Project Management for Managers
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Lecture - 49
Crashing of Networks- II

Good morning friends, I welcome you all in this session. As you are aware in previous session we were discussing about time and cost relationship. And we have seen that as far as direct cost is concerned whenever we crash a project it is direct cost increases. While indirect cost is directly proportional to the duration of the project. When you decrease duration indirect cost will decrease when you increase duration indirect cost will increase.

So, at the end of the day we want total cost which is minimal right. And we have seen method of crashing of a project where in what we did first of all we calculated the total duration of the project, then we found critical path. After finding critical path we reduced those critical activities for which the slope was lowest, isn't it? And this and every time we reduced duration of critical activity by one day, why one day? Because whenever you reduced duration of critical activity by one day there is a possibility of creating another critical path. So, if we had reduced a critical activity by 2 days we would have missed a path which might have generated if we had reduced it by one day right. So, that is the reason we every time reduced duration of activity by one day. So, that was quite a simple method.

However lengthy method, but quite a simple one, right and it gives you optimum solution. Now let us talk different method which is quite an efficient method; however, since it is an efficient it is difficult right. So, we will discuss a method called free float method, crashing of a project by free float method, let us look at this question here you have got different activities. So, these are different activities right. Activity 1 to it is normal time is 5 days normal cost 200 crash time 2 days crash cost 260 it means you can reduce the duration of activity 1 to up to 2 days right.

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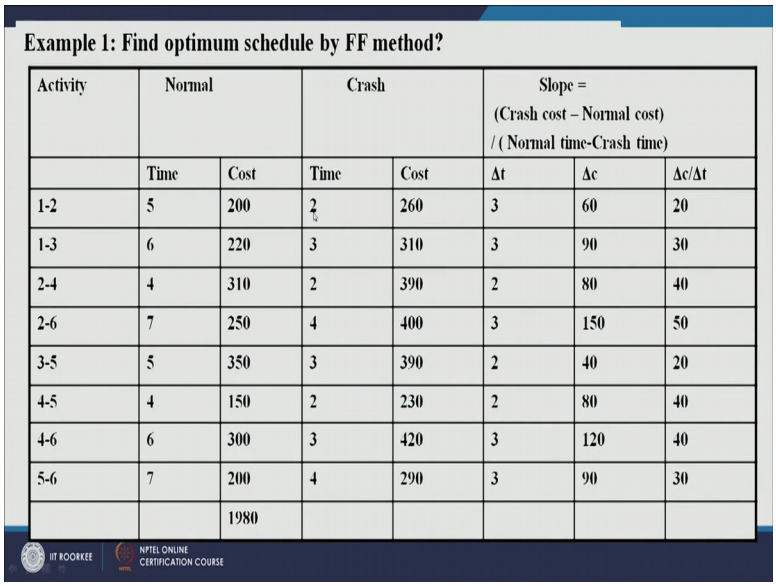

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					

Right, it is not by 2 days right. It is up to 2 days. So, crash limit or this delta t is 3 this also known as crash limit. And Tl change in cost is 60. So, for 5 days cost is 260 for 2 days cost is 260. So, change in cost per day is 20 rupees. So, this for activity 1 2 similarly for activity 5 6 you have been given normal time normal cost, crash time crash cost and this is delta c by delta t in other words this is slope right.

So, the total cost of this project is 1980 right. This is total direct cost. We have been given indirect cost also in this question. So, let us start solving this question, but before we start solving this question, let us revise some of the concepts of floats right. Tl what is float? Float is the float is nothing but you can delay particular activity without affecting duration of the project right. That is float and we have seen 4 types of floats, you have seen total float, you have seen free float, you have seen independent float and safety float right. So, this is what we have seen and Tl all of you know what is the earliest start time earliest finished time latest finish time latest start time, Tl this is total float right.

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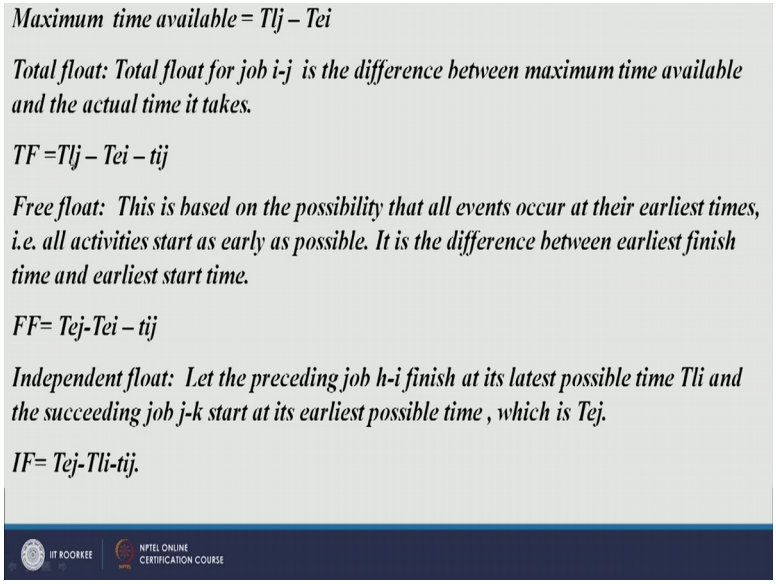

So, Tlj minus Tei minus duration Tej minus Tei minus duration, independent float Tej minus tli right. So, if you look at the formula for total float and independent float, these 2 terms are now interchanged in this particular formula, for independent float right. Tl and finally, this is what we have seen in previous session also. So, if you want to calculate free float, this is this is Tej minus Tei right. So, both are earliest and this is finished time earliest start time right. And this is what also we have seen in previous session. So, let us back let us come back to this question this is a question in which you have been given indirect cost is 40 rupees per day.

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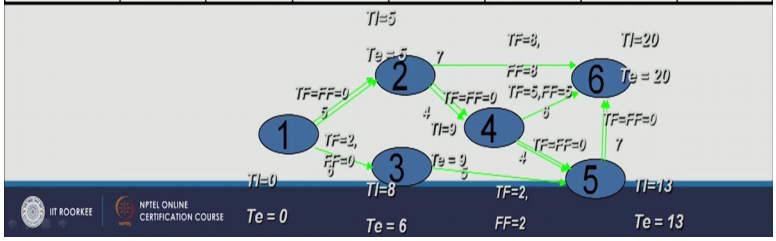
Example 1: Find optimum schedule by FF method? If indirect cost is 40 per day

Activity	Normal		Crash		Slope = (Crash cost – Normal cost) / (Normal time-Crash time)		
	Time	Cost	Time	Cost	Δt	Δc	Δc/Δt
1-2	5	200	2	260	3	60	20
1-3	6	220	3	310	3	90	30
2-4	4	310	2	390	2	80	40
2-6	7	250	4	400	3	150	50
3-5	5	350	3	390	2	40	20
4-5	4	150	2	230	2	80	40
4-6	6	300	3	420	3	120	40
5-6	7	200	4	290	3	90	30
		1980					



So, we have to find optimum solution by free float method.

So, let us start solving this question and initially you have got a network like this right. So, from this table we have prepared this project network right. So, let us solve this question and this is quite a lengthy meth lengthy and complex method, but since you can since you have got computers you can write a program me and you can efficiently solved questions like this right.

So, the first Tl network is this.

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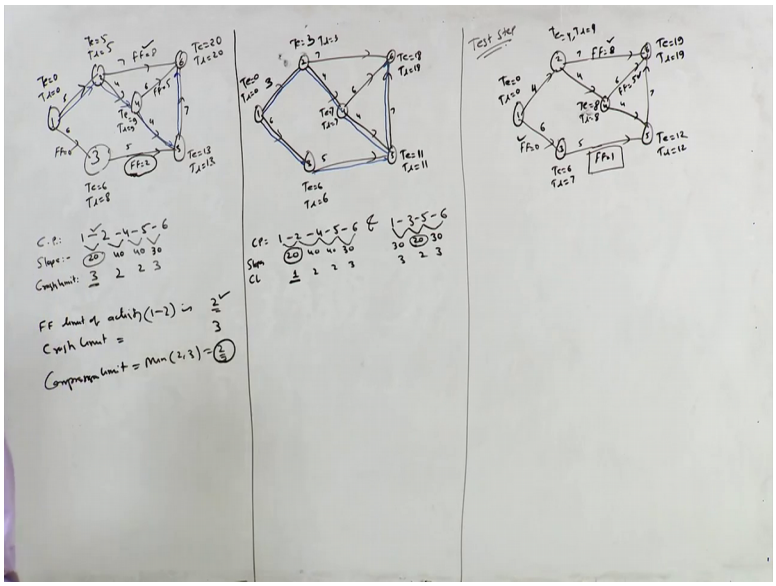

So, this 1 2 this is 3 this is 4 5 and 6 right. So, 6th node is the last node. There is no connection between 3 and 4 it is between 3 and 5. So, there is no dummy activity. So, let us write down their Tl time duration this 5 this is 6 this is 7 this is 4 this is 5 this is 4 this is 7 right. And for 4 6 this is 6. So, we just check your durations for activity 1 2 for activity 1 2 it is 5 for 1 3 it is 6. For 2 4 it is 4 2 6, it is 7 3 5 5 4 5 4 4 6 6 and 5 6 7 right.

So, let us gets started. So, first of all let us find out critical path right. So, T e is equal to 0, T e is equal to 5 T e is equal to 6. T e here is 9. This is 5 plus 4 9. Then T e here would be 9 plus 4 13 6 plus 5 11. So, this is 13 here it would be 20 right. 13 plus 7 is 30. Let us look at Tl values, Tl is equal 20, Tl is equal to 13. Tl here is 13 minus 5 is 8 Tl right. 13 minus 4 Tl is 9. Of course, Tl from here it would be 20 right. So, let us not write that

value. So, Tl here is 5 and Tl here is 0. So, which path is critical path, this path is critical path right. So, critical path is 1 3 sorry 1 2 4 5 6.

Now, we have also seen in previous session that the critical path is a path where you have a total float free float and independent float all are 0. So, there is. So, along this path total floats as well as free float are 0. Now in free float method the first thing you should do after finding critical path is you should find free float of non critical activities right. So, non critical activities are 1 3 3 5 2 6 and 4 6 right. There are 4 non critical activities.

So, let us find out there total sorry free float right. And free float is what it is we have seen what is free float it is earliest time right. So, this is just see this Tej minus Tei right, so T e minus T e not for a critical activity right. Let us calculate it for non critical activity. So, 13 minus 6 is 7, 7 minus 5 is 2 right. Critical path for activity 4 6 would be 20 minus 9 11 minus 6 it is 5 right. So, free float is 5 free float for activity 3 6 would be is 20 minus 15, 20 minus 5 that is 15 15 minus 7 that is 8. Tl free float for this 6 minus 0 minus 6 of free float is 0 here. So, if you look at in this question you will calculated all the free floats of non critical activities right.

Now let us start crashing this network right. So, first of all we should write what we should write what is critical path. So, critical path is 1 2 4 5 and 6 right. Tl what is the slope; slope for activity 1 2. What is slope? Here these are nothing but slopes right. So, this is 20 for activity 1 2 it is 20 right. For activity 1 2 it is 20, for 2 4 for 2 4 it is 40 right. For 2 4 this is your activity 2 4 and this slope is 40 right. So, this is 40 for 4 5 it is 40; 2 4 and 4 5; so, 2 4, 40 and 4 5 40. Then we have got 5 6 which is 30. So, slope for 5 6 is 30. Then you have to see their crash limit right. Crash limit, crash limit for 1 2 is what it is, delta t right. So, for 1 2 it is 3 right. So, 3 for 2 4 simply you can you just subtract a normal duration, from normal duration you subtract crash duration right. So, for activity 2 4 it is 2 for 4 5, 3 4 5 also 2. So, 2 4 2 and for 5 6 it crash limit is 3 right. So, this is the first thing you should do right.

Now, which activity should we selected for compression? For compression you should select activity 1 2 which is got least slope and it is crash limit is 3 right. So, when I say crash limit is 3 you can reduce this duration from 5 to 2. In previous method we reduced it is duration from 5 to 4 first then 5 to 3 and so on right. The free float method we will

not reduce this activity by one day, we will try to reduce it by more than one day and how to decide that duration? Should we should we reduced should we compressing by 2 days or 3 days right. So, since this is this crash limit is more than one, we will apply something called test step, there is something called test step test step. So, in test step what we will do? We will reduce the duration of activity 1 2 by one day. And see the effect of that change on free float of non critical activities of this network.

What is test step? You will reduce the duration of activity 1 2 by one day and you will see how this free floats are changing of non critical activities right. So, this is 1 2 3 4 5 and 6 right. So, let us reduce it is duration by one day right. Since this is the test step. So, we are reducing it by one day. And we will keep all other durations as it is right. This is 7 this is 4 this is 5 this is 4 6 and 7 right. Let us see what happens on free float of non critical activities. So, T e here is 0 T e, T e here is 4 T e here is 6 T e here is T e at this point is 4 plus 4 8 Tl right; 8 Tl plus 4 12. So, this is T e is 12 here, 12 plus 7 19 right.

Let us find out Tl values, 19 12 this is Tl is now 12 minus 5 this is 7 right. So, this is 7 Tl at this point would be 8 Tl right. This 12 minus 4 is 8 Tl, Tl at this point would be and 8 Tl minus 4 is 4, Tl at this point is 0. Tl free float it was 8 Tl 13 minus 13 minus 5 it was 8 Tl here. So, this is 12 minus 5, 7. So, we have calculated all T e's and T l's let us find out changing float of non critical activities. So, what is which were the non critical activities, this was the non critical activities right.

So, T l so, free float for this would be T e minus T e right. So, 19 minus 4, 15 this is 8. Tl free float of this would be Tl sorry, T e minus T e 6. So, free float is 1. And the third non critical activity was beside. So, T e minus T e's of free float of this his non critical activity is 0 and there is one more non critical activity which is this right. So, free float here is 19 minus 8 Tl 11, 11 minus 6 it is 5. So, what has happened to the free float of non critical activities? If you check carefully Tl this was 8 Tl, in this network and this is also 8. So, there is no change in this free float free float was 5 here free float is 5 here also, free float 0 here, free float is 0 here, but free float which was 2 here now reduce to 1. So, this is the change in free float.

So, what is the meaning of this? When you reduce the duration of activity 1 2 by one day, what happened? The free float of 3 5 reduced from 2 to 1 had we reduced this duration from 5 to 3 this would have become 0 and this and would have become a critical activity.

So, free float method will help you in knowing which non critical activity might become critical activity in future right. So, this is known as free float limit. So, free float limit of activity 1 2 is 2 right. Free float limit of activity 1 2 is 2. We do not have to see this limit right. We will have to check this limit right. So, free float limit of activity 1 2 is 2 it is crash limit is what crash limit is 3. So, compression limit compression limit, compression limit would be minimum of these 2, which is 2. It means you can reduce the duration of activity 1 2 by 2 days right. So, let us reduce reduced it is duration by 2 days.

Had we apply it is previous method we have reduced it by one method, but since we have applied we are applying free float method we have changed that if you reduced this duration from 5 to 3 then also of course, a new critical path would generate, but it would not be bypassed right. What is the meaning of bypass? When I say bypass means, when you got to more than one critical paths you need to reduce critical activities along both the paths to reduce duration of the project. So, we have decided that we will compress activity 1 2 by 2 days right. So, let us take the decision and compress it is duration; 1 2 3 4 5 6 right. So, let us make it 2. All other activities will remain same right. So, this is 7 4 4 7 6 6 and 5.

Let us fin let us find out is there any new critical path generating. So, T e at this point is 0, T e at this point is 2. T e at this point is 6, T e here is, what? It is 6. 2 plus 4 is 6 right. So, 6 plus 4 10 this is 11; 11 plus 7 18. Of course, Tl since we reduced this activity from 5 2, no actually Tl compression limit is 2. So, we will reduce it by 2 days. So, this would be 3. So, in that is this is 3, this is 3, is 7. This is 7 plus 4 11 and this also 11 and this is Tl 18 right.

So, when we take this value as 3 these is over t e 8 Tl the last node right. So, Tl 11 Tl here is 11 7 and Tl here is 11 minus 5 is 6, isn't it? This now this is become critical right. This is what we will tested over here right. Tl is equal to 0, and Tl here is 3. Tl at this node is 3. So, which are now critical activities? The critical activities are 1 to 2, 2 to 4 4 to 5 and 5 to 6. So, this critical path and we are we getting one more critical path which is this. So, now, we have got 2 critical paths right.

So, since we have got 2 critical paths what we should do, critical path we have got 1 2 4 5 and 6 right; and 1 3 5 and 6 right. Write their slopes right. So, we know slopes already; so20 then 40 then 40 30. For 1 3, 1 3 we need to find out slope right. For activity 1

through one 1 3 slope is 30. 3 5, 3 5 is 20; so right 30 and 20, 30 and 20. For 5 6 what is the slope; 30; so 30, 20, 30, 20, 40, 40.

Now, since we want to reduce duration of this project what we should do? We should In fact, you we you will have to reduce both the critical paths simultaneously. Or activities along both the critical paths simultaneously right. So, the minimum slope is the minimum slope is this and let me right. Crash limit also this is now one right. Earlier it was 3 right. So, you can reduce activity 1 to by one day only right. So, similarly you can write crash limit is for others also this is 2 this 2 this is 3 this is 3 this is 2 and 3.

Now, since you have to select any of these activities and any of these activities from these 2 critical paths, crash limit is 1. So, from here you should select this activity and from here you should select this activity right. Your direct cost will increased by 40 rupees isn't it? So, should we go for test step here? Since crash limit here is 1, there is no need of test step. When we go for test step when the activity which you have selected for compression it is crash limit is more than one, then only you go for test step.

So, here in this case now there is no need of going for test step. We just crash it by one day right. So, let me stop here for the time being in next session we will continue with this example.

Thank you very much.