Lecture – 31

Lesson - 05

Incorporating Factors Such as Bonus and Penalty: Problem – 04

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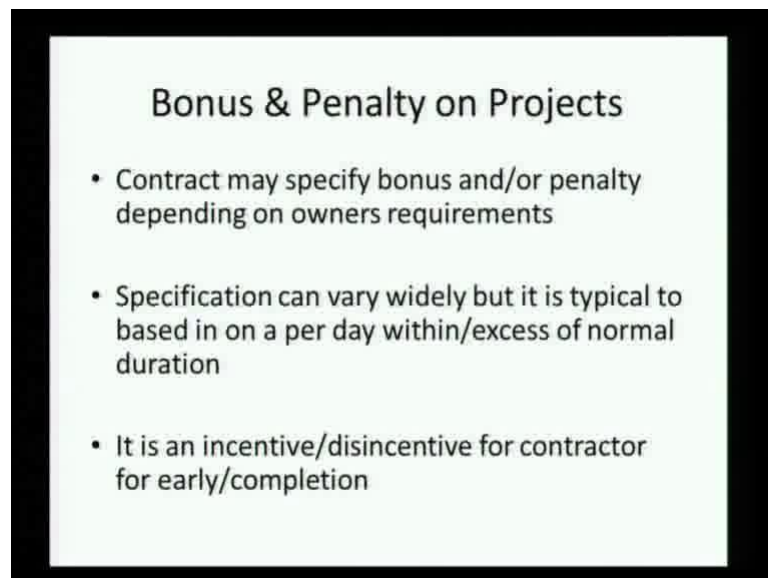
Now, let us move on to the next kind of variation of this problem, which is bonus and penalty. We want to now include bonus and penalty and all of you are aware, that in many contracts there is bonus and penalty clauses in it based on, what the owner requires and typically, it is on a daily or on a weekly basis saying, if you finish so many days ahead we get a, we give you a bonus if you finish so many days late, it is a penalty.

And the reason for this is the owner if he gets a facility early can actually generate revenue out of the facility. So, passes on a little bit of that to the contractor or in the other side if we actually cannot use the facility, he loses money and he penalizes the contract for this. And this is certainly an incentive for the contractor to be able to try to finish earlier.

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So, if we take a problem of which is given here, so we have given a precedence relationship, you have an activity, the predecessor, normal duration, crash duration all these usual information. In addition I have given you an indirect cost of 400 and this is the addition norm. If the project finishes within normal duration there is no bonus and no penalty, if each excess day there is a 300 day penalty and each reduced day, there is a 300 day bonus. So, can you set up this network and start working on it, we will solve it.

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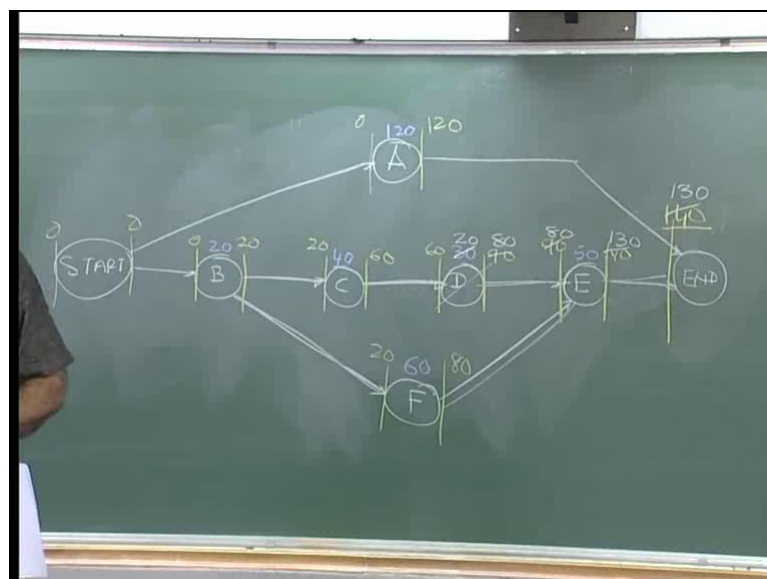
So, it is fairly, so if B with I mean you might have use the tabulation or you might have use the network. You know, so setting of the tabulation takes little more time, for a problem of this nature I would suggest, you can use the network. So, we would do 0, 0,

20, 60, so it is 140 is rather. Again I am not going to do the backward pass, let us just go through it, it is critical path is B C D E, so it goes through...

So, if I want to reduce duration I have to crash one of these, so what are my options D, D at 60 it is so much less than the others and by how much can I, by 10 days if I take it by 10 days I am safe, I would nothing else becomes critical mean while. So, I take D, I make it 20 and this goes to 80, you can keep, you must keep track of the cost. We will show the tabulation and the cost in the end, so I am not going to write it down, we will go through, but there will be cost; obviously, D is 60 into 10, 600. So, it will be 600 and D is also crashed out to the max, I cannot take D anymore.

What would be next and what is my critical path? Yes, now I have B C D E and B F. So, any change, so my... Now, this is the important combinations, what are the combinations. So, if you miss the combination and you do not calculate the cost of the combination, then you miss the whole thing, so you have to actually look at the combinations.

And to see the combinations you can either go to the table or here you can just look at the network. So, if I take D one of the advantages it will pull both paths, because it is the part of both paths, but right now B is 400, C if I take C I would take C and F or even if I take E, it will affect both paths.

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Activity Direct Cost Slope

Activity	Preceded by	Normal duration (ND) (days)	Crash duration (CD) (days)	Normal cost (NC) (u)	Crash cost (CC) (u)	Cost Slope u/day
A	-	120	100	12,000	14,000	100
B	-	20	15	1,800	3,800	400
C	B	40	30	16,000	22,000	600
D	C	30	20	1,400	2,000	60
E	D,F	50	40	3,600	4,800	120
F	B	60	45	13,500	18,000	300
			Total Cost	48,300		

So, my option is E at 120, B at 400 or C and F at what is that 900. So, I will go with E and how much can I reduce E by by 10 days, I can go the full 10 days this goes to 120. Now, what is happening? Activity A has also become critical. So, now, I have all three

parts in the, all three parts becoming critical and any further crashing will require A also to B and A B independent of everything else it has to be a part of all other parts, all other combinations.

So, I can for example, have A and B, so now, E is also gone out of contention. I have A and B or A C F, so A B or A C F, so AB is 600 sorry AB is 500, A C F is certainly more. So, I will go with A and B, how much can I move A by and how much can I... B can only go by 5, so I am limited to that 5. So, I move B to 15 and A cannot go more than, cannot write at this step I cannot take it less than 5, so it gets 115.

So, here we go to 15 and here I take it 115 with that B is also gone out of it I am only left with ACF how much can I reduce ACF, what is the maximum? C is limiting C can go down to 10 days. So, I will go take, so everything and go down 10 days only, so this goes to 30 there are a 50 I should actually done this path before, but we know that they are. So, you can we can put the cost associated with each let us just go to the tables, because I have a cost table.

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Cost table : Direct, Indirect, Total cost
Indirect @ u400/day
(Bonus/Penalty not included)

Duration (days)	Change Made	Direct Cost Change (u)	Direct cost (u)	Total Indirect cost (u)(@400/day)	Total Cost (u)
140	Normal Duration	0	48,300	56,000	104,300
130	Reduce D to 20 days	60*10 = 600	48,900	52,000	100,900
120	Reduce E to 40 days	120*10 = 1200	50,100	48,000	98,100
115	Reduce A to 115 & B to 15 days	500*5 = 2500	52,600	46,000	98,600
105	Reduce A to 105, C to 30 & F to 50 days	1000*10 =10,000	62,600	42,000	103,600

So, you will find that this is the steps you have taken and we had a normal duration and we reduce D and then, we reduced E to not this is not by 20, but it is 220 you reduced E to 40, then we reduced A to 115 and B to 15, then the last step we took A C and F and reduced it and we have the direct cost shown in the table for each and the. So, then in the in this column here we show how the direct cost increases with each step. Now, in the next column we have the total indirect cost we said 400 per day and we have it as each as

each have as the period decreases; obviously, indirect cost will reduce.

And then finally, we have the total cost and this follows us are pattern which we are use to in this kind of relationship and we say that this is where the the minimum is, so for we have not included the bonus and penalty. So, now, what happens we remember bonus and penalty is,

Student: (Refer time 13.41)

So we had a value of how much should we say the bonus and penalty was 300 per day remember it is 300 per day. Now, can you do the calculation can you add can you add the bonus and penalty it to this and see what how would you add this and see how would the results be.

Student: 20 into 300

No

Student: We need to know the schedule first.

Yeah. So, we has to now saying a if say if we take 100, so I normal duration is 140. So, if it is 140 there is no bonus no penalty if it is 130, 10 days of bonus. So, it will it will go to 3000 will be plus if it is goes to 120 it will be another 3000, now what if I exceed 140 if I go to 150

Student: (Refer time 14.38)

Correct. So, my question is can do you see given this cost structure do you see any change in where the bonus will take place or any change in where the minimum cost will take place minimum total cost of the project any, what is the influence of the bonus.

Cost table : Direct, Indirect, Total cost
Indirect @ u400/day
Penalty @ u300/day exceeding 140 days
Bonus @ u300/day finishing before 140 days

Duration (days)	Change Made	Direct Cost Change (u)	Direct cost (u)	Total Indirect cost (u)(@400/day)	Bonus Penalty	Total Cost (u)
150	Delay	0*	48,300	60,000	3000	111,300
145	Delay	0*	48,300	58,000	1500	107,800
140	Normal Duration	0	48,300	56,000	0	104,300
130	Reduce D to 20 days	600	48,900	52,000	(-)3000	97,900
120	Reduce E to 40 days	1200	50,100	48,000	(-)6000	92,100
115	Reduce A to 115 & B to 15 days	2500	52,600	46,000	(-)7500	91,100
105	Reduce A to 105, C to 30 & F to 50 days	10,000	62,600	42,000	(-)10,500	94,100

So, let us look at the table this is how the bonus structure puts in so if I have 150 I mean I have 140, which is my normal duration, which is this which is 0 the minute I exceed I go higher that is fine, as I start as I start going lower as my project duration start decreasing my bonus starts increasing, but my direct cost is also increasing yes, so as my direct. So, now, I have to take three factors into account increasing may direct cost, which is depending on the activity I crash my increasing my it my increasing bonus which is depending on the bonus rate my decreasing indirect cost, which is decreasing at the at the daily rate of the indirect cost and decreasing with duration project duration.

So, if I take all these three into account this is the minimum value, so in the earlier case where how what was that minimum duration 120. So, you can now you will see when you add the bonus to the indirect what is the slope 700, right 400 and 300. so I am basically reducing it at around 700 per day and, so you will have to will have to take that in to account and see, where am I actually going to make that difference this is from a contractor perspective.

Now, we are looking at it from the contract and, but who who makes a contract the client, so the client has decided on the bonus value based on his benefits. So; obviously, he finishes early he is making something also out of it is the not just a contract also. So, there are any questions or discussions on this we can take any further discussions otherwise just quickly to summarize we kind of re visited the time cost rate of procedure we saw how we have to go through the steps and calculate the minimum direct cost of crashing of the you know the network we then added the indirect cost and then, saw that

minimum total cost we kind of introduced tabular approach for calculations we will do a few more examples on this.

And then finally, we saw how you can incorporate factors such as bonus and penalty or any other cost that might come up and it is only an algebraic addition right now, we are not looking at it as a function or it is just an algebraic addition, but it had it has to be done systematically. So, you can see where your total cost changes and you have to, then capitalize on making use of that.

Thank you.