Principles of Construction Management
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Lecture – 15
Introduction to planning and scheduling (Contd.)

[FL]. Welcome back to our lectures on Principles of Construction Management. Today we will continue with our discussion on planning and scheduling.

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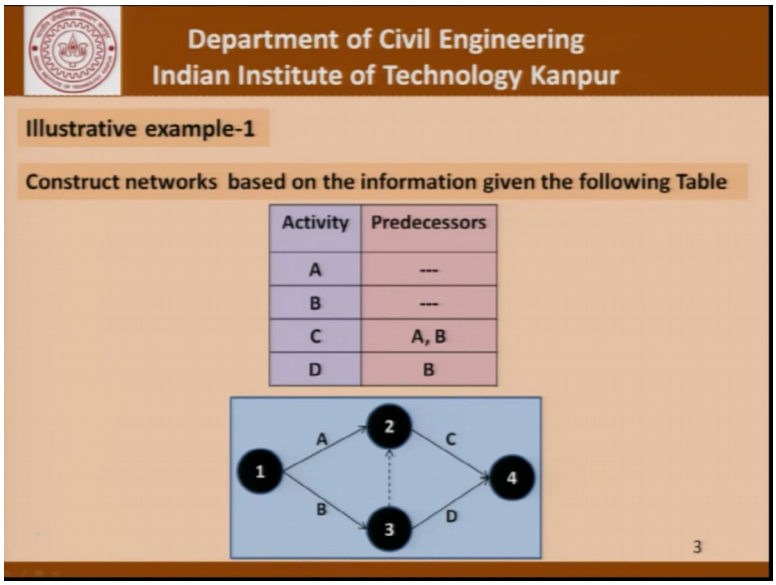

What we had done in the last class was to construct a network based on the information given in this table, and we had made this network.

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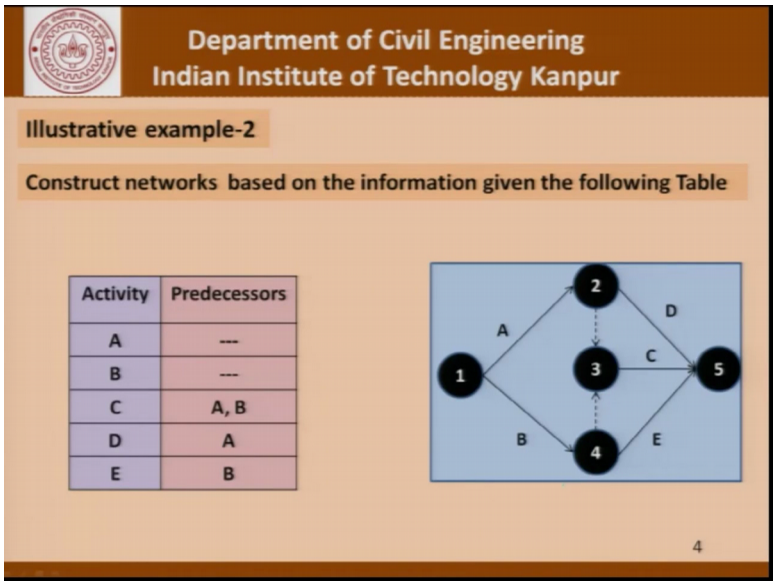

Similarly for another example: when there were 5 activities in the project we had constructed this network based on the precedence's given. Now what we will do today is to have a general discussion on some of the resources that are required for the planning of a construction project.

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So, we will talk of quantification of workload that is in man days or man hours. So, at the end of it what we are given is a quantum of work; whether it is cubic meters of excavation or pouring, a certain volume of concrete, or erecting a certain tonnage of steel

or whatever that is. So, we have to convert that workload to the workload in order to get an estimate of the time involved. Then we have to identify the resources. We have to identify the equipment, we have to identify the labour and so on. We may have to also make judgments on whether to employ this equipment or that equipment or maybe employ no equipment at all. Only then, we can arrive at some kind of an estimate of the time which is required to complete the project.

Then it is also the matter of allocation of resources that is how much resources is allocated to a certain project; most of the time the project manager is not working with infinite resources. So, there is a finite resource whether it is in terms of manpower, it is in terms of equipment, its terms of materials. So, the decision has to be made how to allocate the resources at given point in time. At one point in time it may be deemed or it may be felt that there is one activity which needs a particular source more than the other. And finally, we need to keep in mind the fact that all this effort is being done to figure out or to understand; what are the implications of this exercise in the cost of the project.

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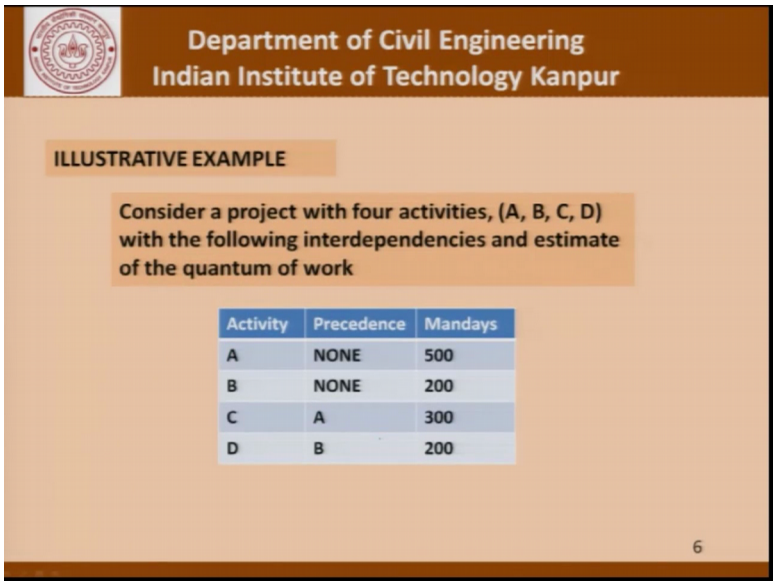

So, having said that, let us try to move forward and go to an illustrative example, which consists of let us say 4 activities A B C and D with the following interdependencies and estimate of the quantum of work. In this case, we have already done the first step that is; we have converted the quantum of work to the man days. So, in this case there are

activities A B C and D: A and B can be started without any dependence on each other and C depends on A, and D depends on B.

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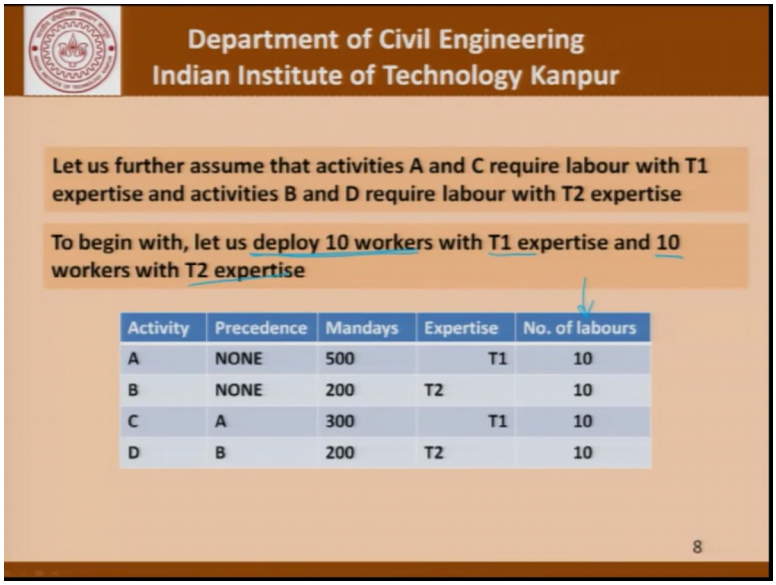

And let us further assume, that the activities A and C require labour with T1 expertise and activities B and D require labour with T2 expertise; and we are talking only in terms of labour deployment.

So, this project is such that it requires only workers, but workers having an expertise in certain area, it could be for example, carpentry and masonry. We have added this information on expertise in the same table and now we have A and C which is one set of activities which require T1, and we have B and D which require T2. And the man days estimates for A and C is 500 and 300, for B and D it is 200 and 200.

So, if we move forward and we make an assumption that we will deploy 10 workers with expertise T1 and 10 workers with expertise T2, which is given here what do we get. This assumption was necessary in order that we are able to get the times required to be able to complete these activities.

So, if we divide this, man days by the number of workers its elementary arithmetic that we can say that well, this activity can be done in 50 days, this can be done in 20 days, 30 days and 20 days. What we have to understand is, that dividing this man days by the number of people who are working is a simplistic approach. And what we are saying is

that the efficiency of the workers is not being taken into account. The learning that happens over the period of time, after all we are talking of 50 days. So, what the kind of productivity of the worker is, in the initial phases need not be the same as in the final phases.

So, given those kind of simplifying assumptions, this basically just gives us a estimate of the time.

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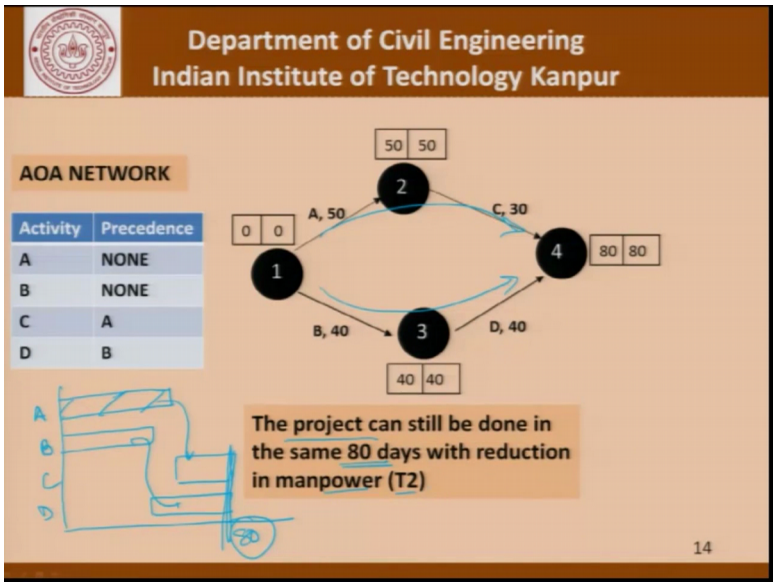

So, now if we move forward from here and try to draw, the activities on arrow network which we have seen last time, this is what we will get. This network shows the activities and the estimated man days for each activity. So, activity A is 1 2, activity B is 1 3 they can be started independently, C can be started only after A has finished, that is activity 2 4, and similarly we have activity D which is 3 4, which can be started only after B has finished. And with these numbers indicating the estimate of the man days we move forward and complete this network, which now gives us the times; which we have also calculated earlier.

So, let us not bother about what is written in this squares, because that is something which we will talk about later. We can complete activity A in 50 days and C which starts after 50 days, we can complete it in another 30 days. And therefore, the project can be completed in 80 days as far as A and C is concerned. Similarly, B and D can be completed in 20 and 20 which is 40 days. So, what is effectively happening is that, if we

plot time here and activity A here, what we are saying is that, this is going to take 50 days, B can be started immediately and it will take 20 days, C can be started only after A is completed and its going to take another 30 days, and D can be started after B has finished so its going to be here its 40.

So, of course, let us not bother about the scale, this should be 50 here so that brings me to 50, this comes to 40 and this is where my 80 is. So, this is one rough representation assuming that, we are starting b at the earliest possible time that it could have been started. This is not really necessary and that is what we are trying to see from this example later on. So, effectively what we are saying as far as this discussion is concerned is; that the project needs 80 days for completion with this kind of deployment of manpower. What was the deployment of manpower? We have put 10 workers for A, 10 workers for B and the same workers which were working for A after completion of A moved to C and the completion of B these workers move to activity D.

We also find from this small chart that B D is not a critical activity, of course critical activities there is a technical definition and we will talk about it in the next class. But it is very obvious that B and D even if they get delayed a little bit here and there, it will not affect the project so long as they can be completed within the 80 days; that is the time that is being taken by the activities A and C to complete.

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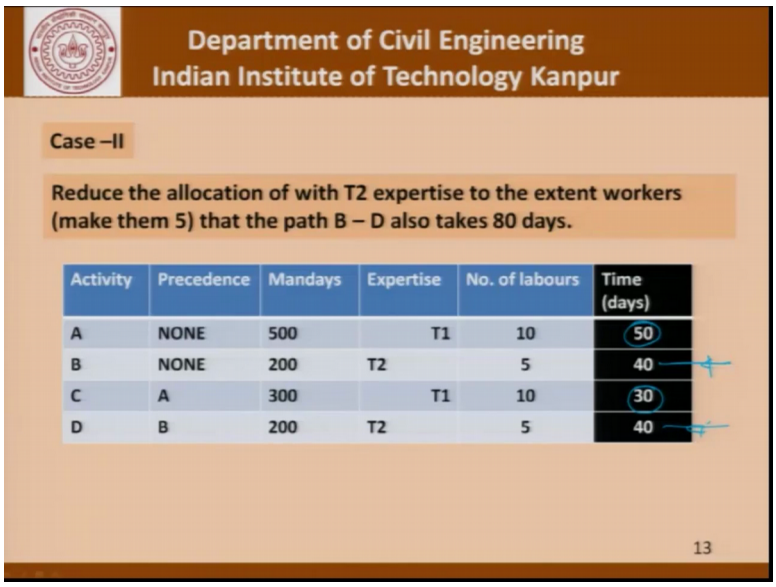

So, if now we move forward, and try to studies different case: what we do is, that we reduce the allocation with T2 expertise that is the workers working for activities B and D to be extend, let us say make the 5, that the path B D now also takes 80 days.

So, what we do is this 10 remains where it is, but this 5 is reduced from 10. Earlier we were working with 10 people even for B and D, but now we are going to put let us say 5 people. So, what happens as a result of this reallocation, the times taken for A and C do not change, but the times taken for B and D, they become 40 each. So, what this results in is something like this, that A and C can be completed in 80 days as earlier; and B and D also now takes 80 days. So, going back to our earlier representation what is happening is that: if I have a taking 50 days, B now taking 40 days, C is starting at the end of A and taking 30 days and D is starting at the end of completion of B and taking 40 days. Now, we have this 80 day deadline, where both A and C and B and D are getting completed at the same time.

So, what effectively has happened is the project is still being running in 80 days, but there is a reduction in the manpower of expertise T2. So, this was an illustrative example as to how we can change the resources allocated to certain activities and try to engineer the duration of that activity, but at the same time not compromising on the duration of the project.

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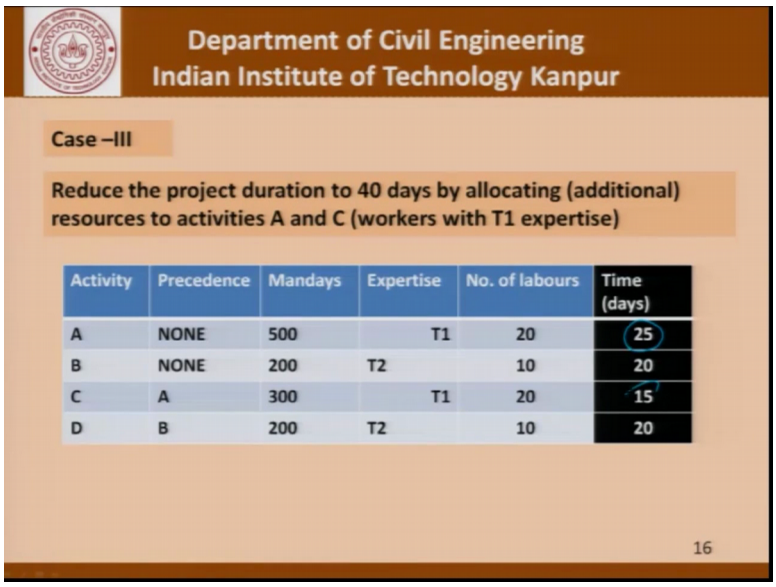

Now, we can do another example, where we try to enhance the allocation to A and C, and try to reduce the project duration to 40 days. Now, where is this 40 coming from? It is coming from the fact that B and D could be completed with 10 people in 40 days. So, now, what we want to see is, is it possible to complete A and C also in 40 days, by just enhancing the manpower. And that is what we are trying to do; we are trying to allocate additional manpower to activities A and C that is being increased by 10 to 20. And what we have now is, that A and C are getting completed in 25 and 15 days and this makes it 40, and this was what the original allocation was, and we are still at 40.

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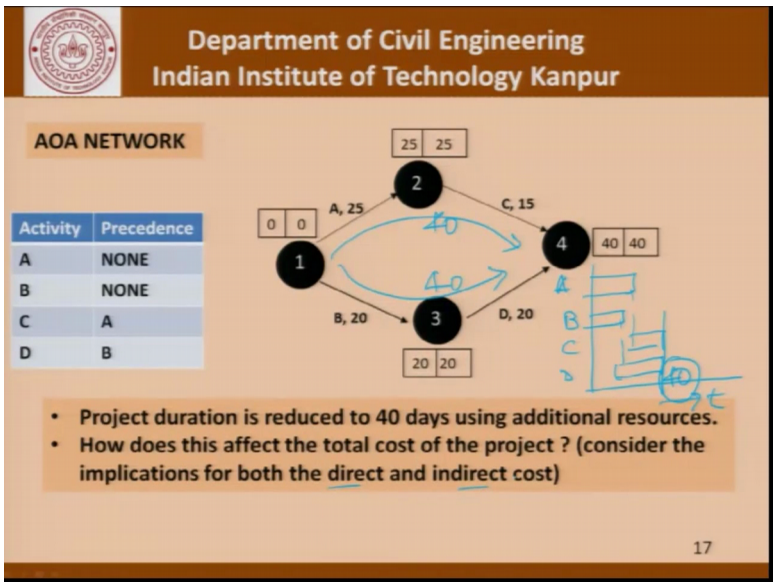

So, going back to that network, we have now A and C having 40 days and B and D also getting completed in 40 days. So, going back to that chart representation that we have if we have this time, what we are doing is A has now been shortened to 25, B is taking 20 days which is just a little less than that, C is starting after 25 which is somewhere here and going to 15 days, and D is a starting just after the completion of B is also getting completed; but project is getting completed in 40 days.

So, this is what we have achieved by enhancing the allocation to activities A and C. So, what we see is that the project duration is reduced to 40 days using additional resources. What we have to think is, how does this affect the total cost of the project? What we have to consider, is both the direct and indirect costs and that is something which we are

leaving as a food for thought for the present and we will address this issue at some point in time later on in this course.

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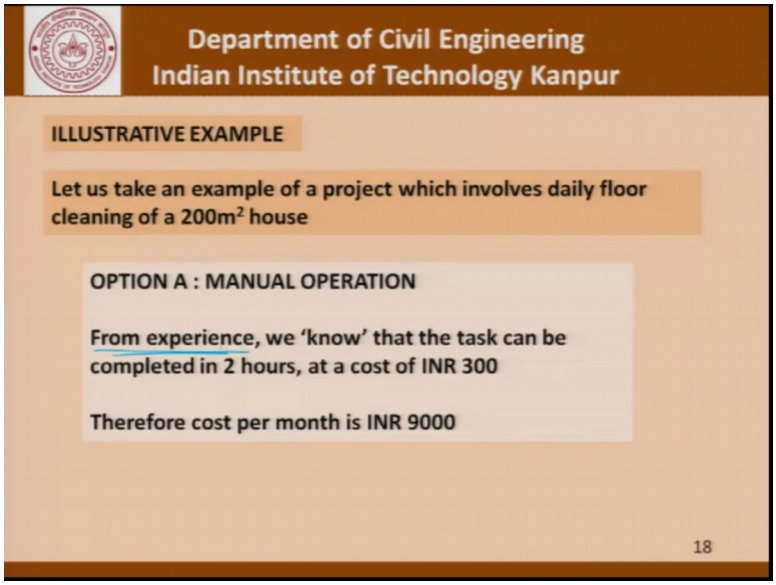

Now, let us move on to another example. Let us talk in terms of an example of a project which involves daily floor cleaning of a 200 square meter house. The option one is to do a manual operation. Using the simplest of tools and tackles and from experience we know that the task can be done in 2 hours every day and the cost is 300 Indian rupees.

So, now we are invoking experience to determine the time. In the previous case we had invoked experience, but it was not obvious because we did not even have the actual work involved; what we had given only the man days involved. So, in this case we are saying that experience tells us that it can be done in 2 hours every day, and the cost is 300 rupees. And therefore the monthly cost is 9000 rupees.

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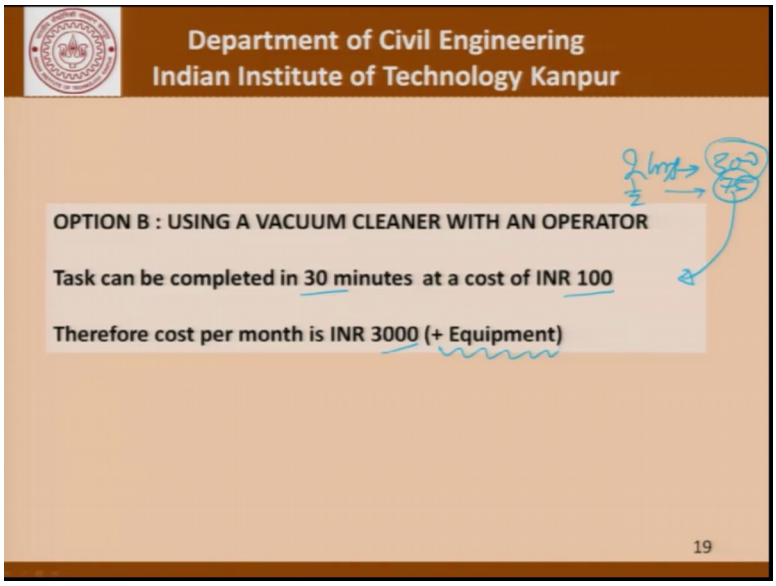

If we were to now do this operation using a vacuum cleaner. And obviously, the vacuum cleaner will have an operator so we have to consider the cost of both of these. And again by experience, we know that the tasks can now be completed in 30 minutes that is half an hour instead of 2 hours and the cost is 100 rupees for the labour.

So, in the previous case when it was 2 hours, we had taken a labour cost of 300. Now if it is half an hour, instead of 75 we are taking a cost of 100. For the simple reason that here it was let us say unskilled labour, but in the case of operating an equipment the kind of labour involved could be different. And therefore, we have enhanced the cost involved as far as labour is concerned. So, therefore, the total cost per month is 3000, which is the labour cost and we have to include the equipment costs.

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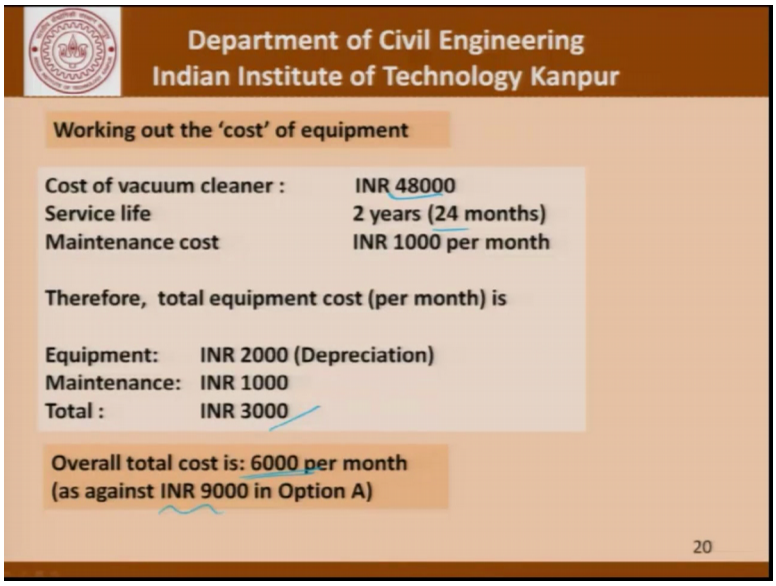

So, now how do we determine the equipment cost? We have to let us say find the cost of the vacuum cleaner which is let us say 48000, and the service life is 2 years with no salvage value. We also say that there is a maintenance cost involved of 1000 rupees per month. So, the total cost as far as equipments is concerned would be let us say 2000 rupees a month which is basically purely depreciation, we take 48000 distributed over 24 so we get 2000. And we have a maintenance cost which is 1000. And my total equipment cost is 3000.

Aand therefore, the overall cost is 3000 for equipment and 3000 for labour, which is 6000 per month as against the 9000 in option A.

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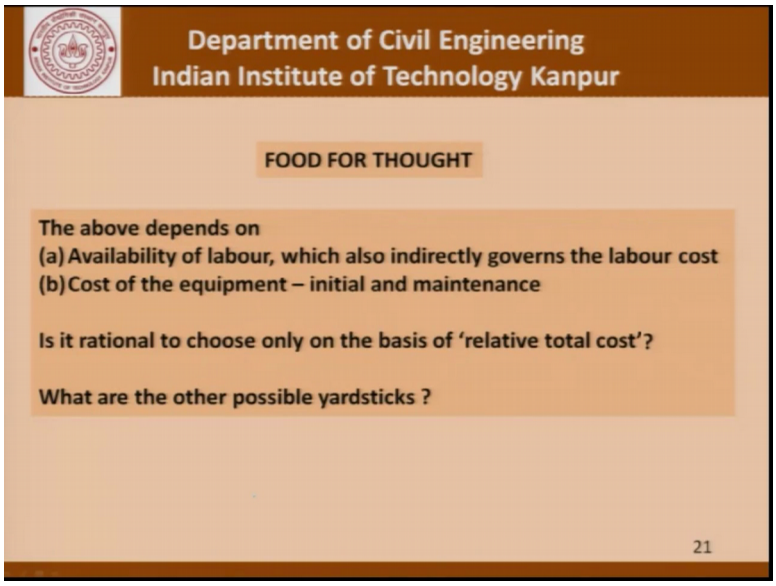

So, what we have to think about is the availability of labour is something which is very very important in calculating the labour cost. And In fact, the labour cost is often governed more or less by the availability of labour. So, if there is shortage of labour, the labour cost will keep going up.

The cost of the equipment initial and maintenance: so through this example what I have tried to do is to illustrate how it can be integrated into a decision making process. What we have to also think is, is it rational to choose only on the basis of relative total cost? What are the other possible yardsticks? And if those yardsticks can be found we would probably be able to make a more rational and a educated decision.

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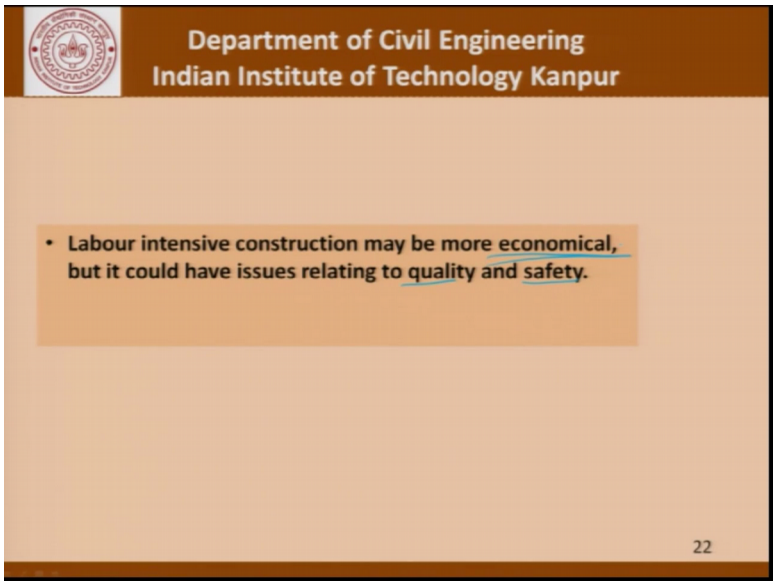

So, some of those things could be quality and safety. In a country or in a situation where labour is cheaply available; so the labour intensive construction may be economical, but what we have to make sure or also understand that there could be issues in terms of quality and safety. As far as safety is concerned there may be situations, where it is difficult almost impossible sometimes to have a worker working; depending on what kind of regulations and specifications are there, it may have to be an equipment which has to be sent in to be able to carry out a particular construction activity- in which case regardless of the cost of equipment we have to really opt for that.

Working with only labour has the problem with quality also at times, because different people have different competence levels and it is difficult to ensure uniform quality which is so much easier to achieve if we are working with equipments. Now mechanization of costs, has also given a quantum leap to capability.That is we are now able to think of and execute projects which were simply not possible earlier because it was not possible to carry out those activities manually.

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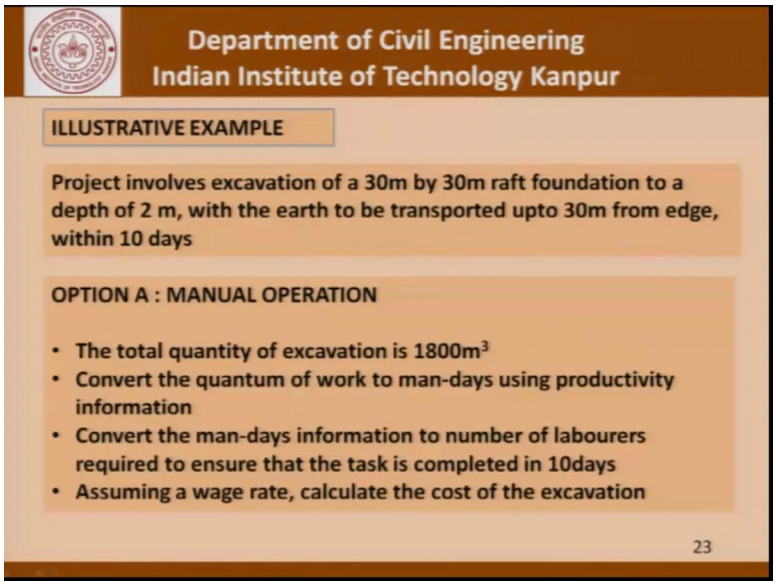

So, let us try to take one more example where the project involves the excavation of a 30 meter by 30 meter raft foundation to a depth of 2 meters, with the earth to be transported up to 30 meters from the edge and the completion time is given to be 10 days.

So, option A if we talk of manual operation. The total quantity of excavation is very clear. The total quantity of excavation is 30 into 30 into 2 which is 18000 cubic meters. We have to convert this quantum of work to man days using productivity information. We have to convert the man days information to the number of labourers used or workers required to ensure that the task is completed in 10 days. And assuming a wage rate calculate the cost of the excavation. So, these are basically the steps involved in calculating the cost of this project using manual labour alone.

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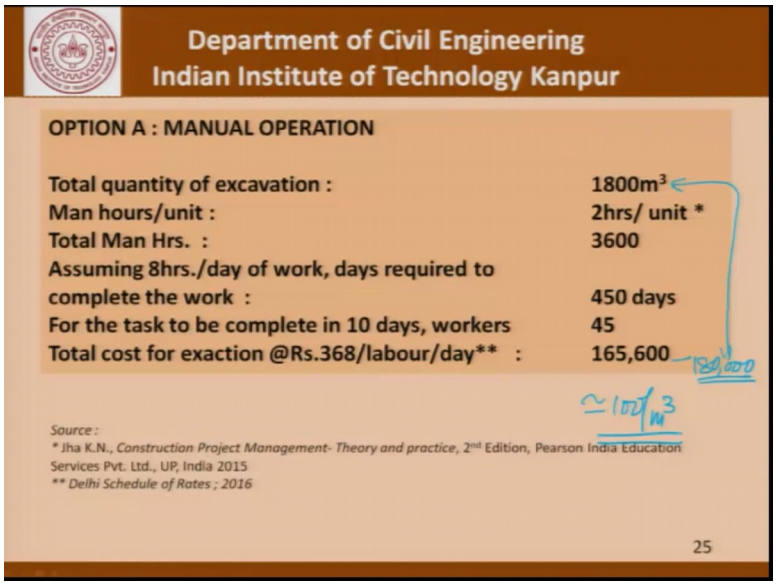

So, if we try to do that the quantity of excavation is given. Man hours per unit let us say 2 hours per unit, in this case the unit is a cubic meter. And therefore, to do 18000 cubic meters we need 36000 man hours. And assuming 8 hours per unit days of work and the days required to complete the work is 450. And for the task to be completed in 10 days we need 45 workers. And now, for these 45 workers the total cost at let us say 368 which is given in the standards or given in regularly published documents, the total cost of excavation turns out to be 165600 rupees for 1800 cubic meters if we do this operation manually.

One way of looking at these numbers could be that, if we take this to be let us say 180000, then what that means, is that 180000 rupees is being taken to do an excavation of 1800 cubic meters. So, basically what we are looking at is a 100 rupees per cubic meter is the rate of the excavation. This weight does not include contractor profits, it does not include water charges or power charges or whatever the miscellaneous charges that may be applicable to a particular site, but that gives you some insight into these numbers.

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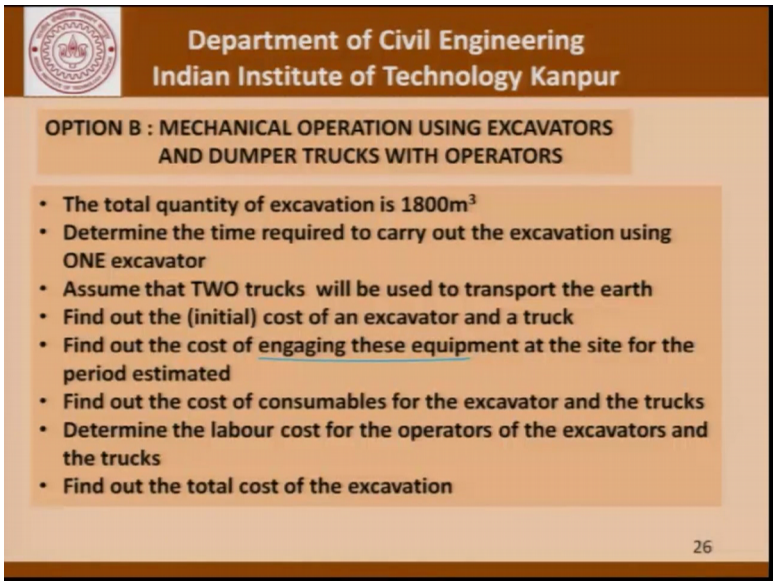

Now, let us continue and try to do this operation mechanically using excavators and dumper trucks. So, the quantity excavation does not change it (Refer Time: 18:24) in 100. Determine the time required to carry out the excavation using one excavator and assume that there will be two trucks which will be employed to transport the earth. In order to determine the cost we need to know the initial cost of the excavator or the truck or we could find out the cost of engaging this equipment at the site for the period estimated. Then find out the cost of consumables for the excavator and the trucks, and determine the labour cost associated with the operators of these equipment. And we will have the total cost of excavation carried out mechanically.

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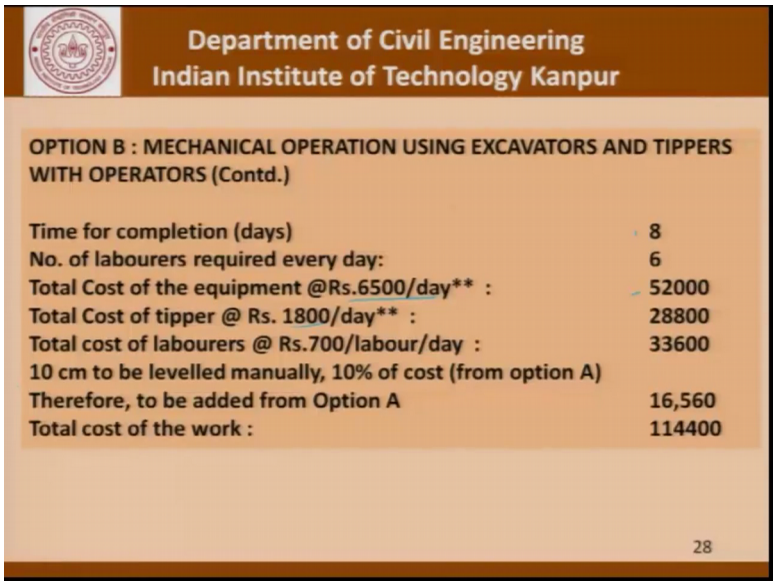

So, for that for an 1800 cubic meter excavation let us assume that the productivity of the excavator is 30 cubic meters per hour. So, what we are looking at is 60 hours of equipment use, it is not man hours in this case, it is more like equipment hours. So, it means that 60 hours is when the equipment should be running. And if we assume that the equipment runs for 8 hours a day, we have that number of days required to complete the project as 7.5.

Now if we assume that this 7.5 is something like 8. So, we say that the time of completion is 8 days. Then the number of labourers or the operators required every day is 6, because we having a excavator and 2 trucks which are operating each of them has 2 people. The cost of the equipment that is the excavator is 6500 rupees a day and for 8 days this turns out to be 52000. Similarly the cost of the tipper which has been taken to be 1800 per day for 8 days and 2 tippers is 28800. The cost of labour at 700 rupees per day for 6 people working 8 days is 33600. To this cost we must add 20 centimeters to be leveled manually. That is what is being considered in this case because using an excavator it is not sometimes possible to get a very plane surface.

So, that last 20 centimeters that is 10 percent of the cost will have to be brought from option A and that cost is 16560. So, if we do that the total cost of work involved is 114400 as against about a 16500 which was the cost that we got for purely manual operation.

So, with this we have kind of completed a comparison of carrying out an excavation of 1800 cubic meters, but we must remember that it is an open excavation, it is a free excavation with no encumbrances. And we have made assumptions in terms of productivities, in terms of what is the labour requirement to do every cubic meter of the work, and in the case of equipment the productivity which we have taken to be 30 cubic meters per hour.

So, with this we come to an end of the discussion today.

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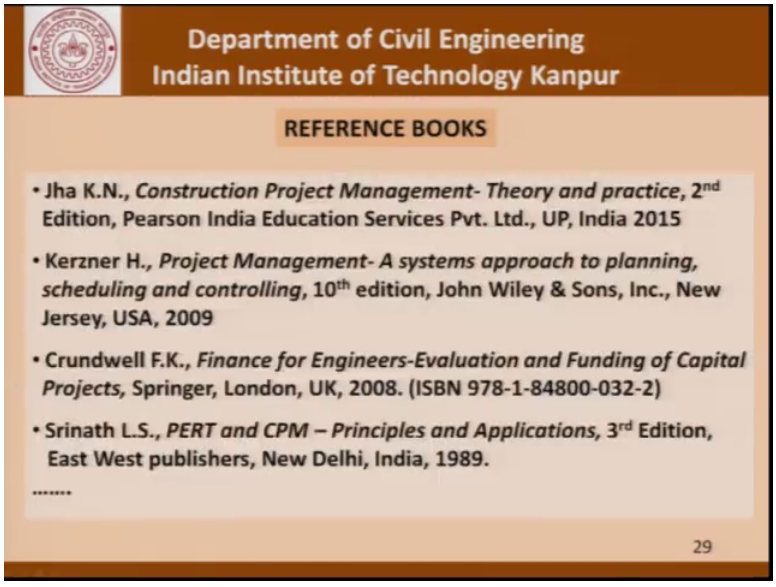

So, these are the reference books which will help you understand the subject better. And before we close the discussion today I would like to leave you with the thought that what we have assumed in the discussion when we are talking about 20 labourers here and 10 labourers there in the first example; what we have said is that over a period of time the labour deployment remains constant.

Now, is this the best way of deploying labour. That is right from that word go till the end of the project it is the same number of people which are working. So, we took it to be 20 we took it to be 5, 10 and so on, but we made an assumption that all of them will be working throughout the project. This is something which we have to think about because it may not be possible to begin your work with this kind of a labour force.

So, what is more realistic is to have a smaller amount of labour in the beginning go to a peak and then gradually reduce the labour force. So, that the total work is completed in still the same time.

So, with this thought I look forward to seeing you once again.

Thank you.