Construction and Project Management
Lecture 6

COST MODEL - Project cost, Direct cost and Indirect cost

For any project the relationship between total cost and overall duration is as shown below,
The following can be observed;
- if a project goes on indefinitely, the cost will increase
- Cost will increase if the project is expedited
- Cost is minimum at optimum project duration

From the curve in the above image, it is understood that, as the project goes on, the cost only goes on to rise. For instance; there might be a project manager who just continues to stay, he sallary increases but the project doesn't get completed, he is an overhead for the project. The man power rates increase, the material rates increase etc, thereby increasing the project cost. There are times when you look forward to curbing the time consumed in completing a project, however, in such circumstances, the costs involved in getting more resources in order for work to be done faster only lands up in costing more. For instance; You ascertain that a project will take 15 months to complete, but the client insists and pressurizes you to finish it within 12 months time. However, you take it upon your shoulder to finish it faster than possible i.e within 9 months time and you complete it within 10 months. Now in order to complete a project that has been initially estimated to be complete by 15 months, you will end up using more resources, more equipments, more man power etc to finish it faster than possible i.e by 10 months. Everything will be more and more, cost only piles up, thereby increasing the project cost. Although you have completed you work, you have a lump sum to pay for.

"Cost is minimum at optimum duration", this is something we need to act upon. Though, the client might want the project to be complete within 12 months time, there is an optimum time that is calculated for every single project. We need to restrict the project completion time within that optimum duration, so that the cost is minimum.

So a project costs more when performed within an extended time duration and a decreased time duration i.e sooner than deadline, hence, every project is assigned with an optimum time duration in order to stick to a minimum cost. How do we find out this optimum cost and duration shall be looked into further.

COST MODEL - PROJECT COST, DIRECT COST AND INDIRECT COST

The total cost involved in any project is known as the Project Cost or the Total Cost. The total cost is divided in two; Direct Cost and Indirect Cost. Direct Cost is nothing but the consumable cost, the cost that is essential/required in order to accomplish work. eg : manpower, material, equipment, hiring charges etc.

Indirect Cost is nothing but overheads, the cost with regard to control or duration of work. For example : overheads like the regional offices that watch over the project process in order for work to be performed effectively and efficiently. Outage loss is something that must be avoided, it is more like a penalty. For instance, you did not finish your work within the stipulated time, so the client inturn makes you pay a fine, a penalty because of delay, this is known as outage cost. Hence, Indirect cost comprises of both Overhead cost and Outage cost. If you see any particular graph of Overhead costs, you would notice that it is a straight slanting line that gradually scales up as the project duration extends while the outage cost is represented as a curvilinear curve. Both the indirect and direct curve is a curvilinear curve. Although a direct curve can be straightened.

Normal cost constitutes cost of every aspect of a project. It includes both direct and indirect costs. Normal cost is the lowest possible direct cost required to complete an activity. It is the maximum time required to complete an activity at a normal cost. For instance; you spend 100 rs on a particular activity which takes about 2 days to complete, the normal time of that particular activity is 2 days and the normal cost is 100 rs.

Crash time is the minimum possible time in which an activity can be completed using additional resources. Say, a block wall can be done with 2 masons in 10 days, you employ 3 masons instead, in order to complete the work faster i.e within 7 days, this means that the activity is getting crashed by 3 days. This particular function of reducing the duration of an activity is known as crashing and the cost involved for that particular activity is called Crash cost. The crash cost is the direct cost i.e anticipated, in completing an activity within the crash time.

CRASHING :

This involves the higher amounts of direct activity cost that would be associated with smaller activity duration times, while longer duration time would involve comparatively lower direct cost. Such deliberate reduction of activity times by putting in extra effort is called crashing. For instance, you have the usual time but to reduce this duration or time taken, you involve more manpower, you are involving more resources to reduce the time. However, there is also a limit to increasing resources in order to reduce the time taken. Suppose, waterproofing is to be done for all the toilet areas, the testing and the whole process would take 3 days for each toilet and there are four water proofing manpower involved so that this takes place each day for work to be completed and this would overall take 10 days to complete all the toilets in an apartment. But you want to increase the manpower in order to complete the work by 7 or 8 days, which is possible since it takes only 3 days for each toilet. So you want to increase resources and manpower all the more i.e upto 100, to be completed within 1 day, but that is not possible since the minimum number of days required is 3 days. That minimum time needs to be there.

COST SLOPE :

Activity cost slope is the rate of increase in the cost of activity per unit with a decrease in time. The cost slope indicates the additional cost incurred per unit of time saved in reducing the duration of an activity. For instance; for one day you spend 10 Rs extra, that 10 rupees is your cost slope. Your time decreases but your cost increases.

Activity Cost slope = (crash cost - normal cost) / (Normal time - crash time)
Crashing can be done only for critical activities since crashing of critical activities can only save project duration. It doesn't happen for non - critical activities no matter the number of time you crash it.

TOTAL PROJECT COST and OPTIMUM DURATION

Total project cost = direct cost + Indirect cost

You have the indirect cost slope which is a straight line and a direct cost slope which is a curvi linear curve. Here it observed that, the project start cost is generally high since one needs to manage man power, machinery etc. Mostly, 80% of project cost is high during the initial and final stages. In between, there is a point at which, the cost is at it's minimum. This minimum point is known as the Optimum duration. The minimum total cost is obtained at some duration known as Optimum duration. The corresponding cost is known as minimum cost.

Say, the same project you complete within 10 months, it is cost x and when completed for 9 months, it is going to be cost y and if completed within 7 months, it is going to be cost z, where y is the minimum cost for me, then the optimum duration becomes 9 months.

CONTRACTING THE NETWORK FOR COST OPTIMIZATION

The Normal time a project will take for completion will be the sum of normal time durations of each activity along the critical path. If the sum of all critical activities is estimated, we can then estimate the project duration. Similarly, the minimum time that the project will take for completion will be the sum of the crashed time duration of each activity along the critical path. We crash down all the critical activity to their maximum limit possible, this total when added will be the minimum time the project is to be sustained/ completed.

STEPS IN COST OPTIMIZATION

Establish - *calculate time and direct cost.* After you prepare your network diagram, you calculate each activity, the time and cost required for each and every activity.

Determine - *Cost slope of each activity in ascending order, minimum to maximum etc.* For each activity you need to list the cost slope in their ascending order. Say activity 1 takes cost slope 3 and another activity takes cost slope 5, other is 0; 0, 3 and 5 is how it must be arranged.

Compute - *the direct cost for network with normal duration of activities*

Crash - *Crash critical activities starting with activity having lowest cost slope.* You need start with the lowest cost slope since it is the cost that estimates how much is involved for you, what is the cost increase if you decrease the time. Hence your denominator should be higher than the numerator, thereby producing the minimum cash slope. If the cash slope is minimum, it only goes to indicate that, one is able to complete a project in a minimum amount of time at a less cost.

Crash activities in ascending order of cost slope until no further crashing is possible for any of the activities.

Crash - by now, a *few non critical activities must have become critical activities crash them. until no further crashing is possible*

Find - *the total cost of the project at every stage of adding indirect and direct cost.*

Plot - *total cost duration curve*

Pick up - *Optimum duration corresponding to which least total project cost is obtained.*

Step 1 : Calculate the cost slope for activities;

for activity 1, the difference between the crash cost and the normal cost for (a) 9500 = 8000 (b) 5500 - 5000 gives you delta C. Hence you derive the cost slope by delta C/ delta t for both activities.

Which must be considered first ? the one with the least cost slope must be dealt with at first.

Let us take only 2 activities into consideration, 1 - 2 and 2 - 3. This is a linear activity. Duration for 1 - 2 is 9 days and 2 - 3 is 5 days and activity 1 - 2 can be crashed upto 6 days and activity 2 - 3 can be crashed upto 3 days. In such a case, activity A can crash 3 days and activity B can be crashed by 2 days. Least cost plan is nothing but our optimum cost.

Hence, **Step 2 :** Calculate the normal duration and direct cost, incorporating all the cash cost and everything. The difference in cost for Activity A is 9500 - 8000 = 1500 and for B it is 5500 - 5000 = 500. That is your delta C and Delta T is 3 and 2. Which one has the least cost slope is to be taken first, so we need to consider activity 2 - 3 for crashing first, which can be crashed for 2 days.

Normal duration of project = 9 + 5 = 14 days

Normal duration cost = 8000 + 5000 = 13,000

Step 3 : Activity 2 - 3 has least slope, that has to be crashed first.

Say its crashed for 2 days, cost for crashing activity = 2 x 250 = 500.

Project duration = 9 + 3 = 12 days, and direct cost for 12 days duration = 13000 + 500 = 13,500 - project cost.

Step 4; Crash activity 1-2 from 9 to 6 days,

Extra cost for crashing = 3 x 500 = 1500

Project duration = 6 + 3 = 9 days.

Direct cost for 9 days project = 13500 + 1500 = 15000
If I want to complete the project in 9 days, the project cost will be, 15,000. 1 - 2 is 6 days and activity 2 - 3, 3 days have been crashed, I have completed the activity in 9 days.

Step 5 : Total cost of project
Direct cost + indirect cost, Indirect cost has already been mentioned to be 300 Rs.

So for 14 days, it is 300 into 14 i.e 4200 + 13,000 = 17,200 for 14 days.
If it is for 12 days, I have crashed the activity 2 - 3, after that, the direct cost is 13,500 and the indirect cost is 3,600 and the total cost is 17,100 for 12 days.

Crashing of activity 1 - 2, leaves the project to be completed in 9 days, Direct cost of 15,000 and the overhead cost 2,700 and the total cost 17,700 for 9 days.

Step 6 : Cost duration on curves.

This is to be plotted on the graph now, the cost will always be on the y axis and duration will be on x axis. We need to plot all three things individually. It is observed that, when you crash the project for 12 days, you have the minimum cost i.e 17100 which is also known as the Optimum cost and the period of 12 days will be known as the Optimum duration.

Thus, we have found the Optimum duration for this particular project. 12 days is my Optimum duration and Rs17,100 is my Optimum project cost.