AN APPLICATION OF PROGRAM EVALUATION AND REVIEW TECHNIQUE IN THE CONSTRUCTION OF A WATER SUPPLY PROJECT

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Introduction

Program Evaluation and Review Technique (PERT) is a Project Management technique used to plan, organize and control projects. The PERT was designed for Project Management when the time requires to perform each activity is essentially a random variable. The focuses of PERT is to determine when the project should be completed, to schedule when each activity in the project must begin in order to keep the project on schedule and estimating the probability of completing the project by a given deadline. Also, to find the best possible way to conduct the project at the least cost if the project has to be finished earlier than planned by performing a crash cost analysis (Guptha and Hira, 1979).

This paper explains a Linear Programming (LP) approach to find the minimum project time and the least cost to complete the project.

Methodology

Drinking Water Supply Project in Dehigama Gramasewa Division, Kuliyapitiya was the selected project to be analyzed using PERT. Initially the most influential activities with regard to the project were identified and hence, time duration of each activity was estimated. It was found that time duration of each activity follows a Beta-Distribution. According to the Beta-Distribution three time estimates: Pessimistic time (t_p), Most likely time (t_m) and Optimistic time (t_o) were estimated for the time duration of each activity. The water supply project was interpreted as a network and hence the required LP models were formulated to estimate the Earliest Start Time (EST) and Latest Start Time (LST) (Seal, 2003).

Data Collection and Processing

Activities, time duration (days) and normal and crash costs (rupees) of the project are given in Table 1 (Appendix).

Experimental Results

Expected duration is given by $t_e = \frac{t_o + 4t_m + t_p}{6}$ and the standard deviation is given by $\frac{(t_p - t_o)}{6}$.

To determine EST and LST, the following LP model is formulated. The objective is to minimize the time duration of the project. That is,

Minimize, $\sum_{i=A}^{R} T_i$ where

i=*A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P, Q, R.*

Subject to the constraints:

$T_B - T_A \geq 90.00$, $T_C - T_B \geq 23.33$, $T_D - T_B \geq 23.33$, $T_F - T_B \geq 23.33$, $T_E - T_C \geq 21.33$, $T_E - T_D \geq 15.33$, $T_G - T_F \geq 20.00$, $T_H - T_D \geq 15.33$, $T_I - T_E \geq 12.83$, $T_J - T_D \geq 15.33$, $T_K - T_E \geq 12.83$, $T_L - T_G \geq 2.17$, $T_M - T_L \geq 24.67$, $T_N - T_M \geq 7.83$, $T_O - T_I \geq 12.83$, $T_O - T_H \geq 12.83$, $T_P - T_C \geq 21.33$, $T_Q - T_J \geq 4.00$, $T_Q - T_K \geq 3.17$, $T_Q - T_N \geq 3.17$, $T_Q - T_O \geq 4.00$, $T_Q - T_P \geq 15.00$, $T_R - T_Q \geq 14.00$, $T_i \geq 0$.

where

T_i = Earliest Start Time of the activity i $i=A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R$.

According to the solution obtained to the model, the minimum time duration for the completion of the project is 188 days and the critical the critical path is,

A ▶ B ▶ F ▶ G ▶ L ▶ M ▶ N ▶ Q ▶ R

Finding the probability of completing the project by a given deadline (suppose 190 days). Project Mean Time (μ) = 188.167 days, project Standard Mean Time (σ) = 5.2994 days.

Therefore, z = 0.065271,

where $P(z < 0.065271) = 0.635310984$.

So the probability of completing selected water supply project within 190 days is 0.635310984; that is about 63.53%.

The LP model to minimize the total project crash cost is

$$\sum_{i=A}^{R} C_i L_i$$

$i=A,B,C,D,E,F,G,H,I,J,K,L,M,N,O,P,Q,R$, *where*

C_i = Crash duration of activity i and

L_i = Linear cost per day.

Subject to the constraints:

$C_A \leq 10$, $C_B \leq 15$, $C_C \leq 15$, $C_D \leq 3$, $C_E \leq 3$, $C_F \leq 4$, $C_G \leq 1$, $C_H \leq 3$, $C_I \leq 3$, $C_J \leq 1$, $C_K \leq 1$, $C_L \leq 5$, $C_M \leq 3$, $C_N \leq 1$, $C_O \leq 1$, $C_P \leq 3$, $C_Q \leq 0$, $C_R \leq 1$, $C_i \geq 0$,

$T_B - T_A \geq 90.00 - C_A$, $T_C - T_B \geq 23.33 - C_B$, $T_D - T_B \geq 23.33 - C_B$, $T_F - T_B \geq 23.33 - C_B$, $T_E - T_C \geq 21.33 - C_C$, $T_E - T_D \geq 15.33 - C_D$, $T_G - T_F \geq 20.00 - C_F$, $T_H - T_D \geq 15.33 - C_D$, $T_I - T_E \geq 12.83 - C_E$, $T_J - T_D \geq 15.33 - C_D$, $T_K - T_E \geq 12.83 - C_E$, $T_L - T_G \geq 2.17 - C_G$, $T_M - T_L \geq 24.67 - C_L$, $T_N - T_M \geq 7.83 - C_M$, $T_O - T_I \geq 12.83 - C_I$, $T_O - T_H \geq 12.83 - C_H$, $T_P - T_C \geq 21.33 - C_C$, $T_Q - T_J \geq 4.00 - C_J$, $T_Q - T_K \geq 3.17 - C_K$, $T_Q - T_N \geq 3.17 - C_N$, $T_Q - T_O \geq 4.00 - C_O$, $T_Q - T_P \geq 15.00 - C_P$, $T_R - T_Q \geq 14.00 - C_Q$.

Crash time of activity $i \leq$ allowable crash time of activity i, $T_i \geq 0$,

T_i = Earliest Start Time of activity .

Minimum total project crash cost obtained from the model is Rs.160,290.00 and by crashing the project can be completed in minimum time duration of 150 days.

Discussion and Conclusion

Identifying nine critical activities out of eighteen project activities will support the management to realize the important activities which must be completed on time and it will support them to put much effort on those. Also, PERT helps to identify the total crash cost needed to complete the project by crashing the minimum length of time.

Because of the proven importance of this application in project management it can be concluded that the use of this element in project management as an essential component to complete projects efficiently and effectively.

References

Guptha. P.K. & Hira, D.S., (1979). Operations Research. 3rd ed. New Delhi: S. Chand & Company.

Seal, K.C. (2003). A Generalized PERT/CPM Implementation in a Spreadsheet: INFORMS Transcations on Education, 2(1): 16-26.

Appendix

Table 1. Activities, time durations (days) and normal and crash costs (rupees) of the project

Activity	Description	t_o	t_m	t_p	t_e	Std. Dev.	Total cost in normal time	Total cost in crash time	Crash time	Linear cost per day (L_i)
A	Designing the pipe flow & Purchasing	80	90	100	90.00	3.33	200,000	250,000	80	5,000.00
B	Excavation of the well 1	10	25	30	23.33	3.33	130,500	160,000	10	2,212.50
C	Excavation of the well 2	8	23	28	21.33	3.33	123,800	128,000	8	315.00
D	Internal construction of the well 1	12	15	20	15.33	1.33	250,200	265,000	12	4,440.00
E	Internal construction of the well 2	10	13	15	12.83	0.83	238,300	240,000	10	600.00
F	Frame work of the slab (tank)	15	20	25	20.00	1.67	112,600	115,200	16	650.00
G	Concrete Slab of tank	1	2	4	2.17	0.50	325,300	352,800	1	2,3571.43
H	Pump house construction for well 1	10	13	15	12.83	0.83	145,900	156,400	10	3,705.88
I	Pump house construction for well 2	10	13	15	12.83	0.83	145,900	156,400	10	3,705.88
J	Cover slab 1	3	4	5	4.00	0.33	40,000	45,000	3	5,000.00
K	Cover slab 2	2	3	5	3.17	0.50	38,000	42,000	2	3,428.57
L	Frame work of the tank	20	25	28	24.67	1.33	95,300	126,800	20	6,750.00
M	Construction and Plastering the tank	5	8	10	7.83	0.83	66,500	72,800	5	2,223.53
N	GI & PVC Pipe fixing	2	3	5	3.17	0.50	26,600	31,500	2	4,200.00
O	Wiring & pipe fixing	3	4	5	4.00	0.33	220,000	224,000	3	4,000.00
P	PVC laying	12	15	18	15.00	1.00	822,500	870,500	12	16,000.00
Q	PVC line checking	14	14	14	14.00	0.00	19,600	19,600	14	0.00
R	Painting	2	3	4	3.00	0.33	18,340	20,440	2	2,100.00