AN OPTIMIZATION TECHNIQUE IN CORPORATE SUSTAINABILITY BY ANALYZING ACTIVITIES OF ANY CORPORATION

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ABSTRACT: Project management in construction encompasses a set of objectives which is to be accomplished by implementing a series of operations subject to resource constraints. The design process can be characterized by a series of actions that are highly interactive. In this work we introduced an effective technique to estimate optimum cost and budgeting by scheduling time to manage a construction project. The main objective of this study is to develop an effective technique in planning, designing, financing, constructing, and operating physical facilities with increasing economic sustainability. We use here some deterministic tools such as PERT, CPM and then to use crashing to find an efficient way. The traditional method of crashing PERT networks has been to convert the model to a deterministic model by analyzing activities of the project. The network is then crashed in a series of iterative steps until the expected completion time of the project is acceptable, the cost of crashing exceeds the benefits, or all activities have been crashed as much as possible.
Keywords: economic development, resource constraints, corporate sustainability

1. INTRODUCTION

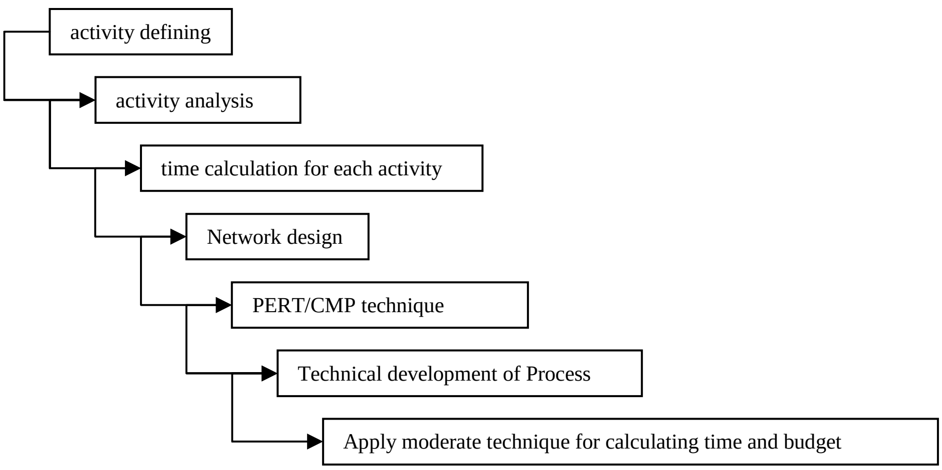
Project Management is the combination of Planning, designing, financing, constructing and physical facilities. The process of planning, designing, financing, constructing and operating physical facilities has a different perspective on project management for construction. In Bangladesh prospect, its efficient management can save lot of currency as well as the social cost of the under developing country. The over all review of this work explain a moderate technique of schedule time and budget of any construction project by using the PERT/CPM whereas crashing has an effective role to provide a new time and budget estimation for any construction project. Therefore it is easy to take decision for the firm's manager to complete the project successfully which maximize social impacts. Corporate sustainability is important in economic development in developing countries (e.g. Bangladesh) and to protect the environment.

2. METHODS

The series of actions taken in the conceptual design process can be described as follows:

- Formulation refers to the definition or description of a design problem in broad terms through the synthesis of ideas.

In this sense our effective moderate technique takes some sequential steps to complete the project. This sequence of activity compute minimum required time and cost for successful completion of a project. The series of activity are as follows:



- Analysis refines the problem definition or description by separating important from peripheral information and by pulling together the essential detail. Interpretation and prediction are usually required as part of the analysis.

Our moderate technique follows analysis of the total project by means of some small unit of activity. Therefore the project will be divided into number of activities. In our research we classify the total project in the following manner:

Activity	Event	Preceding Activity
ac1	Foundation upto PL Site Cleaning and Preparation (x_1) Earth work in Excavation (x_2) Earth work in Box cutting (x_3) Single layer brick flat soling (x_4) Foundation up to estimated floors (x_5) Sand filling in foundation (x_6)	×
ac2	Making ground floor	ac1
ac3	Internal and external plinth wall	ac1
ac4	Internal and external brick wall	ac3
ac5	Lintel work	ac4
ac6	Doors and windows works	ac5
ac7	Making hole for electric and other purpose	ac1, ac4
ac8	Railing and stair works	ac4, ac6, ac7,
ac9	Works for other floors	ac8
ac10	SANITARY AND WATER SUPPLY WORKS	ac9
ac11	INTERNAL ELECTRICAL WORKS	ac9

- Search involves gathering a set of potential solutions for performing the specified functions and satisfying the user requirements. In this paper we introduce some deterministic tools for calculating the required time for each activity.
- Decision means that each of the potential solutions is evaluated and compared to the alternatives until the best solution is obtained. In this work we compute the time for each activity and use them for formulate corresponding variance which determine the percentage of work remaining and the amount of work we have to do within the projected time.
- Specification is to describe the chosen solution in a form which contains enough detail for implementation.

Basis of these presented data we developed a network diagram by following the preceding and succeeding activity of any project and then use two deterministic tools. Such as:

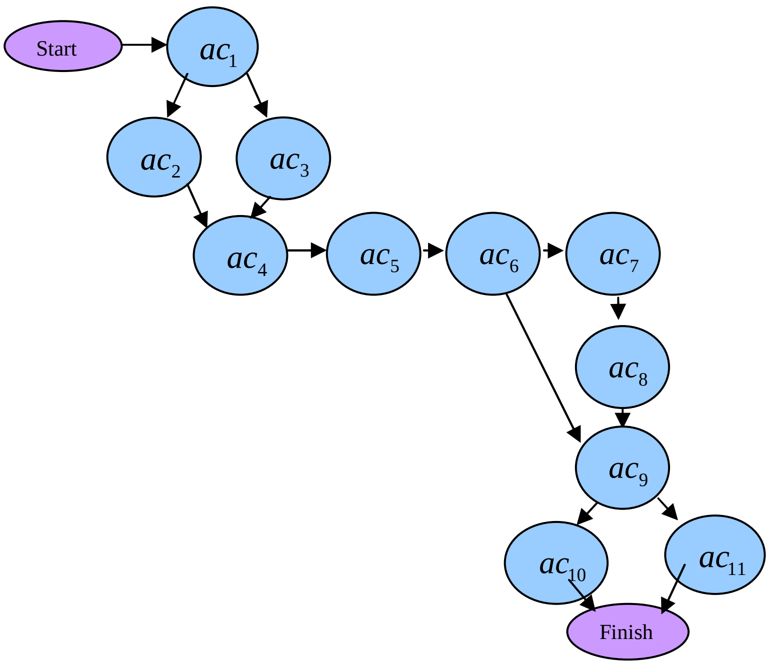
a) PERT (Project Evaluation and Review Technique) and

b) CPM (Critical Path Method).

where algorithms define the Critical Path of the project and different tools of Critical Path also be illustrated according to the process of calculation of CPM[1].

- Modification refers to the change in the solution or re-designs if the solution is found or if new information is discovered in the process of design. Finally this paper shows the moderate technique for calculating the minimum time and budget for successful completion of the defined project in gradually from beginning to the end.

Figure 1. Network Diagram of the Project activity



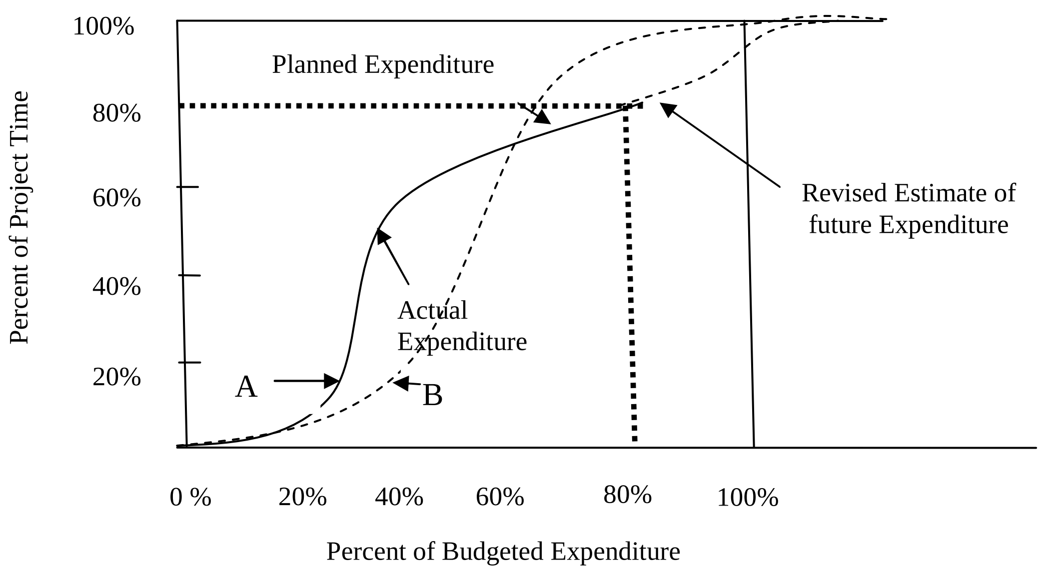
In general, the actions of formulation, analysis, search, decision, specification and modification still hold, but they represent specific steps with less random interactions in detailed design. The design methodology thus formalized can be applied to a variety of design problems.

Critical Path on the project activity:

The critical path is one having longest-time span through the total system of events. The Critical path is the path where the slack time is zero. Critical path of our selected project is shown in table 2. Figure 2 shows the originally scheduled project progress versus the actual progress on a project. This figure is constructed by summing up the percentage of each activity which is complete at different points in time; this summation can be weighted by the magnitude of effort associated with each activity. Also in figure 2, the project was ahead of the original schedule for a period including point A, but is now late at point B by an amount equal to the horizontal distance between the planned progress and the actual progress observed to date. Schedule adherence and the current status of a project can also be represented on geometric models of a facility. The result is a mechanism to both indicate work in progress and schedule adherence specific to individual components in the facility.

In evaluating schedule progress, it is important that some activities possess float or scheduling leeway, whereas delays in activities on the critical path will cause project delays. In particular, the delay in planned progress at time t may be soaked up in activities' float (thereby causing no overall delay in the project completion) or may cause a project delay. As a result of this ambiguity, it is preferable to update the project schedule to devise an accurate portrayal of the schedule adherence. For cash flow planning purposes, a graph or report similar to that shown in the following figure can be constructed to compare actual expenditures to planned expenditures at any time.

Figure 2. Illustration of Planned versus Actual Expenditures on a Project



The Budgeting Process:

In the budgeting process it is required to determine how much is to be spent per unit time (day). To attain the unit time cost the following four steps are followed:

a) Identify all types of cost associated with each of the activities and sum up them together to obtain the total estimated cost or budget for each activity.

b) In case of a large project, combine groups of several activities into a work package (a logical collection of activities).

c) Transform budgeted cost per activity into a cost per unit time. The assumption is that the cost of completing any activity is spent at a uniform rate over time.

d) With the help of earliest and latest start times, estimate how much money should be spent per unit time in order to complete the project within the given deadline.

Activity cost per unit time and the total cost for the project are presented in the table 3. On the basis of the steps we formulate the budget for the project herein the table 4.

Monitoring and Controlling Project Cost:

Its aim is to highlight whether the project is on schedule, behind schedule or ahead of schedule and also to ensure that cost overruns are kept at minimum. In that purpose the status of the project should be checked periodically. In case of negative activity difference, there is a cost under run and in case of positive activity difference there is a cost overrun. The total budgeted cost, percentage of work completion, value of work completed, actual cost and activity difference are shown in Table 5. Generally, project manager needs to speed project work to finish on time, and also carefully control the activity cost in order to eliminate the current cost over run. For careful monitoring and controlling project cost, the budgeted amount, the value of work completed and the actual costs should be calculated periodically.

Critical Path Method (CPM) for crashing project activity:

The objective of crashing is to reduce project duration while minimizing the cost of crashing. It has already been mentioned that CPM is a deterministic network model. CPM uses two sets of time and cost estimates for each activity: a normal time and associated cost, and a crash time and associated cost. The normal time of an activity is like the expected time of PERT to finish the activity and the normal cost is an estimation of the associated cost. The crash time of an activity is the shortest possible activity completion time and the crash cost is the associated required cost. The critical path calculation for CPM is the same as in PERT. The process of shortening a project is called crashing and is usually achieved by adding extra resources (overtime, hiring additional temporary help, using special time saving materials, engaging a special equipment, etc.) to an activity.

Project crashing with CPM:

Step 1 Find the normal critical path and identify the critical activities.

Step 2 Compute the crash cost per unit time for all activities in the network using:

$$\text{Crash cost/unit time} = \frac{\text{Crash cost - Normal cost}}{\text{Normal time - Crash time}}$$

Step 3 Select the activity on the critical path with the smallest crash cost per unit time. Crash this activity to the maximum extent possible or to the point at which desired project completion time has been reached. If the desired completion time is attained, go to step (5) else follow the next step 4.

Step 4 Check whether the critical path is still critical (often a reduction in the activity time in the critical path causes a non-critical path or paths to become critical). If the critical path is still critical, return to step (3). If not, find the new critical path and then return to step (3).

Step 5 Stop

The table 6 gives the data for normal and crash times and their costs, maximum reduction in activities times and crash cost per day.

Project Crashing:

The modeling approach will be explained here with the modeling of data (Shaheedullah and Associates Ltd.'s Bangladesh). The modeling of the project has eleven activities. Thus we have to make an algorithm for crashing of eleven activity of the construction project.

Assume that activity 1 for activity ac_1, activity 2 for activity ac_2, activity 3 for activity ac_3… activity 11 for activity N.

Let x_j = reduction in the activity time of activity j in obtaining the best project crashing Schedule

y_j = start time of an activity j for j = 2, 3,…,11. (no such variable is needed for ac_1, since an activity that begins the project is automatically assigned a value of 0)

y_c = Project completion time with crashing activities. Then using the crashing cost per week in table 6, we have to minimize the total cost of $282862.26x_1 + 48202.24x_2 + ... + 54445.29x_{11}$. For each of the activities 2, 3,…,11.

Start time of an activity ≥ (start time + duration) of the immediate predecessor activities

So, duration of an activity with crashing = its normal time - x_j. For example, activity ac_5 is the immediate predecessor of the activity ac_6. Normal time of activity ac_5 is 0 days and its duration after crashing is $0 - x_5$. So from the above formula we have

$$y_6 \geq y_5 + 0 - x_5$$

Thus activity ac_6 cannot start until activity ac_5 starts and completes its duration $0 - x_5$. Again consider activity ac_7. Both activity ac_1 and activity ac_4 are immediate predecessors of activity ac_7. After crashing:

- activity ac_1 has the duration $10 - x_1$
- activity ac_4 has the duration $1 - x_4$

Thus, the relationships between these activities are:

$$y_7 \geq y_1 + 10 - x_1$$

$$y_7 \geq y_4 + 1 - x_4$$

These 2 inequalities together indicate that activity ac_7 cannot be started until both of its predecessor activities are finished. Thus the mathematical model of the LPP problem The objective function Minimize

$$Z = 282862.26x_1 + 48202.24x_2 + ... + 54445.29x_{11}.$$

Subject to the constraints

1. Non-negativity constraints

$$x_j \geq 0\,(j = 1, 2, ...14);\, y_j \geq 0\,(j = 2,3,..12).$$

2. Constraints for maximum reduction in the normal activity time (from the table)

$$x_1 \leq 10, x_2 \leq 2, ..., x_{11} \leq 2.$$

3. Constraints for activity start time

Activity ac_1 has no predecessor and each of activities ac_2, ac_3, ac_4, ac_5, ac_6, ac_{10} and ac_{11} has only one immediate predecessor while each of the activities ac_7 and ac_9 has 2 immediate predecessors and ac_8 has three immediate predecessor. Also the activities ac_{10} and ac_{11} are the end activities, that is, they have no succeeding activities. Constraints for them are listed below accordingly:

Constraints with one immediate predecessor

$$y_2 \geq 0 + 10 - x_1$$

$$y_3 \geq 0 + 2 - x_2$$

$$y_4 \geq y_3 + 1 - x_3$$

$$y_5 \geq y_4 + 0 - x_4$$

$$y_6 \geq y_5 + 0 - x_5$$

$$y_{10} \geq y_9 + 3 - x_{10}$$

$$y_{11} \geq y_9 + 2 - x_{11}$$

Constraints with two immediate predecessors

$$y_7 \geq y_1 + 10 - x_1$$

$$y_7 \geq y_4 + 1 - x_4$$

$$y_9 \geq y_1 + 10 - x_1$$

$$y_9 \geq y_8 + 3 - x_8$$

Constraints with three immediate predecessors

$$y_8 \geq y_4 + 1 - x_4$$

$$y_8 \geq y_6 + 0 - x_6$$

$$y_8 \geq y_7 + 2 - x_7$$

4. Project duration (after crashing) constraint

$$y_c \leq 187.30$$

3. DISCUSSION

In this section, we demonstrate the quality of the presented technique which includes activity analysis and the associates Estimated cost of the planning process of the project.

Table 1 shows the activity duration of each activity and the variance It also concentrate the three possible time of each activity.

By the earlier approach, Table 2 formulated the critical path of the project on the basis of proceedings and succeeding activity on the project.

Table 3 illustrates the schedule activity cost and budget of the project for each activity on the continuation of this process Table 4 shows the total calculation of the budget for each activity by expressing time of the activity where Table 5 find out the Controlling and Monitoring of the cost.

In the final stage of the technique Figure 3, shows the gradually increment of the project in terms of time and budget expenditure and finally, Table 6 brief the Crashing time of the project and associates cost for every activity.

4. CONCLUSION

In this paper presented method includes a moderate technique to calculate time and budget for any project. Results show that the technique is more effective than any other methods. Also it is easy to identify activities which are parallel on project completion process. More over by the presented moderate technique of Crashing reduced the Budget of the project while Crash time indicates the shortest possible activity completion time.

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Table 1: Time Estimation for each activity

Activity	Optimistic time (x_o)	Most pessimistic time (Y_p)	Most likely time (N_m)	Estimated time	Variance
ac_1	40	60	30	36.66	11.11
ac_2	25	27	22	23.33	0.11
ac_3	10	12	8	9	0.11
ac_4	3	7	5	5	0.44
ac_5	2	6	4	4	0.44
ac_6	2	5	4	3.83	0.25
ac_7	20	25	22	22.16	0.69
ac_8	4	6	5	5	0.11
ac_9	24	26	22	23	0.11
ac_{10}	10	14	8	9.33	0.44
ac_{11}	7	10	5	6.16	0.25

Table 2: Identification of activities on the critical path

Activity	Duration Dij	Earliest start time E(i)=ES(i,j)	Latest finish time L(j)=LF(i,j)	Latest start time LS(i,j)
A (0,1)	44.16	0*	44.16	0*
B (0,2)	23.33	44.16	67.49	32.99
C (1,2)	12.16	44.16*	67.49	44.16*
D (1,3)	7.00	56.32	85.65	55.32
E (2,3)	6.00	56.32*	85.65	56.32*
F (2,4)	8.00	62.32	107.81	76.48
G (3,4)	22.16	62.32*	107.81	62.32*
H (3,5)	7.00	84.48	176.81	146.48
I (4,5)	69.00	84.48*	176.81	84.48*
J(4,6)	9.33	153.48	183.14	144.15
K(5,6)	6.16	153.48*	183.14	159.64*

(*) Indicate the Critical activity of the project.

Table 3: Schedule and activity Cost for the Project

Activity	Earliest time (EST)	Latest time (LST)	Expected time (t)	Total Budget	Budget cost/day
ac_1	0	44.17	44.17	2082338.00	47143.71
ac_2	0	56.32	23.33	1124558.37	48202.24
ac_3	44.16	56.32	12.16	227424.46	18702.66
ac_4	44.16	62.32	7.00	1008567.46	144081.06
ac_5	56.32	62.32	6.00	500957.65	83492.94
ac_6	56.32	84.46	7.00	140688.42	20098.34
ac_7	62.32	84.46	8.00	32871.76	4108.97
ac_8	62.32	153.48	22.16	26838.38	1211.12
ac_9	84.48	153.48	69.00	3092797.53	44823.15
ac_{10}	84.48	153.48	9.33	333104.00	35702.46
ac_{11}	153.48	159.82	6.16	335383.00	54445.29
				Total=8905529.03	

Table 4: Budgeted Cost for the Construction Project.

Activity	Day						
	1×6	2×6	3×6	4×6	5×6	6×6	Total
ac_1	282862.26	282862.26	282862.26	282862.26	282862.26	282862.26	
ac_2							
Total	282862.26	282862.26	282862.26	282862.26	282862.26	282862.26	1697173.56
Total to date	282862.26	565724.52	848586.78	1131449.04	1414311.3	1697173.56	
Activity	Day						
	7×6	7.36×6	8.36×6	9.36×6	10.36×6	11.24×6	
ac_1	282862.26	102301.85					385164.11
ac_2			289213.46	289213.46	289213.46	256917.93	1124557.71
ac_3				112216.01	112216.01	2992.42	227424.44
Total							956246.86
Total to date	1980035.8	2082337.6	2371551.1	2772980.6	3174410.0	3434320.42	
Activity	Day						
	12.24×6	12.40×6	13.40×6	14.40×6	14.56×6	15.56×6	
ac_4	864486.4	144081.10					1008567.5
ac_5			500957.65				500957.65
ac_6				120590.07	20098.34		140688.41
ac_7				24653.82	8217.94		32871.76
ac_8						7266.71	7266.71
Total							1690352.03
Total to date	4298806.8	4441887.9	4943485.5	5088729.4	5117045.7	5124312.45	
Activity	Day						
	16.56×6	17.56×6	18.25×6	19.25×6	20.25×6	21.25×6	
ac_8	7266.71	7266.71	5038.26				19571.68
ac_9				268938.91	268938.91	268938.91	806816.73
Total							826388.41
Total to date	5131579.1	5138845.8	5143884.1	5412823.0	5681761.9	5950700.86	
Activity	Day						
	22.25×6	23.25×6	24.25×6	25.25×6	26.25×6	27.25×6	
	268938.91	268938.91	268938.91	268938.91	268938.91	268938.91	1613633.46
Total							1613633.46
Total to date	6219639.7	6488578.6	6757517.5	7026456.5	7295395.4	7564334.32	
Activity	Day						
	28.25×6	29.25×6	29.75×6	30.75×6	31.30×6		
ac_9	268938.91	268938.91	134469.45				672374.27
ac_{10}				214214.79	118889.19		333103.98
ac_{11}				326671.75	8711.24		335382.99
Total							1340861.24

Total date	7833273.2	8102212.1	8236681.5	8777568.13	8905168.5		

Table 5: Monitoring and Controlling budgeted cost of Project

Activity	Total Budget	% of completion	Value of work completed	Actual Cost	Activity Diff. (TK.)
ac_1	2082338.00	100	2082338.00	2052336.85	-29999.15
ac_2	1124558.37	100	1124558.37	1185320.50	60762.13
ac_3	227424.46	100	227424.46	224800.75	2623.71
ac_4	1008567.46	10	100856.74	98875.50	-1981.24
ac_5	500957.65	15	75143.65	72250.00	-2893.65
ac_6	140688.42	5	7034.42	8003.50	969.08
ac_7	32871.76	0	0	0	0
ac_8	26838.38	0	0	0	0
ac_9	3092797.53	0	0	0	0
ac_{10}	333104.00	0	0	0	0
ac_{11}	335383.00	0	0	0	0
			Total 3617355.64	Total 3641586.35	56480.88

Table 6: Data for normal and crash times and their associated costs

Activity	Time in days		Cost (Tk.)		Maximum in reduction	Crash cost/ day Saved
	Normal	Crash	Normal	Crash		
ac_1	44.17	10.00	2082338.00	2129481.71	6.00	282862.26
ac_2	23.33	3.00	1124558.37	1269165.09	1.00	48202.24
ac_3	12.16	2.00	227424.46	264829.78	1.00	18702.66
ac_4	7.00	1.00	1008567.46	1152648.52	1.00	144081.06
ac_5	6.00	0.00	500957.65	500957.65	0.00	0
ac_6	7.00	0.00	140688.42	140688.42	0.00	0
ac_7	8.00	2.00	32871.76	41089.58	1.00	4108.91

ac_8	22.16	3.00	26838.38	33471.74	1.00	1211.12
ac_9	69.00	6.00	3092797.53	3361736.43	4.00	179292.60
ac_{10}	9.33	3.00	333104.00	440211.38	2.00	71404.92
ac_{11}	6.16	2.00	335383.00	335383.00	1.00	54445.29

Figure 3: Gradually increment of the Project