Project Planning & Control

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Lecture – 28

Lesson – 05

Time-Cost Trade-off: ABCD Example Project, Steps for Crashing

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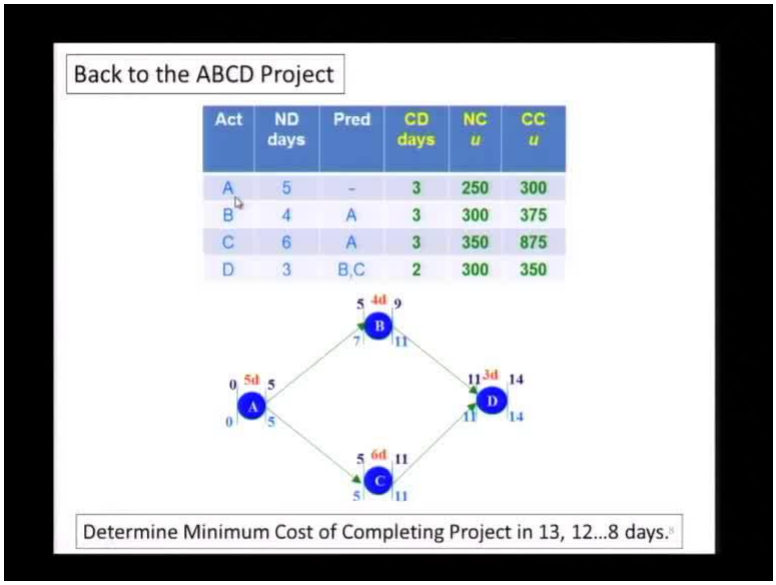

Now, let us come back to this project I have given you, so this was the earlier we were dealing with the first three columns. We had activity, we had duration, we had predecessor. Now, we are also dealing with we are calling this a normal duration, right? now I am giving you crash duration and I am giving you normal cost and crash cost, these are the inputs we need to be able to do a calculation to find, what is the, how much should I what is the cost of crashing.

So, we had the 14 day project duration and what we are going to do is to determine minimum cost of completing the project as the duration starts reducing. So, how much would it cost in 13 days, 12 days and what is the maximum I can crash the project to. So, as an initial exercise we will go through, we'll take this simple problem and work it out for each of the days of reduction in duration. So, what do you think when you look at this intuitively, what is the first step you would do.

Student: Crash those which cost lesser.

Crash those, I mean crash those which cost less and on the critical path, so you can see the, you know A, C, D is on critical path. So, I've to find the cost of crashing A unit cost of crashing A, unit cost of crashing C, unit cost of crashing D and then, use that as my benchmark.

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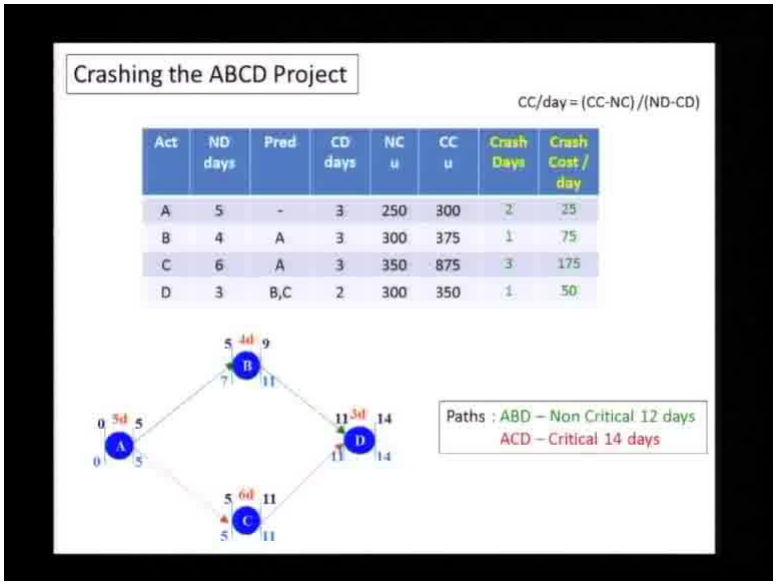

So, if I go into the next level I have actually calculated the days, so here you can find you will see that we have all these, we have all the values we had earlier I've used these values to calculate crash days, crash day is the normal day minus crash day; that is how many days can I crash the path. So, for example, we are making an assumption A cannot be done in less than 2 days, I am sorry less than 3 days. The maximum I can crash A is 2 days or C cannot be done in less than 3 days, so these are assumptions that go along with the network.

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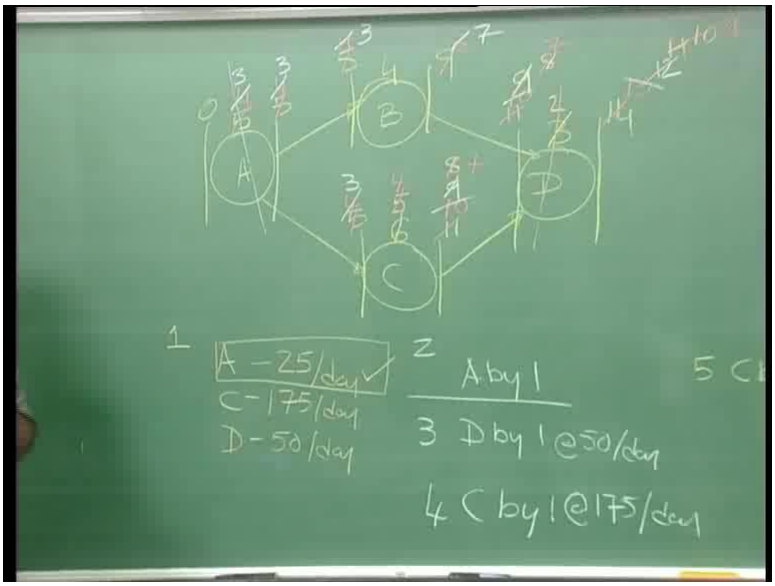

So, let us take this, let us get to the board and see what, how we would work this. So, we have the network A, B, D we have the 5, so that is on one side. So, now, if I look at the crash cost, so what are my options of crashing, I have option of crashing A at what cost.

Student: At 25.

At 25 per day and I want to take it stepwise, I want to go all the way from 14 in steps of 1 to the last, because that will illustrate what we are trying to do. I have an option, so in my first step I have A at 25, B should I use B at all.

Student: No.

No, so I do not even want to use B, because B is not on critical path. C?

Student: Equal to 175.

C is 175 per day, the value is there and D 50 per day. What would I choose? I will choose to crash A and for now, I am going to choose to, so basically what I am going to take A and move it down to 4 days. So, my duration here will go to 4 and this first step has basically cost me 25 rupees or units of cost. I put units of cost as U there, because I did not want to use a currency value are as of now, we are just looking at the value.

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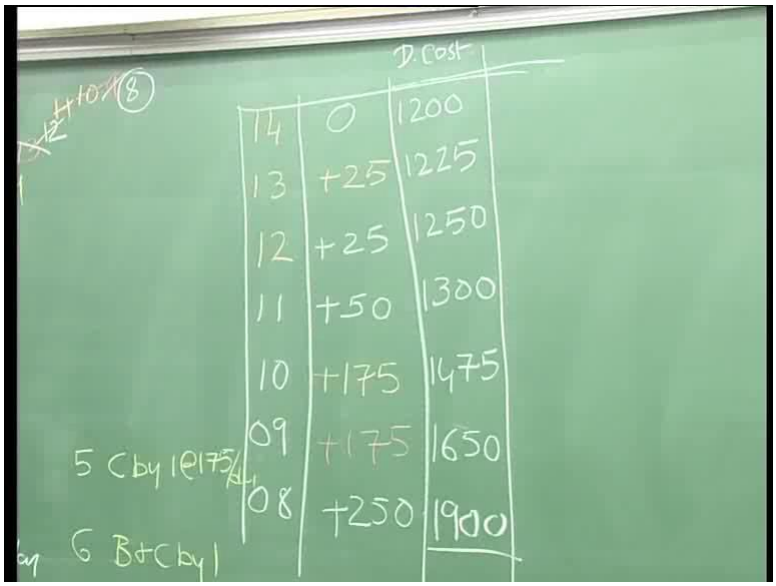

Now, what has, so we have managed, so for third for doing this in 13 days, so at 14 days it was my basic cost, 13 days I had to spend plus 25. Now, as my second step, again what is my critical path A, C, D options are.

Student: Again A, C or D.

It is the same options, again this there because A can go up to 3 and in my second step also I use A by 1. So, again it cost plus 25, cumulative is 50 from moving from this step to this step its 25. Now, I want to go to my third step. What are my options?

Student: C and D.

What has happened to A now?

Student: A is crashed out.

A is fully crashed, so I cannot touch here, 3 days is the duration in which we have to do I cannot crash A anymore. Now, my critical path is going through A, C, D and my options are either C at 175 or D at 50; obviously, it is 50 D, D by 1 at 50. How it is, so D has now moved from 3 to, I am going to use a different color here and this has gone down to 11. What has happened to D now? It is I cannot, so D has also reached the maximum crash I cannot move this anymore.

And we are now going to the fourth step, where what are my options. A is fully crashed, D is fully crashed, my critical path still goes through C and how many days can I crash C by, 3 days. Can I crash C by all 3 days, what will happen?

Student: Then, B will also become critical

So, if I start move this to 3, 3 plus 3, it will go to 6, but then you can see B has already become critical, before C went to 6. When C was at, how much C was at 4, when C went to 4 itself, when C's duration is reduced to 4 itself you have two critical paths. So, even if I spend all the money and reduce C to 3 I am actually wasting a day, because now B is controlling the path. So, I can do step wise reduction of C, so let me get this value here, so when I went down to 11, I added another 50.

So, now, my I can take C and take it down to 5 let me go step by step, so that is my only option my fourth step is I can go C by 2, yes I can set C by 2. I can I just want to take it step by step here, C by 1 at 175 per day. So, I am taking it down to 5 and 8, 8 and this was now 2 going to 10, so to go get it 10, there is another fine. Now, I can go again my 5th step will also be C by 1 day, I am going to write my 5th step here right? So, now, I am going to move this down to 4, 7, 7, 9.

So, now, what happened, so now, let me get this, so this at, so 9th day I am down to 9 days and I have spend another 175, now both paths have become critical, so both are 3, 7 and 7. So, B has also become critical and I by crashing my A is fully crashed out, D is fully crashed out. The only way I can reduce duration is by reducing B and C, so from my 6th step I have to do B and C by 1. So, B can go maximum by 1, B can only move to 3, take it a 6 and after that B is maxed out, C also goes from 4 to 3 goes to 6, both them come on 6 here plus 2, 8 and the cost is how much? B plus C.

Student: 75

That is 75, B is 75 plus C is 175, so my 8th step I get at plus 250, so this is my variation of my direct cost, so I my additional direct cost additional direct cost. Now, let me put a table here which says, let me put a column which says a direct cost. So, you can see that my, if I did this within 14 days, what is my total cost, base cost is how much you can add up. So, that is a normal cost 250, 300, 350, 300, 1200 and as I go down my cost keeps increasing.

So, I can now do this computation let us do it. So, remember, so if I, so to do in 13 days how much is it going to, I am going to do cumulative 1225, 1250, 1 1 5, no this is plus 175, 1 6, 1 9. So, this is my total direct cost on the on what, so on the project. So, this is my whole project cost and if I plot a graph I will, you will see that as the project duration decreases my direct cost is increasing.

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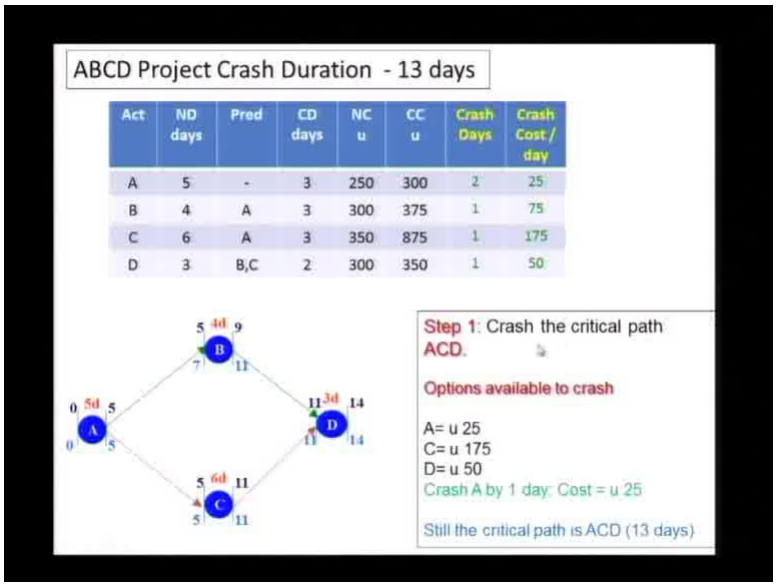

So, I have a graph on the power point let me just go through the power point, so that we go through this in a in this way So, we did it all of this as we when through we first crashed A as a step 1 and we know, so when what was 14 became 13, then in the second step we crashed A again brought it to 12, and then next step we took 12 and we chose to crash D 11. And then, we said A and D cannot be crashed any further we found critical path just still A, C, D we had to crash C we crashed C by 1 and then, we went back again crashed C again by one now both path became critical and then, we had to do C and B by 1. And we reach the maximum crash duration which was 8.

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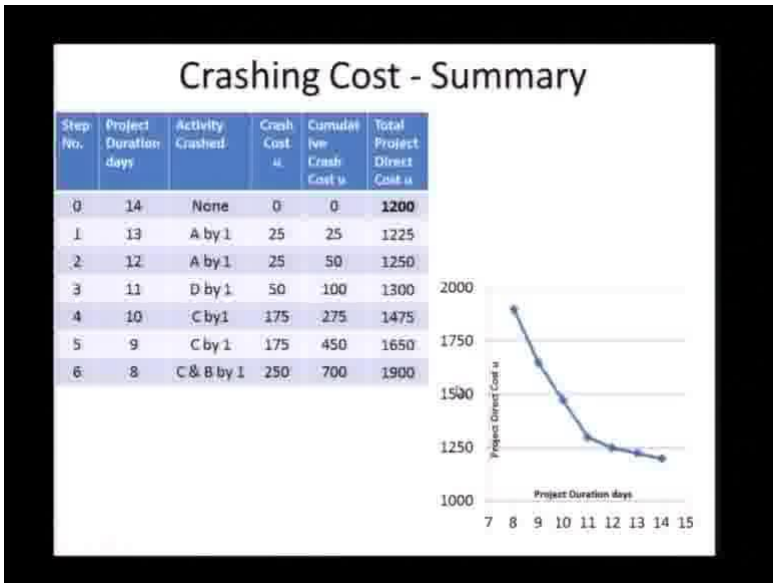

So, this was the maximum crash and we now have a plot of the, what we have done here

we have a plot of the for the project duration versus project direct cost and you can see that this is the nature of the graph.

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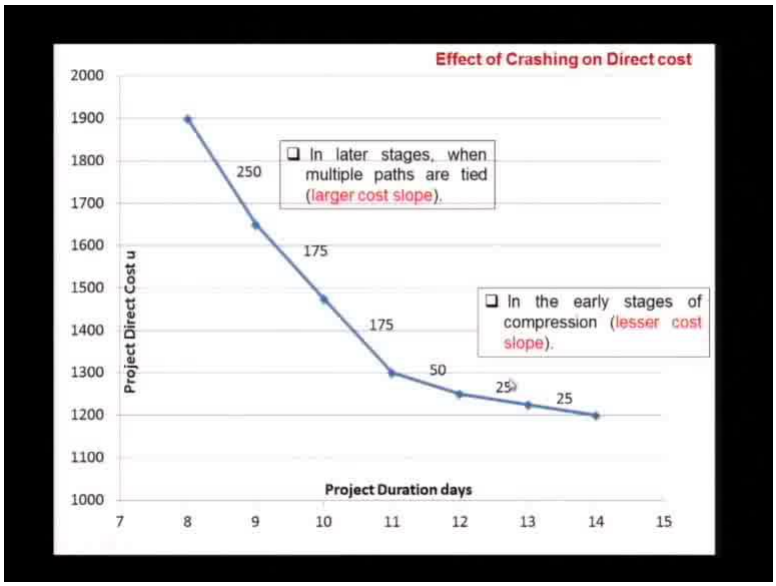

And what I've shown here is the, is the slope of the graph as it for each step in which we crashed, so we went you know this was a first steps of A, D, C and B and C. So, this is typical and; obviously, because we are looking, so this graph shows the minimum direct cost of the project as we reduce duration. Now, you this is the outer envelope this is a minimum graph I can reduce as you can see here I do not need to reduce A first I can reduce in the in my first step, if I had reduced C first, what would have happened I would have still got a reduced project duration, but at the expense of additional money.

So, I mean I can have different graph of as of relationships between project direct cost and project duration, but this is the envelope of minimum. So, for example, you can have a similar envelope for maximum, what would be the maximum cost to which means when I come down to my first crash, what should I crash C I could do the total reverse and will I get the envelop for the maximum.

Now, if I crash B and C together will there be any use now, in each thing I would go with the maximum and I would get the envelope of maximum. So, just remember that this is only one of the curve you can plot for cost time direct cost versus time and, but this is the minimum and this is what we are interested in. Any questions on this one?

Student: It is the maximum crash cost.

So, might not need in a specific project, but you might want to be know extremity of,

what let us say you do not go through the procedure very systematically, what is the border what is a envelop of where your cost can go to having said that I should also say that if you go in to practice very few times is this procedure used while it is a, what you say a nice procedure from a network analysis point of view and from a mathematical relationship point of view it is not very much used in practice, because of issues and quantifying all of these costs.

And then, if you are using a linear assumption it might not even hold good in a practical situation and, so all the analysis does not really yield you a result and then, you know people do not go into the problem. So, fast tracking is used very much to reduce duration and if they are going to do this it is probably still done more heuristically until we can get much better models of cost time relationship for a activities it will be limited from using this in practice.

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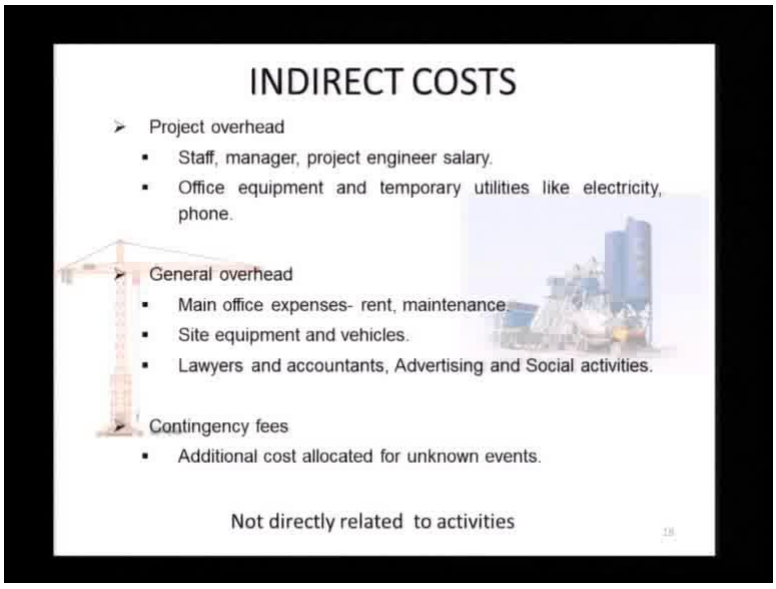

Now, let us move on we now add something called indirect costs, so far we have talked only about direct cost, but there are many other cost on a project. So, for example, the salaries of the project manager the project engineers establishment of facilities on the project things like tower crane, batching plant you do not build this to an activity. It is general costs on a project which is the, we are going to electricity on the project we are going to pay for you know facilities all of these are generally called indirect cost.

And the indirect as in they are not direct to an activity they are general project overhead are other expenses. Now, what it you think about relationship between project duration

and or let me ask you this way, what you think is indirect cost and how it is vary with time on a project each day I it would be constant each day I would expect to pay about the same indirect cost, because assuming my staffing levels are the same my electricity usages is about the same you know I have to pay for a site establishment charges and all of this.

Student: Obviously,

That is at when the duration, so I what I am saying is on a daily bases I will pay the same amount rate per day is about the same total the total will; obviously, change the total; obviously, change. But, my rate in per day is the same and if I actually go into the if I take rate per day the same and as I start increasing my project duration, what happens cost goes up and if I start decreasing my project duration; obviously, the cost goes down.

So, while are direct cost is how is the direct cost is changing the direct cost is changing is increasing with decreasing project duration the indirect cost is decreasing with project duration. So, now, is there should be some area in between where the total project cost, which is direct cost plus indirect cost will reach an optimum or a minimum value in between this. So, let us see if we can calculate a let us see, how this behavior takes place.

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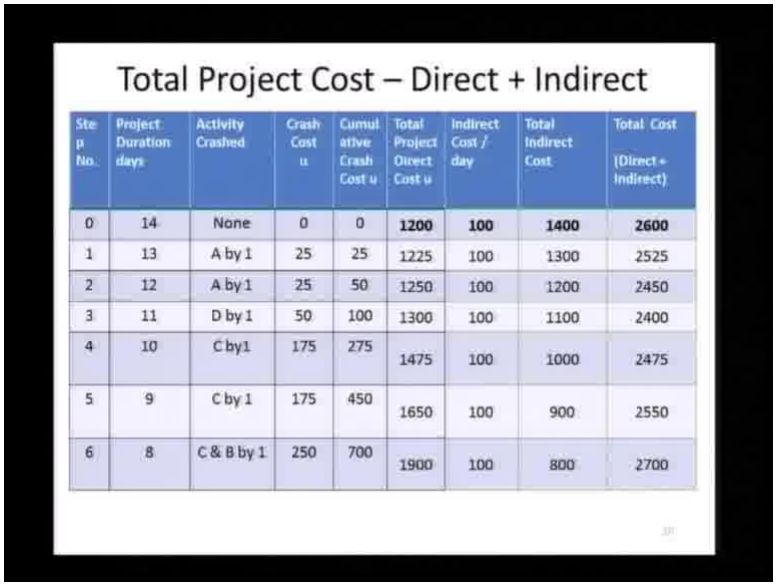

So, what I have here is that is a table and you can see the values we have a put out here are the total project direct cost that is the values we have 1200, 1475, 1650, what I have now added is I am assuming indirect cost of 100 per day.

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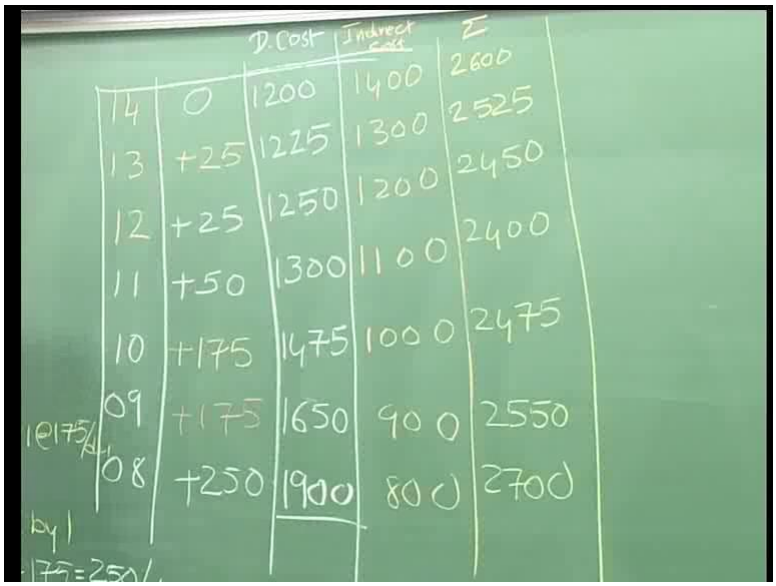

So, every day there is a charge of 100 for which the project is active, which means if I am there for, 14 it is 1400 as my project. So, if I am going to put these values here so that we can also, so kind of see, so as my project duration decreases it is straight forward and I've made the numbers straight forward, so we can think through it. So, here you find increasing and here you find this is indirect cost here the numbers are decreasing, now if I sum it up I get ((Refer Time: 23:13)) 2, 5 can you read it out to me, so that I can write it down you know 2450, 2400, 2475, 2550, 2700 what is the pattern you see.

So, this is basically a sum of direct and indirect it that is what we are doing, what is a pattern you see 26, 25, 24, 50, 2400 and then, it starts increasing again. So, this 11 days if I can finish if I can bring my project to the 11^{th} day I have actually this is higher this I have the optimum value. Now, the graph can be shown this way, where I have my direct cost we saw this graph my indirect cost going up and decreasing as the project duration decreases this is the total cost and you have the total cost decreasing and then, increasing.

Now, can you we talked about cost per day reduction in cost per day and all of that I mean the crashing from per activity we talked about crashing cost per day on in overhead cost we talked about the constant value on each day. So, can you rough guess when, where this optimum, where this minimum occurs I am going to actually go back to this graph, what is the relationship between?

Student: Activity C has been considered.

Yeah, no no, what is the relationship between my overhead cost value and my cost slope

value

Student: Drastically…

More than drastically can you can you quantify see here right now, here the cost of a cost of 1 day of crash is 25 how much do I save on my indirect how much I save 100.

Student: 100.

So, my total saving is 75, so here again my total saving is 75. 50 once I cross this my how much I pay for indirect the slope the amount is more than what I save on my I am sorry what I spend on my direct is more than what I save on my indirect and, so that is why the graph then starts increasing.

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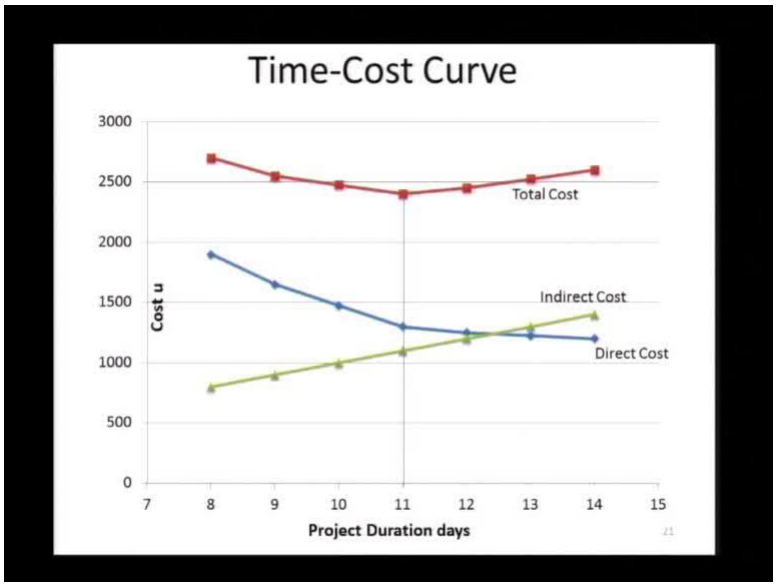

Now, this is an interesting relationships and I mean, so this is a this is true in practice challenge is really to get the good value good data to find, where this project duration lies, where I will experience minimum cost.

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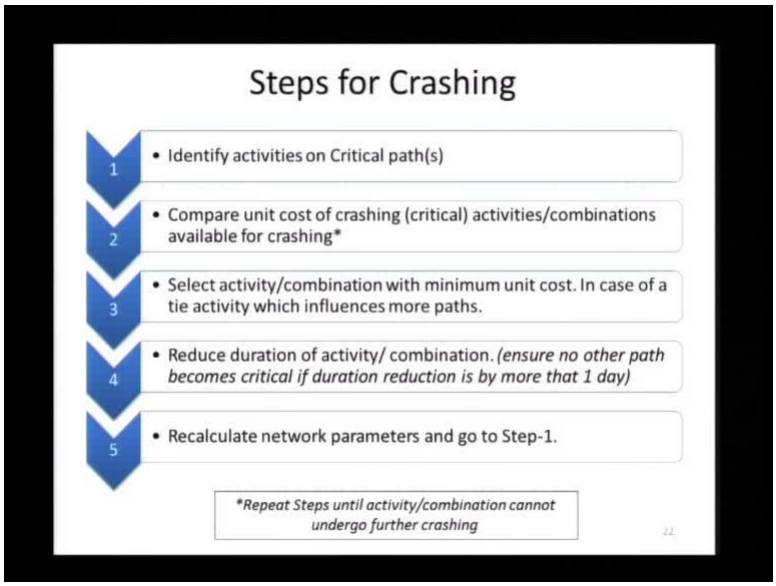

Now, let us just summarize when we look at the steps for crashing we have to identify the activities on critical path have to compare the unit cost of the activities on critical path and they have combinations to select, what we need for crashing. And then, we finally actually select the activity combination with minimum cost and in case of a tie if there is a tie between few activities it is always better to select the activity, which has more influence on the network we will come we will see this, then we come to some examples which we will do later.

So, then we reduce the duration of activity combinations and ensure no other path becomes critical if the duration is reduced by more than one day we saw that in B you know C we cant reduce C by too much because by more than two because B will become critical. And then, once you do the reduction recalculate the network go to step one go back to the process repeat the step until there is no further crashing can be done. So, in two you will have to find out you know is there any further crashing possible and if not stop.