Operations Management
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Lecture – 39
Time Cost Trade Off (Crashing)

[FL] friends welcome to session 39 in our course on Operations Management. And in the 8th week of our discussion our focus is on pert and today our focus will be on time cost tradeoffs which is an important aspect of projects project management.

If you remember in the last 2 weeks our focus has been on project management or operations management in the form of a project. So, once you define a project we can do the calculations, as we have seen in our previous sessions in the terms of time as well as in the terms of cost also. So, whatever examples we have taken till today they were all related to the time management only. So, in operations management we were considering project management, in project management we were focussing on time management only. We have seen that the overall project has to be divided into number of activities each activity will required certain resources. Now resources can be in terms of manpower, in terms of money, in terms of cost, in terms of time and whatever calculations we have done were related to time.

Now, suppose a project as you remember in the previous session we have taken a pert problem the project consisted of 11 different activities and each activity had 3 time estimate, from these 3 time estimates we calculated one expected time for each and every activity and then we constructed a network and did the calculations and found out the critical path has the 23 hours. So, that is the calculation related to time that how much time will be required for the successful completion of this project. Then we identified a critical path also we also learnt how to calculate the probability of completion of a project beyond the expected duration of 23 hours or prior to the expected duration of 23 hours. So, most of the calculations that was done for related to or in terms of the time domain only.

Today we will focus on slightly different domain that is a cost domain. So, our focus will be on cost. that what is a time cost trade off. Now what is the requirement of a time cost trade off, we will try to understand today also we will try to understand that up to what

duration we can go for a project duration by saving the cost for our organisation and saving the cost means that there is going to be an optimum duration for which the overall project cost will be minimum and we will focus on identifying finding calculating establishing that optimum project duration for which the overall project cost is minimum.

So, there are two things to be clear about is duration in terms of time. So, our focus will be on finding out how many day, how many hours, how many years, how many months, is the optimum duration for this project for which the overall project cost will be minimum. And project cost will consist of the direct cost and indirect cost. So, before understanding the problem of crashing, now let us first understand the direct cost and indirect cost and how they vary with the project duration. So, let us first quickly have a theoretical understanding of the term crashing and then I will try to explain it with the help of diagrams.

Every activity of the network or project consume certain resources which I have already explained and it also requires time. So, time is also an important resource hence cost is associated with it. Now, suppose we are constructing a house we need laying a foundation we need erection of walls we need flooring we know need roofing. So, for each and every activity we require cost we require time we require manpower. So, everything we can be may be taken into one important parameter that can be cost. Now cost can include the cost of manpower, the cost of equipment or machines the cost of consultants, the cost of architects, the cost involved in taking the approvals. So, everything can be added up in the form of a term called cost. So, every activity will have certain cost involved with it.

Now cost of an activity can be divided into 2 categories. So, we can see direct cost or indirect cost. So, why we are now focussing on cost because already I have explained in the discussion part today in our session that we have to find out the optimum duration, optimum duration or optimum time for a project for which our overall project cost will be minimum. So, how we can find out that duration is dependent upon establishment of cost for each and every activity. Now, for every activity we have seen that there is a direct cost and indirect cost. So, the total cost of the project will be the summation of the direct cost and the indirect cost.

Now, in time cost trade off or in crashing, what we are going to do? We are first going to focus on the direct cost. So, the direct cost is it is the cost associated with an activity which is directly dependent on the amount of resources and time it is the cost of the material equipment and labour associated with the particular activity.

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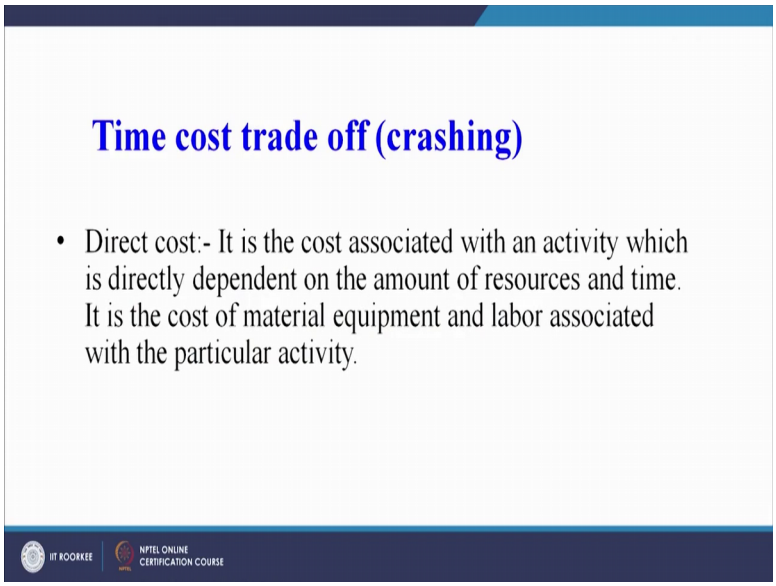

So, we can see that direct cost is directly related to the activity. So, direct cost is for an activity for example, in our previous session we have seen that there are eleven activities in a project starting from A to I J and K finally. So, we have seen that we have eleven activities. So, our direct cost I must address here will be for each and every activity and it will include the labour cost involve, it will include the matt machine cost involved, it will include the material cost involved. So, direct cost is related to each and every activity and includes for example, materials equipment and labour involved in the project or in the activity sorry.

Then the indirect cost now we have seen there are total project cost is going to be made up of the direct cost and the indirect cost. Direct cost is related to each and every activity and each activity will have a direct cost which will include the cost involved in labour. material and equipment or the director resources that are being used for the completion of that activity. Now indirect cost this is a cost associated with an activity which represent the indirect overhead expenses. So, it is maybe always related to the project duration and it is calculated usually on per day basis is required to perform the activity

the expenses may variable or fixed. So, you can see fixed expenses are independent of time for example, administrative and general expenses the variable or indirect expenses are time dependent expenses. So, you can have direct or fixed expenses or indirect or variable expenses.

So, indirect expenses are time dependent expenses. For example, depreciation of machine or resources interest on capital that we have raised from the market. So, there are in broad sense we can say two types of costs involved in a project one is a direct cost of the activity and another one is the indirect cost and we add up these two cost to in order to calculate the overall cost of the project. So, indirect cost is usually calculated and is specified in terms of number of days for example, rupees 10,000 per day is the indirect cost of the project where as for a cost of an activity we will see that if the activity is completed in normal duration this is going to be the cost. If the activity is going to be done in a hurried manner or is in a crashed manner then we will say the cost will escalate cost will increase. I will draw the diagrams and try to explain this direct and indirect cost. But right now first question we must be able to address is that what is the classification between direct and indirect cost and what are the constituents of a direct cost and what add up to make the indirect cost.

So, in indirect cost just to summarize administrative and general expenses make up the indirect cost depreciation of machine or resources for the interest that we have to pay on the capital of the loan that we have taken from the bank. All these will add up to the indirect cost. For example, suppose we are manufacturing a pencil. So, direct cost for manufacturing the pencil maybe the wood that we are using, the graphite that we are using, the shaping of the wood that we are doing the process involved the material involved the labour involved maybe the direct cost. The indirect cost maybe general and administrative cost involved it maybe the interest on the loan that we have to pay for buying the raw materials that we have done that will be the indirect cost. Similarly, the depreciation of the equipment and machine will also be the indirect cost.

So, again I am emphasising indirect cost is usually represent it some amount or amount of money per day maybe 10,000 rupees per day is the indirect cost and for every activity we will have a normal cost and crash cost because we are now studying the concept of crashing. The crashing means that when we have to reduce the duration of the project we will have to spend some extra amount of money that basically will be called as the crash

cost. And the process of reducing the overall project duration is called the crashing activity in case of project management.

Now, this is a very good depiction of the indirect cost and the direct cost.

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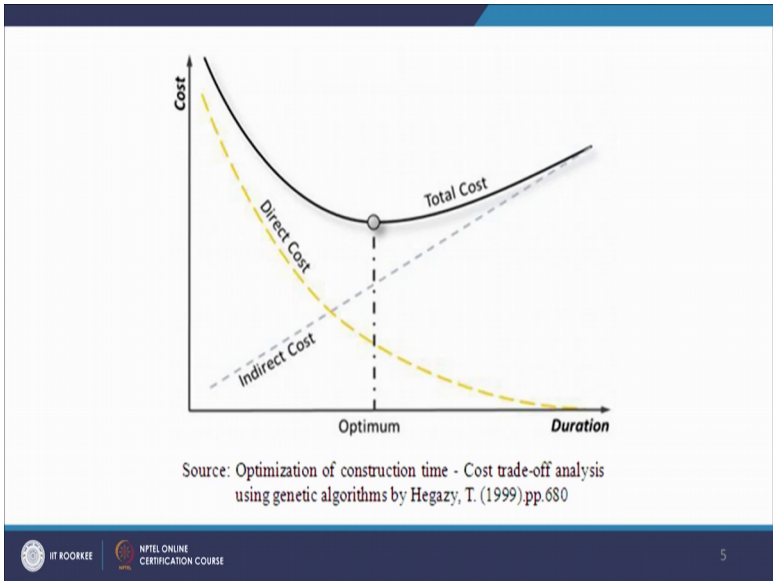

You can see on x axis we have duration of the project and on y axis we have the cost. So, the indirect cost you can see on your screen is continuously increasing. So, if suppose optimum is 10 days. So, 10 days this is my indirect cost. But suppose here I have 20 days. So, for 20 days the cost is higher than that 10 days. So, as I have already told it is given on per day basis. So, if suppose it is 200 rupees per day for 10 days it will be 200 into 10 for 20 days it will be 200 into sorry 20 into 10. So, if it is 10 rupees per day 10 into 10 and 20 into 10. So, maybe very easily we can calculate it is suppose x rupees per day. So, for 10 days 10 x, for 20 days 20 x, it is higher as we increase the duration of the project.

But indirect costs if you see suppose here on 10 days this is the indirect cost, but if we reduce the duration because direct cost we will be incurring for reducing the duration of the crashing when we are doing we are trying to reduce the activity duration the direct cost will keep on increasing. So, you can see the direct cost for normal duration is this much and if we reduce the duration of the activity it is going to increase. So, we have to focus on our total cost and wherever our total cost will be minimum that duration we will call as the optimum duration. So, this is optimisation of the construction time, this is time

cost trade off analysis using genetic algorithm, this article the authors name is also given. Optimisation of construction time cost trade off analysis using genetic algorithms. So, this is basically the summary.

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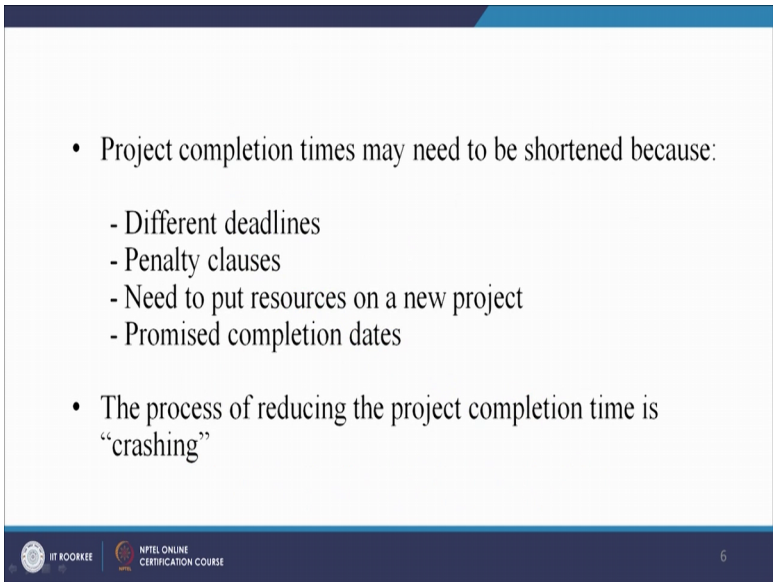

Now, let me just try to explain the concept of the direct cost and indirect cost.

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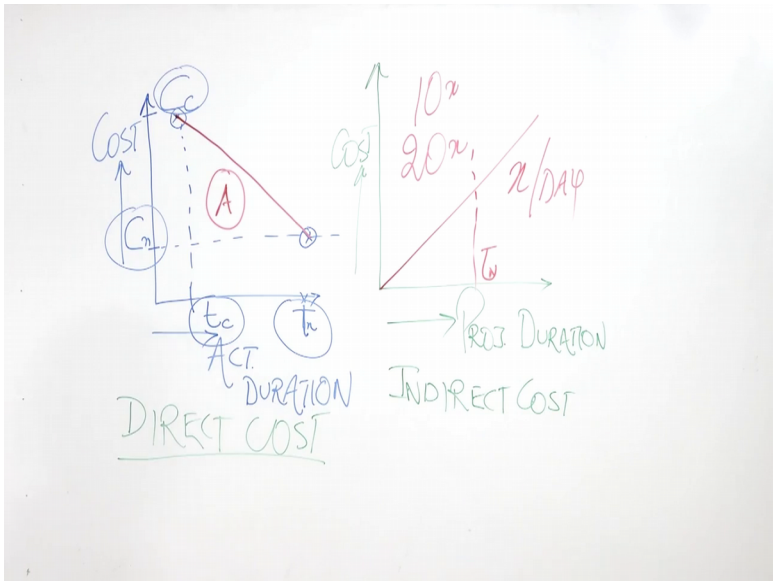

So, you can see this is cost and this is the activity duration. Now, suppose this is the normal duration I called it as t n let us take it as small t n this is a normal duration for the activity and this is suppose the crash duration for the activity and this is the cost on the y

axis. So, suppose this is the normal cost related to the activity and this is suppose crash cost related to the activity this point crash cost. So, we can see, normal time, normal cost this is the point crash time which is certainly less than the normal time and we have to pay extra crash cost this is the cost this is the point, crash time duration and the crash cost.

So, what we have where is that when you have to complete in activity in the normal time you have to spend less, but if you reduce the duration of the time now you have to complete it in the crash duration. Now, suppose normal duration for that activity is 4 days and crash duration is 2 days. So, you have a gap here of two days available with you, you can reduce the normal duration by 2 days, but what you have to do you have to spend more money. So, you could have completed within 4 days using this much this cost that is a normal cost, but now you are trying to do it in 2 days, but you are doing it at the additional cost that is a difference between C c and C n. So, your direct cost graph comes like this.

So, here we are assuming that there is a linear relationship for this time cost trade off. So, this is supposed for activity A, similar type of graphs we will get for all the activities. So, this type of graph will be possible for each and every activity that we are going to have in our network. So, for every activity we must now have 4 important data points, that is for every activity like here we have activity A we must have the normal duration that we normally have in case of CPM for every activity we have got a normal duration. I think it is clear to everybody. But in addition to that we must have a crash duration also that what is the possibility of reducing the duration of that activity.

Similarly, we must have the cost data also that is the normal cost involved for completing the activity in normal time and the crash cost involved for completing the activity in the crash duration, why do we want to do crashing that we will see in our subsequent slide.

So, this representation of the direct cost for activity A now similar types of analysis or similar types of plots or graphs you can draw for activities B C D and E. Then the other part is, the other cost element for the project is all of you must be able to prompt now we have seen the direct cost for activity A now we have to see the indirect cost. So, this is direct cost for activity you know it is activity A now this is the indirect cost and in this case here we have the project duration and this is our cost.

Now, how this will vary? As I have already told you its start from day one and it will be varying like this. So, maybe for any particular day that is we say t n for the project we can calculate it suppose it is x per day. So, on the 10th day it will be 10 x, for a 20th day the indirect cost will be 20 x, x per day is already calculated. So, we can see that we have direct cost for each activity we have indirect cost, the indirect cost is varying with the project duration if the at the project duration if you see in our previous session 23 hours was the project duration. So, here if we do this for sorry hourly basis we can say this much is the indirect cost per hour, if you do it on a daily basis it can be this much cost per day, if you do on monthly basis it can be indirect cost is rupees x per month. So, this is related to the project duration. So, the total cost will be that cost direct cost plus the indirect cost.

Now, what is our target? Our target is to find out the optimal duration. So, we will see the optimal duration how we can calculate the optimum duration, optimum duration can be calculated by plotting a graph like this.

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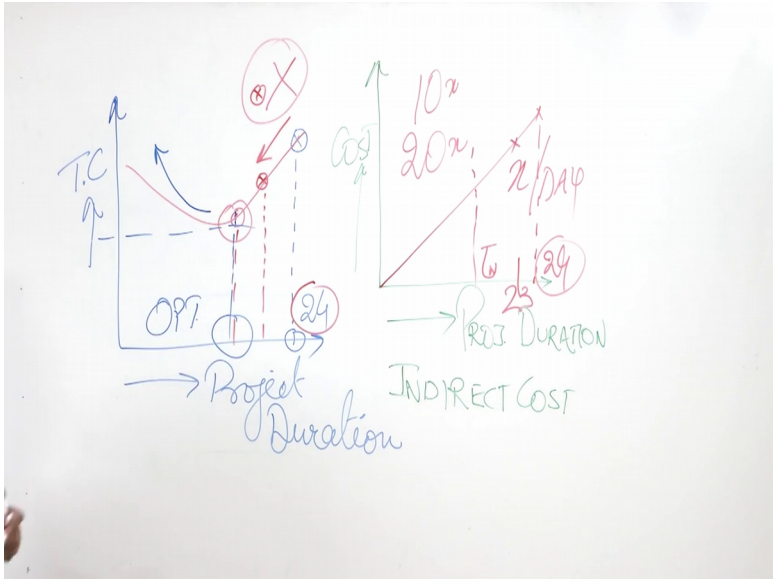

Now, suppose this is our total cost and this is our project duration how it can be calculated now. Suppose this is our expected duration of completion of the project. So, suppose this comes out to be 24 days this value is 24. So, for 24 days we will do this calculation this point is giving us the summation the total or sum total of the direct cost and the indirect cost for 24 days. Now, we will see what all activities we can crash

because the graph that I have I have drawn here earlier similar graph will be drawn for each and every activity no need to draw the graph we can directly do the calculation we will see in our problem that how we can calculate when we have the all these 4 values a normal duration crash duration normal cost crash cost for every activity we can calculate the cost slope for each and every activity.

Now, what all activities we have to focus? We have to focus on the critical activities only of the activities that lie on the critical path because that is the longest path. So, if we want to reduce the duration of our project we have to focus on the critical path so that when the duration of the critical path will reduce the overall project duration will reduce. So, now, in our case our critical path is for is of 24 days for example, now suppose you want to complete the project in 23 days we will crash any activity that is lying on the critical path.

Now, suppose we reduce the duration of activity A by one day this is my cost, because now my earlier suppose this was the cost involved for 24 days indirect cost now I am able to complete the project in 23 days. So, the project cost will automate the indirect cost of the project is being reduced, but if you remember the direct cost will increase as we have drawn a graph earlier. So, there is an increase in the direct cost of the project, but there is a reduction in the indirect cost of the project. So, what we have to do? The word trade off, we have to do a trade off we have to see that whether the overall project cost this is a total cost overall project total cost is a total cost is reducing we will crash the activity. But in case the total cost is increasing suppose we reduce from 24 22 days and this is my cost over project cost then there is no need of going for this crashing activity.

So, we will crash the activity only if there is a reduction in the overall project cost we are doing a trade off between the reduction in the, reduction in the indirect cost at the cost of increase in the direct cost. So, if you remember the previous graph that I have drawn for the direct cost all of you must remember that there was a normal duration the cost was less the crash duration the cost was more. So, if a crashing activity A, we have to spend more money, but by reducing the duration of the project by one day we are saving some money here. So, we will do a trade off between the two, we will see that the overall project cost is reducing. So, we will go for that crashing activity may be further we can

come down to 22 days also and then this graph may take this form. So, we will say this is my optimal project duration after that the cost of the project has started to again increase.

So, what is my focus area? My focus area is the optimum duration of the project for which the total cost is minimum. So, this is the duration that we have to calculate. So, maybe why crashing is required quickly we can go through that project completion times may need to be shortened because of different situations that different deadlines, we have to change the deadlines because of certain problems. There are penalty clauses involved, so we are delayed in the completion of the project because of some miss happening or because of some accidence or because of some in editable delays so the penalty clause is kind of threatening us.

So, what we need to do? We need to crash we need to do the activities quickly, we need to spend more money increase the direct cost or cost of crashing, but at the same time we save some money from the indirect cost also. So, the penalty clause also sometimes lead to the crashing of the activities and sometimes we need to put resources on a new project. So, that is again one reason for which crashing may be required promised completion dates we have a commitment to a company that we will be able to deliver the product by a specific stipulated date and we have to meet the deadline and therefore, sometimes we may need to go for the crashing activities that is the reduction in the project duration time. So, the process of reducing the project completion time is often called as crashing.

So, I think I have been able to explain the concept of crashing in today's class. And in next session which will be the last session for week 8 our focus will be on the numerical problems related to crashing because it is difficult to understand the concept, but it is easier to understand it with the help of a numerical or a mathematical problems.

So, next session our focus will be on two mathematical problems of different types and we will try to understand this concept of crashing.

Thank you.