Project Management
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Module No # 07
Lecture No # 32
Project Scheduling and Crashing an Example

Welcome back my dear students, this is the thirty second class which is happening for the project management one, and if you remember before staring the thirty first class I did make a sincere request to all of you that the problem even though I tried to explain it in simple terms with very simple example but it becomes very complicated if the project has a lot of activities, lot of inter relationship between activities.

And the cost structure is not linear, they are either quadratic or some polynomial sort of thing and the inter relationship I have taken in a simple terms and I have basically considered one or three different instances how you can reduce the duration of any activity and what is the overall consequence on the critical path, whether the critical path remains as it is or more activities or set of activities now become critical.

And I also considered the overall cost structure for the project as you reduce the number of days for the activities which are there on the critical path. So just as I mentioned that we did start the discussion of this problem at the fag end of the thirty third, thirtieth class we discussed that in the thirty first class and this is the thirty second class by which I am sure we will try to wrap up the discussion of the problem.

So now the overall job sequence of the crashing I'm trying now, now trying to do on three accounts.

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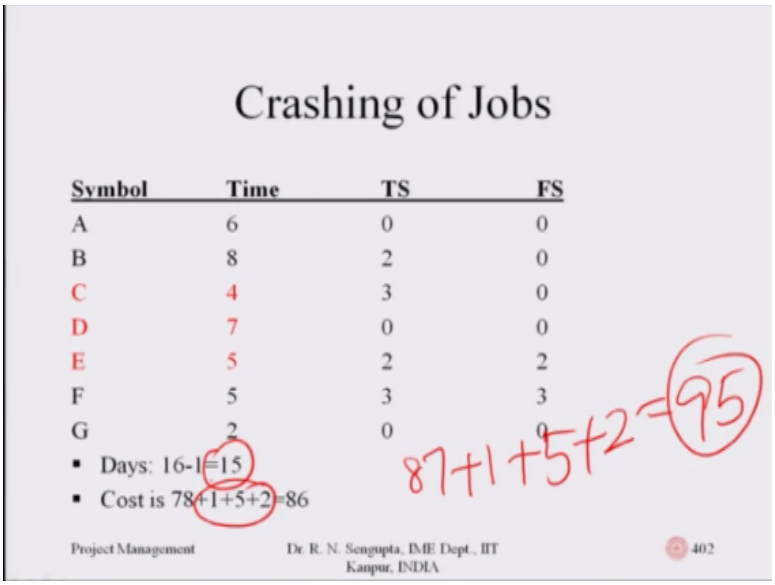

Which are as marked in red color C, D and E being done simultaneously by one one days, for them. So one one day is basically means that if I am trying to reduce the number of days, one means all of them are decreasing by one days but the overall consequence is decrease which is happening from sixteen to fifteen. Point one, point number two is that you should remember that when you are trying to do that C, D and E at one go.

You should also understand whether there are other activities in the overall sequence of the jobs. Such that they continue to be in the critical activity or the set of activities, and they do not violate the general precedence concepts and all the other assumptions based on which you are doing your project management. So this point even though I did not mention when we are discussing the problem in the thirty first class. But that is the actual underlying assumption.

Now the cost structure if you now concentrate would increase on three accounts, number one, one day reduction in C, number two, one day reduction in D and number three is one day reduction in E. So let us concentrate on the reduction, it will be one rupee, one euro, one dollar, for C similarly five units for D and two units for E. So whatever the cost was so whatever the cost was let me go back to the last slide.

It was eighty seven year, last to last line eighty seven here, so now it will be 87 + 1 + 5 + 2 which will be 95. So now if you concentrate the cost having increased from 55 to 95 units on the

reduction of the days for the whole project is basically is starting from 22 to 15. So if you consider all this inputs you will try be basically balance that these cost increase whether it can be offset by the overall profit you are going to make.

Or the revenues you are going to make on different accounts, and if that is true obviously we will try to analyze your total project in a very simplistic sense in the set of diagrams or set of consequence of discussions which we just discussed.

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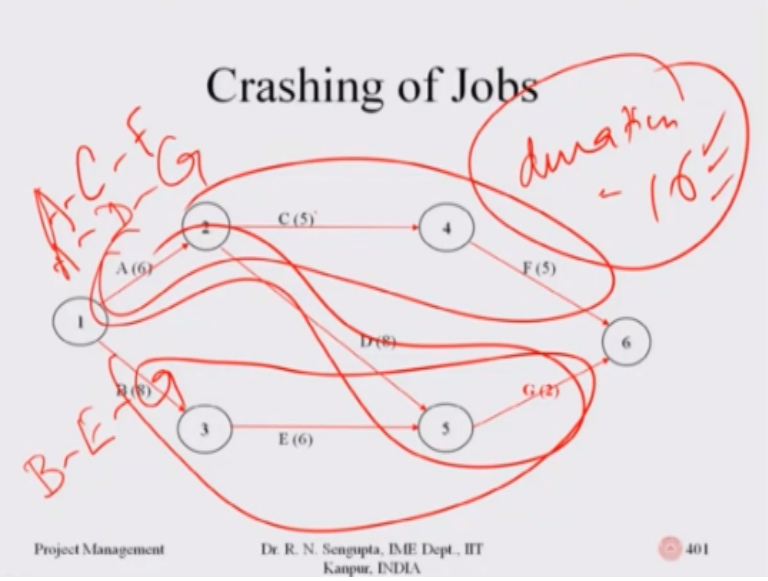

So now, the set of jobs which are bold red in color which is C, D, and E are shown, so those are the reduction which is happening in the total job reduction number of day as of now. And also the consequence of what is the total cost are just been mentioned in the last slide. Now you may be thinking that why did I take C, D, and E at one go, I could have done by only considering C, but the point is that all of them are now critical.

So before you took part of C, D, E, if you remember the number of days of reduction has happened in such a way, that it was 16 for all of them. So where let me go back again the slide, so here 6 + 5 which is 11, 11 + 5 which is 16, 6 + 8 is 14, 14 + 2 is 16, 8 + 6 is 14, 14 + 2 is 16. So all of the paths which was A, C, F then A, D, G and finally the last one B, E, G all of them are critical number of day is 16.

So that is why you have to look at those sets of jobs or those set of jobs collectively such that the reduction in the critical path happens for all the jobs which are now critical. Because they these set of activities as I am marking, all of them are critical so obviously you have to look at them on a macro level such that the reduction is happening on the same contemn for all of them.

Reduction in the number of days so obviously the cost consequence if you remember will be coming both, for C which is here, and also for D and also for E. So based on that you proceed that any reduction apart from that is not possible then you have to basically stop and give that whole set of sequence for discussions as that some collective and holistic discussion can take place as you are able to take practical decisions.

Based on the fact that if the number of reduction of the job the activities has decreased from 22 to 15 and the cost has increased from 55 to 95 whether it is feasible and whether you should go ahead with that**.** So now before discussing further problems I will go into some more theory and conceptual ideas so with that statement I will start the discussion.

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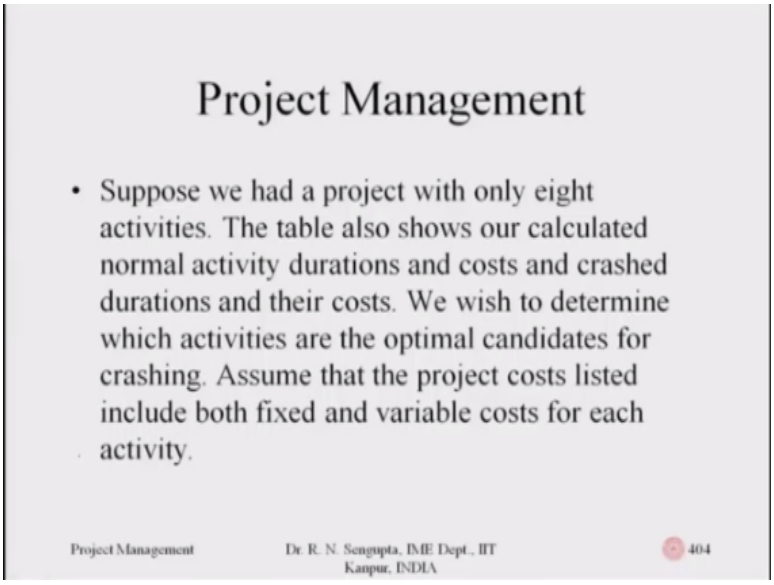

So, suppose we had a project with only eight activities, the table also shows our calculated normal activity durations so and the cost and crashed duration and their respective cost. So this is exactly the problem which you have done, I am trying to basically explain with different problem not complicated but a different type of problem with its integrity and the niceties.

We wish to determine which activities are the optimal candidates for crashing, assuming that the project costs listed include both fixed and variable costs for each activity now, here you noticed that the first time I am going to bring the concept of variable cost and the face cost. For the last problem which we started during the discussion in the thirtieth, thirty first and this thirty second, initial part.

The problem had only linear cost so I did not differentiate between whether they were fixed, whether they were variable or those things, so if the variable part comes so it is obviously it will be non-linear as I did mention.

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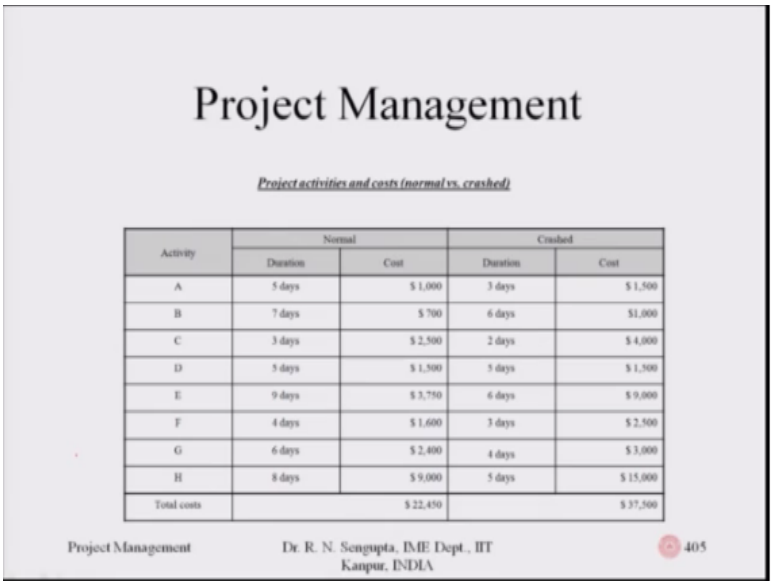

So here in this table you have again in this similar way the activities are mentioned in the first column on the left, the duration of the normal costs are given so for a it is five days, for B it is seven days, for C it is three days and so forth. The costs are given so the costs are for a it is one thousand dollars, rupees, yens whatever it is, so it is your dollars, US dollars it can be.

Canadian dollars it can be, Australian dollars, New Zealand dollars for B it is seven thousand, for C it is two thousand five hundred, for D it is one thousand five hundred, for E it is three thousand seven hundred and fifty, for F it is one thousand six hundred for G it is two thousand four

hundred and for H it is nine thousand. So the cost are considering the fact that you have the practical implication of the problem in front of you.

Now you want to crash it, so all of them would be crashed accordingly, so if you crash it you will try to find out that A can be crashed from 5 to 3, not beyond that. So obviously there is a limitation in the maximum crash to the crash number of days of A is two, similarly for B it is one day, and the cost is given initially it was seven thousand now it is one thousand.

Similarly for C it is one days cost has increased from two thousand five hundred to four thousand, D is zero number of days obviously there is no increase in there. Cost is E is basically as similar as it is given and all the cost are given.

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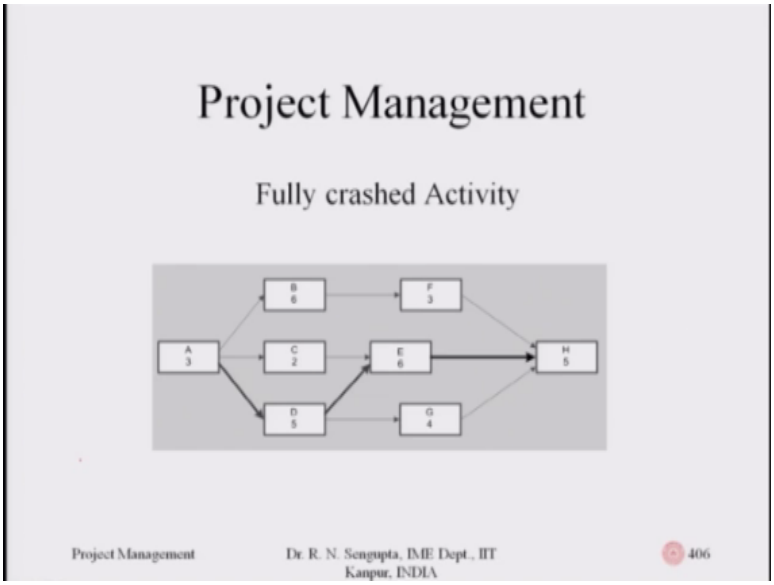

So the fully crashed activities in the sense they are given as it is, so this is very similar sort of problem, exactly conceptual in the same line light so you activity A, activity B, activity C, D, E, F, G, H. So only difference you may find out intrinsic it is not much of a difference in the initial problem it was the activity about arc, now it is the activity on note, so that will not make much of a difference.

Only thing subtly, you can point out is that in the initial problem I had mentioned only fixed cost and he concept of variable cost was not there but here I am in this problem I am mentioning the concept of variable cost also.

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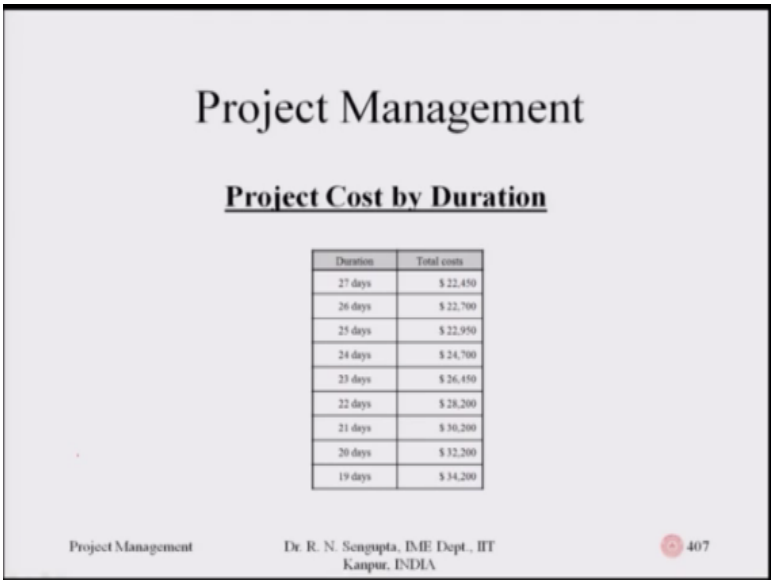

So the project duration by cost by the number of days, so consider it is given as duration as twenty seven days total cost is now twenty seven where is it coming if you calculate the forward cost method concept utilize the backward cost past method concept use the concept of total slack, use the concept of free slack.

I am not going to do that immediately but I will strongly advice students to solve the problem before or pause the slide number and do this calculation in excel sheet then resume the discussion which we are having here in this project management course.

So for the durations twenty seven reduction to twenty six to twenty five to twenty four to twenty three, twenty two, twenty one, twenty and nineteen corresponding total cost is given as twenty two thousand four hundred and fifty for the twenty seven number of days and the maximum cost for ninety nine number of days is given as thirty four thousand two hundred.

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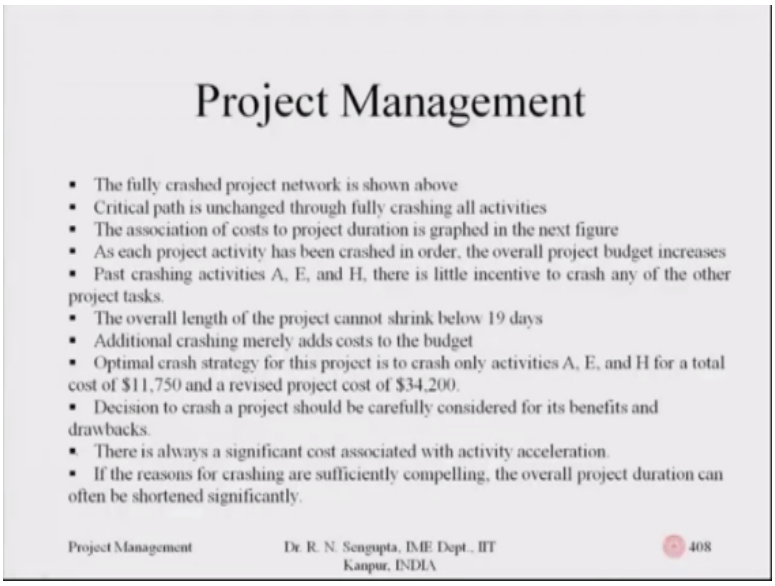

Now in this discussion the fully crashed project network is shown as just discussed, the critical path is unchanged fully crushing all the activities at one go, so in the first initial problem which we discussed we had basically taken one activity at a time and then seen that at the fag end all the activities which were there were taken in such a way that all the paths were critical and they had to basically tackled on a collective sense.

So when you are trying to tackle few of them in the last instance, they were done in such a way that all three of them separately or collectively affected the critical paths such that it was decreased from twenty two to fifteen, so that one deduction from 16 to 15 happened in such a way that all the three separate jobs have to be taken in a collective sense. The association of the costs to project duration is graphed as we just discussed.

And as each project activity had been crashed in order the overall project budget increases as mentioned in the table in the last slide, past strategic crashing activities A, E, H, there is little incentive to crash any of the other project tasks. Few remember that I did mention that qualitatively you are choice of which set of activities apart from the practical notion, apart from your experience whatever it is you will take those set of activities.

One at a time so that it makes logical sense to reduce the number of days which is there for crashing a particular jobs such that the overall increase in the cost or the total cost happens and in

the least possible manner. So if you remember the activity G, that had got marginal cost of eight, so rather than basically concentrating at the first instant only eight G, you would rather concentrate on other job such as reduction in one number of days in any one of the activity of the job.

Would be possible in the sense of the total cost would not be per day more than eight, it has ti be less than eight so it has to be 7, 6, 5, 4 whatever it is. So obviously you will be tempted, logically so who take those set of jobs so that the reduction in the per day in the number of days it happens is one, but the increase in the cost only happens to that tune to which is less than eight.

So obviously you will take the marginal eight for which is the least, the overall length of the job cannot shrink bellow nineteen days because as mentioned here the number of days are accordingly mapped the additional crashing merely adds costs to the what so if you want to add cost to the job further the number of days which is mentioned here in the bulletin point which is 19 days.

You will basically inquire more cost without added any advantage, optimal crash strategy for this crash project is crash activity is A, E and H for a total cost of eleven thousand seven hundred and fifty, and a revised project basically now becomes thirty four thousand two hundred which means that we go back to the last slide. The initial cost was basically twenty two thousand four hundred and fifty, the actual cost now after the reduction on the number of days is to 19 as shown in the last row the cost becomes is thirty four thousand two hundred.

So what we have is that the total cost is eleven thousand fifty, and it has become three thousand two hundred, the total number of days reduced and as of now is 19. So we will basically find out that it has basically decreased from I am repeating it please bear with me, it is decreased from twenty seven to nineteen the cost have been increased from twenty two thousand four hundred to thirty four thousand two hundred.

Decision to crash a project should be carefully considered for its benefits and drawbacks as I mentioned wherever you want to crash a job you should be careful in trying to analyze which set

of jobs or which set of activities should be crashed in such a way that gives you the maximum benefit, there is always a significant cost associated with activity accelerations so those activity acceleration which you are doing.

Acceleration means you are trying to reduce the number of days, as you do that it will have a negative impact on the total cost but obviously you will you need to balance that with your total revenues. If reasons for crashing a jobs or set if activities sufficiently compelling the overall project duration can often be shortened significantly such that you face some cost benefit and analysis which in the long run is positive for your overall decision making process.

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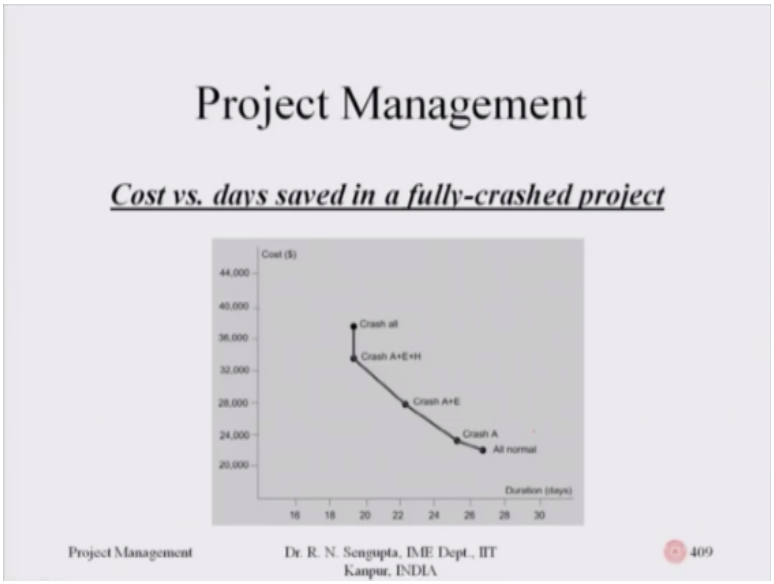

So if I consider the cost versus day saved in a fully crashed project, so now consider this which would be giving you some idea that even for any for any activity we consider we consider linear function what if we consider the total effect on the total job, or the total project which you are consuming it is not linear. It is non-linear. So technically what I would if I have to change the rate of cost structure as it increases for one day reduction.

I will basically join per day so this would be the per day save decrease which is happening along the x-axis. So we will join this points so the join points will be joint in such a way that this graph which you have will be best replicated by the whole point, set of point which is there, so if I want

to find out the rate of change of decrease in the number of days with respect to the cost, increase in cost I will basically find out the D Y, D X of that portion of the curve which is in front of me.

So what you have in front of you, so the graph is basically where you are trying to draw the duration of which is days or weeks or whatever it is. Along the X axis, the total cost along the Y axis you have to be careful that how you basically bring all the after effect of all the activities collectively to find out the total cost increase of the project which is in hand.

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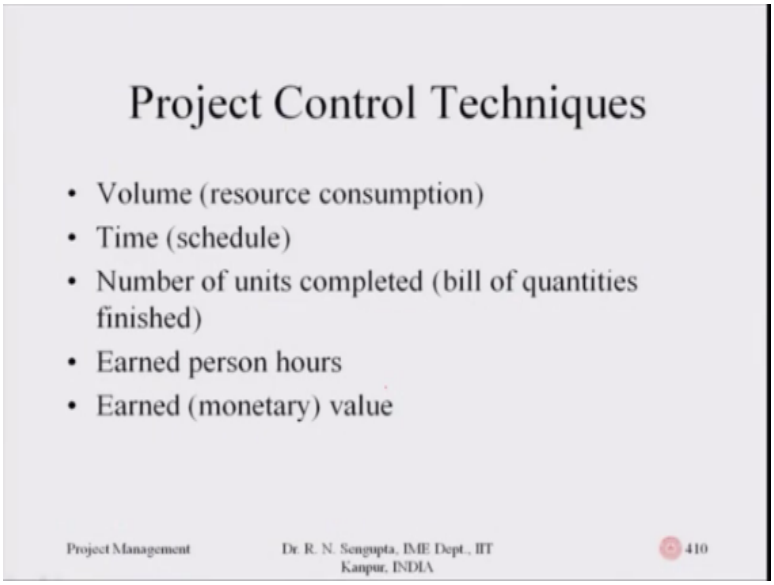

So for the project controlling techniques, you will basically consider the volume total resource consumption which is there and obviously consider that how resource scheduling resource leveling should be done considering the early start, early finish, late start, late finish, concepts are being utilized. You will consider from the time and the schedule and consider the critical path and how it is affecting all the activities which are there on the critical path.

That you are able to take a collective decision where you are trying to reduce the number of days, respect to the cost, so the cost will also increase, but on the other end the days will also decrease so you have to make a balance. So number of units completed on the bill of the quantities should be finished so as you do that you will also try to understand that if the average time which you are trying to decrease is happening which respect to the due date.

Which is there we will try to find out what proportional portion of the total set of activity is finished on or what is the proportion of the project is finished. If you think that some of the critical activities are to be finished if you reduce the number of days for the overall project by trying to crash some activities by two or three days. So now obviously it makes sense for you to go for that type of reduction even if the cost increase because in a long run you will basically benefit by crashing those set of activities of jobs.

You will also try to analyze that the earned person hours that you are paying some money so this amount of outflow of money which is happening whether it is happening we are trying to basically take this services of vendor, whether you are trying to take the services of a skilled labor, whether you are trying to take the services of expert engineer or whether you are trying to take the service of the best such designer.

Whatever it is they should be utilized in such a way that the crashing of the activities, crashing means I am trying to reduce. So the reduction what I am saying is that only for one day it can happen for an one and a half day also. It can happen say for example for a three forth of a day, so whatever it is happening you should basically try to analyze the problem, from two point of view, what are the individual cost reduction or cost increase.

Reduction means that you are able to utilize special information for less number of days such that you will reduce the cost but on the other hand you are trying to utilize the services of extra manpower, extra design engineers, extra utilization of extra CNC machine you are trying to basically rent from a vendor in such a way that they are balanced that means in the long run they should be positive effect for your end.

So the earned monetary value should also be calculated when you are trying to find out that what is the overall return and equity or return on investment which is happening such as that gives you to benefit, positive benefit. Monitoring the status of a project using S-curves so if you remember the curves which we considered for the early start late start, early start early finish, late finish, for the total cost that is the cumulative cost functions.

So, if you**,** I am sure you would remember we drew the early start the late start, early start, early finish, late finish the overall cumulative cost so this was the total cost, commutatively, this was the time duration, so it was the T. So based on that fact, then you leveled if you remember the resource leveling was there, whether increase in the overall utilization of the resources, was not more than capital R, and also not less than small r.

So those balancing needs to be done. So utilizing those S curves, it becomes a simple tracking problem, you track at each stage and take a decision accordingly. At conclusion of each given time period, we simply total the cumulative project budget expenditures to date and compare them with the anticipated spending pattern which you think would have happened. Any significant deviations between actual and planned budget spent reveals a potential problem area such that you have to take collective actions accordingly.

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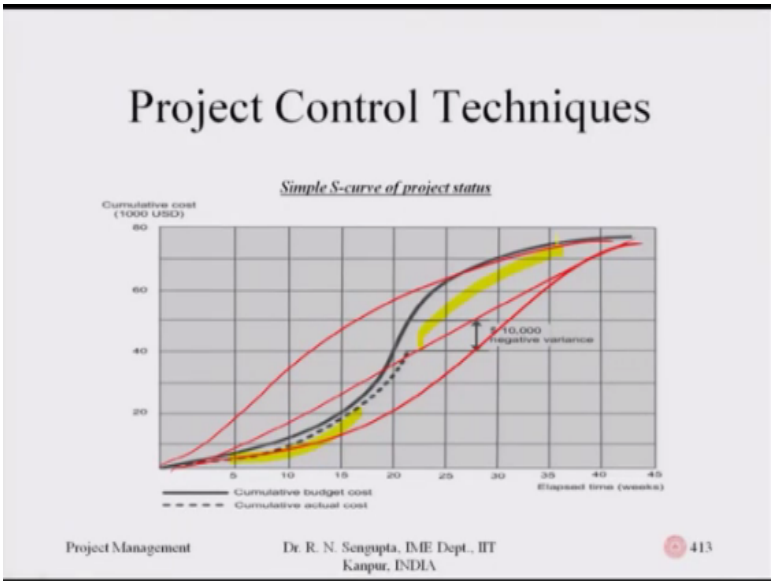

So this S curve which is there in front of you is exactly the same here you have the elapsed time, duration along the X axis, the cumulative cost is given on the Y axis and the overall project in general cost so consider the early start and the late start you have basically fitted the best fit line between both of them, such that you are able to utilize the resources on an optimum average value. So if there is any keys of decrease of the cost.

So those with which I am trying now to do using the highlighter one either it can be below, or it can be above. So if it is bellow and above which means that if the total cost is fixed and if you are already starting spending much more in initial weeks which means some corrective actions needs to be taken. So which means that you are trying to overshoot your cost or you expenses for the initial activity have been misjudged in such a way that you need to be basically be cautious and recalculate.

Your total cost or do such management of the activities in such a way that your total cost is reduced. So here, in the bold one and in the dotted one cumulative budget cost and the actual cost are given such that you are able to make a comparison between the budgeted and the actual cost which is happening.

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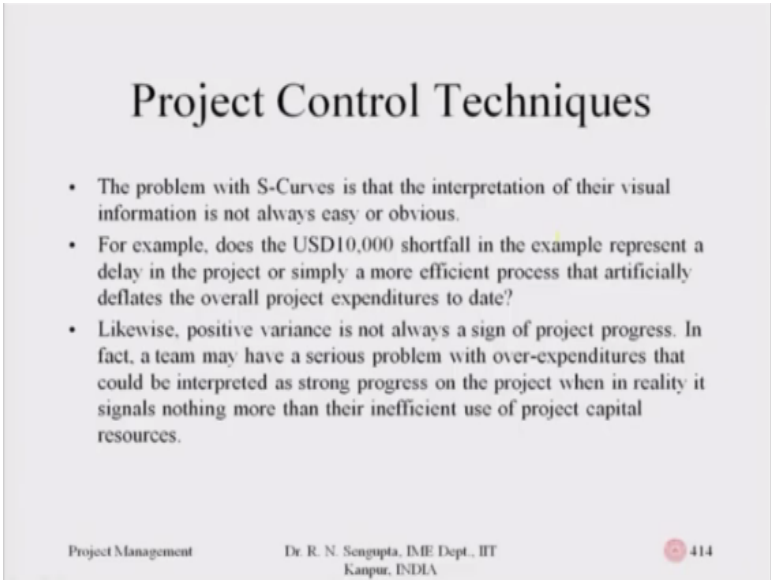

The problem with S curve is that the interpretation of their visual information is not easy to obtain it may be easy for on macro level. But on the on it may be easy on a micro level but on a macro level it may not be possible. Because micro level, what you are trying to do you have lot of information for each an activities possible, but when you trying to combine them the inter dependence of the structure the looping effect.

Which you have or the overall sequence of the activities or the sequence of the jobs or the sequence of the resources are in such a way, that it may become difficult for you to analyze the

overall budget with respect to the actual cost which is happening. For example, does US dollar of ten thousand short fall in the example represent a delay in the project. Or simply more efficient process that artificially deflates the overall project has effect on the expenditure with respect to the date.

So you have to basically answer those type of question and then take a decision collectively. Likewise, positive variance is not always a sign of project progress. In fact, a team my have a serious problem with over expenditure that could be interpreted as strong progress on the work when in reality it signals nothing more than inefficient use of the project capital resources, which means that if you are trying to utilize your resources in the very big way initial.

You may be thinking you are able to work, finish the work before entire time. But in the end, when you try to basically analyze your problem with the respect to the cost and with respect to the time, you may think that you have been able to save time, but the overall cost may have shot up by a huge amount such that it will have a negative effect on your total budget and your budgeting, total cost and benefit analysis for the project when you are trying to analyze the problem.

So the bottom line is simply evaluating the project status according to its performance or on a time versus budget, expenditure may easily lead us into making inaccurate assumptions, inaccurate predictions. About the project performance, in short because S curves which is basically you are trying to analyze the problem from the budgetary cost perspective to the practical cost perspective so using S curves only link time to the budget expenditure.

We have no way of knowing the true status of the project. So we must use dollars spent on an daily basis or on weekly basis or on unit times that you can take collective decisions accordingly. What we need is to means to determine how the project is actually doing besides just how much money has been spent on an equitant of time. We need a way of assessing the value the project which has generated to date.

And try to basically balance the overall value of the project with respect to whatever our plan was. Earned value management is just such a method for assessing the project status based on which you can take a decision whether your actual work which is going on is in line, with whatever you have planned, now all the discussions we have been doing till in the thirtieth class in the thirty first class in the thirty second class has been based on the fact that few of the assumptions.

Even though I am repeating it many time again and again please bear with me is number one you are always considering the concept of end to start concept. Or the sequencing of the jobs, number two, the concept of looping was not there. Never in all this set of lectures starting from the first till this thirty second class you have never considered looping as a practical way of trying to handle the problems even though practically to handle the problems.

In the short floor in the project management perspective really does makes sense. By trying to bring in the picture when you are trying to handle them from a theoretical perspective may become difficult. Point number two is that we did consider the concept of the distribution to the beta and we did consider the A value the B value the M value. But in all the cases it may not be true that how you tackle the problem.

Number three is that cost perspective which we have are not linear they are non-linear hence find to find out the marginal rate may be difficult. Number three is that when you are basically trying to find out the total cost there would be inter relationship between the activities so if you consider the activities which was there, when you are trying to basically sum of the variances we did consider that the activities are independent which is not true.

And also considering the central limit to your, that means you are trying to use the normal distribution was nice way of trying to tackle a problem for a very simplistic probabilistic point of view or distribution point of view. But in generally that may not be true. So with this I will just end the thirty second lecture with the note that the two different type of problems are discussion we had for the crashing of the jobs were simplistic.

We agree but I am sure they would give a very good view point that how the concept of crashing of the job trying to analyze the problem from trying to see how the cost increases whether it is feasible or not, whether the critical paths are which were initially whether they now encompass all the activities, they should be considered step by step such that we get a much better picture, how the problem can be solved.

Plus we should also try to analyze the problem from the monitory perspective that what is the overall excess cost we are trying to utilize over run of the budgets such that we are able to make some actual practical and realistic decision in respect to the resources with respect to the time and with respect to the cost which are basically we are incurring. And obviously that has to be balanced from the resource cost perspective.

So with this I will end the thirty second lecture and from the next day from the thirty third till the last lecture we will try to basically cover other topics related to GERT, Q-GERT and other such important concepts which are very heavily used in project management. Have a nice day and thank you very much.