RSSB-JE 2020

Rajasthan Staff Selection Board

Combined Junior Engineer Direct Recruitment Examination

Civil Engineering

Construction Management

Well Illustrated **Theory** *with*
Solved Examples and **Practice Questions**

MADE EASY Publications

Construction Management

Contents

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CHAPTER 5

Crashing

5.1 Introduction

- In CPM, time is related to cost and the object is to develop an optimum time-cost relationship.
- The overall project duration can be reduced by reducing the duration of only the critical activities in the project network. The durations of such activities may be reduced in two ways.

  (a) by deploying more resources for the early completion of such activities.

  (b) by relaxing the technical specifications for such activities.
- In whole of CPM Cost Model, we will be assuming that project duration is reduced by deploying more resources on critical activities.
- In CPM, there are two time and cost estimates for each activity: 'normal estimate' and crash estimate'. In the normal estimate, the emphasis is on cost with time being associated with minimum cost. The 'crash' estimate involves the absolute minimum time required for the job and the cost necessary to achieve it. Here the emphasis is on 'time'.

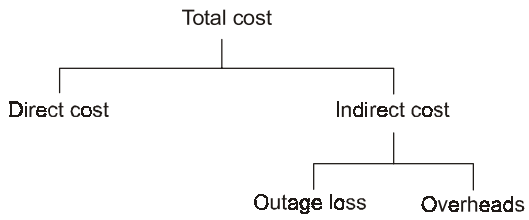
5.2 Project Cost

Total project cost is the sum of two separate costs:

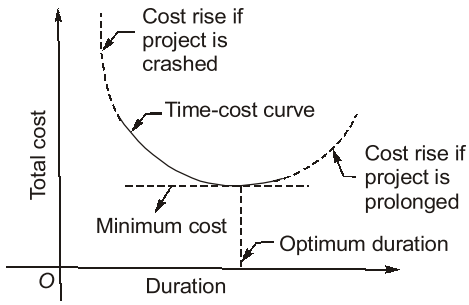
(a) the direct cost for accomplishing the work, and

(b) the indirect cost related to the control or direction of that work, financial overhead, lost production, and the hike etc.

The components of the total cost are shown in figure below.



Various Types of Costs

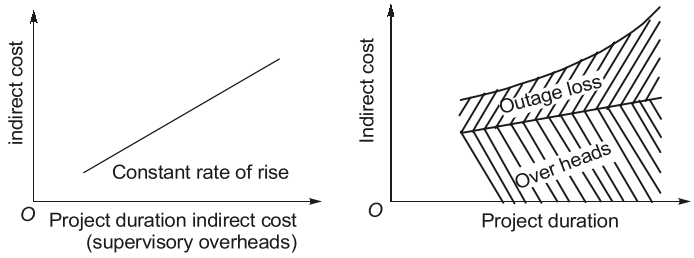


Cost-Time Relationship of a project

5.3 Components of Project Cost

5.3.1 Indirect Project Cost

- Indirect costs on a project are those expenditures which cannot be apportioned or clearly allocated to the individual activities of a project, but are assessed as a whole.



Indirect Project Cost

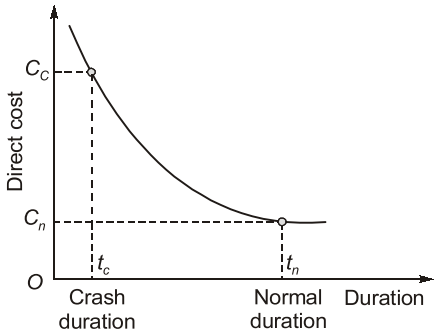
The indirect cost includes the expenditure related to administrative and establishment charges, overhead, supervision, expenditure on a central store organization, loss of revenue, lost profit, penalty etc.

- Indirect cost rises with increased duration, considering only overhead and supervision. It is represented by a straight line, with a slope equal to daily overhead.
- But when there is a loss in profits, due to inability to meet demand or due to some penalty due to delay, a corresponding cost increase must be added to the cost of overheads, producing the curve. Such a loss is called the outage loss.
- The total indirect cost curve will thus be curved.

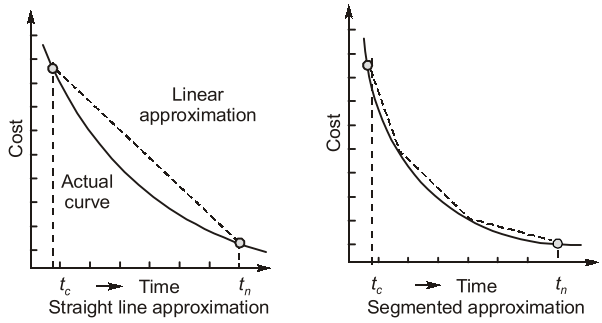
5.3.2 Direct Project Cost

These include labour cost, material cost, equipment cost etc.

- The direct cost curve, having many segments, thus falls with increase in duration. However, the total indirect cost curve rises with increase in duration.
- The project has the highest cost corresponding to the crash duration, and has normal cost corresponding to the normal duration.
- **Normal time (t_n):** Normal time is the standard time that an estimator would usually allow for an activity.
- **Crash time (t_c):** Crash time is the minimum possible time in which an activity can be completed, by employing extra resources.
  Crash time is that time, beyond which the activity cannot be shortened by any amount of increase in resources.
- **Normal cost (C_n):** This is direct cost required to complete the activity in normal time duration.
- **Crash cost (C_c):** This is the direct cost corresponding to the completion of the activity within crash time.



Generalized direct cost-time curve



Generalized direct cost-time curve

Direct Project Cost

- The straight line or segmented approximation of the direct cost curve is helpful in carrying out the project cost analysis. In such analysis, the cost slope is used.

Cost Slope:

- The cost slope is the slope of the direct cost curve, approximated as straight line. It is defined as follows :

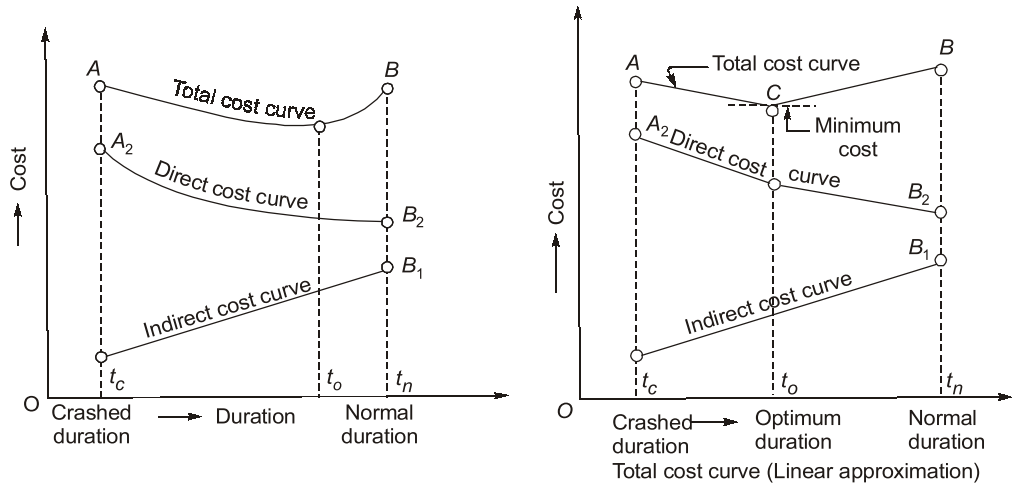
$$\text{Cost slope} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}} \quad \text{or} \quad C_S = \frac{C_c - C_n}{t_n - t_c} = \frac{\Delta c}{\Delta t}$$

Do you know? Crashing of critical activity is started in systematic manner i.e., starting with that activity which has the least cost slope.

- The segmented approximation of cost curve, having multiple cost slopes, is more accurate but calculations involved are more. Generally, single cost slope is assumed.

5.4 Total Project Cost and Optimum Duration

- The total project cost is the sum of the direct cost and the indirect costs.
- We find that the minimum total cost is obtained at duration known as the optimum duration. The corresponding cost is known as the minimum cost. If the project duration is increased, total cost will increase, while if project duration is decreased to the crash value, project cost will be the highest.



Total Project Cost and Optimum Duration

Do you know? Crashing of non-critical activities does not serve any purpose as they do not control the project duration and completing them earlier does no benefit rather it increases the project cost.

5.5 Crashing

The process of reduction of total project duration along the longest path (timewise) of the network i.e. along the critical path to obtain the optimum project cost and optimum duration is called as crashing.

5.5.1 Procedure

- Draw the network diagram.
- Determine critical path.
- Indicates critical path along network diagram or time scale diagram.
- Determine cost slope of each activity.
- Start crashing the activities along the critical path having minimum cost slope.
- Activity having minimum cost slope is crashed until its crashing potential is exhausted and new critical path are formed.
- If new critical path is formed then we have to crash combination of critical activity (parallel activity) having minimum cost slope and continue till there is no further scope of crashing.
- For each crashing determine cost implications and draw total project cost Vs. time curve.

Example - 5.1 Activity *P* is followed by Activity *Q* which in turn, is followed by Activity *R*. The direct cost of these activities in relation to the choice of feasible durations table is given below:

	Activity P			Activity Q			Activity R		
Duration in days	7	6	5	8	7	6	9	8	7
Direct Cost Rs. '000	12	14	15	20	23	27	40	42	45

For all the three activities taken together the minimum possible direct cost for a total duration of 21 days will be

(a) Rs. 81,000 (b) Rs. 79,000
(c) Rs. 78,000 (d) Rs. 77,000

Solution: (d)

The activity with least cost slope is to crashed first. So for one day crash, the cost slope of activities are :

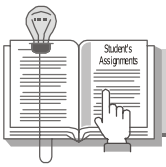
Activity	Cost slope (Rs. 000)
P	2
Q	3
R	2

So crashing *R* by one day first, and then *P* by one day. Now the direct costs of each activity and duration will be

Activity	Duration	Direct Cost Rs.'000
P	6	14
Q	8	20
R	8	42
Total	22	76

Now one day crashing is required to reach at desirable duration of 21 days. The activity P has least cost slope of Rs. 1000. So

Activity	Duration	Direct cost Rs.'000
P	5	15
Q	8	20
R	8	42
Total	21	77



Student's Assignment

Q.1 Total Project Cost versus Time curve is/an
(a) S-shaped curve (b) Parabola
(c) U-shaped curve (d) Straight line

Q.2 In the cost optimization procedure the cost slope for each activity can be estimated by the formula

(a) $\frac{\text{crash cost} - \text{normal cost}}{\text{crash time} - \text{normal time}}$

(b) $\frac{\text{crash time} - \text{normal cost}}{\text{crash cost} - \text{normal cost}}$

(c) $\frac{\text{normal time} - \text{normal cost}}{\text{crash cost} - \text{normal cost}}$

(d) $\frac{\text{crash cost} - \text{normal cost}}{\text{normal time} - \text{crash time}}$

Q.3 The normal duration and normal cost of an activity are 10 days and Rs. 350/- respectively. The cost slope is Rs. 75/- per day. If the crash duration is 8 days, then what is the crash cost of the activity?
(a) Rs. 400/- (b) Rs. 500/-
(c) Rs. 600/- (d) None of these

Q.4 In the time-cost optimization of a project, the project can be crashed by expending
(a) all activities on the critical path
(b) critical activities having minimum cost slope
(c) activities on subcritical path
(d) critical activities having maximum cost slope

Q.5 In the time cost optimization, using CPM method for network analysis, the crashing of activities along the critical path is done sorting with the activity having
(a) congest duration (b) highest cost slope
(c) least cost slope (d) shortest duration

Q.6 Match **List-I** with **List-II** and select the correct answer using the codes given below the lists:

List-I (Cost)	List-II (Features)
A. Optimal cost	1. Activity related
B. Overhead cost	2. Developed by crashing process
C. Direct cost	3. Project-related
D. Indirect cost	4. Contained in or contributing exclusively to the related product

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	4	1	2	3
(d)	2	3	4	1

Q.7 The activity with minimum _____ should be crashed first
(a) Cost slope (b) Normal cost
(c) Crash cost (d) Normal time
[Haryana : JE]

Q.8 The optimum duration is the
(a) the summation of normal-durations of each activity in the project
(b) summation of the normal-duration of activities on critical path
(c) one, which gives the minimum total cost for completing the project
(d) summation of crash-time of activities on critical path

Q.9 Which of the following represents the reduction in duration?
(a) Crashing (b) Negative slack
(c) Variance (d) All of the above

Q.10 The reduction in project time normally results in
(a) decreasing the direct cost and increasing

indirect cost

(b) increasing the direct cost and decreasing the indirect cost

(c) increasing the direct cost and indirect cost both

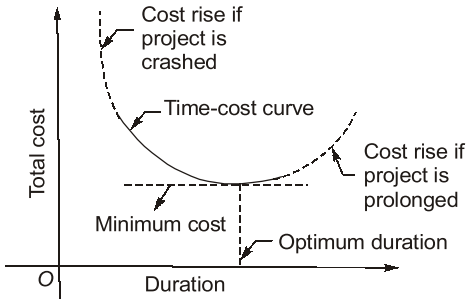
(d) decreasing the direct cost and indirect cost both

ANSWER KEY // STUDENT'S ASSIGNMENT

1. (c)	**2.** (d)	**3.** (b)	**4.** (b)	**5.** (c)
6. (b)	**7.** (a)	**8.** (c)	**9.** (a)	**10.** (b)

HINTS & SOLUTIONS // STUDENT'S ASSIGNMENT

1. (c)



Cost-Time Relationship of a project

5. (c)

Activity having least cost slope in a critical path is crashed first.

7. (a)

The process of reduction of the total project duration along the longest path (time wise) i.e., critical path of the network to obtain the optimum project cost and optimum duration.

Crashing is always done of the activities lying on critical path having least cost slope.

8. (c)

The direct cost increases with decrease in duration while the indirect cost decreases with decrease in duration. The optimum duration in the crashing of activities will correspond to minimum total cost (direct + indirect) of project completion.

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