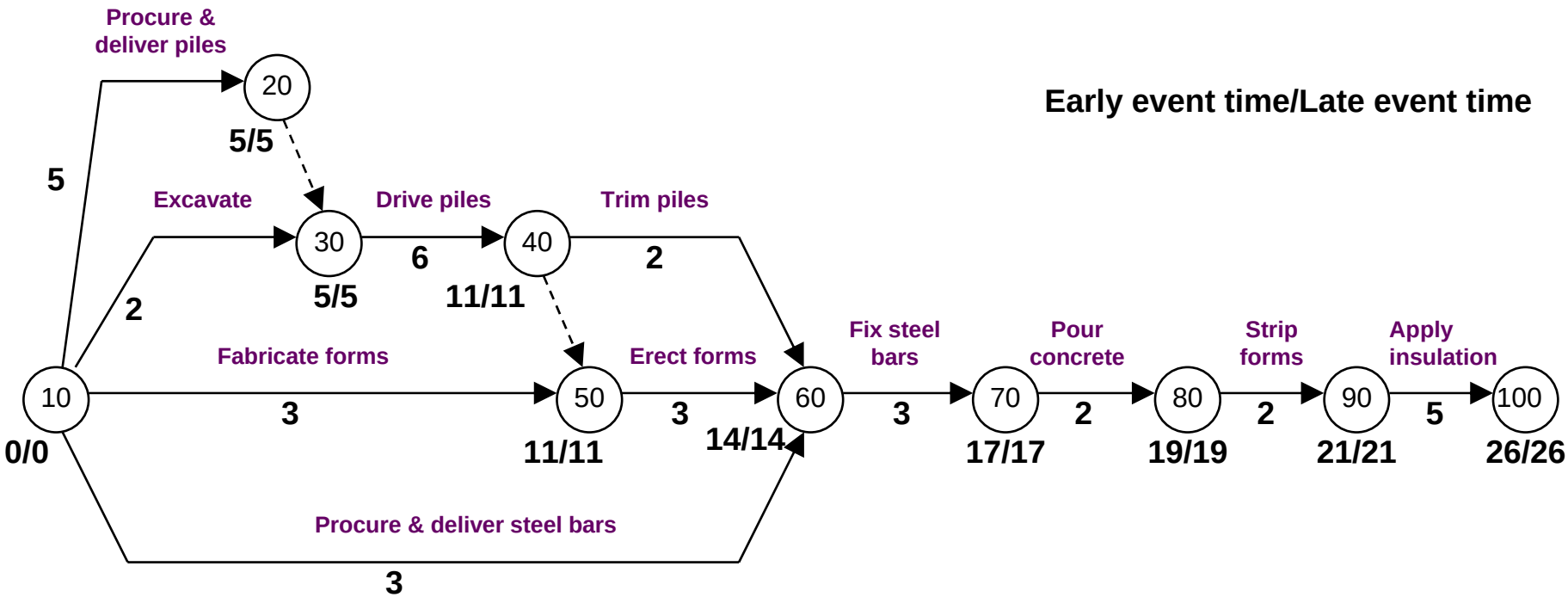




Planning (Arrow notation)

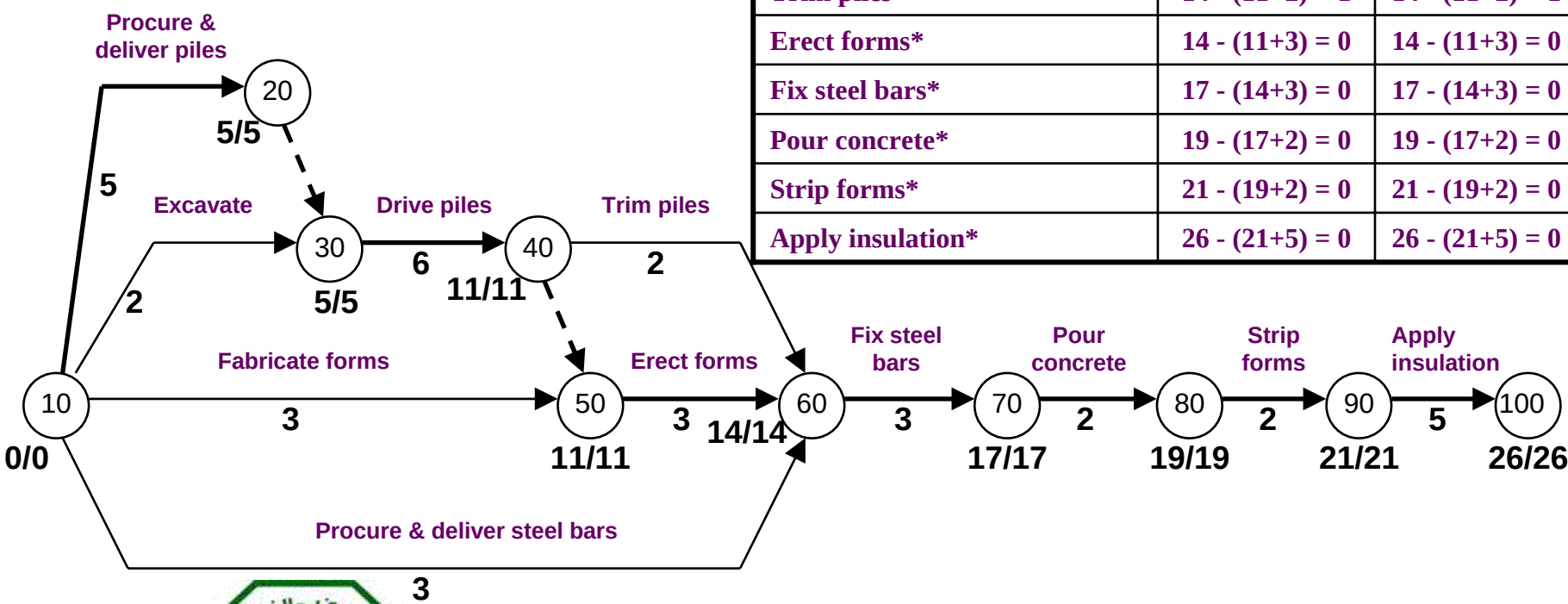


Event times


Procure & deliver piles
20
5/5
5
Excavate
Drive piles
Trim piles
30
40
6
2
5/5
11/11
2
Fabricate forms
Erect forms
Fix steel bars
Pour concrete
Strip forms
Apply insulation
10
50
60
70
80
90
100
3
3
3
2
2
5
0/0
11/11
14/14
17/17
19/19
21/21
26/26
Procure & deliver steel bars
3
Early event time/Late event time

Activities' floats

Activity name	Free float	Total float
Excavate	5 - (0+2) = 3	5 - (0+2) = 3
Procure & deliver piles*	5 - (0+5) = 0	5 - (0+5) = 0
Procure & deliver steel bars	14 - (0+3) =11	5 - (0+3) = 11
Fabricate forms	11 - (0+3) = 8	11 - (0+3) = 8
Drive piles*	11 - (5+6) = 0	11 - (5+6) = 0
Trim piles	14 - (11+2) = 1	14 - (11+2) = 1
Erect forms*	14 - (11+3) = 0	14 - (11+3) = 0
Fix steel bars*	17 - (14+3) = 0	17 - (14+3) = 0
Pour concrete*	19 - (17+2) = 0	19 - (17+2) = 0
Strip forms*	21 - (19+2) = 0	21 - (19+2) = 0
Apply insulation*	26 - (21+5) = 0	26 - (21+5) = 0



Project Scheduling

- **Provides an answer to the question of when (when to start an activity and when to finish).**
- **Insures the continuity of work from the project start to the completion.**
- **Works as a projected timetable of construction operations that will serve as the principal guideline for the project execution.**

Steps of project Scheduling

- Estimate the time required to carry out each activity.
- Complete the network calculations to obtain activities early and late times, and total project duration.
- Establish time intervals within which each activity must start and finish to satisfy the completion date requirements.
- Identify those activities whose expedient execution is crucial to timely project completion.

Activities' durations

- **Prior experience enables contractors to estimate.**
- **If there is no experience with an activity use the formula:**

$$T = \frac{T_0 + 4\,T_m + T_P}{6}$$

Where:

T **Weighted average time for the activity.**

T_0 **Optimistic time**

T_m **Most likely to occur**

T_P **Pessimistic time**

Rules for estimating Activities' durations

- Assume that materials, labor, equipment, and other needs will be available when required.
- If there is reasons to believe that the first assumption is not true, then the use of a preceding restraint may be in order.
- For each activity, assume a normal level of resources.
- Concentrate on estimating the duration of the individual activity and ignore all other time considerations.
- Use consistent time units throughout.
- Production rate is used to figure out a good estimate.
- Contingency is usually added as a separate activity.

Network time computations

- Activity times are expressed in terms of expired working days.
- Forward-path computations

Early Start (ES):

The earliest time that the activity can possibly start allowing for the times required to complete the preceding activities.

Early Finish (EF):

The earliest possible time that the activity can be completed and is determined by adding the activity's duration to its early start time.

Network time computations

- **Backward-path computations**

Late Finish (LF):

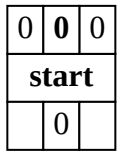
The very latest that the activity can finish and allow the entire project to be completed by a designated time or date.

Late Start (LS):

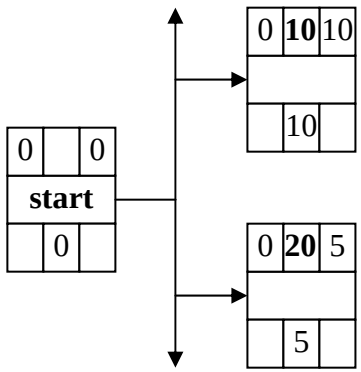
The latest possible time that the activity can be started if the project target completion date is to be met and is obtained by subtracting the activity's duration from its latest finish time.

Forward-path computations

(Early times)



ES = 0 (project start)
Duration = 0
EF = ES + duration = 0 + 0 = 0



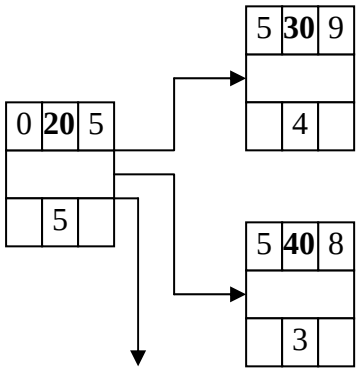
ES = EF of activity start = 0
duration = 10
(EF) = (ES) + duration = 0 + 10 = 10

ES = EF of activity start = 0
duration = 5

EF = ES + duration = 0 + 5 = 5

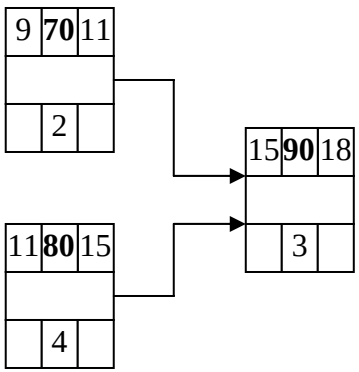
Forward-path computations

(Early times)



ES = EF of activity 20 = 5
duration = 4
(EF) = (ES) + duration = 5 + 4 = 9

ES = EF of activity 20 = 5
duration = 3
EF = ES + duration = 5 + 3 = 8

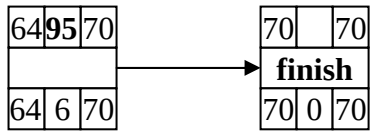


ES = latest EF of activity 70 or activity 80 = 1 5
duration = 3
EF = ES + duration = 15 + 3 = 18

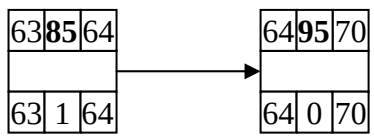
Backward-path computations

(Late times)

LF = LS of activity finish = 70
duration = 6
LS = LF - duration = 70 – 6 = 64



LF = LS of activity 95 = 64
duration = 1
LS = LF - duration = 63 – 1 = 62



Backward-path computations

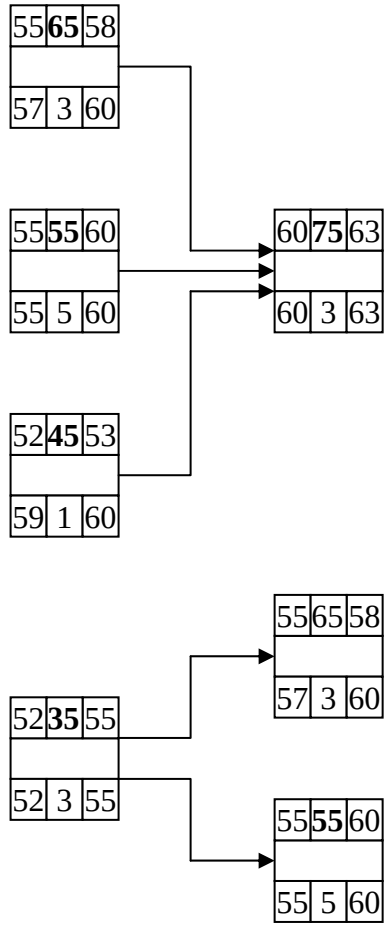
(Late times)

LF = LS of activity 75 = 60
duration = 3
LS = LF - duration = 60 – 3 = 57

LF = LS of activity 75 = 60
duration = 5
LS = LF - duration = 60 – 5 = 55

LF = LS of activity 75 = 60
duration = 1
LS = LF - duration = 60 – 1 = 59

LF = Earliest LS of activity 65
or activity 55 = 55
duration = 3
LS = LF - duration = 55 – 3 = 52

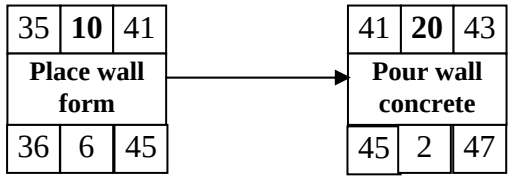


Lag relationships

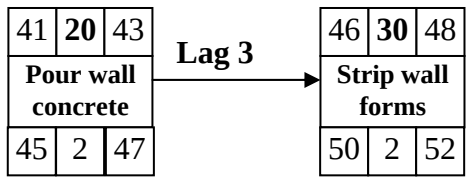
So far, planning and scheduling have been on the basis of two important assumptions.

- **An activity can't start until all the immediately preceding activities have been completed.**
- **Once all antecedent activities have been finished, the following activity can start immediately thereafter.**

Finish to start relationships

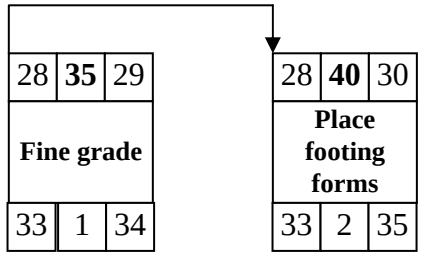


- **The wall concrete can be poured immediately after the wall forms have been completed with no delay.**

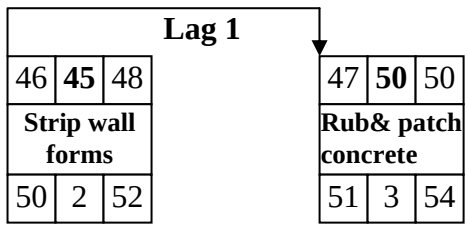


- **The wall forms can't be stripped until three days after the wall concrete is completely poured.**

Start to start relationships

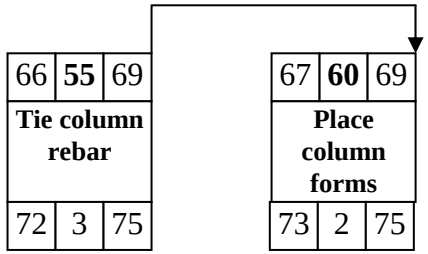


- **Placing footing forms can start immediately after the start of fine grade.**

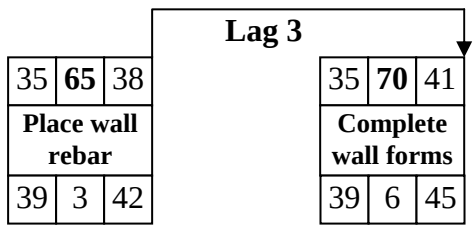


- **After one day of stripping wall forms, the cement masons can start patching and rubbing the wall surfaces.**

Finish to finish relationships

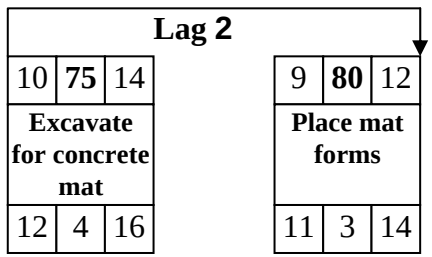


- **The finish of placing concrete forms occurs immediately after, but only after, the completion of columns rebar.**



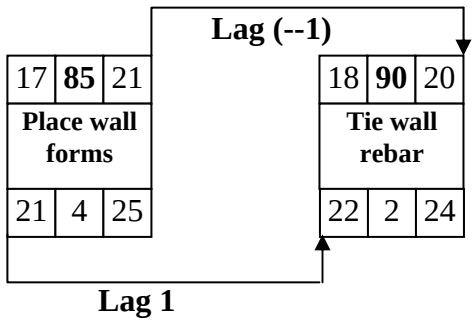
- **The finish of wall forms follows the completion of wall rebar placing by three days.**

Start to finish relationships



- **The finish of placing mat forms is achieved two days after the start of excavation for concrete mat.**

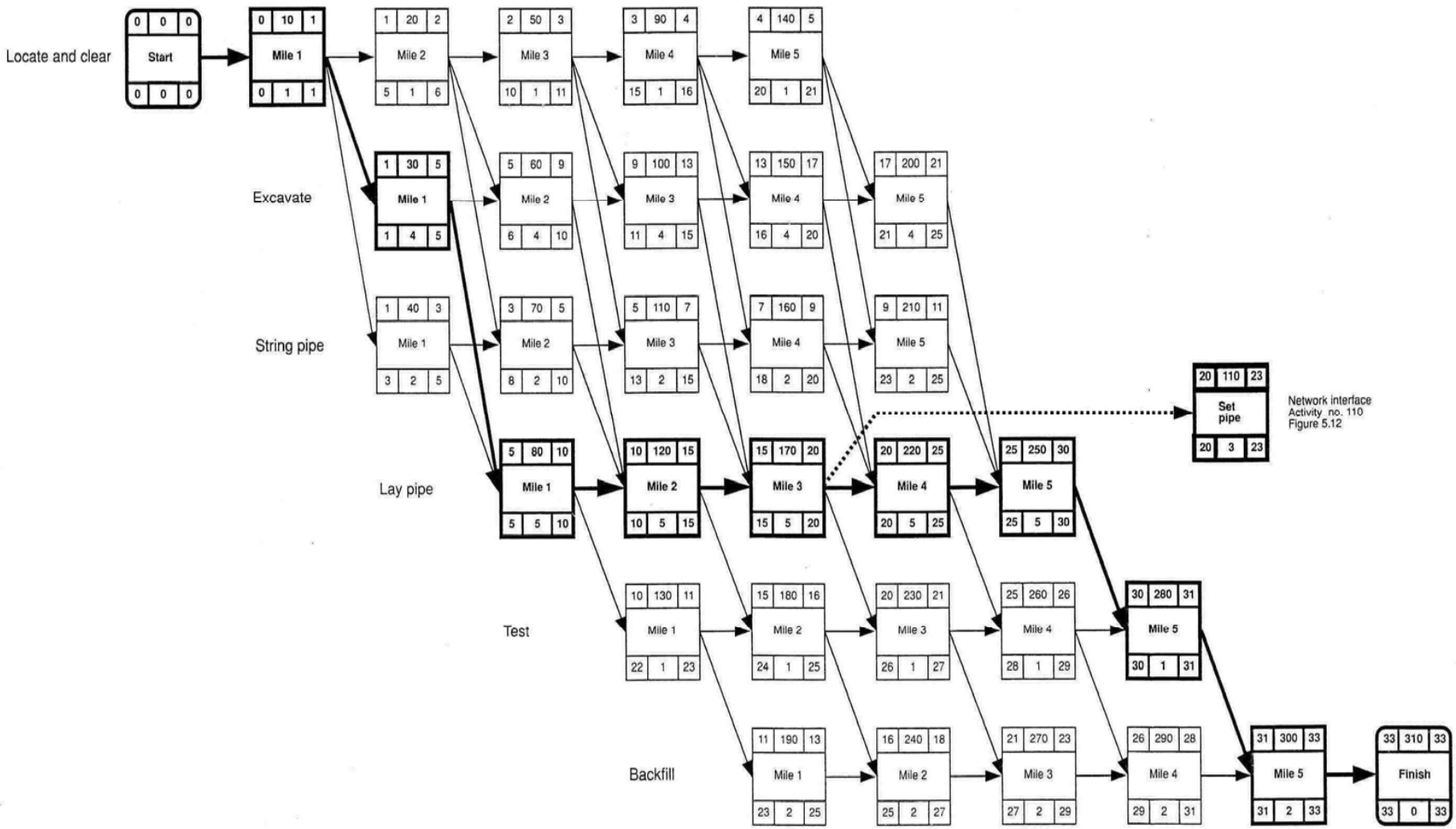
Combination



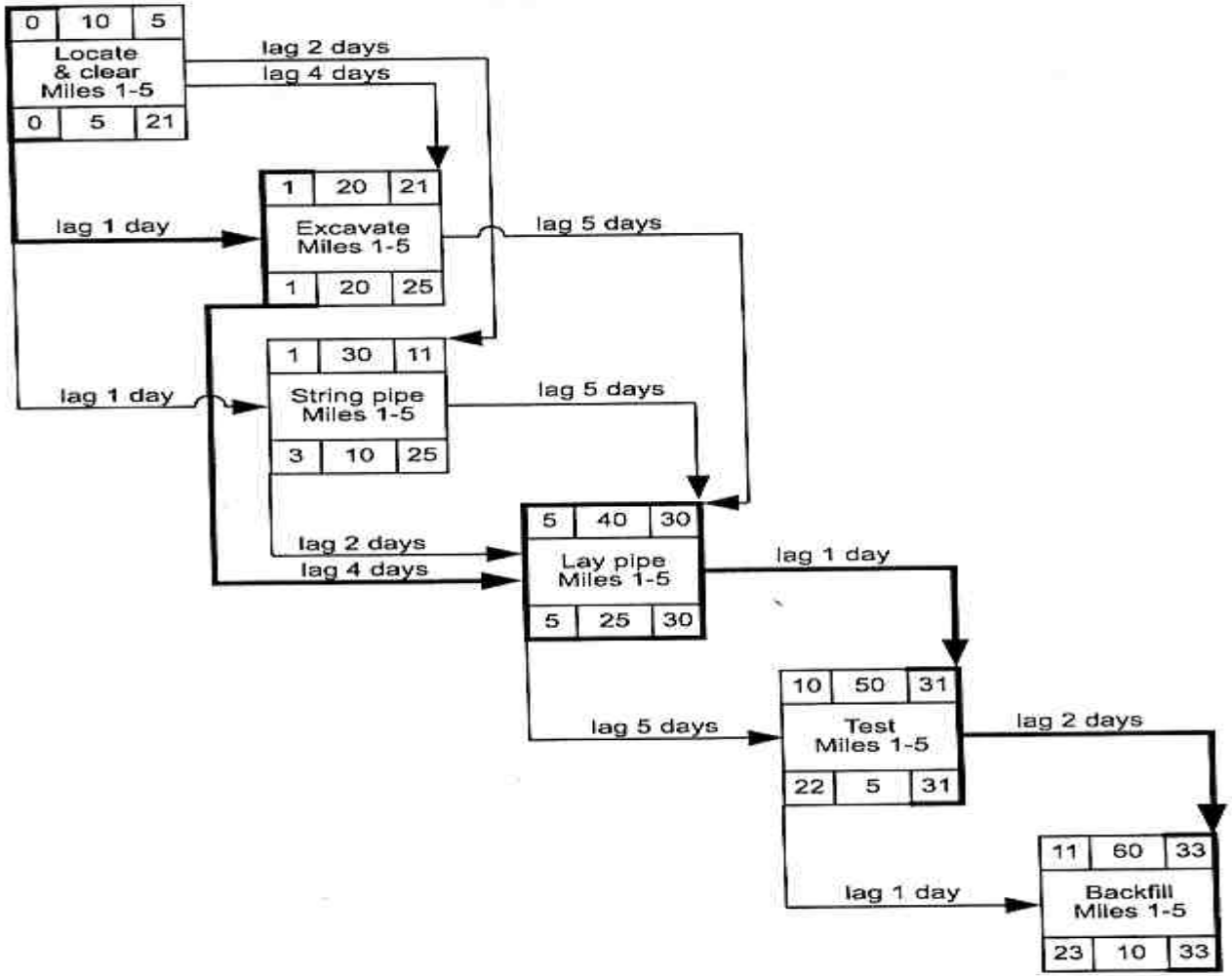
- The start to start lag of one day indicates that tieing reinforcing steel can start one day after the wall forming has begun.

- The finish to finish dependency of -1 (lead time of 1) indicates that placing wall forms cannot finish until one day after completion of the reinforcing steel placement.

Repetitive projects



Repetitive projects



Project Interface