Principles of Construction Management
Prof. Sudhir Misra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture – 14
Introduction to planning and scheduling

[FL], welcome once again to this lecture in the series on Principles of Construction Management and today we will basically talk about planning and scheduling in construction activities.

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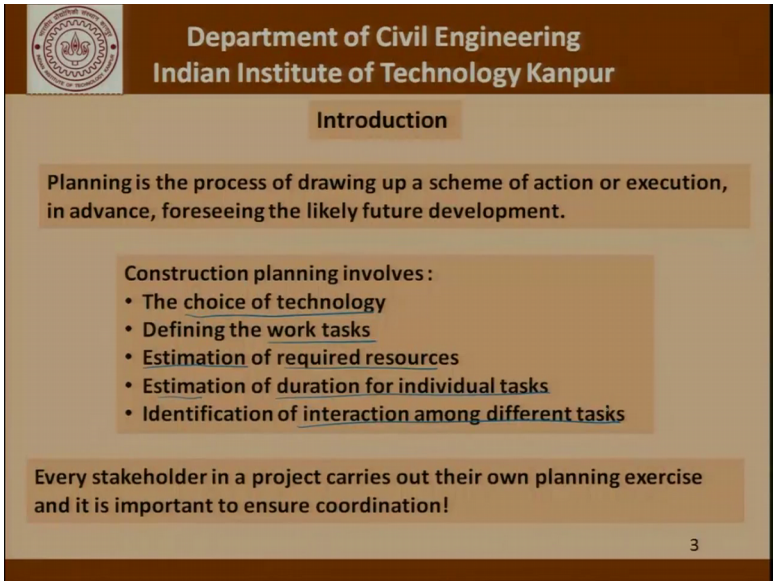

So, now planning is the process of drawing up a scheme of action or execution in advance foreseeing the likely future developments. In construction industry or in planning for a construction project, it could involve choice of technology; it could involve defining the work tasks that is we break up the project into individual jobs or works. So, as part of the planning exercise we try to break the project down into different jobs or different tasks. Then there is this aspect of estimation of required resources we break a job down to different activities different tasks and then try to find out for each task or job what are the resources required in terms of manpower equipment consumables and so on. The estimation of duration is a very very critical part of our planning exercise. We must know whether a project is going to be completed in 10 months or 20 months or 1 months.

So, in order to be able to do that effectively accurately we have to have an idea of the resources that are required and whether or not by just increasing the number of resources or just increasing the resources that we allocate to a particular activity can we keep reducing time. It may not be possible sometimes to reduce the time beyond a certain point. Identification of interaction among different tasks this is a very critical part of our understanding when we try to understand or when we try to analyze whether we can take up one task without completing some others which tasks in a particular project can be independently taken up if one process requires another process to be completed. For example, in the kind of boundary wall example that we talked about we cannot fabricate the angle unless the angle has been procured we cannot fabricate the reinforcing bars for the footing or the columns unless they have been procured, but once they have been procured we can go ahead and fabricate the reinforcement cage for the footings or for the columns

So, basically identification of interaction determining the inter dependencies is a very very important part of project planning. Now every stakeholder in a project carries out their own planning exercise and it is important to ensure coordination. So, we know that we have talked about it at the outset of our discussion in this course, a project has different stakeholders there is the client there is a contractor, there is the designer, is possibly a person who is financing the project. So, all these people they look at the project from different points of view and carry out their own plans.

So, now their plans can be looked upon as focusing on the quality sometimes, sometimes safety, sometimes manpower, sometimes equipment, sometimes time itself and so on.

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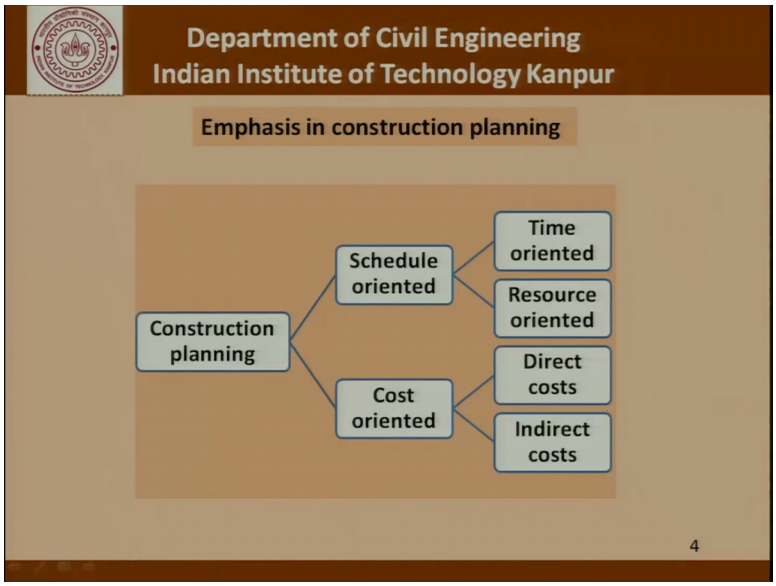

So, now looking at the emphasis in construction planning; Construction planning is either schedule oriented or cost oriented in the schedule oriented side we have time and resource orientation and in the cost oriented construction planning we are most of the time talking about direct and indirect costs associated.

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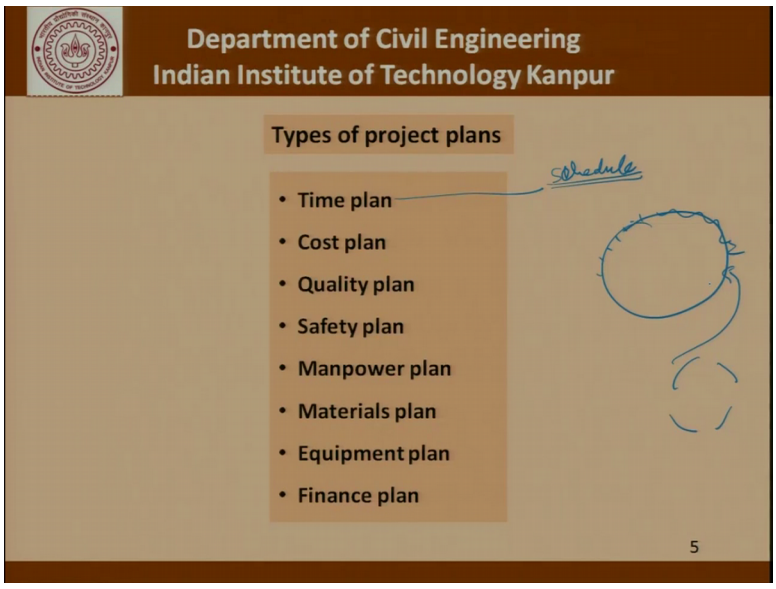

Now, we talked about the different types of plans it could be the time plan.

So, basically what we are talking about here is this schedule how much time it is going to take to complete an activity if we are slipping then what should be done to cover the time

and so on. Then there is the cost plan how much is the project going to cost what is the kind of cash flow that we need if we want to accelerate the project try to complete the project earlier what is the kind of cost that we need to incur or additional cost that we need to incur and so on. Then there is the quality plan a project has different activities if you consider a tunneling project there is a boring of the tunnel that has to be done there has a stabilization of the soil that has to be done independently we are making segments which have to be then brought and assembled at site.

So, now each of these activities has to have a quality plan. We should know what are the parameters to control as far as quality is concerned for each of these activities and have a plan so that the people who are executing those activities are aware of what are the quality control measures to be adopted. Similarly there has to be a safety plan we must make sure that there is no accident at site. There is a manpower plan depending on the time of the project different kinds of people that is people with different skills are required and we must know what is the kind of people that are required at different points in time. So, that we are able to either recruit them into the company or transfer them to that site from other sites and so on.

Then there is a materials plan, equipment plan and a finance plan. So, there are different ways of looking at the planning exercise.

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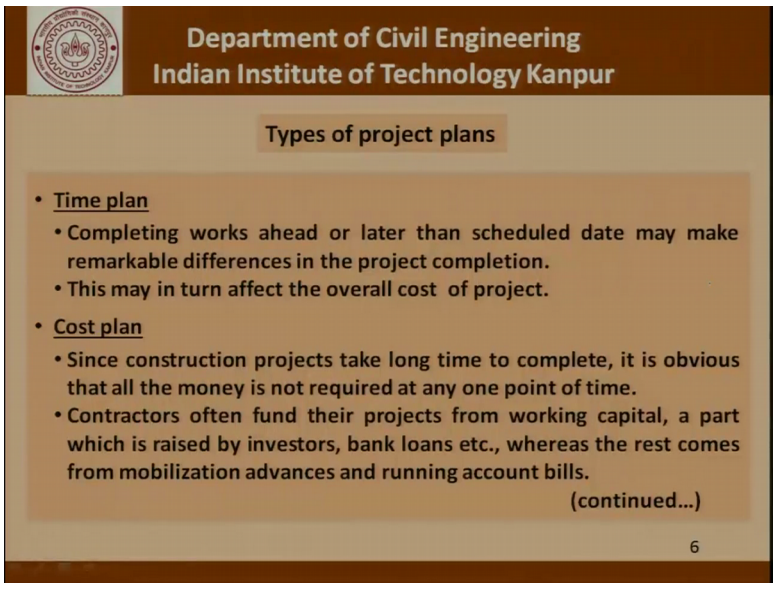

So, continuing with our discussion as far as the project plans are concerned time plans basically refer to completing the work ahead or later than scheduled dates may make remarkable difference in the project completion. That we have an estimate of completing the project, but there may be a bonus associated with completing the project earlier, there may be a penalty associated with completing the project later so these are things which we have to keep at the back of our mind when we are carrying out a planning exercise in terms of time of course, as I said it will affect the overall cost of the project. As far as the cost plan of the project is concerned since they take a long time to complete it is obvious that all the funds are not required at one point in time.

So, we have to keep in mind the concept of cash flow that we have talked about and contractors often fund their projects from working capital a part of which is raised from investors, bank loans whereas, the rest comes from mobilization advance and running account bills. So, all these things have to be carefully thought about and foreseen. So, foresight is a very very important part of a construction managers job and that is why some of these things are difficult to appreciate unless there is a real example unless there is real experience that you have. So, the idea as far as this course is concerned is to basically introduce you or expose you to some of these ideas. So, that you better prepared for professional experience.

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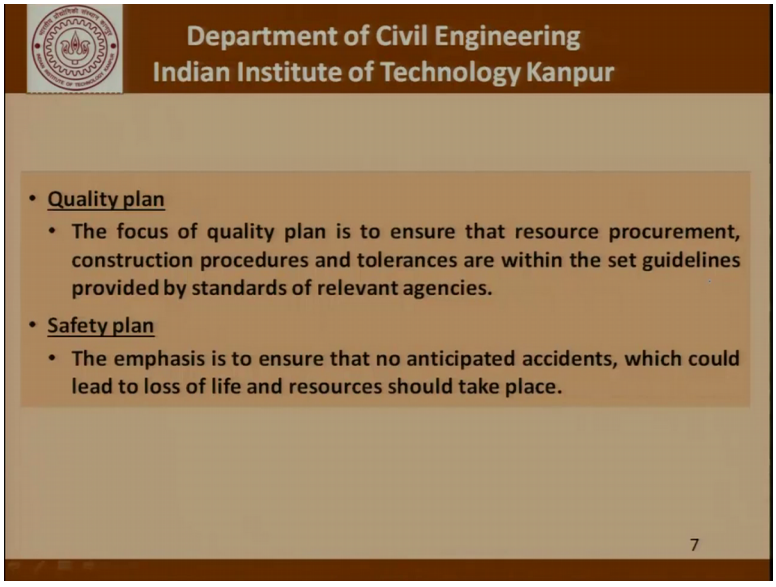

Now, coming to the quality plan and the safety plan. The focus on the quality plan is to ensure that the resource procurement construction procedures and tolerances are within the set guidelines provided by standards of relevant agencies. So, this relevant agency is very important because depending on the agency involved there would be different tolerances that happen because the criticality of each of those projects or each of these activities is different depending on concepts like consequence of failure importance of the structure and so on. The emphasis in the safety plan is to ensure no accidents we must ensure that there are no accidents at site which could lead to loss of life and property.

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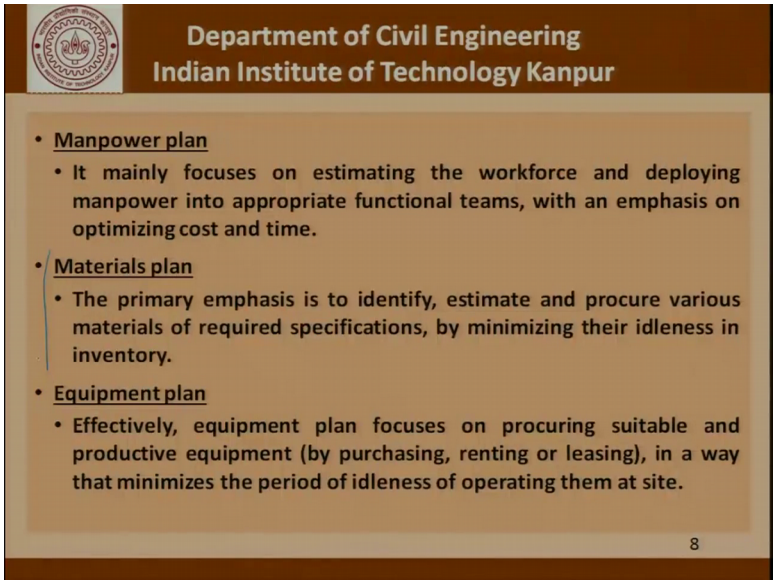

If we talk about the manpower plan it mainly focuses on estimating the workforce and deployment of manpower in appropriate functional teams with an emphasis on optimizing cost in time.

As far as the materials plan is concerned the primary emphasis is to identify estimate procure various materials of required specifications by minimizing their idleness in inventory. We must remember that the efforts should really be to procure the material in time for its deployment or use at site. There is no point in buying the material way in advance before it is used because that is dead inventory that is dead cash we have should invest the money only when it is really required. So, an inventory plan requires us to know exactly when a particular component or a particular material will be required as far as construction is concerned and then taking into account the time that it takes to procure

the material some of these materials or components may not be readily available just off the shelf.

So, there would be a certain time for the manufacturer of those materials to put that thing together there may be a time involved as far as transportation is concerned. So, your inventory team has to have a plan of how and where these different materials will be procured from how they will be transported to site in a manner that their non availability does not become a reason for delay in the project. As far as the equipment plan is concerned effectively this plan focus on procurement of suitable and productive equipment by purchasing renting or leasing in a manner that minimizes the period of idleness of operating them at site.

So, we should know when we need cranes what size cranes, we should know what size of welding equipment, we should know what size of concreting equipment, we should know what kind of JCBs or excavators and so on and so forth. Now before we proceed further with more analysis of planning and scheduling I would like to also introduce to you the idea of a work breakdown structure.

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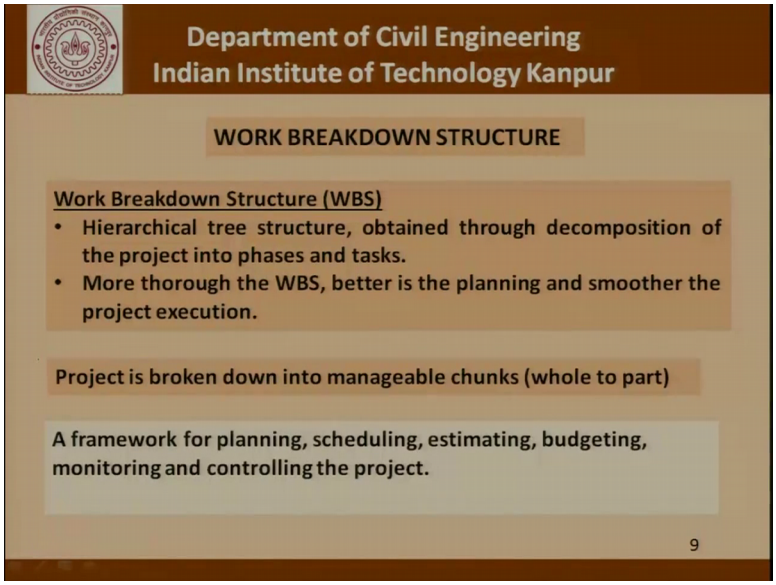

Now, this WBS refers to a hierarchical tree structure obtained through decomposition of the project into phases and tasks. We basically try to break down as the name suggests we break down the project into activities and sub activities try to divide it into different classes and then try to look at the resources required for each activity. We must

remember that the more thorough WBS better is the planning and smoother is the project execution. If we are able to foresee exactly how the project is going to be executed we will be in a much better position to execute the project smoothly. If we are not able to foresee certain things then the project will be stop and go something will happen which is unforeseen the project will stop we will make some stop gap arrangements, make the project get started again and so on.

Whereas if we have seen all the possibilities we know exactly the flowchart which will be followed if this happens then what should be done if this happens then what should be done then the execution is much more smooth and that can be achieved if we have a clear breakdown structure with all the kinds of possibilities worked out. Now this is what I mentioned the project is broken down into manageable chunks we are working from a whole to parts kind of a philosophy and this basically is a framework for planning scheduling, estimating, budgeting, monitoring and controlling the project.

So, all these important functions relating to a project can be carried out if we have a well planned and a well done work breakdown structure for that project.

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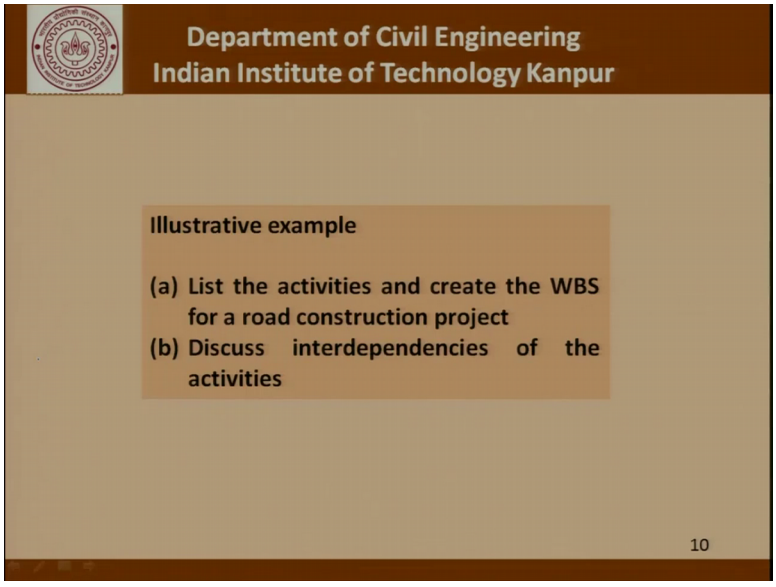

Now, let us try to see what a work breakdown structure really means through an illustrative example where we are asked to list the activities and create the WBS for a road construction project and also discuss the inter dependencies of the activities. So, what we are talking about is a project where a road construction has to be carried out and

what we will try to do is to break down this project into activities of course, we will stop way short of what is a final breakdown structure, but I think you will have some idea about it.

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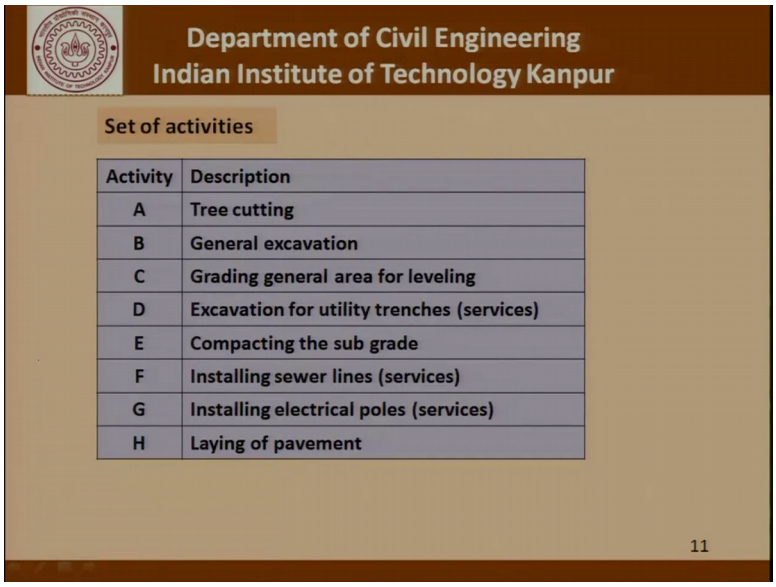

As far as a set of activities is concerned let us say there are 8 of these activities tree cutting, general excavation, grading general areas for leveling, excavation for utility trenches which is services, compacting the sub grade, installing sewer lines which is services again, installing electric poles which again services and finally, laying the pavement. So, we have broken down a project of pavement construction into these 8 activities. I must point out at this stage that this is not necessarily the only way in which this activity breakup can be done; it depends on the engineer actually as to how he defines the different activities.

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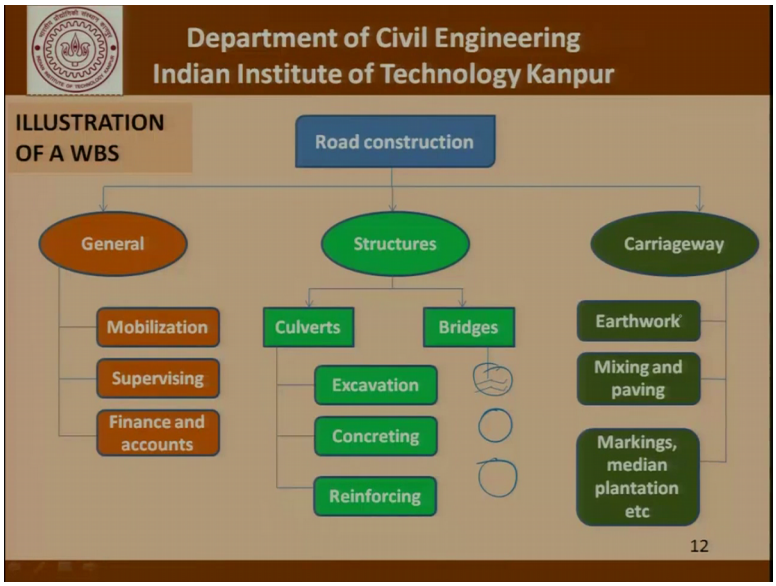

Now, another way of drawing up a work breakdown structure for this project would be as shown here. So, we divide the road construction into general structures and carriageway as far as general is concerned we talk in terms of mobilization supervising finance and accounts. As far as structures are concerned we break it up into culverts and bridges where we say that well culverts are further broken down into excavation concreting and reinforcement work and a similar such structure can be drawn up for bridges and when it comes to the carriageway again there is earth work mixing and paving, markings, median plantation etcetera.

So, this shows different ways of how a work breakdown structure can be drawn up for a given project and this facilitates planning. So, when we talk of culverts we can drop a plan when we talk of markings and median plantation we can drop a plan and so on and so forth. So, going back to the previously defined 8 activities now let us try to see what is the precedence relationship, what is the kind of relationship that governs one activity with respect to the other.

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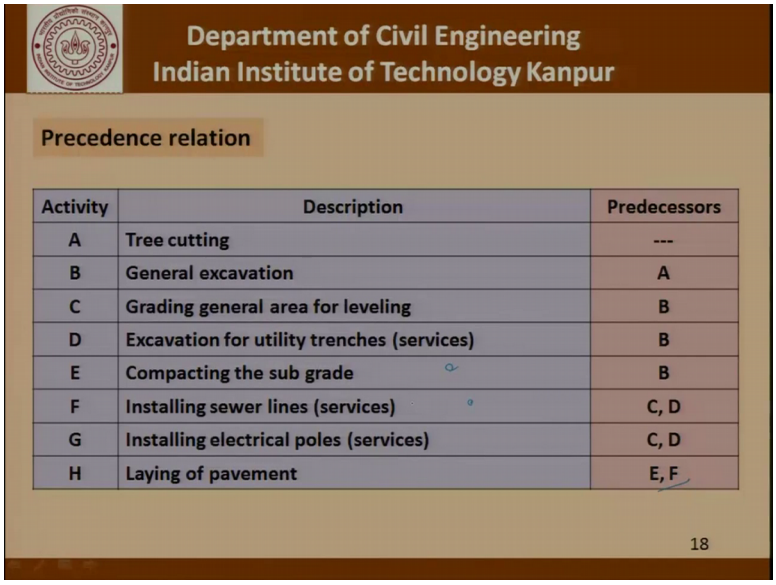

Now, as far as tree cutting is concerned it does not require any preceding activity except of course, what it assumes is that something what is called land acquisition has already been completed.

So, unless of course, the land acquisition has been completed there is no question of cutting trees. In fact, if you read literature as far as road construction is concerned you will realize that actually land acquisition is often a bottleneck as far as construction work in highways is concerned. What often happens is while constructing a road from this point to this point you may have acquired land for this package, you may have acquired land for this package, you may have acquired land for this package, but there will be a package somewhere here and a package somewhere here where land acquisition is an issue.

So, that does not mean that you do not start the construction work very often we start the construction work, but hoping that while the construction reaches this point here and it reaches from here to this point these pockets of un acquired land will also be acquired. So, of course, coming back to our example if the land acquisition is cleared we can go ahead with tree cutting without any preceding activity, but as far as excavation is concerned it is not possible it is not proper to start excavation you cannot start excavation unless you have completed activity A which is tree cutting. As far as activities C D and E are concerned that is general grading of the area excavation for utility trenches and compacting the sub grade they can all be started only after a general excavation has been completed.

So, continuing further activities F and G which is installing sewer lines and installing electric poles they depend on C and D that is they depend on grading general area for leveling and excavation for the utility trenches. Finally, the laying of pavement depends on E and F that is compaction of the sub grade and installation of the sewer lines, installation of the sewer lines because very often the sewer lines actually run below the pavement. So, only once you installed the sewer lines can you complete the laying of the pavement.

Now, from this example it is clear that there exists an inter dependency among various works involved in a project and they can be actually represented in a logical sequence.

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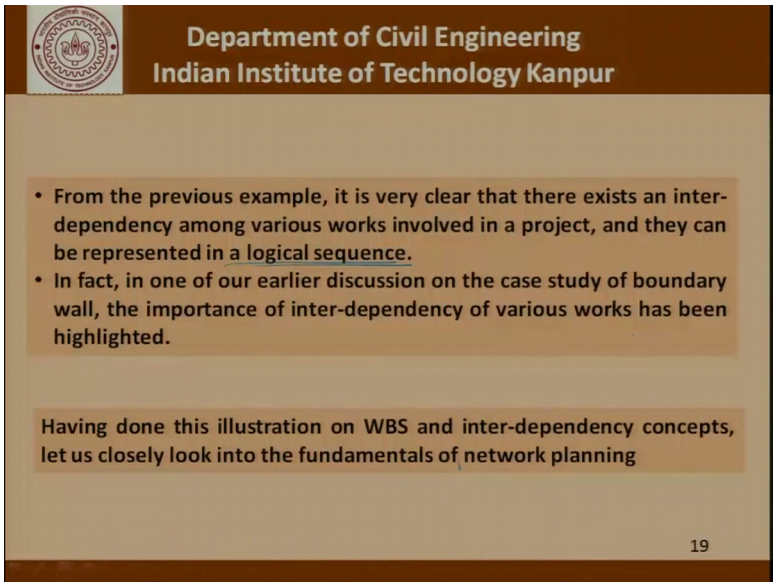

In this case we represented it by means of a table where we listed the different activities and had a column where we listed the required preceding activities to have been completed before those activities are taken up now. In fact, one of our earlier discussions also when we talked about the boundary wall we had given 19 activities as part of the breakdown of that boundary wall construction and had left it to you to complete the or think about the inter dependency the way we talked about just now.

Having done this illustration on the work breakdown structure and the concept of inter dependency let us closely look at the fundamentals of network planning because we would like to represent the different activities by way of a network that is so much easier

to represent explain and use when we are trying to monitor the project as the construction work goes on.

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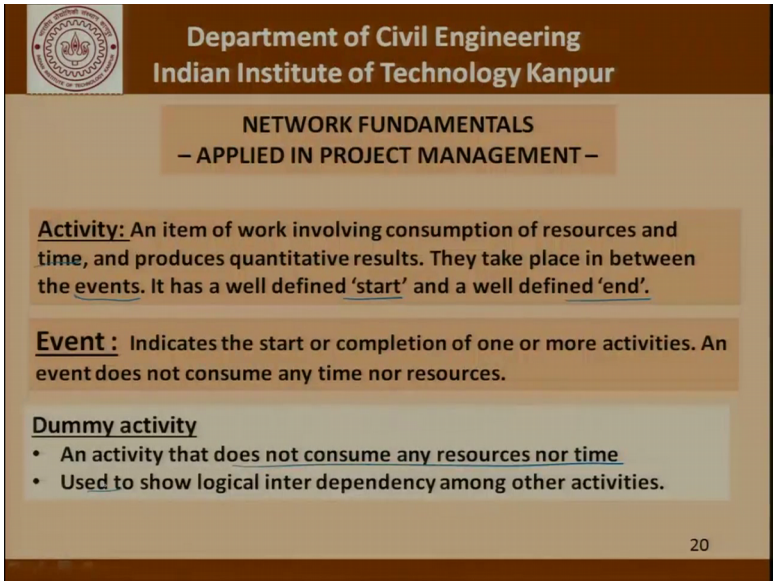

So, before we start application of networks to are construction scenario let us try to first we study a little bit about the network fundamentals let us define a few terms, let us talk of an activity. This is an item of work that involves consumption of resources and time of course, time can also be looked upon as a resource and produces quantitative and measurable results the activities take place between events and they have a well defined start and well defined end.

So, if there is an activity called digging the trench or concreting a roof there is a very well defined start to that activity and a well defined completion of that activity. Coming to that event it indicates the start or completion of one or more activities and even does not consume any time or resource of course, there are some dummy activities which we will see when we try to see the logical compulsions in drawing up networks and representing the inter dependencies in the form of a network. We will find that we need to have what is called a dummy activity and these activities do not consume any resource or time and are used only to basically complete the logical inter dependency among the different activities.

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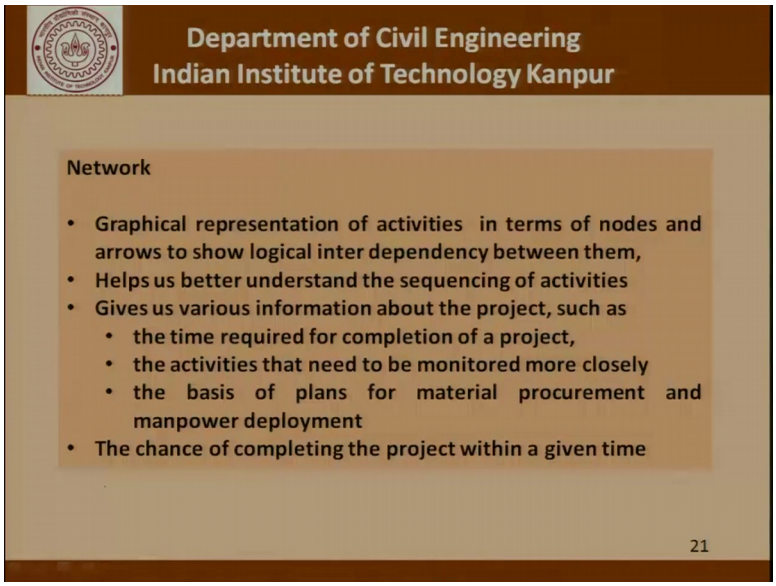

And what is a network? It is basically is a graphical representation of activities in terms of nodes and arrows to show logical inter dependency between activities. The network helps us better understand the sequencing of activities gives us various informations about the project such as the time required for completion of a project, the activities that need to be monitored more closely than other activities and the basis of plans for material procurement manpower deployment cash flow and so on. And of course, we can also use this whole concept to determine the probabilities of completing the project within a certain time.

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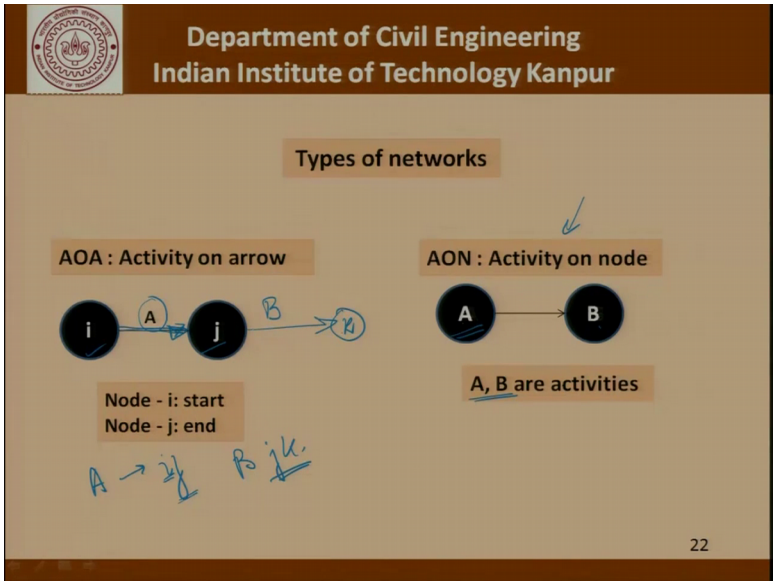

Now, there are two types of networks - one is called the activity on arrow activity on arrow means that there is an activity a and there is this arrow between nodes i and node j. So, this activity a is actually represented as i j where i represents the start of that activity and j represents the end of this activity and A itself sits on the arrow connecting i and j. So, these arrows are directional. So, it is an i to j arrow and not j to i it is not interchangeable it is an activity i j which means it starts at i and ends at j. On the contrary we can have an activities on node kind of a network where A and B are represented as nodes and there is an arrow in between which shows the dependence that is B depends on A, you cannot start B unless you complete A.

So, if this concept of A and B being related the way they are shown here in the activities on node representation then what we will do here is to put B here and put A node k here which means that A is the activity i j when this j activity is completed we can start and B is represented as j k. So, the node j is the start of activity B and is also the end of activity A. So, these two representations are the same except that in this case the activities are on the node A has to proceed B in this case the activities are on the arrow and i j k are the nodes. So, the activities are to repeat i j and j k.

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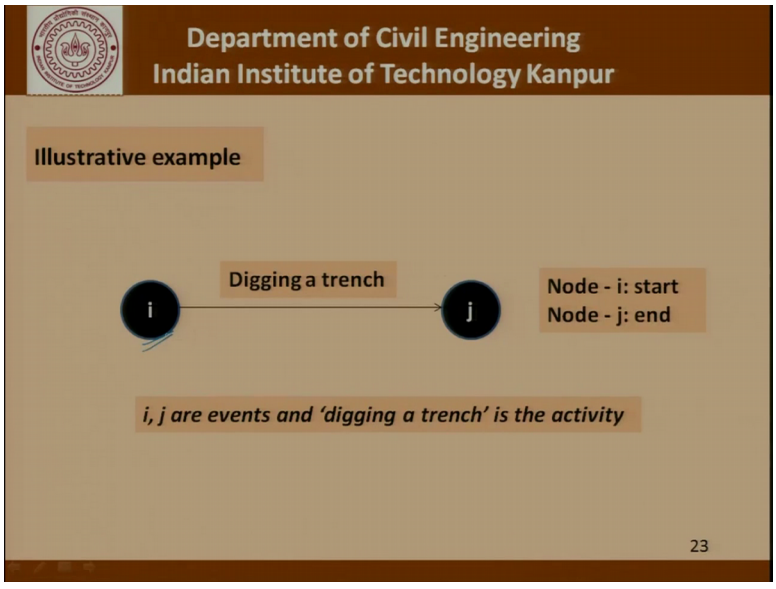

Now, continuing with this example there is an activity let us say digging a trench I and j it basically represents the start of the digging of the trench and completion of digging of the trench.

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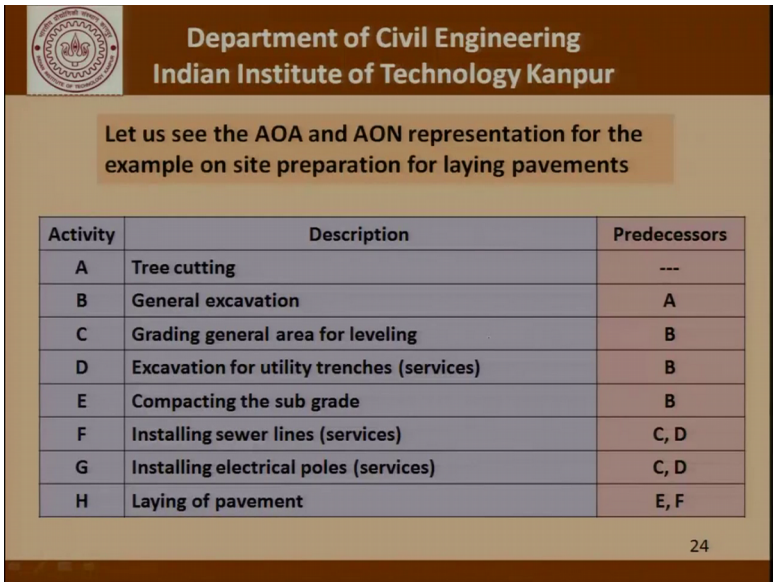

Activity	Description	Predecessors
A	Tree cutting	---
B	General excavation	A
C	Grading general area for leveling	B
D	Excavation for utility trenches (services)	B
E	Compacting the sub grade	B
F	Installing sewer lines (services)	C, D
G	Installing electrical poles (services)	C, D
H	Laying of pavement	E, F

Now, going back to the previous example of 8 activities let us try to see how we can represent this information of 8 activities in terms of an activities on arrow and an activities on node network.

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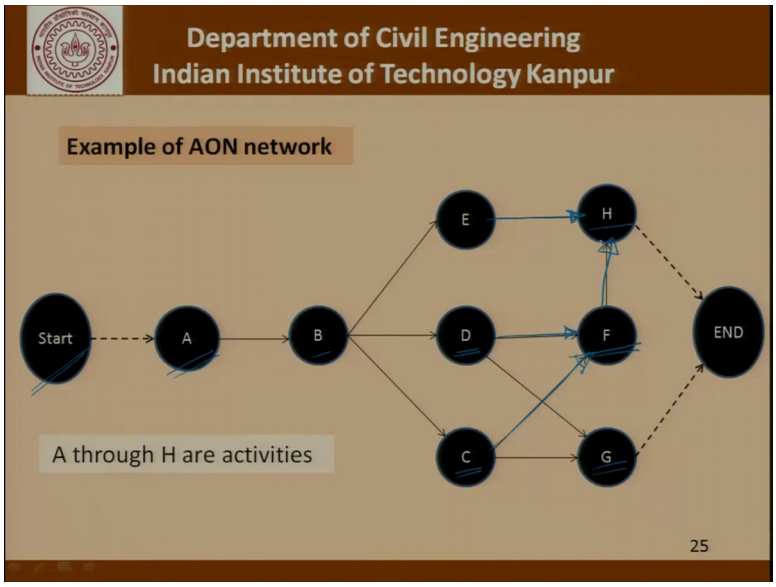

So, if we look at this picture here this is an activities on the node representation we start this project here this is activity A B C D E F G and the project ends and we can see that the information given in the previous picture A can be started without any preceding activity not counting land acquisition because that is not part of the eight activities that

we have listed B can be started only after a has been completed C D and E can be started if b has been completed.

So, here its G can be started only if activity C and B have been completed similarly F can also be started only after activity C has been completed and activity D has been completed and H can be started if activity E has been completed and activity F has been completed. So, this is how we have represented those 8 activities A B C D E F G and H in a activities on node network.

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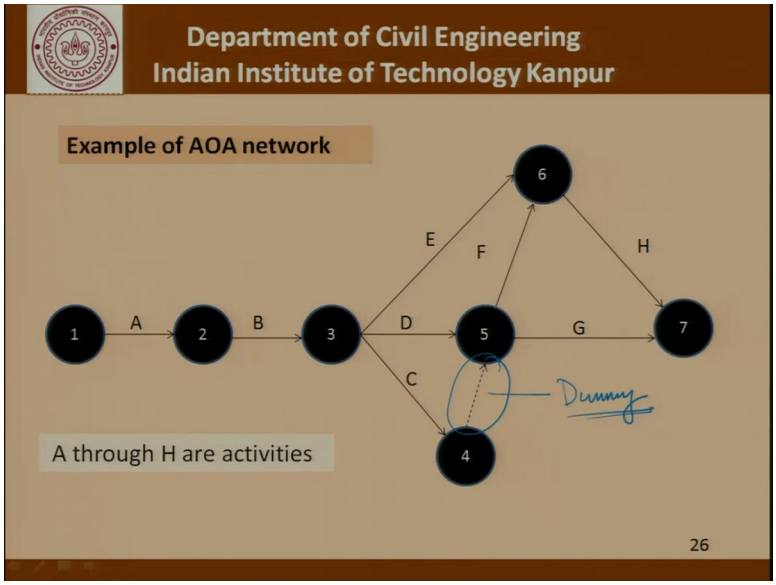

So, now let us try to do the same exercise in the activities on arrow and I leave it to you to make sure that the representation is correct. A is 1 2, B is 2 3, C is 3 4 and so on and so forth.

So, I leave it to you to verify that A does not depend on anything, B depends on A, C D and E depend on B, F and G depends on C and D and H depends on E and F. Now here you will find this activity here this is precisely what is a dummy activity basically to show that G depends on both C and D. The reasons for that will become clearer in some other examples that we do later on in this course.

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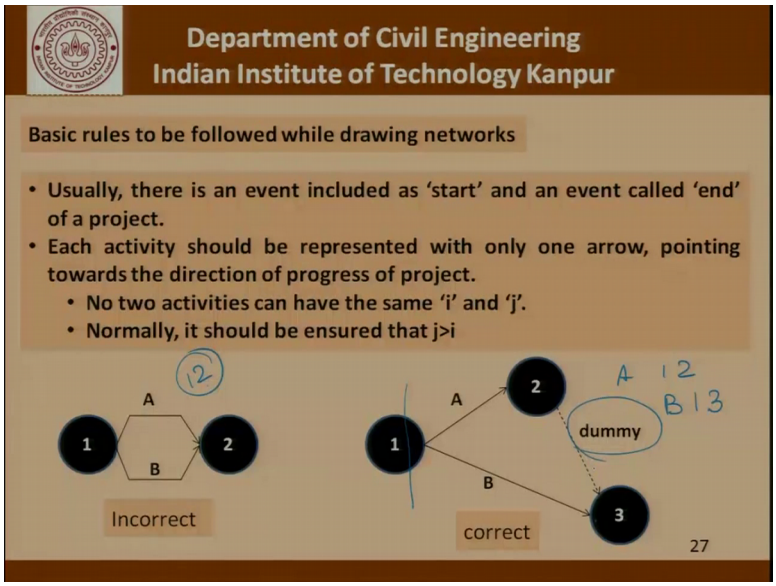

Now, continuing with our discussion let us try to see what are the basic rules to be followed when drawing networks. Usually there is an event included as a start of the project and an event called the end of the project. Each activity should be represented with only one arrow pointing towards the direction of the progress of the project no two activities can have the same i and j for example, both A and B cannot be represented as 1 2. What has to be done is that we have to use a dummy activity and try to say that well activity A is 1 2 and activity B is 1 3. The node 1 represents the start of activity A and the start of activity B, the node 2 represents only the end of activity A and the node three represents the end of activity B normally it should be ensured that j is greater than i.

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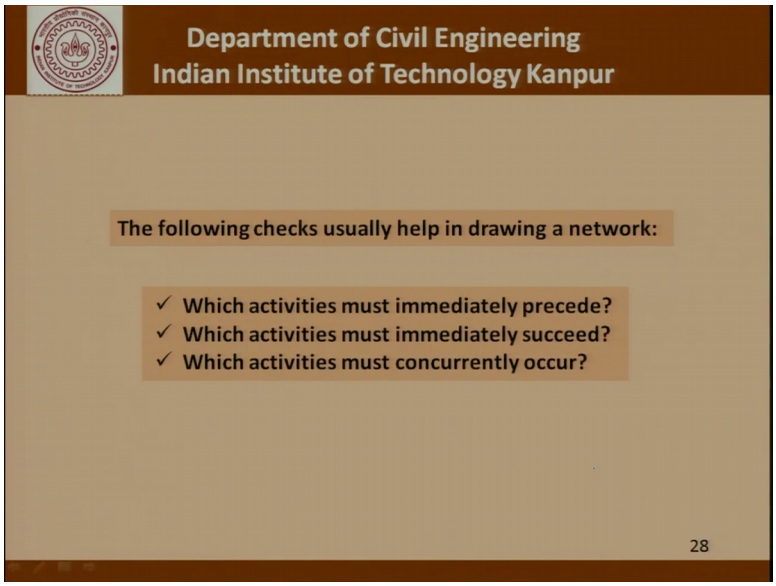

Now, the following checks usually help in trying a network the first thing being which activities must immediately precede a given activity then which activities must immediately succeed a given activity and finally, which activities can be done concurrently. So, if we are able to keep track of these three issues we will be able to draw a network.

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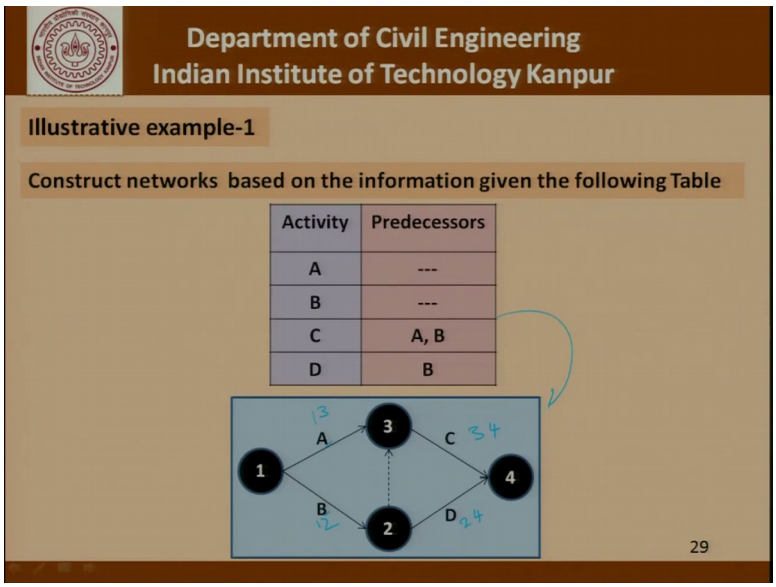

Now, let us try to carry out this exercise using an illustrative example where what is given is a project with 4 activities A B C and D where A and B can be started

independently C depends on both A and B and D depends only on B. Must try to construct the network we start the project with A which is 1 2, B which is 1 2 they can be both started immediately and node 1 represents the start of both A and B, node 3 represents the end of a whereas, node 2 represents the end of B.

So, C is the activity 3 4 and it can start only after A and B have both been completed, but D can be started as soon as B has been completed and is the activity 2 4, A and B are of course, activities 1 3 and 1 2 as is shown here. So, now, we have converted this tabular information into a network diagram like this.

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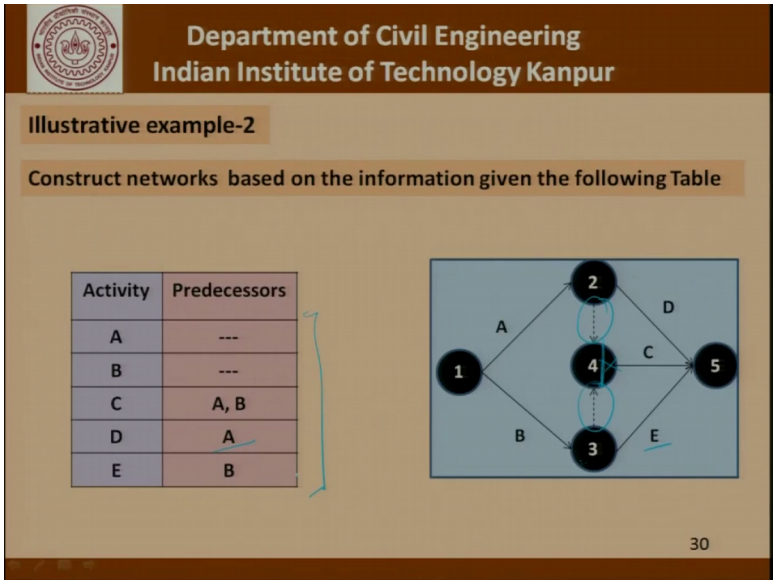

Let us try to do another example where information about the activities is given as follows. Activities A through E 5 activities, A and B start independently C depends on A and B, D depends only on A and E depends only on B. Now for this particular situation a is let us say 1 2 and B is 1 3, we have A C which is 4 5 created with the help of two dummy activities 2 4 and 3 4. Nodes 2 and 3 represents the completion of activities A and B and once both these activities have been completed we are in a position to a start activity C at node 4 and 4 5 is the activity C with 5 showing the completion of activity C. Activity D which depends only on a is represented as 2 4 and similarly activity 3 5 is the E.

Please remember that this is not the only way of representing this information in the table. There can be another network which shows this, but one of the points that we must

keep in mind when we drawing networks is that the number of nodes should be kept to minimum, the number of dummy activities that are used that should be kept to a minimum and so on, and that comes through experience. As we draw more networks as we become more adept at drawing the networks that comes naturally.

And with this we come to a close for the discussion for today where we have basically tried to introduce the concepts of networks and how to translate activities which are given in a tabular form along with their logical preceding activities and trying to convert that tabular representation into a network situation. These books will probably help you understand the subject matter better and I look forward to seeing you once again.

Thank you.