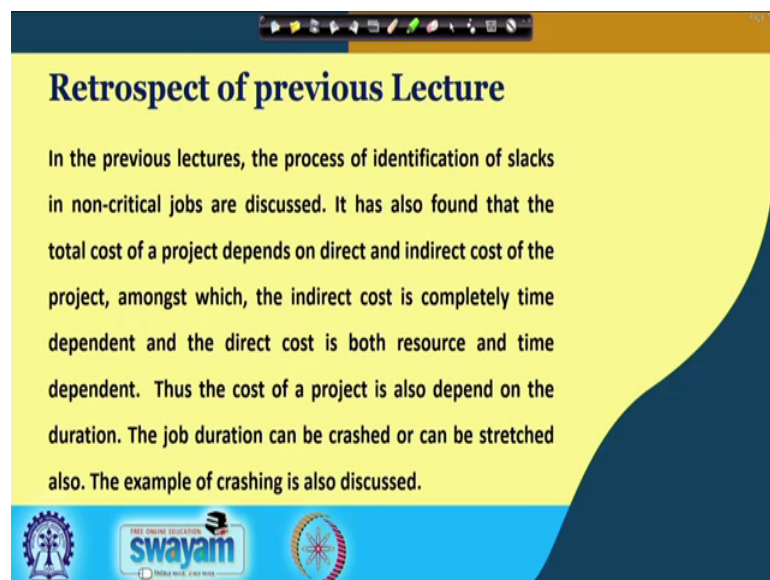**Network Analysis for Mines and Mineral Engineering**
Prof. Kaushik Dey
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture - 14
Crashing and stretching of jobs

Let me welcome you to the 14th lecture of NPTEL online certification course on Network Analysis for Mines and Mineral Engineering. The title of this class is basically stretching of the jobs.

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In last class let us retrospect we have seen that the process of identification of the slacks in non critical jobs are discussed. It has also found that the total cost of a project depends on the direct indirect costs which are time dependent. And cost of your project is also depends on duration. The job duration can be reduced by expediting or crashing and it also can be stretched or increased. And the example is example of crashing is already discussed.

And we can find out that the lowest cost schedule can be determined using the crashing system. Similarly, it can be obtained for the stretching also and that can be also considered here. But first let us again retrospect how you we can interpret the project due date in terms of stretching that is very very important.

So, stretching up a job let us actually you can understand the stretching means it is the extending. So but it is better you can understand it through this example. Say it is well known example to you the forecasting of sales surveying pricing and this is the network of that. Where this is the critical path and these are the jobs are having some slacks. And that means, there is a possibilities we can slack these jobs or stiff these jobs instead of doing it in that particular normal hour normal duration we can extend that job.

Let me give you one small example in this case suppose this survey pricing let us this survey pricing is expected to be completed in 3 days. And consider we need to deploy 10 people to carry out this surveying for 3 days then it will be completed. That means, the man days requirement this 3 into 10 is 30 is the direct cost for this job. Now, instead of that if we deploy say 10 people instead of deploying 10 people if we deploy 5 people.

Then 5 people required 6 days to complete the survey. If we deploy 3 people, it will take 10 days to complete this one. So that means, and our pricing will be reduced for that because we are keeping only three manpower instead of 10 manpower. Though their daily salary will be man day's salary will the same, but there may be other benefits which are basically a constant factor.

And that may be reduced because we are reducing 7 percent that indirect benefit will not be given to them. So, the cost will be reduced in this case if we are stretching this job. And the benefit is that instead of 3 days if it is completed in 10 days also it will not affect

the total schedule of the project, but it will give benefit us in terms of costing this is one type of understanding.
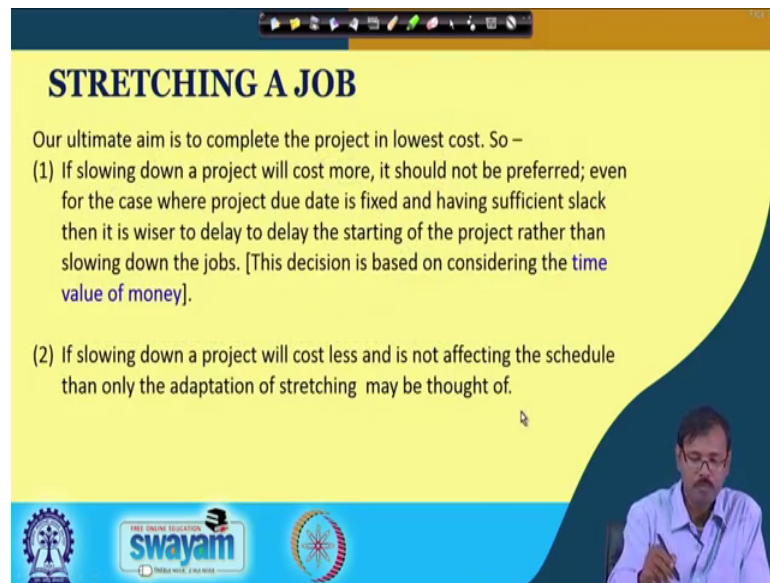
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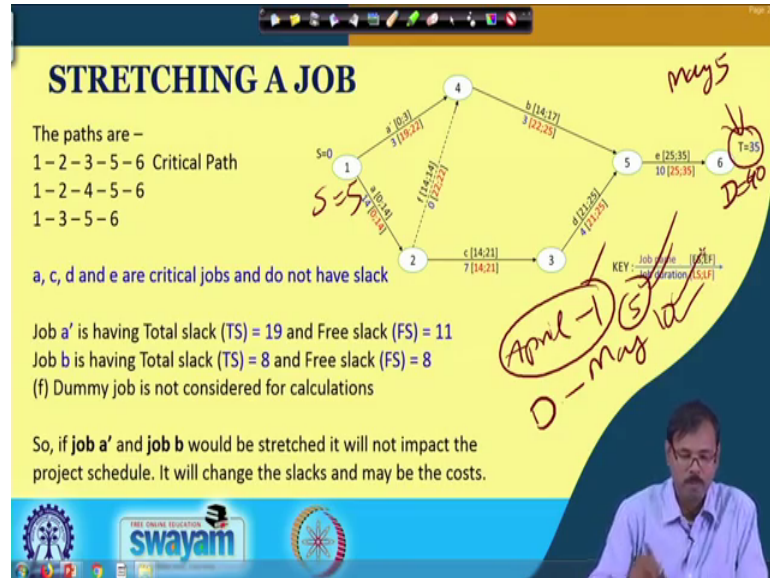
But generally it is it you have to look it on the perception of the due dates. Suppose you are considering this one where the project due date is this one project target date is this one, but the due date is something say D is equal to 40. Now if D is equal to 40 then we are having slacks everywhere additional slacks of 5 days are available.

So, now, if this additional slacks of 5 days are available; that means, in the in one class we have discussed we are starting it on April 1. And our target date due date is finishing this one is May 10 and we are completing in it by May 5 using this schedule. But if we are having this option we may have start it instead of S is equal to 0 we can start at S is equal to 5. That means, instead of starting it on 1st April we can start it in 5th April.

Then what will happen? Then our invested amount which we are investing on 1st April closing the investment on 5th may. But the payment will be received by us on May 10 that was the invested amount are lying with the project for five additional days interest on which are not being paid to us. Instead of that if we start it on April 5th and complete it on May 10th then the interest we are gaining for April 1 to 5 on the invested capital which is not invested but returning with some in banking agencies. So, that is basically the benefit because the time value of the money has to be considered.

So, let us look into this once again our ultimate aim is to complete the project in lowest costs. So, if slowing down a project will cost more it should not be preferred. Even for the case where project due date is fixed and having sufficient slack. Then it is wiser to delay the starting date of the project rather than the slowing down of the jobs because the time value of the money we are gaining from this already.

Slowing down the project may have some uncertainty which we are not dealing in the deterministic approach. And that is why because of that in general slowing down is not considered rather than the differing of the starting time that is mostly wished. But some cases stretching maybe also observed. If slowing down a project will cost less and is not affecting the schedule that only the adaptation of stretching maybe thought of.

It is not a very very judicious idea to go for stretching a lot. But were a huge slacks are available in that case stretching maybe an option to be considered if it is it reducing the cost.. So, especially for where the higher manpower etcetera are there in those cases it can be considered in these cases or the higher equipment.

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So, understanding the costing of a job in the perspective of stretching; if we are considering this. Earlier, the direct and indirect cost of a jobing is discussed in which it is considered that the direct cost is the resource based and fixed. However, certain it additional resource cost is required. So, suppose let us see one example here. Suppose the lathe machine is there which is manufacturing 100 bolts a day.

And now suddenly we are having our demand that 100 bolts we have to produce in hour. So, almost 24 times or maybe a scheduled hour if you are considering 8 times it is being made. So, our option is that we have to install additional machine or we have to hire this from the outsource at a price. So, this is basically we are reducing the time duration or increased production read demanding ask the crashing or expediting the job which we have already discussed.

Suppose we are having the opposite one of these that is the second case, if our targets is now reduced to 50 bolts per day then either we have to ideal our machine for 50 percent time of the day that is the slack time is available. Then instead of having that machine we are having the option we can buy a smaller machine that will give us the lower costing and our 50 bolts per schedule will be attained without failure.

So, that is why basically this is instead of half a day schedule using a smaller machine we have gone for a full schedule of a day and that is with a reduced price or reduced direct cost. So, the direct cost is being reduced here by stretching the job using a different

types of machine maybe also an option in this case which is basically the deducts in the job costs.

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 Let us see another example to understand it in a different way. Suppose we have to dig a lake or pond using the higher excavators, which is hiring prices 40,000 rupees per day or 40,000 unit per day plus one time mobilization charge of 10000 rupees or 10000 unit. And it has been found that if we hired 3 machines, then it can be completed in 4 days. And we are having a slack time in this job or 15 days suppose 15 days is required for constructing a pump house which has to place the water into the pond or lake or whichever it is that takes 15 days.

So, for that 15 days this job has to be waited or there is it possible that we can utilize this 15 slack days for this particular job. Now; that means, we can stretch this job instead of completing in 4 days if we complete it in 15 days or 6 days or 15 days also then also the problem will be solved without any delay in that total schedule of the project. Now in this case suppose instead of hiring 3 machines.

So, calculated total cost for 3 machine normal cost for 3 machine of 4 days has been found 4 into 40000 is the hiring charge of the machine for 4 days 10000 is the mobilization charges for 3 machine it is costing us 5 lakhs 500 10000 unit for 4 days is the total costing of this hiring. Now, instead of hiring 3 machine instead of hiring 3 machine if we hire two machines, then?

The job duration is that instead of 4 days it will be completed in 6 days simple 4 into 3 is the total machine days. Now it deploying 2, it can come to 6 days is the two machine it is coming to 6 days requirement. So, if you are deployed to machine then the total cost coming 6 into 40,000 is the hiring charge 10000 is the mobilization charge.

So, the total costing is covering 50000, but the duration is increased to 6 days. And as you can see this is the days early start is 14 late start is 16 early late finish by 31 early late starting by 27. So, if we are deploying this one then the project schedule will become 12 and 18 early start early finished time and late start late finish time will became 31 and 25.

So, the impact 31, 25 the impact is not there on the succeeding job or nor on the preceding job in this case. So, that is why it is very very applicable. But this is giving us a reduced costing of 10000 unit. So, that is why it is beneficial to us in terms of direct costing if we are stretching that job.

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Now, let us see if we are deploying instead of 3 machine only 1 machine. Then it is further reduced to 490000 and job duration is becoming 12 days. So, our early start early finish figure will like this, this will become 12 and this will be 31 and 19. So, that means, this is also not impacting on the succeeding or preceding jobs for this one. And that is why it is also equally acceptable.

So that means, our normal one which we have considered initially. If we stretch that job to this condition that is giving us some savings in the direct costing, but not impacting on that total schedule of the network. So, this type of stretching is always possible and always welcome in a particular network.

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So that means stretching a job is possible reason behind in most of the cases stretching a job is limitations or non availability of the resources, lack of manpower. Or basically in multi project companies whose number of projects are demands in manpower varies in this those cases. if you are having a slack in a particular job then the manpower from that job.

May be diverted to the other critical jobs where you need to expedite the speed. So, that is why the lack of manpower is coming for that particular job where the manpowers are being withdrawn. And that is becomes stretched because of that then the diversion or of the manpower as we have discussed here change in the priority of the utilization of resources suppose say we are having some particular project here which has been going on which is being going on particular project which is being going on.

And suddenly another project is also available, another project is also available. But as slack is there we can change the priority and we utilize this job, for that particular instead of this activity, for that particular activity stopping this activity, delaying for some period.

So, we have stretched these we have stretched these little bit because huge slacks are available here. But this is of higher priority and higher beneficial to the company.

And that is why the change in the priority utilizing the resources occurs. And it is considered diversion of that one. So, that is why this can be another point where the stretching of job can be possible. And stretching of the job is also possible for the alternative resources. Suppose x is not available go for the alternative resources who is basically stretching the job duration little bit. But it is not affecting the total time scale schedule of the project.

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So, I believe now you have more or less understood what is stretching and how we can consider stretching in which case. But in this case one maybe have some idea that if the job is being stretched with the reduced costing. Then why we are considering the normal duration of the job is that one, why you are not considering the reduced price of the job at the reduced price as the duration of the project job? So, that is why let us consider what is the normal time, we are considered in the CPM analysis or the critical path method analysis.

Generally normal time given in the CPM analysis is considered the optimum cost or lowest cost time for that job, but it is not always true. Say sometimes normal job may indicate the possible or most likely time considered the transportation time between 2 cities maybe 10 hours with the average speed of 66 kilometer, but may become 40

minute at 90 kilometer which may reduce the cost due to better efficiency of the engine and diesel.

But this is not considered because this is risky one. 90 kilometers per hour average speed is it a congested road or maybe in that condition may be very risky one and that is why though it is cheaper then also it is not considered. So, there are n number of other parameters safety, security, costing maybe some constants are there say that road may not allow speed more than 70 kilometers that is the limited speed that is why only that our speed of 60 is being considered.

So, these are the different factors has to be considered for analyzing or for arriving at the normal time in a critical path method analysis. Say two groups are presented here, here this is the cost this is the time for a particular job it is not the indirect costs, this the direct costs for the direct costs are being reduced with the time in this case. And then it is increasing little bit and this is the lowest cost time or the normal time is being considered.

So, this is the first case where we are considering. However in this case this is the lowest cost time then also we are considering this is the normal time not the lowest cost time where the cost is a little bit higher. So, that may be the reason we are considering it in this type of case. So, in this case it may be considered this may be the consideration of the time for this particular case.

So, all these are to be considered in the different places with the particular other considering the other effects affecting parameters into that consideration of the normal time and the normal cost of the project. So, this understanding is very very important I believe that you are able to understand that what are what is normal time and how that can be arrived at for the different cases.

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So, now, let us consider one problem which will go for stretching. So, this problem is already known to you forecasting of the sales and the pricing the sales and finally, the budgeting of that one. So, in the step 1 let us consider the total cost of the project in the normal duration is P last problem we have considered it is O.

So, now, the duration givens now these are the normal duration this is the maximum possible stretch duration, this is the stretching cost that is the saving occurred by stretching this and this is the same for the project B. We cannot have stretching possibilities in these jobs because these are the critical jobs and must be addressed with time, but we are having the option for stretching this one.

So, in this case the similar way we carried out the calculation in the crashing or expediting we can go for the stretching one our this is critical path. So, cannot be stretched these are the two other paths which can be a considered for stretching and we can identify the in path B and C can be stretched for 8 hours or 8 days or 19 hours on 9 days respectively. So, we have identified that these are the two paths which can be stretched and among that you can identify what are the activities that can be stretched.

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So, now step 2; is to come out in the activity. So, for stretching this one we are having we have identified either you can stretch A or we can stretch B. The normal job duration is three for both maximum job duration is 15 and 9for both. And this savings in stretching is rupees 5 per day for job a dot and 2 for job b dot. So, now, if we are considering stretching the path B gives us for not path B for job B this gives us still savings of 2 unit. If we are going for path C or job A dot it is benefiting us 5 unit.

So, the job can be stretched for a job from 3 to 15 that can be stretched for 12 days. So, by stretching the job a dot for 12 days we can save 60 unit price. And that is why our total costing will become P minus 60 in this case. And though if you see now our stretching is complete at this position the earliest possible time is now for a dot is changed to 15. And the late start and late finish time is now change to 7 comma 22.

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So, this is the for a dot job earlier early possible early finish time is this late finish late start time is this. And this is very much within the following schedule of T is equal to 35, but this is gives us a savings of 60 unit for the total project cost.

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Now let us look into the next option in step 3; if we are looking it is already crashed sorry for this one I forgot to change this one. So, this is already crashed now we are having only option we can crash for the B activity. And we are having the option that it

can be sorry not crashing we can stretched B activity. And it can be stretched for 6 days, and the 6 days gives us the saving of 12.

Now if we look into this, this is our network now present network this is earliest possible starting time of this one is this. And if we go for stretching job B from 6 to 9 then there will be an additional savings of 12 unit and our total project cost will become P minus 72 and no more stretching is possible. So, now, our present network will become like this, if you look into this the present network is that this will be a dot will be changed to 0 15 early start early finish time. And this will become then 15 to this will become now 6.

So, 21 sorry this is not 21 this will be 24, 15 plus 9 24 early start early finish time. And this is 25 35. So, basically T is equal to 35 is not being affected because this portion is not being affected by this. So, it is now easily understood that this critical path is not is not is remain undisturbed. But this A and B jobs are no stretched there early start early finish times are now changed.

If we are considering late start late finish time is also change. And now it is becoming late start late finish time one 16 and 16 25 for B. So, the project network is not affected in this case, but the total project cost is now reduced to 7 to 2 unit reduced by 72 unit from it is original cost.

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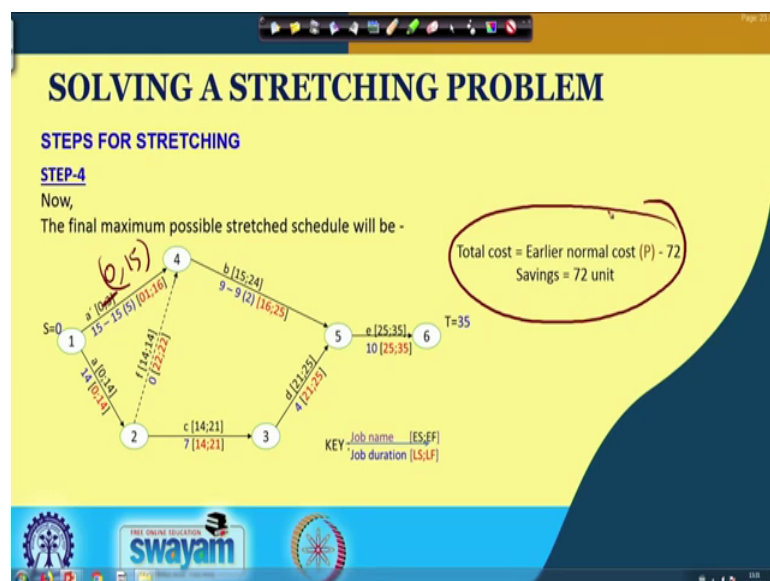
So, that is the benefit of stretching in this case. But it may not be always true for all the cases. And you can see the new network is now becoming like this. So, that again has to be changed this is 0, 15. So, and the total saving is becoming 72 unit.

So, stretching I think more or less now you are able to understand what is stretching. This is more or less over on the stretching part, some critical network they are crashing their algorithm for crashing or expediting network scheduling will be discussed in the next class.

Thank you.