

Project Planning & Control

Lesson 4

Time-Cost trade-off: Problem- 3, Tabulation Approach

Koshy Varghese, Ph.D.

Professor

Building Technology & Construction Management

Department of Civil Engineering

I.I.T. Madras



Learning Objectives

- Review of crashing process with example
- Tabulation approach to crashing process
- Other influences such as bonus/penalty on total project cost

Problem-3

- Develop a network diagram and develop least cost curve for the project. Assume an indirect cost of u200/day.

Activity	Preceded by	Crash cost (CC) (u)	Normal cost (NC) (u)	Crash duration (CD) (days)	Normal duration (ND) (days)
A	-	3,900	3,600	6	7
B	A	6,500	5,500	3	5
C	B	7,200	6,350	7	9
D	B	4,900	4,700	18	19
E	B	2,200	2,050	9	10
F	C	1,700	1,200	6	8
G	F	7,200	7,200	5	5
H	E	10,000	9,450	10	11
I	D,G,H	4,700	4,500	6	7

Activity Direct Cost Slope

Activity	Preceded by	Crash cost (CC) (u)	Normal cost (NC) (u)	Crash duration (CD) (days)	Normal duration (ND) (days)	Slope	Duration Reduction
A	-	3,900	3,600	6	7	300	1
B	A	6,500	5,500	3	5	500	2
C	B	7,200	6,350	7	9	425	3
D	B	4,900	4,700	18	19	200	1
E	B	2,200	2,050	9	10	150	1
F	C	1,700	1,200	6	8	250	2
G	F	7,200	7,200	5	5	NA	0
H	E	10,000	9,450	10	11	600	1
I	D,G,H	4,700	4,500	6	7	200	1
		Total Cost	44,500				

Steps for Crashing

1

- Identify activities on Critical path(s)

2

- Compare unit cost of crashing (critical) activities/combinations available for crashing*

3

- Select activity/combination with minimum unit cost. In case of a tie activity which influences more paths.

4

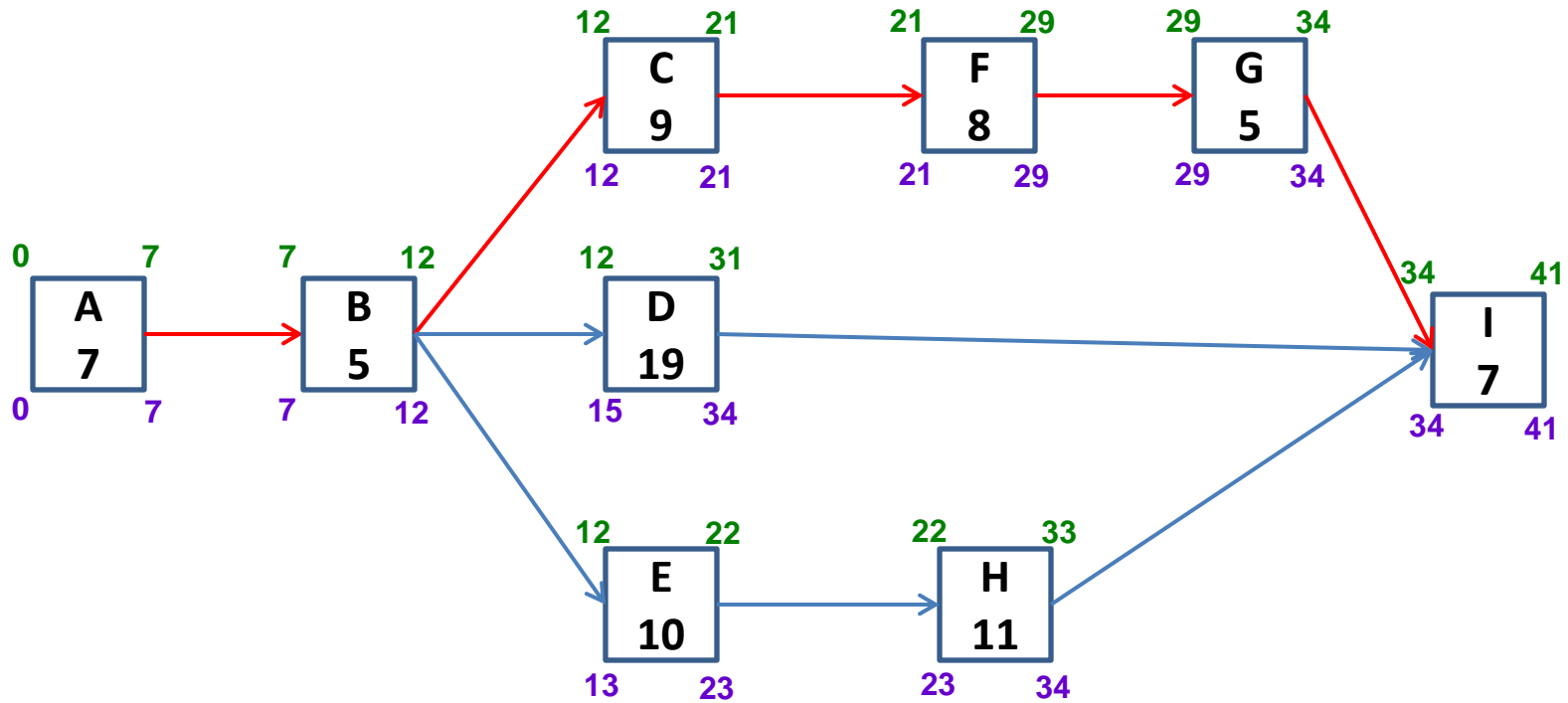
- Reduce duration of activity/ combination. (*ensure no other path becomes critical if duration reduction is by more than 1 day*)


5

- Recalculate network parameters and go to Step-1.

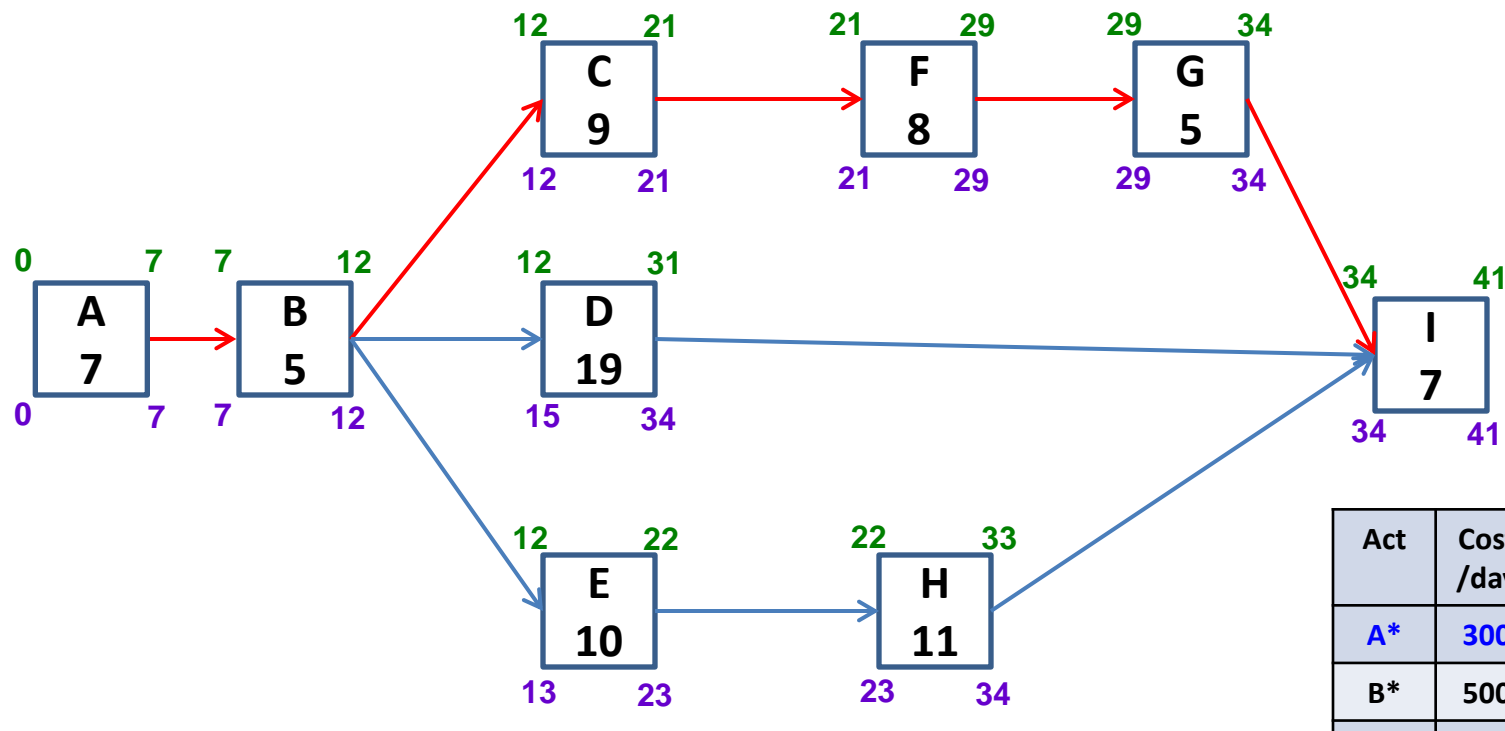
**Repeat Steps until activity/combination cannot undergo further crashing*

Network Analysis – Find Critical Activities



Paths Available : ABCFGI- 41days 
ABDI- 38 days
ABEHI- 40 days

Select Least Cost Activity to Reduce Duration

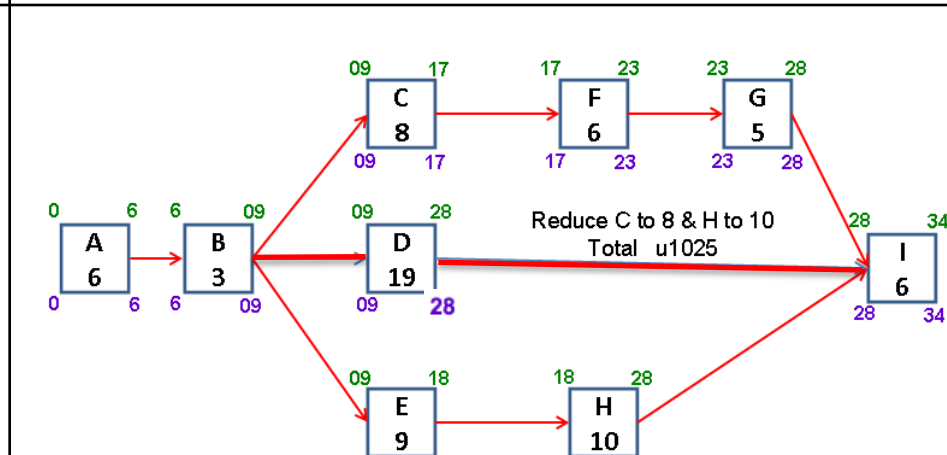
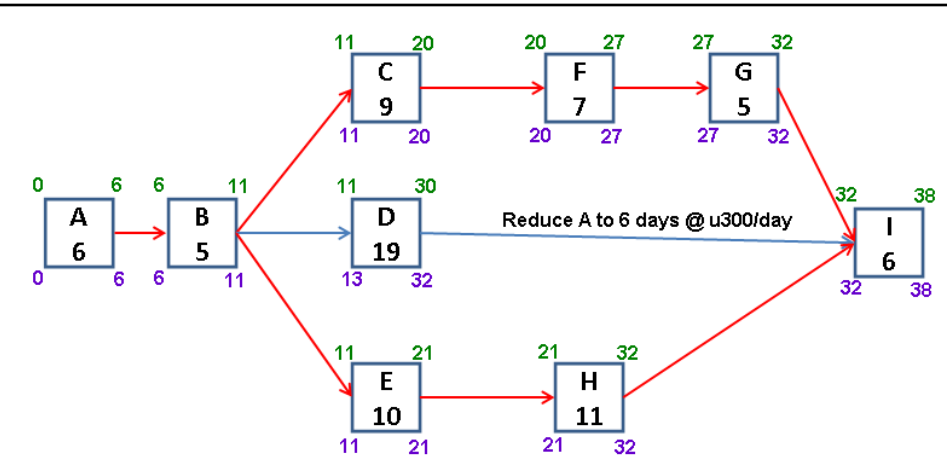
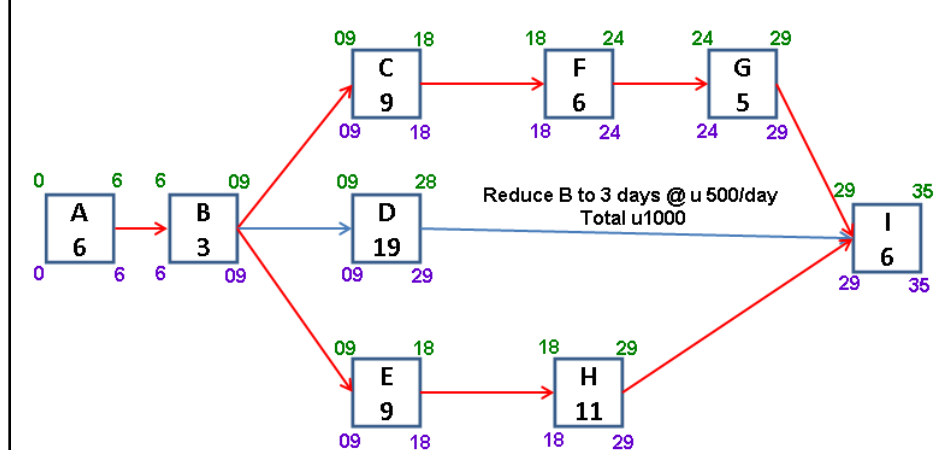
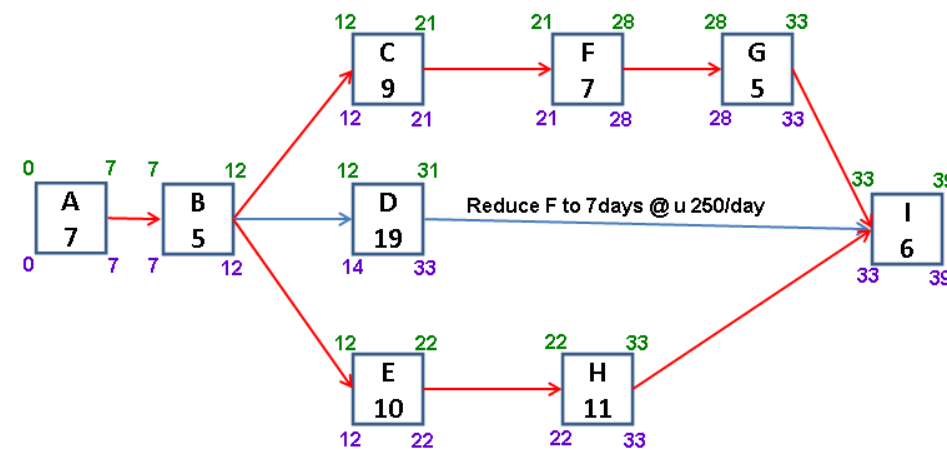
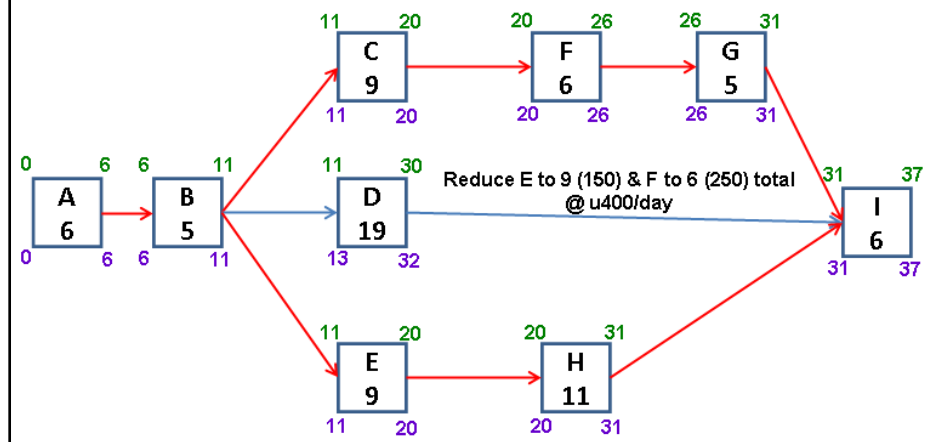
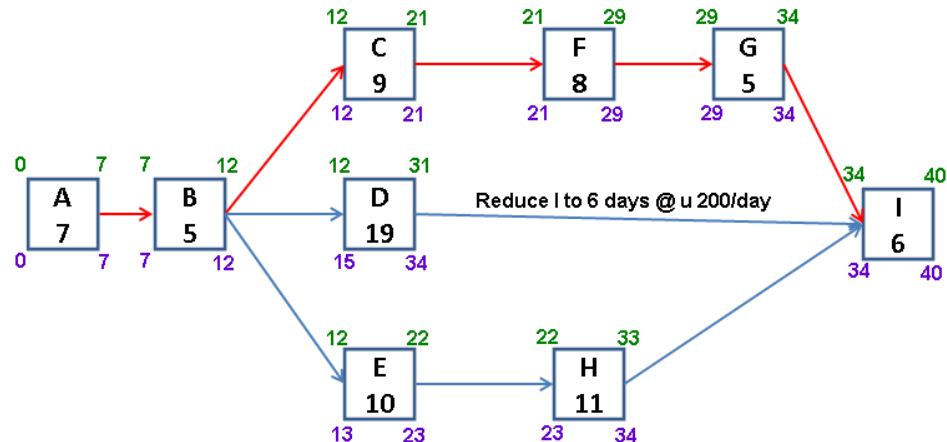


Path to be crashed : **ABC**FGI- 41days

Reduce I to 6 days @ u 200/day

Act	Cost /day	Dur Red
A*	300	1
B*	500	2
C*	425	3
D	200	1
E	150	1
F*	250	2
G*	0	0
H	600	1
I*	200	1





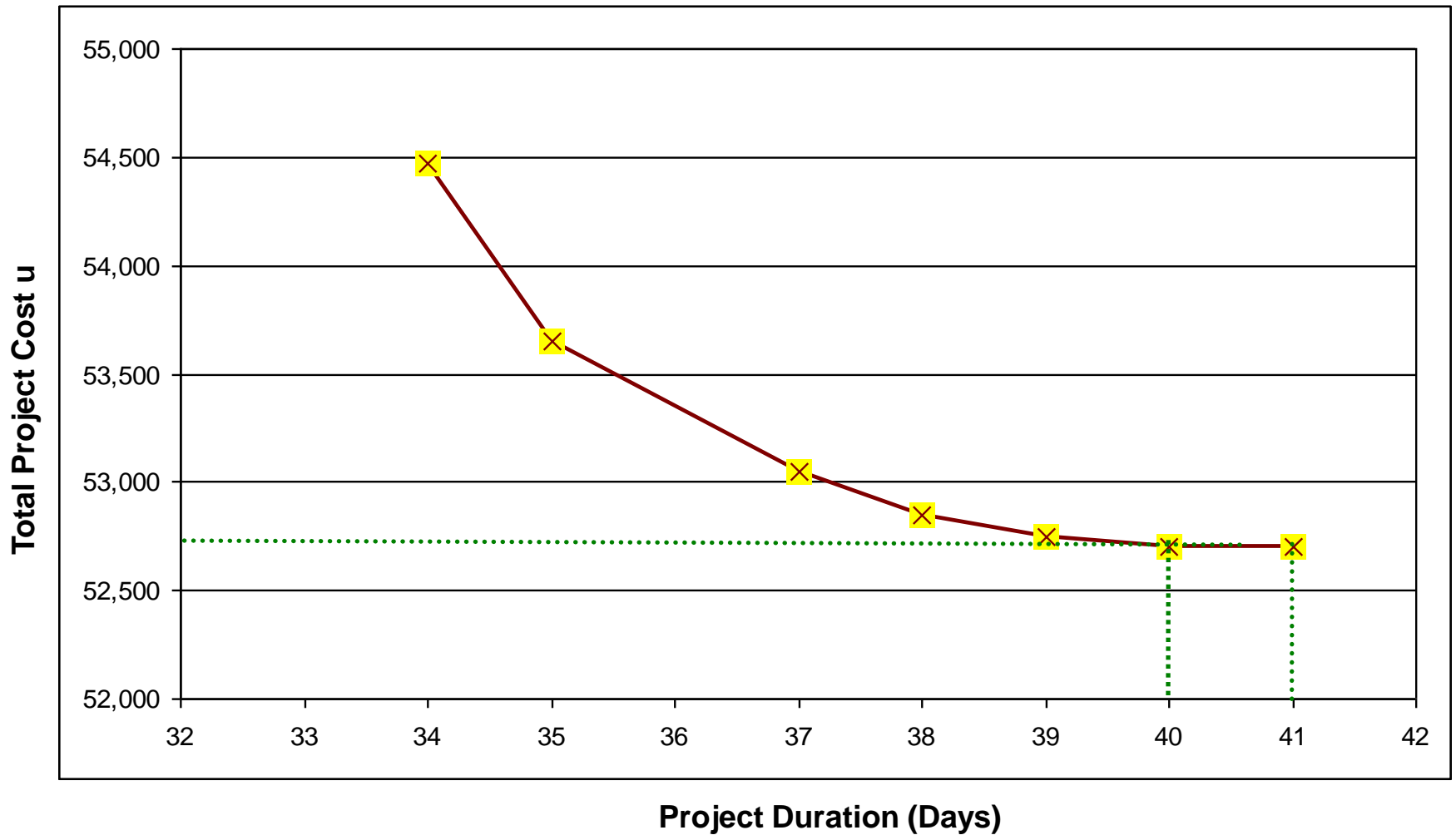
Cost table : Direct, Indirect, Total cost

Duration (days)	Direct Cost Change	Direct cost (u)	Indirect cost/day	Total Indirect cost (u)	Total cost (u)
41	0	44,500	200	8,200	52,700
40	+200	44,700	200	8,000	52,700
39	+250	44,950	200	7,800	52,750
38	+300	45,250	200	7,600	52,850
37	+400	45,650	200	7,400	53,050
35	+1000	46,650	200	7,000	53,650
34	+1025	47,675	200	6,800	54,475

Minimum total cost = **52,700**

Duration for minimum cost = **41 or 40** days

Project Duration vs Total Cost



Tabular Approach for Time Cost Trade-Off

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
A											
B											
C											
D											
E											
F											
G											
H											
I											
Initial Path length				Iteration	Action			Iteration cost			Cum-cost
Path Length											
											12

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
A	1	1	1	300	1						
B	1	1	1	500	2						
C	1	0	0	425	2						
D	0	1	0	200	1						
E	0	0	1	150	1						
F	1	0	0	250	2						
X G	1	0	0	0	0						
H	0	0	1	600	1						
I	1	1	1	200	1						
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
					Crash I by 1 day						
											13

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
	A,B,C,F,I										
A	1	1	1	300	1	1					
B	1	1	1	500	2	2					
C	1	0	0	425	2	2					
D	0	1	0	200	1	1					
E	0	0	1	150	1	1					
F	1	0	0	250	2	2					
X G	1	0	0	0	0	0					
H	0	0	1	600	1	1					
X I	1	1	1	200	1	0					
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
					Crash F by 1 day						
											14

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
						A,B,C,F,I	ABCF				
A	1	1	1	300	1	1	1				
B	1	1	1	500	2	2	2				
C	1	0	0	425	2	2	2				
D	0	1	0	200	1	1	1				
E	0	0	1	150	1	1	1				
F	1	0	0	250	2	2	1				
X G	1	0	0	0	0	0	0				
H	0	0	1	600	1	1	1				
X I	1	1	1	200	1	0	0				
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
	39	37	39	2	Crash F by 1 day			250			44950
					Crash A by 1 day						
											15

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
						ABCFI	ABCF	ABCFEH			
X A	1	1	1	300	1	1	1	0			
B	1	1	1	500	2	2	2	2			
C	1	0	0	425	2	2	2	2			
D	0	1	0	200	1	1	1	1			
E	0	0	1	150	1	1	1	1			
F	1	0	0	250	2	2	1	1			
X G	1	0	0	0	0	0	0	0			
H	0	0	1	600	1	1	1	1			
X I	1	1	1	200	1	0	0	0			
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
	39	37	39	2	Crash F by 1 day			250			44950
	38	36	38	3	Crash A by 1 day			300			45250
					Crash F,E by 1 day						
											16

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
						ABCFI	ABCF	ABCFEH	BCFEH		
X A	1	1	1	300	1	1	1	0	0		
B	1	1	1	500	2	2	2	2	2		
C	1	0	0	425	2	2	2	2	2		
D	0	1	0	200	1	1	1	1	1		
X E	0	0	1	150	1	1	1	1	0		
X F	1	0	0	250	2	2	1	1	0		
X G	1	0	0	0	0	0	0	0	0		
H	0	0	1	600	1	1	1	1	1		
X I	1	1	1	200	1	0	0	0	0		
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
	39	37	39	2	Crash F by 1 day			250			44950
	38	36	38	3	Crash A by 1 day			300			45250
	37	36	37	4	Crash F, E by 1 day			400			45650
					Crash B by 2 day						
											17

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
						ABCFI	ABCF	ABCFEH	BCFEH	BCH	
X A	1	1	1	300	1	1	1	0	0	0	
X B	1	1	1	500	2	2	2	2	2	0	
C	1	0	0	425	2	2	2	2	2	2	
D	0	1	0	200	1	1	1	1	1	1	
X E	0	0	1	150	1	1	1	1	0	0	
X F	1	0	0	250	2	2	1	1	0	0	
X G	1	0	0	0	0	0	0	0	0	0	
H	0	0	1	600	1	1	1	1	1	1	
X I	1	1	1	200	1	0	0	0	0	0	
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
	39	37	39	2	Crash F by 1 day			250			44950
	38	36	38	3	Crash A by 1 day			300			45250
	37	36	37	4	Crash F, E by 1 day			400			45650
	35	34	35	5	Crash B by 2 day			1000			46650
					Crash C,H by 1 day						18

Activity	Paths requiring time reduction			Cost Slope (u/day)	Available Crash time (ND-CD)	Iteration					
	ABCF GI	ABDI	ABE HI			1	2	3	4	5	6
						ABCFI	ABCF	ABCFEH	BCFEH	BCH	CH
X A	1	1	1	300	1	1	1	0	0	0	0
X B	1	1	1	500	2	2	2	2	2	0	0
C	1	0	0	425	2	2	2	2	2	2	1
D	0	1	0	200	1	1	1	1	1	1	1
X E	0	0	1	150	1	1	1	1	0	0	0
X F	1	0	0	250	2	2	1	1	0	0	0
X G	1	0	0	0	0	0	0	0	0	0	0
X H	0	0	1	600	1	1	1	1	1	1	0
X I	1	1	1	200	1	0	0	0	0	0	0
Initial Path length	41	38	40	Iteration	Action			Iteration cost			Cum-cost
Path Length	41	38	40	0	-			-			44500
	40	37	39	1	Crash I by 1 day			200			44700
	39	37	39	2	Crash F by 1 day			250			44950
	38	36	38	3	Crash A by 1 day			300			45250
	37	36	37	4	Crash F, E by 1 day			400			45650
	35	34	35	5	Crash B by 2 day			1000			46650
	34	34	34	6	Crash C,H by 1 day			1025			47675

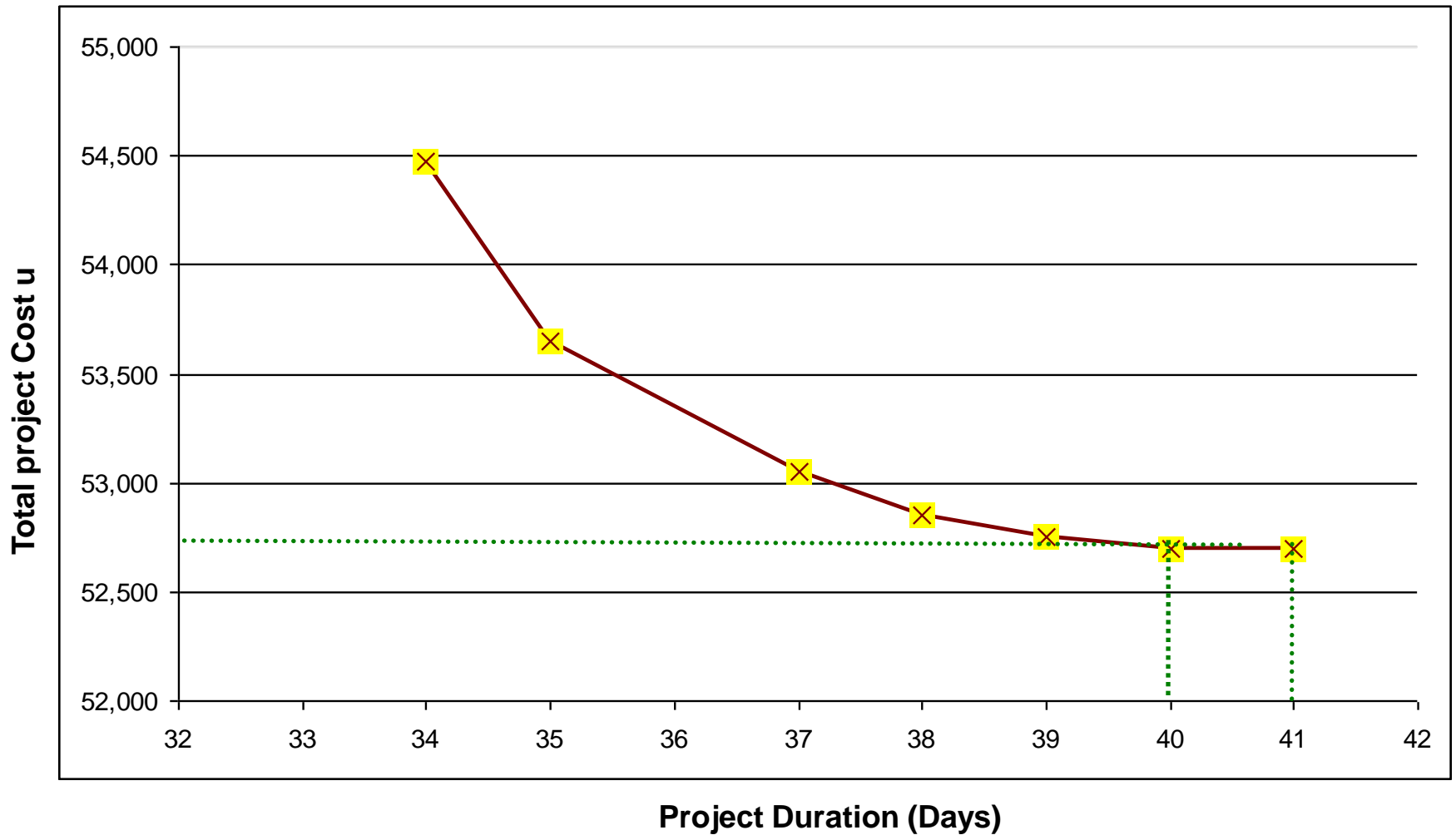
Cost table : Direct, Indirect, Total cost Indirect @ u200/day

Duration (days)	Direct Cost Change	Direct cost (u)	Indirect cost/day	Total Indirect cost (u)	Total cost (u)
41	0	44,500	200	8,200	52,700
40	+200	44,700	200	8,000	52,700
39	+250	44,950	200	7,800	52,750
38	+300	45,250	200	7,600	52,850
37	+400	45,650	200	7,400	53,050
35	+1000	46,650	200	7,000	53,650
34	+1025	47,675	200	6,800	54,475

Minimum total cost = u52,700

Duration for minimum total cost = 41 or 40 days

Project Duration vs Total Cost Indirect @ u200/day



Cost table : Direct, Indirect, Total cost Indirect @ u300/day

Duration (days)	Direct Cost Change	Direct cost (u)	Indirect cost/day	Total Indirect cost (u)	Total cost (u)
41	0	44,500	300	12,300	56.800
40	+200	44,700	300	12,000	56,700
39	+250	44,950	300	11.700	56,650
38	+300	45,250	300	11,400	56,650
37	+400	45,650	300	11,100	56,750
35	+1000	46,650	300	10,500	57,150
34	+1025	47,675	300	10,200	57,875

Minimum total cost = **u56,650**

Duration for Minimum Total Cost = **39 or 38 days**

Project Duration vs Total Cost Indirect @ u300/day

