Proceedings of the 4th International Conference on Civil Engineering for Sustainable Development (ICCESD 2018), 9~11 February 2018, KUET, Khulna, Bangladesh (ISBN-978-984-34-3502-6)

PROJECT PLANNING USING SCHEDULING TECHNIQUES: TIME & COST ASPECTS

Jhumana Akter[1], Akramul Hoq Hriday[2] and Tareq Rahman[3]

[1] *Assistant Professor, Department of Building Engineering and Construction Management, KUET, Bangladesh, e-mail: jhumana@becm.kuet.ac.bd*
[2] *Undergraduate Student, Department of Building Engineering and Construction Management, KUET, Bangladesh, e-mail: hridayhoq97@gmail.com*
[3] *Undergraduate Student, Department of Building Engineering and Construction Management, KUET, Bangladesh, e-mail: Tareq2626@gmail.com*

ABSTRACT

Completing a project on time and within budget depend on dead line or completion date of the project. Cost generally increases if we want to complete the project shorter than its completion time. This process reminds as crashing. Which involve additional cost of project. However, we need to find minimum project cost that makes the project successful. Proper Project planning and scheduling plays a central role in predicting both the time and cost aspects of a project. This study is aimed at finding trade-off the cost within expected time that will be required to complete the project foundation [TSC-block-A] in 60 days due to weather impact in rainy season. The calculation data was obtained from KUET Engineering section. Both (CPM) and (PERT) method were used for the analysis. Project duration for foundation work was 106 days. Using PERT techniques, we get 78 days completion time, which is 27 days shorter than schedule time. Due to this, shorten time cost also increase. This amount was tk.950000. Because of unfriendly climate, state project delay 6 month, instead of 12-month completion time. For this work budget was approximately tk.10076000.But our completion baseline was 60 days. there is need to 18 days crash than critical time 78 days .so that additional cost is required.so in this study our objective is to find minimum additional cost associated with the reduction in timing is tk.800000 which increases the total expected cost required to complete the substructure from tk. 10076000 to tk.11826000.

Keywords: *Construction planning, Critical Path Method, Project Evaluation and Review Technique, crashing.*

1. INTRODUCTION

Completing a project on time and within budget is not an easy task. In spite of advances in the field of project management today, most projects in Bangladesh today face cost and time over-runs which increases with the increase in complexity of the project.A various number of factors influence to delays that comprise primarily of contractor delays, client delays, consultant delays, labor related delays and Various other external delays. These delays causes time overrun, cost overrun, dispute, negotiation, total rejection and litigation. This is because small amount of project activities are critical in the common sense that delay in their beginning will delay the overall project completion time. Hence good planning and scheduling of project is important to overcome this problem. For many years, two approaches that have been proven to be useful for planning, scheduling and controlling construction projects have been the Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT).(Adebowale & Oluboyede, 2011) These techniques enables project managers to evaluate the early and late times at which activities can start and finish, calculate activity float (slack), define critical activities, and evaluate the impact of variations in duration, logical relations and cost on the overall project duration. Both CPM and PERT are network based techniques and therefore help in programming and monitoring the progress of the stages involved so that the project is completed within the deadline.(Sharma, 2006) In doing this, it specifies the part of the project that are crucial which if delayed beyond the normal time would increase the completion time of the project as a whole. It help to assists in allocating resources, such as labour and equipment and thus helps to make the total cost of the building project a minimum by finding the optimal trade-off between various costs and time involved .Hence CPM assumes preceding experience with similar projects from which the relationships between resources and job times are obtainable. On the other hand, PERT includes uncertainties in activity times in its analysis.(Adebowale & Oluboyede, 2011) It determines the possibilities of completing various stages of the project by specified deadlines. It also calculates the expectedtime to complete the project. In further words, it detects the activities that have high potential for causing delays in completing the project on schedule. Thus, even earlier the project has started, the project manager knows where he or she can guess delays. Then manager can take the necessary preventive measures to decrease possible delays so that the project schedule is on track. Actually, both techniques, PERT and CPM,(Grant, 1983) were developed almost simultaneously. Project managers (PM) often meet the problem of having to shorten the scheduled completion time in order to accelerate the execution of a project. Reducing the project duration can achieved by adding more resources to the, resources or by assigning additional labor. This managerial decision of supplementary resources, overtime and labor will however rises the overall cost of the project thus trimming down the project duration of activities on critical path. This idea of project management which involves investment of extra budget in order to minimize the duration to meet the targeted date is known as crashing.(Adebowale & Oluboyede, 2011) The objective of accelerating project by crashing total project duration is helpful so that delays can be recovered and liquidated damages can be avoided.

2. STUDY AREA & METHODOLOGY

2.1 Study location and data description

"TSC-building-KUET" (Figure 1&2) which is situated in besides KUET auditorium in Teligati, PhulBari Gate was selected as our study area. This building consists of 4-block. Block –A was selected for analysis. It is two storied building. Specifically we work with foundation portion (Figure 2) illustrate this.

Figure 1: Location of TSC from google earth

Figure 2: Site construction image of TSC-KUET

The project plan of the TSC building foundation work has the various activities that would be carried out, as well as the duration (days) and cost of each activity in KUET area. The activities included planning, procurement of materials, excavation, plumbing and so on. The data contains the level of precedence among various activities, as well as the cost of each activity. To prevent clumsy analysis, activities were grouped.

2.2 Methods

This study focused on the cost and on the available duration (days) of the activities of carrying out the project. The duration is in multiple time estimates, that is, the optimistic time, the most likely time and the pessimistic time estimate. The network analysis procedures were used in analyzing the data; this involves the critical path method (CPM), project evaluation and review technique (PERT) and probability estimation. The aim of estimating probability is to find out the possibility that a node j in the network will occur by a pre-specified scheduled time, Sj, assuming that all the activities in the network are statistically independent. This probability was estimated in this study using

In CPM networking, all the activities time estimates are single values with the assumption that activity time are known with certainty by using a single activity time estimate. In reality however, it is rare to have activity time estimate to be certain. This is because projects longest time is the activity required to be completed assuming everything went on normally. Therefore, the three time estimates were subsequently used to estimate the expected time (mean) and variance of the distribution. Expected time is the weight average of the three time estimates (optimistic (a), pessimistic (b) and most likely time (M).(Adebowale & Oluboyede, 2011)
Average of the three time estimates (optimistic (a), pessimistic (b) and most likely time (M)):

$$Expected\ time\ (\ mean\ )\ =\ \frac{a+b+4M}{6} \tag{1}$$

$$Variance\ =\ \frac{(\ b-a\ )\wedge 2}{6} \tag{2}$$

Project crashing was done using:

$$Cost\ slope\ =\ \frac{Crash\ Cost(\ CC\ )-\ Normal\ Cost\ (NC)}{Crash\ Time(\ CT\ )-\ Normal\ Time\ (NT)} \tag{3}$$

The data were collected from KUET Engineering section scheduling & costing tender document & site engineer. The floor plan of the building is the first phase of the building project after clearing of the bush on the site.

PERT analysis was used to obtain the cheapest cost by crashing as many activities as possible on the critical path.

3. ANALYSIS & RESULT

3.1 Data presentation & Activity selection

Table 1 shows the description of activities involved for the construction process of TSC-block [A] construction project inTeligati, PhulBari Gate, at KUET. The construction activities begin with activity A and ends with activity k. Table 2 shows the distribution of the project activities relative to the actual number of days to complete individual activity and their respective cost implication in terms of Bangladeshi tk. of the project. The costs are basically labour costs based on the assumption that materials are already available for use. If, once the materials are available, the reduction in number of days to complete a particular activity will only be affected by the cost of hiring additional labour. Table 3 shows the project activity according to activities that must be performed before the next activity can begin, this is called the predecessor. The optimistic estimate (a), most likely estimate (m) and pessimistic estimate

(b) of the building were determined to see the variations in the estimates as they affect the construction activities, were computed as shown in Table 4. The critical path calculations (Kelley Jr & Walker, 1959)involve two passes: The forward pass determines the earliest occurrence times of the events, and backward pass calculates their latest occurrence times (Oberlender & D, 1993). The earliest time is calculated as follows:

Table 1: Description of activities in a research process to completion the project foundation

Activity	Activity description	Predecessors
A	Site clearing & removal of trees	—
B	Earthwork Excavation	A
C	Grading General area	A
D	Earth filling & brick flat soling	B,C
E	Footing formwork & concrete placing	B
F	Rever binding for column & GB	D,E
G	Installing utility lines	B,D
H	Formwork for column & GB	F,G
I	Pouring concrete	H
J	Removal of formwork	I
K	Filing with sand up to plinth	880

3.2 Critical path method (CPM) & PERT analysis

Using activity relationship from (table-1) critical path was drawn. Where i is the starting node number for a particular activity; j is the ending node number for a particular activity; tij is the expected time to complete activity.

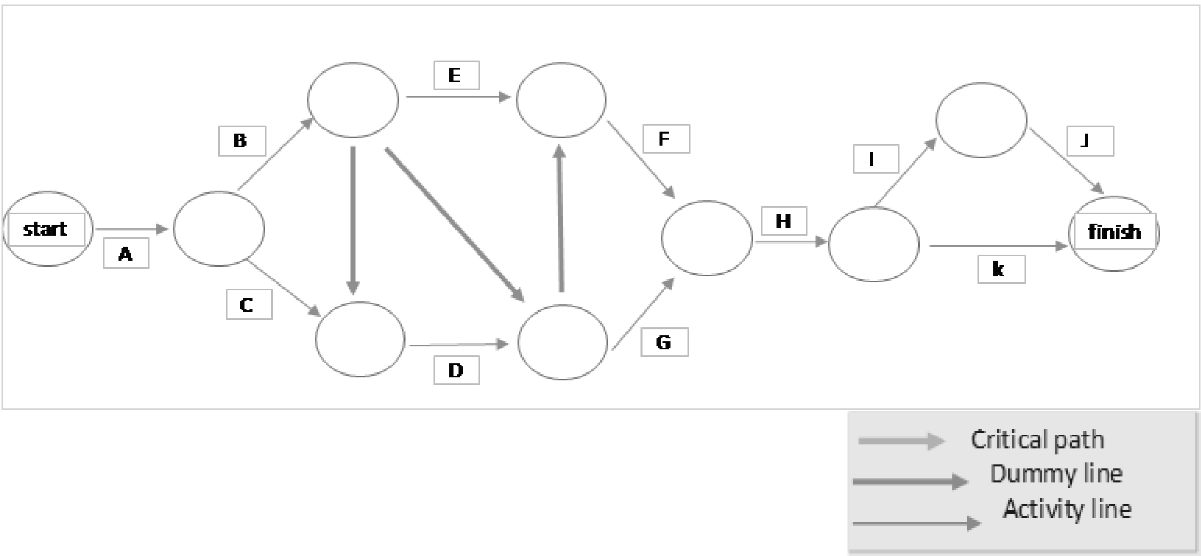

Figure 3: Network diagram of --TSC-block [A]

Table 2: Project Activity, Predecessor, optimistic estimate (a), most likely estimate (m) and pessimistic estimate (b) of a construction project TSC-block [A]-foundation work

Activity	Predecessors	Optimistic estimate (a)	Most likely estimate (m)	Pessimistic Estimate (b)
A	—	17	19	27
B	A	12	14	22
C	A	5	7	14
D	B,C	5	8	10
E	B	7	10	15
F	D,E	5	7	13
G	B,D	4	6	10
H	F,G	4	6	8
I	H	9	11	19
J	I	4	6	14
K	H	4	5	9

Table 3. Mean and variances of activities of a building construction project at KUET area, in PhulBari-Gate

Activity	Predecessors	Expected duration-(a+4m+b/6)	Standard Deviation (sigma)-(b-a/6)	Variance $(b\text{-}a/6)^2$
A	—	20.00	**1.67**	2.78
B	A	15.00	1.67	2.78
C	A	7.83	1.50	2.25
D	B,C	7.83	0.83	0.69
E	B	10.33	1.33	1.78
F	D,E	7.67	1.33	1.78
G	B,D	6.33	1.00	1.00
H	F,G	6.00	0.67	0.44
I	H	12.00	1.67	2.78
J	I	7.00	1.67	2.78
K	H	5.50	0.83	0.69

The analyses of the paths are shown as:

Various path:

1. PATH-1: A-B-E-F-H-I-J (time= 78 days)
2. PATH-2: A-B-E-F-H--K (time= 64.5 days)
3. PATH-3 : A-C-D-G-H-I-J (time = 67 days)
4. PATH-4: A-C-D-G-H-K (time = 54 days)
5. PATH -5 : A-G-I-DUMMY-K-L-M (time = 26.08)
6. Path-6 : A-G-I-J-L-M (time =24.75)

Table 3 shows the Means and Variances of Activities along the Identified Critical Path. In actual fact, many project work are full of uncertainties, in this project however, the longest path is ABEFHIJ (critical activity), which means the completion time is approximately 78 days. Then, it becomes necessary to know how realistic this will be by estimating the probability of achieving this scheduled date. Therefore, in order to know whether this project time can be completed at this time, we assumed a completion number of days say 85. Thereafter, we computed the concept of crashing.

3.3 Project variance & probability analysis

Project variance on critical path = 2.78+2.78+1.78+1.78+0.44+2.78+2.78= 15.12

Therefore, in order to know whether this project time can be completed at this time, we assumed a completion number of days say 85. Thereafter, we computed the probability that the project will be completed in less than 85 days as:

$$Z = \frac{x-\mu}{\sigma} \qquad = \frac{DUE\ DATE - EXPECTED\ DATE\ OF\ COMPLETION}{\sqrt{PROJECT\ VARIENCE}} \tag{4}$$

$$= \frac{90-78}{\sqrt{15.12}} \quad = 1.80$$

p(z≤ 1.80) from Z distribution table = 0.961 = 96% (approximate.).Therefore, the probability that project will be completed in less than 85 days

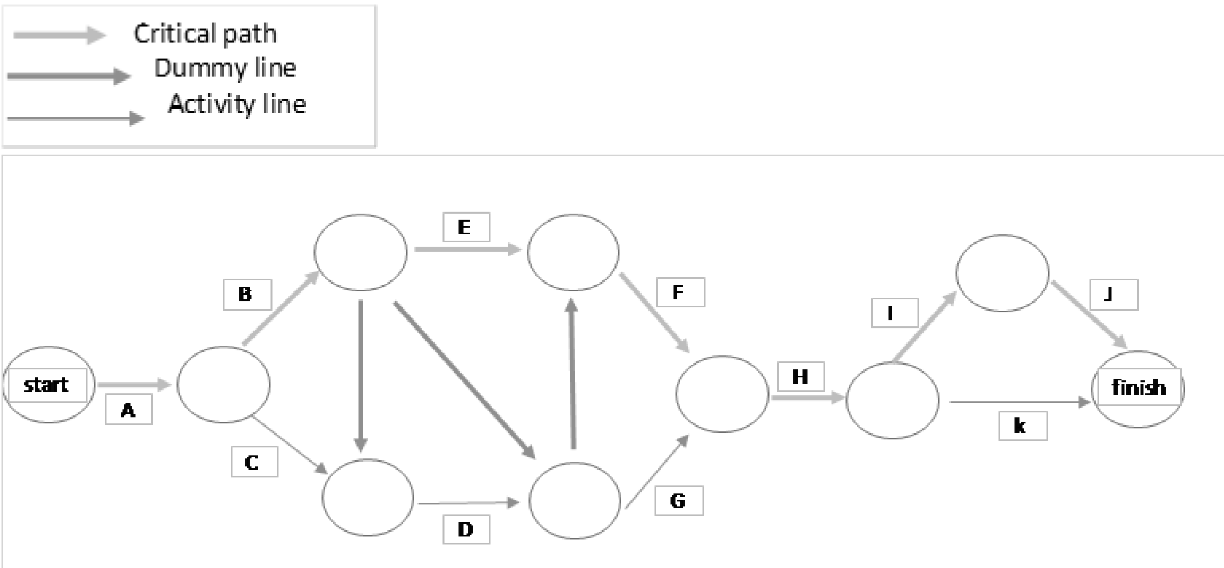

Figure 4: Network diagram with critical path--TSC-block [A]

Table 4: The earliest time, latest time and slack activities of a building construction project at KUET,in Teligati,PhulBari Gate

	Duration	ES	EF	LS	LF	Slack(TF)
A	20	0	20	3	20	0
B	15	20	35	0	35	0
C	7.83	20	27.83	5	37.5	9.67
D	7.83	35	42.83	7	45.33	2.5
E	10.33	35	45.33	9	45.33	0
F	7.67	45.33	53	21.33	53	0
G	6.33	42.83	49.16	10.33	53	3.84
H	6	53	59	11.33	59	0
I	12	59	71	16.33	71	0
J	7	71	78	23.66	78	0
K	5.50	59	64.5	22.33	78	13.5

3.4 Cost analysis using crashing

This building project analyses will be incomplete if the cost associated with its monetary terms is not worked out. The essence of cost analyses is to determine the optimum cost of the project using the method of least cost scheduling.(Wiest & Levy) This was done by reducing the time of activities on the critical path with the lowest cost slope.(Adebowale & Oluboyede, 2011) If the time is reduced this will in turn increases the cost. This could result to extending the hours of work per day or hiring more labour:

$$Cost\ slope\ =\ \frac{Crash\ Cost(\ CC\ )-\ Normal\ Cost\ (NC)}{Crash\ Time(\ CT\ )-\ Normal\ Time\ (NT)} \tag{5}$$

Table 5: Project Activity, Days (actual and crash) and cost (actual and crash) of TSC-block [A] foundation construction project at KUET in Teligati, PhulBari Gate

	Duration (days)		Cost (tk* 10^3)		
Activity	**Actual**	**crash**	**Actual**	**Crash**	**Cost slope**
A	20	15	338	423	17
B	15	10	468	608	28
C	7.83	5.83	250	310	30
D	7.83	5.83	2060	2310	125
E	10.33	7.33	2260	2560	100
F	7.67	5.67	1450	1630	90
G	6.33	4.33	550	620	35
H	6	4	800	950	75
I	12	8	650	760	27.5
J	7	5	450	525	37.5
K	5.50	4.50	800	880	80
		Total	**10076**	**11576**	

Table 6: Activities crash cost/day calculation of TSC-block [A] foundation construction project at KUET in Teligati,PhulBari Gate

Activity	Actual time	crash time	maximum crash time	Actual cost 1000 tk	Crash cost	crash cost /day
A	20	15	5	338	423	17
B	15	10	5	468	608	28
C	7.83	5.83	2	250	310	30
D	7.83	5.83	2	2060	2310	125
E	10.33	7.33	3	2260	2560	100
F	7.67	5.67	2	1450	1630	90
G	6.33	4.33	2	550	620	35
H	6	4	2	800	950	75
I	12	8	4	650	760	27.5
J	7	5	2	450	525	37.5
K	5.50	4.50	1	800	880	80

Table 7: Crashing analysis of TSC-block [A] foundation construction project at KUET ,for 18 days reduction from critical path duration.

A-B-E-F-H-I-J =73 DAYS (AFTER 5 DAY CRASHING)	this is critical path & A crash due to lowest cost slope
A-B-E-F-H-I-J =71 DAYS (AFTER 2 DAY CRASHING)	this is critical path & H crash due to lowest cost slope
A-B-E-F-H-I-J = 67 DAYS (AFTER 4 DAY CRASHING)	this is critical path & I crash due to lowest cost slope
But now we get two critical path of same time 67 days path -1 & path-3	
A-B-E-F-H-I-J = 64.5 DAYS (AFTER 2.5 DAY CRASHING)	this is critical path & B crash due to lowest cost slope
A-C-D-G-H-I-J= 65 DAYS(AFTER 2 DAY CRASHING)	this is not critical path & C crash due to lowest cost slope
But now we get two critical path of same time 64.5 days path -1 & path-2	
A-B-E-F-H-I-J = 62 DAYS (AFTER 2.5 DAY CRASHING)	this is critical path & B crash due to lowest cost slope
A-B-E-F-H-K= 62 DAYS (AFTER 2.5 DAY CRASHING)	this is critical path & B crash due to lowest cost slope
But now we get two critical path of same time 62 days path -1 & path-2	
A-B-E-F-H-I-J = 60 DAYS (AFTER 2 DAY CRASHING)	this is critical path & J crash due to lowest cost slope
A-B-E-F-H-K= 61 DAYS (AFTER 1 DAY CRASHING)	this is not critical path & K crash due to lowest cost slope

Table 8: Crashing cost of TSC-block [A] foundation construction project in Teligati, PhulBari Gate at KUET after 18 days reduction from critical path duration

Activity	calculation	cost(TK*10^3)
A	338+(5*17)	423
B	250+(2*30)	608
C	468+(5*28)	310
D	2060	2060
E	2260	2260
F	1450	1450
G	550	550
H	800+(2*75)	950
I	650+(4*27.5)	760
J	450+(2*37.5)	525
K	800+(1*80)	880
	Total	10876

4. CONCLUSIONS

The problem of poor project execution, non-completion And behind schedule, which are rampant in our society. A various number of factors influence to delays.Due to cost and time over-runs can increases complexity of the project.so that this require proper analysis to control. Our main objectives to find minimum cost in project completion time. For this actually use PERT & CPM to find optimum time which is less than schedule time 105 days in foundation work of TSC-block[A]. That we find that was the longest path in network (critical path). Where we get time 78 days less than 105 days .in this path slack was zero. Our completion time was 60 days .which is less than 18 days of 78 days. So that crashing was required to reach completion time & find cost minimum.so for his finally we get total project cost TK.10876000. If network analysis tools are employed and incorporated into the project plan at the onset of work activities. Also, the task of building project management can be improved if network analysis technique is adopted, this will identify minimum time a building project can take before completion. It will eliminate any sort of redundancy or dangling of activities, so that the developer can meet the needs of other clients who need its services at other building sites. So that we can complete in due time the project TSC-block [A] KUET, where it was delay 6 months than its schedule time 12 months.

ACKNOWLEDGEMENTS

Actually this work is very difficult to do because management system is not popular in Bangladesh, so that proper data collection was difficult. Thanks to Assistant professor (Mrs.) Jumna Akhter, Eng. Ikramul Hoque (BECM, KUET) for guideline & Eng. Saidul Islam (Engineering Section KUET) for tender document providing.

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