Scheduling Techniques in Projects
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Lecture - 12
Other Scheduling Techniques

Welcome to all of you. So, we are towards the closing of this course, so the last, but one lecture is Other Scheduling Techniques, ok.

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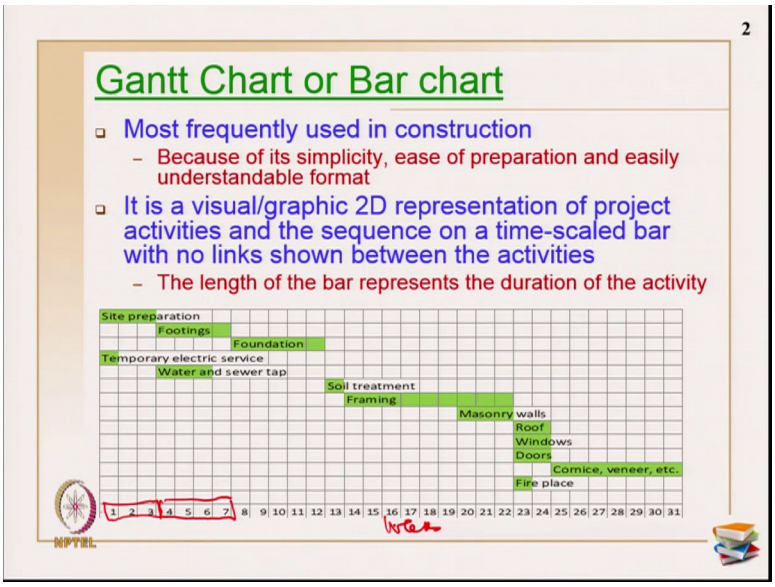

So, now let us start with bar chart. So, bar chart now and then I have discussed here and there, but we have not given a proper introduction on to what is this bar chart and what are the other varieties as well. So, bar chart, the name has come because of the shape of the bar, the shape of the activities are shown as a bar which is like a rectangular shape and hence the name has come as bar. And the other name is Gantt Chart, because of the person who introduces bar chart is Henry L Gantt, that is the other reason why we call this as a bar chart.

It is a most frequently used tool in construction and because of the simplicity, ease of preparation and easy understandable format, it is very widely used. Even today many construction firms are very happy in showing a bar chart representation. Now let us take this example, ok. So, here if you see, the X-axis primarily shows the timeline, so these are all the duration in weeks, ok; and the y axis primarily this is duration in weeks, and

the y axis shows the list of activities. For example, site preparation, it starts from 0, it takes to 3 weeks to finish ok; after the site preparation is over, footings starts and it take another 4 weeks to finish, ok. So, like this the bar chart representation goes on, and then foundation, temporary electric service can start in parallel. After this height preparation, we have water and sewer tap. Then after foundation, we have soil treatment, after then we have framing, so then masonry walls; so this is primarily a structure built, an architectural structure built for the construction ok.

Now in this example, the drawback here is; it is not used as a proper document for in case of disputes ok, only the CPM schedules or PDM are used or they are considered as an efficient document in case of disputes and so on, Because no relationship between the activities are shown here ok. And the other problem is sometimes you also when you are updating on maybe some activities have slipped or extended and so on. It is very difficult for somebody to update on the activities unless you know the predecessors and successors relationships ok; because network as such will not help you to do that because there is no relationship shown between the activities ok.

Now this x axis I have told, y axis also I have told, it is a list of activities; x axis shows a timeline and the length of the bar represents a duration of all the activities ok, that is the main significance of the bar chart. So, it is a visual or a graphic 2D representation, it has only two axis x and y axis of a project activities. And the sequence on a time scale bar with no links generally shown between the activities, there are other varieties which shows; but the conventional bar chart will not show any relationship between the activities ok.

Now, activities representation generally it is a continuous bar, that is what we have seen; but bar charts can also show non-continuous activities what we call it as an activity splits ok. If you see here footings, it actually starts on 7, then at the time of 4th to 5th week, primarily in that week there is a gap ok; which implies no work on footings happens and then the work resumes in the next week onwards ok. So, you can show with a blank space, so which is like this. This notation is also possible; otherwise, I can also show like this. This notation on bar chart is also possible and the other way to represent the activity splits are the necking of bars, which implies I am going to make an activity like this, in the no show period it is a very slender bar and then we have another rectangle piece ok.

That is the way we represent the activity splits in a network ok, in the bar chart representation.

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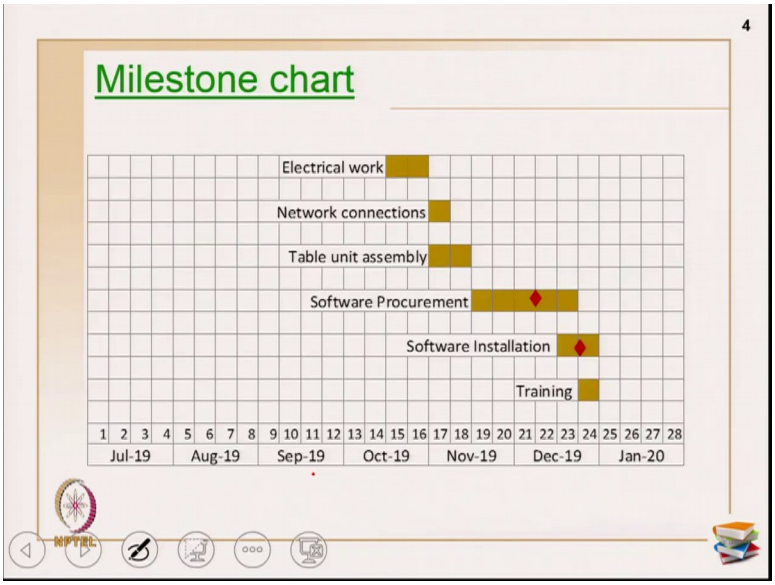

Then, next is Milestone chart, you know what is a milestone, we have introduced in the first week itself. So, milestones are events which does not consume any duration nor any resources. Milestones are significant events which just gives you an information, that something critical has to be completed or started on a particular date and so on, so that is an indication on milestone. And bar charts can also represent milestones and what we called it as a milestone chart. So, this example you remember very well, this was a development of a computational laboratory and there we talked about milestone planning and so on ok.

So, primarily, when the agenda is to set up the laboratory for January 2020s teaching session; then everything from the, all activities regarding the computer, setting up laboratory has to be completed before December end that is the plans actually. This is broken down into 4 quarters ok. Now, if you look at this. So, primarily if you go from the last, so software procurement, software installation and then training has to be done, then only you can start the lab sessions ok; training for the tutor, staff, the faculty whoever you want on important software's are required.

Now, software procurement, I have marked a milestone here. This talks about the class oriented software procurement. When we discussed on this problem, we discussed there

were two things, two classifications; one is primarily for large number of users for class teaching and other one is few users who use those software only for research purposes ok. So, now, for the class teaching, so there were few software and this procurement has to be finished somewhere in the first week of December. Installation has to be over in the third week of December that is the indication I have given. Last week primarily we can plan for training, so that the entire lab can start by functioning by Jan. So, there are some milestones and these milestones can be used in the bar charts also.

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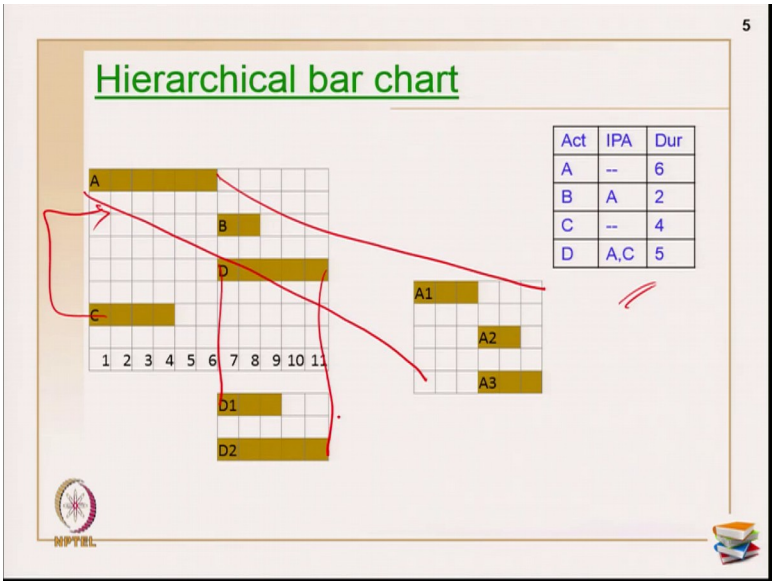

Now, coming to next hierarchical bar chart. So, this example you are familiar with is a hypothetical example. The representation of the same example and a bar chart I have given here, but general representation on a bar chart is, the activities has to be represented or arranged based on the order of early start. So, which implies the C has to be coming here and then we have to have B D; but there is another purpose of putting this bar chart, I primarily wanted to show the hierarchical, so I have kept it like this ok.

Here, I am just wanting to show that there are some hierarchical bars for activity A which is like this and for activity D ok; so this D is like an aggregation of several activities and A which is taking 6 days duration is an aggregation of several activities put together, there may be several sub activities, relationships, different durations and so on. So, bar charts can also show multiple hierarchical next level layers of representations as well ok.

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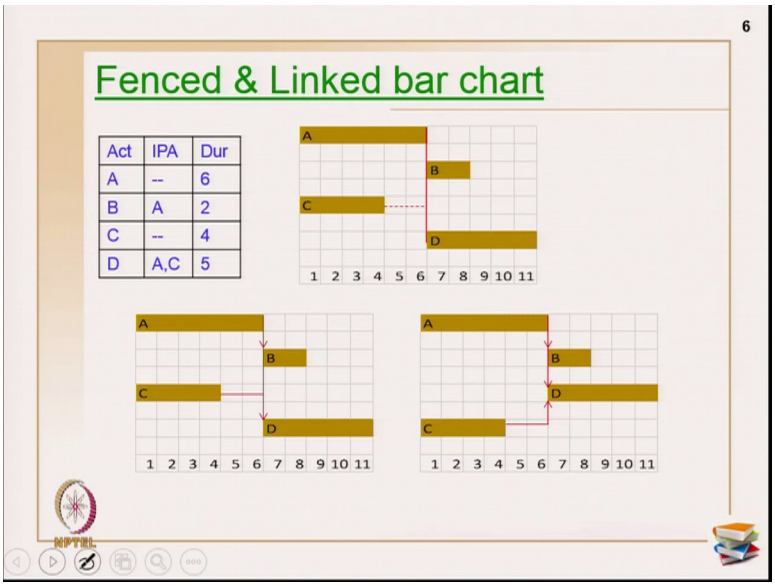

Now next is Fenced bar chart. The main drawback in bar chart we have already told, they fail in showing up the relationship between the activities ok.

So, now this is a Fenced bar chart. So, fenced bar chart just use a straight lines, so as I have shown here in red color. So, from A to B there is a red line ok, which is seen here and from for an activity D I have again taken an A here and to show the C, because there is a float value. So, there is a dash and then I am again using a C here. So, that is primarily visible here ok.

Now, this is primarily the fenced bar chart. Now let us talk about the Linked bar chart. In Linked bar charts what happens is you primarily use arrow marks to show the relationship. So, in a way it is easy to understand rather than the fenced cases ok. Linked bar charts we will see there is an arrow mark from A to B, this shows A and B are dependent and then I have a straight line here and then again from A to D and from C to D, I still have.

Now, here you may have a confusion; the arrow mark from here, is it from A or from B or from both that you do not know. So, there is a procedure called cascading of networks ok. So, primarily what happens is you can rearrange the starts of activities in such a way that it just coincides and forms a shape like a cascade form.

So, you can flow the activities like this from both the ends and then it starts merging up just like I have shown here. Now A gives information to B and there is one more arrow, so this A also gives information to D and C is to D is shown here, ok. This is primarily called linked bar charts.

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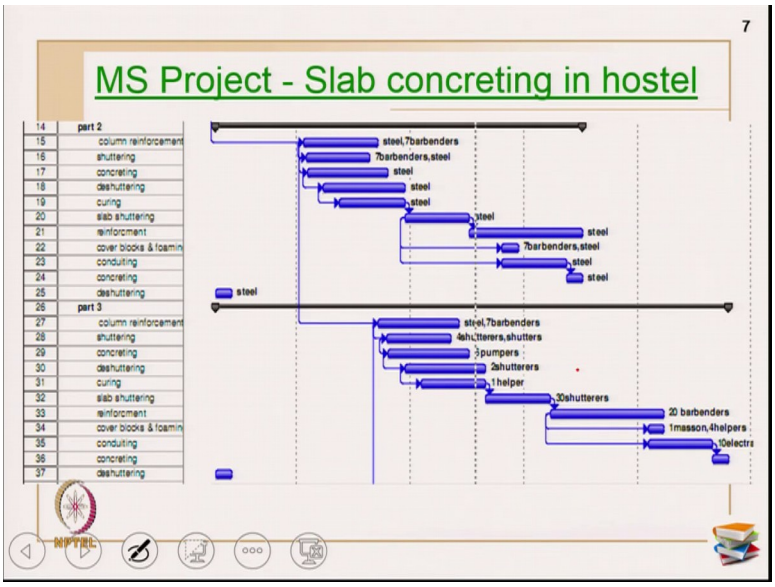

Now, primarily in your MS project, there is a bar chart view. MS project always represents CPM or PDM network, this is a slab concreting work in hostel ok; but there is a bar chart or Gantt chart view also. I think people who worked in scheduling techniques know well about this. You can also do resource leveling, resource loading, you can also show cost control on projects, everything you can do and there is a Gantt view on the whole MS project which is like this.

Now, this Gantt view if you see, it is more like it is more or less looks like a linked bar chart only ok. So, for example, so this is primarily the aggregated activity or we call it as a hammock activity. So, the part 2 of concreting, then I have part 3 of concreting ok. So, in the part 2 of concreting, column reinforcement, shuttering, concreting, deshuttering, these are all the resources I need for all these activities. This is only to show the bar chart representations and the software also I am introducing now then and there in parallel ok.

So, MS project predominantly we use is very eligible, it is good for CPM, PDM and or your bar chart views ok. Now let us move on to Time scale diagram. So, I have a small example, time scale diagram is very simple, the representations of a network schedule.

So, primarily it is a CPM schedule, representing a CPM schedule on and timescale is primarily what we call it as a time scale network diagram. In a way we call it as AoA representation on a time view ok; because, only on activity on arrows, you represent the activities on the arrows, so it is just combining like bar chart and AoA views on to the time scales ok.

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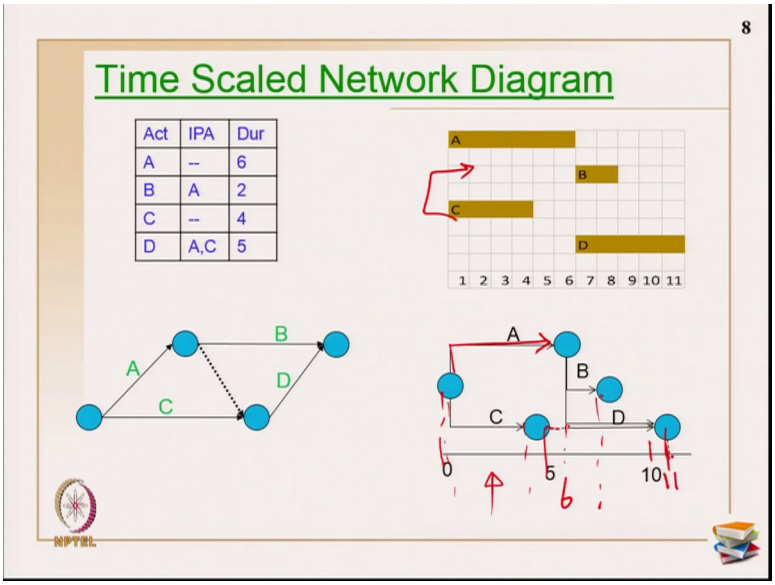

So, this is a bar chart which you; obviously, know ok. Sorry here also mistake C has to come here ok. Now this is AoA representation. So, I have activity A and C are in parallel ok, it is they starts in parallel, this is activity AoA representation and after activity A, B starts and after A and C, D starts; with the help of a dummy you are showing that logic representations. Now what happens in time scale diagram, this is a time scale diagram, the same relationship I have shown 0, 5 and this is 10 and this is exactly 11 here ok.

Now, if you want you can arrange all the critical activities on the bottom and non-critical activities on the top or you can rearrange it in your own form ok. Now activity A is shown here ok. So, which is like this; this implies A takes from 0 till, till this is still 6 ok. Now if you see here C, C is starting till here, it is less than 5 still here, so this takes a 4 day duration and B takes a 2 day duration which is shown here and after A and C is also shown with the dotted line. So, I am having here two links are coming in, so this is activity D and this is an activity D relationship and it is shown on a time scale view like this ok. So, this is all about on a time scale diagram and purpose of using, so only few

people use this time scale diagrams because bar chart is very convenient for people with the linked bar charts ok.

Now, the next technique, we are just moving on. So, if you look at the history also, let us see first bar charts came in existence and then your network schedules on AoA first came, then AoN s, after then little later only PERT, PDM all came in existence ok

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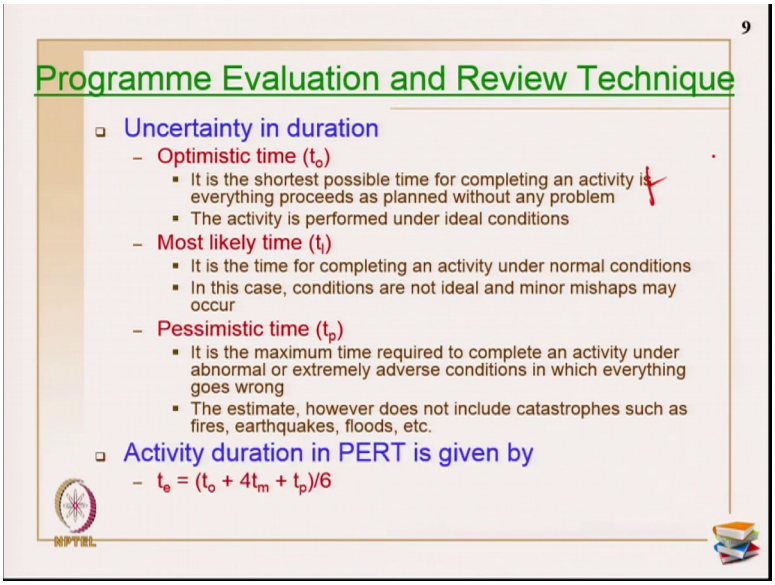

PERT is the expansion for PERT is Program Evaluation and Review Technique. PERT was developed mainly to assist in uncertainties in duration. In CPM schedules if you see, the duration is always deterministic. What do I mean by that is, the activity duration which is consumed by any activities is always given in single number, deterministic number and there is no uncertainty in the duration on CPM networks and all.

In PERT what happens is, it allows uncertainty. So, primarily the uncertainty is covered in three forms ok. Three time estimates are given; one is optimistic time, then most likely and the pessimistic time. And because of this uncertainty, this PERT also used for doing probabilistic estimation on critical paths, sub critical paths or project completion time; it can also help you to judge or estimate on the probability completion on any activity and so on.

So, now, let us see optimistic time. So, it is a shortest possible time for completing an activity, if everything proceeds as planned without any problem ok. So, if everything

proceeds as planned without any problem and here the activity is performed under ideal conditions ok; no breakdowns, no delays, no waiting for anything, engineers come, labors come, everything starting in time. So, such a short time for completing an activity, what we call it as an optimistic time ok.

Most likely time, it is a time for completing an activity under normal conditions. So, in this case the conditions are not ideal, minor mishaps may happen here and there; for example, labors always come 10 minutes late that happens on almost on all the days of the execution. So, like this all normal scenarios generally happen ok, waiting time, this that and the time duration for all those waiting on it happens in the same way.

The next is pessimistic time, it is a maximum time required to complete an activity under abnormal or extremely adverse conditions in which everything goes wrong. Let us assume, the labors were not even available, they could not even come to the site, it was heavy rain, this that. So, something happened only on the particular day and it got too much of delayed. So, it is primarily the maximum time which has taken. It will not have occurred earlier days in the execution ok But here this estimate does not include natural catastrophes or artificial catastrophic like fire and natural issues like earthquakes, floods etc it is not that pessimistic nature ok.

So, what happens when you are having a duration estimate in three times; primarily the optimistic, most likely and pessimistic, what do you do, the activity duration in PERT you generally convert into your one time value and then you still go on in executing the calculations just like how you did in CPM ok. So, the activity duration in PERT is given by t_e equal t_o plus 4 t_m plus t_p by 6.

So, the most likely time it takes the maximum number of occurrences ok. So, you are taking 3, you are taking 6 times I estimate; one time on optimistic, one time on pessimistic because it rarely happens and 4 times on the most likely and divided by 6, there is a statistic background for all this. Anyway I am not covering all those, but only giving you the formula now, and I am not also going to talk about the project finish probabilities and so on.

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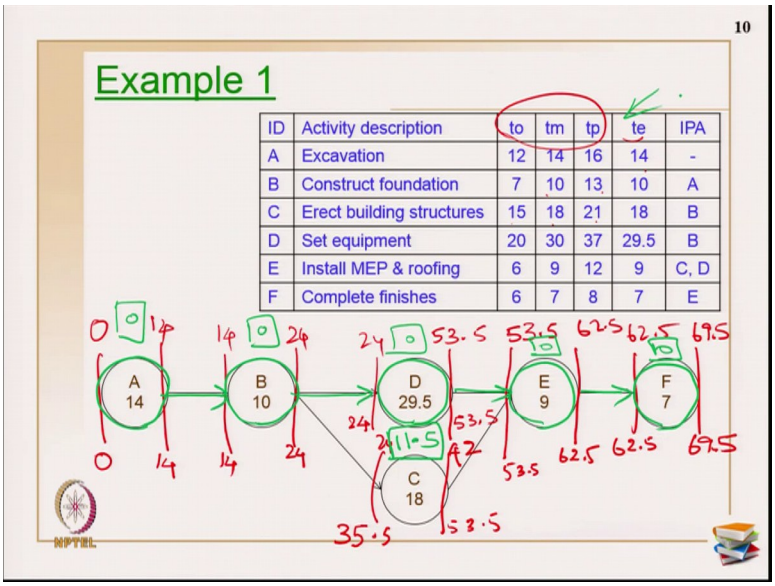

Now, this is a simple example I have taken, there are 6 activities in this example, so excavation, construct foundation, erect building structures, set equipment, install MEP and roofing and complete the finishes ok.

So, the three time estimates for all the activities are given here as to, tm and tp. And I have also calculated the t_e ok. t_e, I have calculated with the formula t_o plus 4 t_m plus t_p by 6. So, which implies for an excavation 12 plus 4 into 14 plus 16 by 6, so I got this as 14; 7 plus 4 into 10 plus 13 by 6 this is 10; 15 plus 4 into 18 plus 21 by 6, this is 18 and the IPAs for all these activities are also given ok. Now, if you look at textbooks earlier to 1990 s, 2000 even, you will find most predominantly PERT networks are always shown on AoA ok; activity on arrow networks.

But after then researcher said you can use any form of the notations either AoA or AoN. So, I have used to shown it in AoN network ok. So, as I told you the 3 time estimates primarily you are going to convert into one time estimate the t_e values, expected time for completing an activity. And if you are working on AoA you will still calculate early event times, late event times, slack and then you will find the duration. If you are doing it on AoN, then you will do all the float calculations just like your early start, early finish, late start, late finish of activities; and total float, free float just like how you did for AoN analysis.

So, just to recollect your memory, so, I am going to work it out. So, this is a AoN network. So, A is the starting activity. After A I have to do B and after B I have to do my C and my D, then after C and D is my activity E, then my activity F, durations are all dumped ok, C is 18, D is 29.5, this is 9, 7, I have written. So, now, this is a forward pass I am going to do, so this is 0, 0 plus 14 is 14, so this is 14; 14 plus 10 is 24 here, so this is now 24; this is also 24 ok. So, now, if you add, so this becomes 0.5 13 1, 53.5 ok.

Now, here it is 12 1 42 ok, now MAC back. So, E is early start of activity E is maximum of early finish of these two activities, so this is 53.5; 53.5 plus 9 becomes 62.5. So, now, this is 62.5 and then this is 69.5. So, now, working backward pass which is the late starts and late finishes so, this is 69.5 ok, 69.5 minus 7 is 62.5, so this is 62.5; 62.5 minus 9 is 53.5, so this is 53.5 and this is also 53.5; 53.5 minus 18 is, so this is 0.5 this is 5, 4 minus 1 is 3 and what about here, so this become 0. So, 13 minus 9 is 4 this is 24 ok.

Now the minimum of these two values is 24, so I have to go with 24; 24 minus 10 is 14, so this is also 14; 14 minus 14 is 0 ok. Now if I want to do the total float calculations, I am going to change my pen color now, ok. So, 0 minus 0 is 0 ok; 14 minus 14 is 0; 24 minus 24 is 0 and 53.5 minus 53.5 is 0; 62.5 minus 62.5 is 0. Now this is 0.5, 1, 11.5, is my total float. Then the critical path is activity A, then I have activity B, then I have activity D, and then I have activity E, and then I have activity F.

So, the same way you have. So, primarily the pert you are converting into deterministic times on expected; so t_e is expected time of completing an activity and then you have to go with the same procedure like how you did for CPM calculations ok. So now, we have discussed so far on non-network schedules bar chart comes in that category, the various I would say the other updates or improvements in bar chart also we have seen. The next we saw PERT, so primarily it is close to CPM. So, CPM and PERT we have seen what is the difference. So, CPM, pert, PDM also we have discussed in detail.

Now, let us move on into advancements in these techniques ok. So, CPM, the other one is called GPM ok.

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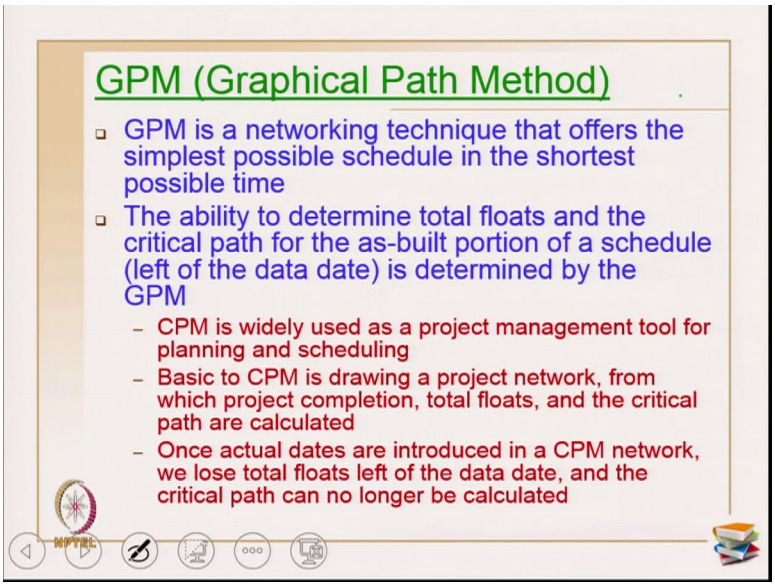

GPM the abbreviation is graphical path method ok. These techniques I may not be showing you duration calculations and scheduling and so on, they are not that powerful techniques; but I am just giving you an awareness that there are so many techniques available in scheduling and you should know what are all available. So, GPM it is a network technique again that offers the simplest possible schedule in the shortest possible time ok. So, the abbreviation is graphical path method.

Now what happens here, so this GPM it has come after your primarily on the CPM network only; and what happens is when you are showing your calculations on total float and you are calculating on a critical path and so on. And once the project is progressed and during the as-execution period ok, half of the project has progressed and so on. And if you want to know what has happened in the as-built portion, then it is very difficult for somebody to look at the updates and do analysis on the as-built portion ok.

The GPM is a method which helps you to analyze the as-built portion and helps you to identify the float places, drifts and so on where are the buffers available, what has happened, so it helps you to analyze where any mistake has gone and so on ok. That is the primary advantage of using a GPM; the ability to determine total floats and the critical path for the as-build portion of a schedule primarily the left of the data date, ok. When you are working on project controls you will know what is a data date; data date

other name is called status date, it is a date on which you take updates on the project progress ok, that is primarily determined by the CPM.

Now CPM is widely used; now these are the steps I would say on the building of the GPM. So, CPM you know is widely used as a project management tool for planning and scheduling. And the basics to CPM is primarily you have to draw a network and from where you calculate the project completion time, total floats, critical path, etc. primarily you do network schedules and also you do network analysis on AoN network ok.

Now once the actual dates are introduced in the CPM network like maybe, you plan 6 days it takes, but what happens is the first date may be on 1st of July and the sixth date may be on 7th of July when the actual dates are implemented and the as-built drawing is really generated. We start losing out the information on the data date, which implies a previous data date like total floats and where are all what happened the flaws, where are the delays happened and so on. We generally, we do not take a notice of, we miss all those and the critical path can no longer be calculated. So, in for those instances, GPM is very widely used ok.

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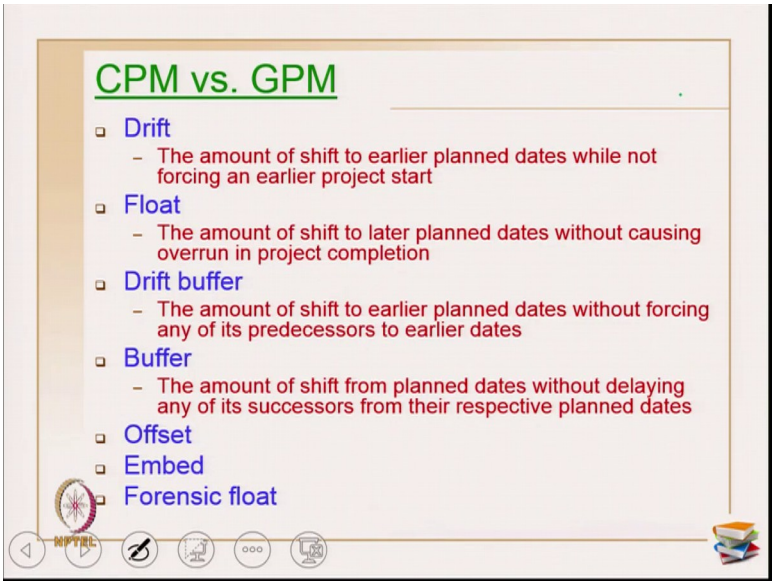

Now, if you see there are certain terminologies we have specifically for GPM; number one is called Drift this is not the complete list there are so many terminologies like this. Number one is drift, the amount of shift to earlier planned dates while not forcing an earlier project start it is primarily called as a drift. The next is Float, the amount of shift

to later planned dates without causing an overrun in a project completion. So, in a way it is like a total float sort of set up in your CPM, we call in GPM, the name given in GPM is float. The next is Drift Buffer the amount of shift to earlier planned dates without forcing any of it's predecessors to earlier dates ok.

So, primarily what happens is, there is an end point software for operating on GPM. So, when I am shifting an activity it tells me how much I am shifting and because of my shifting pre-data date ok; is there any predecessor activities or should be deviated or it gives me a caution as to the predecessor activities have to be also preponed and so on ok. So, accordingly you have to see how much is a drift, how much was a buffer these activities have consumed, we can still explore.

Next is buffer the amount of shift from planned dates without delaying any of it's successors from their respective planned dates; in a way it's like your free float we have in CPM terminologies; then we also have other terminologies like offset, embed, forensic floats and so on ok.

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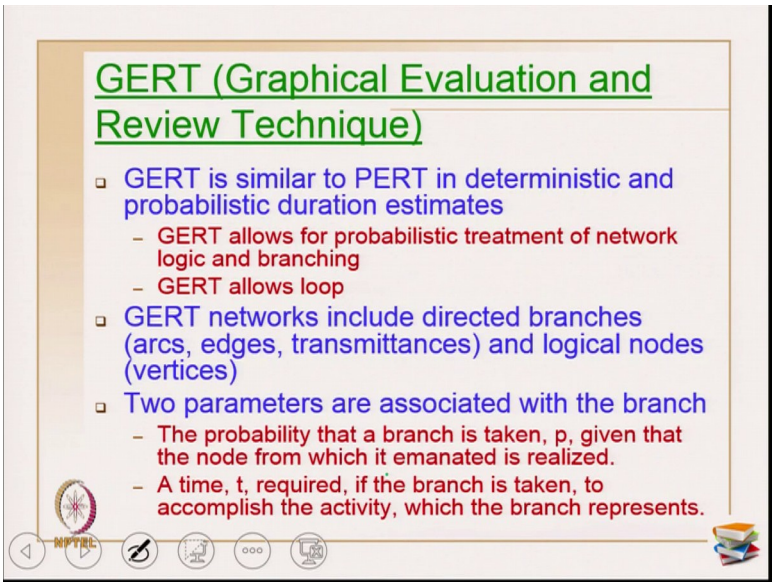

Now, let us move on, because my purpose is only to introduce these techniques to you the next is GERT. So, GERT similarly like GPM it is an advancement to PERT ok. In PERT you know, why we introduced PERT; PERT has come into existence only to allow uncertainties in durations ok. So, GERT has developed by Pritsker, it has developed as means to advancements in PERT ok. So, in GERT also we can allow deterministic

duration as well as probabilistic duration estimates just like your PERT. So, GERT is same as PERT in that sense; but GERT is different from PERT in two ways, one is it allows loops ok. If you take any of the network schedules like your CPM, PDM, PERT, etc, they does not allow loop even your GPM; but GERT can allow loop because of the probabilistic branching and so on.

And GERT also allows probabilistic treatment of network logic and branches. In the sense it can also have two links and one of the link can be operational and the other one will operate only at the certain situations or circumstances. So, it can allow either one link to operate, both the links to operate, so it allows branching off that is what we call it, as a branching of a network, with example you will understand later. Then GERT networks include directed branches ok, which implies arcs, edges and transmittances and logical nodes also which we call vertices. So, two parameters are linked with the branch; one is a probability time and the other one is the time taken, time required for the branch to take.

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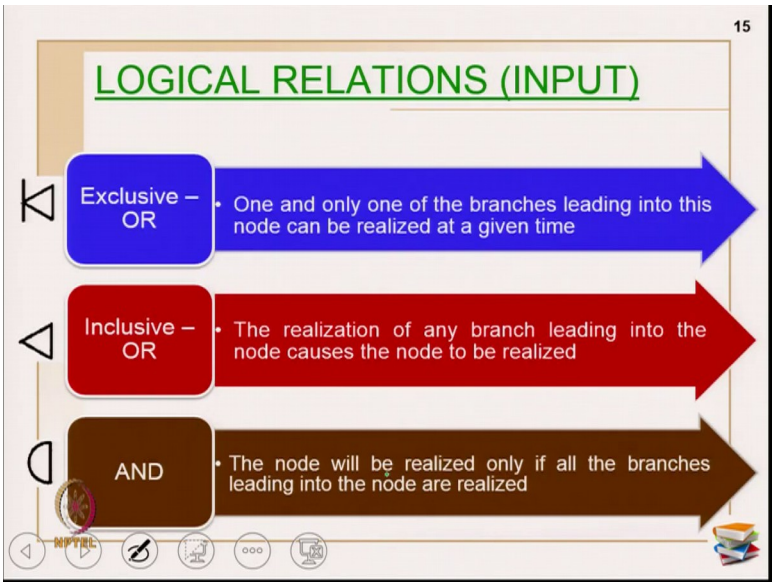

Now, there are certain terminologies in GERT ok; one is called input terminology and the other one is output terminology. And how do you draw the network, because I told you the network itself is very probabilistic and so, the network itself should be you know guided as to, whether this arrow should work out or this arrow should work out. In CPM if you draw two arrows, both the arrows will be operational at every point of time ok; in

GERT it need not happen. So, logical relationships on the input, now let us see the symbols and then we will see an example.

So, when I am drawing a straight line with a triangle it is called Exclusive OR and one and only one of the branches leading into this node can be realized at a given time. So, only one branch leading from the node will be realized here ok. The next is Inclusive OR, the realization; so primarily it is only a triangle shape, the realization of any branch leading into the node causes the node to be realized, ok. So, whatever comes in it just does it's operations ok.

Next is AND, the node will be realized only if all the branches leading into the node are realized. I may have two three links entering into this set up. So, what happens is, all when all the links are having a ready for start then only this branch will work; otherwise it would not work, so this is the input.

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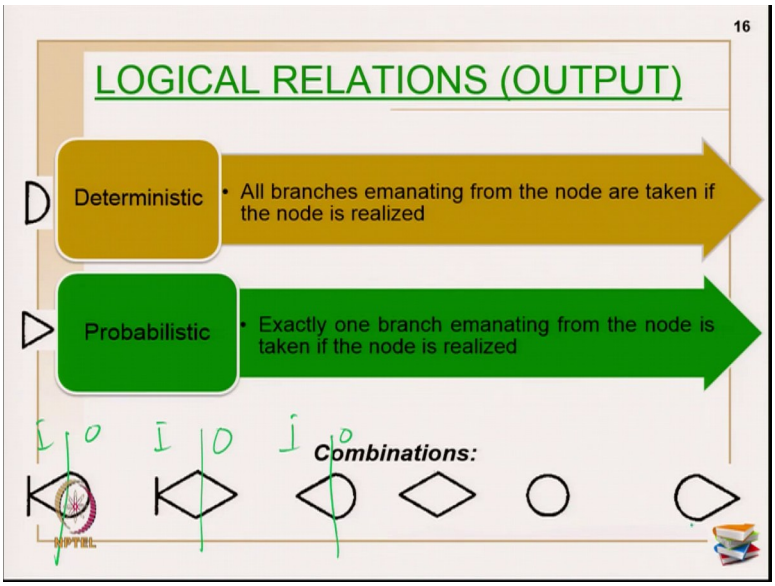

Now let us see the output symbol. So, primarily I am having two symbols here ok; one is like a D shape and the other one is a triangle shape. So, D shape stands for Deterministic and the triangle stands for Probabilistic ok.

Now here the D, all the branches emanating from the node are taken if the node is realized ok, so all branches will be operational here. Then Probabilistic, exactly one branch emanating from the node is taken if the node is realized; whenever there is an

enough input coming in only one branch will be operational ok. Last three cases we have seen only on the input, so I am talking about arrows coming into the network. In this case on the output when you have this symbol in the end, I am talking about arrows starting from the particular network.

Accordingly, now I have several combinations here, you will see there are so many combinations here, ok. So, this stands for input and this stands for output, in all the cases this stands for input and this stands for output, ok. If you see here, so you cannot use this separately, you have to use combinations only because you need to know what is the input criteria for taking up the network and what is the output criteria ok. If you see here, the first one is primarily exclusive OR and deterministic; the next one is exclusive OR and probabilistic and the third one is exclusive OR and deterministic; then the next one is inclusive OR and probabilistic; then next is AND and deterministic AND and probabilistic ok.

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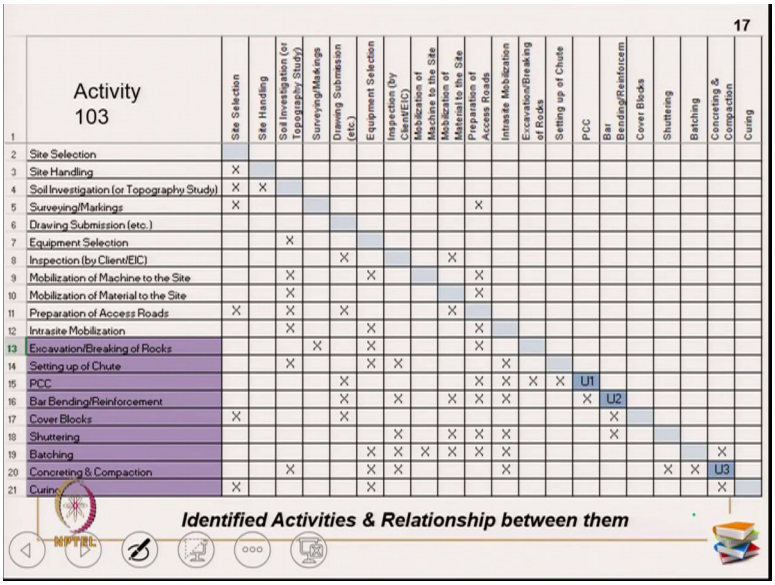

Now, let us take an example, I would say this is a gas station construction which happens in a hill station ok. I would say that landslides are more in number, this network was drawn with DSM; but primarily what I wanted to show here is there are three uncertainties which are encountered in the entire network.

Whenever you have an uncertainty only then you want to draw a GERT network. So, we have taken these three as uncertainties here; number 1 is on PCC plain cement concrete,

number 2 on bar bending and reinforcement, number 3 on concreting and compaction. So, it is primarily excavation of breaking of rocks and then disposal of rocks, then PCC primarily pouring of concrete, then bar bending or reinforcement, cover blocks, then shuttering, batching, concreting compaction and curing ok.

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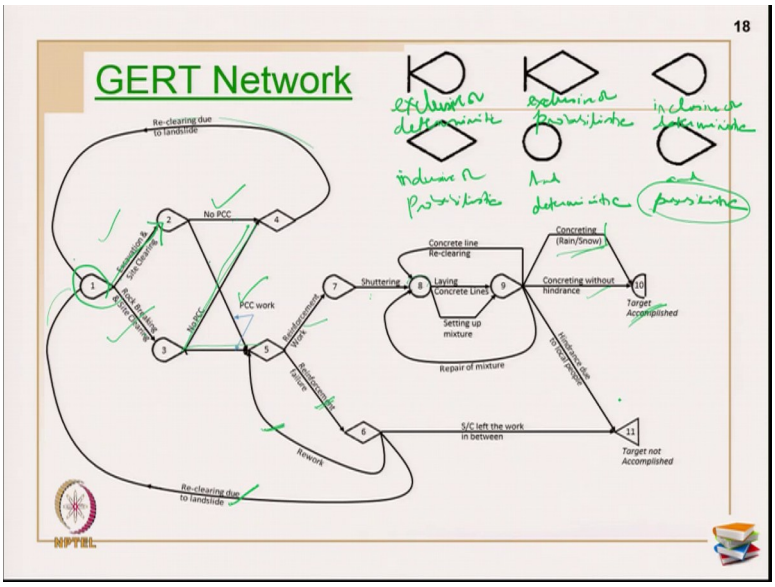

What happens with the hill station with a lot of landslides; every time you may have to redo the work again if the landslides have occurred, maybe you have done excavation, landslides have happened, then you may have to RE-clear the site for the next level of excavation, ok.

So, this is the simple network which we have taken it up and the representation on GERT looks like this ok. Now these are the symbols which I have used earlier in combination symbols; every time you may have to use this combination symbols ok. Only in the start or end you may use a single symbol ok. Now let me write everything, so that it is easy for us to understand. So, this is exclusive OR and deterministic ok, this is exclusive OR probabilistic this is inclusive OR deterministic; so this is inclusive OR probabilistic; this is AND deterministic this is AND probabilistic ok.

So, I am starting and what shape is this, this is AND probabilistic, this has come because of the link I have in here. So, now, let us start with the activity, do not see the symbol, the symbol will be operational only when the back link works ok. So, I have two arrows

coming in; one is excavation and site clearing and the other one is rock breaking and site clearing ok.

So, I have two modes, either I may have to clear up my earth by excavation or I may have to do rock clearing also. So, that is an uncertainty coming in ok. So, AND implies all the links coming earlier has to be considered and probabilistic is, so either one of them will be operational ok; either I may have to do excavation or I may have to do the rock breaking and unsite clearing. Because I have told probabilistic end, I may have only one link operational.

So, suppose I am taking excavation ok, there is no rock I am only doing excavation there ok. So, again what happens as and when this link works this will start again I may have either one of the links only; either I may have to do no PCC or I may have to do PCC work. So now, what happens here is, there may be a problem with the pouring of concrete itself because I told uncertainty happens at that place itself. So, I may have to do PCC or I may also avoid my PCC ok; because of what there may be a landslide which has happened. So, when the landslide happens, I may not be able to do PCC I may have to reclear due to landslides and again I may have to repeat the process ok.

If the PCC happens in the sense, if there is no landslide, no uncertainty has happened, then I am going to go to the second step in my operations which is the plain cement concrete work. Same thing, instead of excavation I had rocks available, then I may have to do rock breaking; and when the rock breaking happens, again there may be a landslide which may happen. So, once either I may do no PCC or I may have to do PCC and then do the land clearing process that is what.

So, if there is a land clearing, then I may have to come here and do the land clearing and again repeat the steps accordingly. If there is no land clearing, if there is no landslides then I may do with the PCC work ok. So, whether I have taken excavation work or my rock breaking work, then I could do my PCC if there is no uncertainty that has happened. Now there is again an inclusive or probabilistic link given here, ok.

Now either reinforcement work can happen or reinforcement failure can happen ok. Maybe because of my quality of reinforcement or something, reinforcement failures are more common their or maybe I have tried to put in the reinforcement in the excavated portions and landslide has collapsed everything. Some uncertainties can happen with the

reinforcement also; in the earliest slide itself, I have shown you three places with the study on previous projects we have identified that uncertainties can happen on these three instances.

So, reinforcement work can happen or as I told you only one link may work or reinforcement failures can happen. Now when the reinforcement failures happen then rework has to be happen. So, again the reinforcement work has to be passed on or because of the poor quality of reinforcements or if the landslide has happened and collapsed my reinforcement, then re-clearing of the landslide has to happen, again excavation and all these work has to happen and proceed. Then once the reinforcement is done then we go on to shuttering work this is primarily the AND deterministic, for shuttering I need the concrete line re-clearing and also the repair of the mixture or setting of mixture. So, I need all the things to be ready and then only I have to go with my laying of concrete lines ok.

Now, with the concrete lines I may again have a failure, concrete may happen when there is rain or a snow, then I know what precautions to take; sometimes concreting may not also happen with the hindrances ok. So, concreting happens and concreting has not happened. So, this is concreting without hindrance and concreting has failed because of the rain or snow ok. Now what happens here is, now this has gone to the target accomplished stage ok.

Now if there is a hindrance due to local people or something then target not accomplished and then this network has to go in loops. When you give the probability value as to what is the probability that PCC may fail or your reinforcements may fail according to the probabilistic values you dump in onto the network then what happens is accordingly the durations can be calculated. But still no far has worked on duration calculations on this, but it can help you to draw the network on probabilistic branches and roots, so this was drawn up by Pritzker ok.

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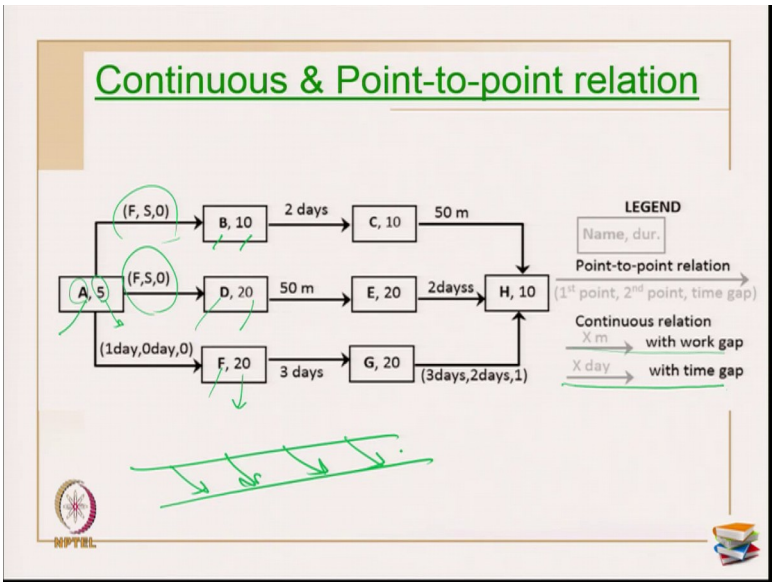

Now, moving on into, so primarily if you have seen, we have covered CPM and PDM very much in the first few classes. Now previous to PDM or CPM we had the bar charts that we have discussed right now, then we had PERT which we missed, advancements to CPM also we have seen GPM, advancements to PERT is the GERT that also we have seen. The next is your PDM relationships and advancements to PDM we can say it is the BDM or your RDM ok, relationship diagramming method and beeline diagramming method are generally called as an advancements, Beelines are to represent multiple relationships. And when you want to have a resource dependency shown on the network, then RDM can play a picture these are all called advancements.

Now in the BDM network itself if you want to represent more information, then some researchers have developed their network called continuous and point to point relationship ok, this was developed by Hajdu, Miklos Hajdu and what does he say is, I am having an activity this is a legend with which you can understand, the legend has name of the activity and duration.

So, this says activity A duration is 5, activity B duration is 10, activity D duration is 20, activity F duration is 20 and there are different types of relationships given; point to point relation it says primarily the 1st point, 2nd point and the time gap. In your BDM you always had N1 and N2 and if you want to have N1, N2 with the time gap, then you can mark this as F, S and O primarily the finish the first segment, the second segment

and then the time lead or lag ok. So, (F, S, O), (F, S, O) here there was no finish to start and there was no time lag here no time lag here. So, after this activities done only you have to start, but here after one day of activity you can give information to F and there is no weight, so it primarily the start and then I have a 0, so there is no lag here ok.

Now here there are also written in terms of duration and distance ok. So, the X m it talks about work gap and the X day it talks about time gaps. So, now when you have F S 0 on the arrows it means it is a point to point relationship and when you are having an X days or X m it talks about time gap or the work gap, which implies continuously between two activities I am having a relationships here. When you are talking about repetitive activities in for example, what happens is you may have let us assume I am doing excavation with one stretch second unit, third unit and so on.

And suppose if you want to maintain a continuous interval between all these segments, then I may have to maintain a time gap or it may be a distance gap ok. One meter ahead I should not keep all my equipment and there should be a minimum clearance of one meter, then you can write one meter there it shows a work gap. Otherwise one day later the activities should progress, then throughout excavation and the second activity then you can maintain the X day as a distance buffer ok.

So, this technique is very helpful in showing the repetitive activities also because what these researchers say is, in reality you may have activities with continuous and non-continuous put together. So, you need a representation which shows a non-continuous segment also along with the continuous or repetitive portion of activities ok, for that case this is very useful ok.

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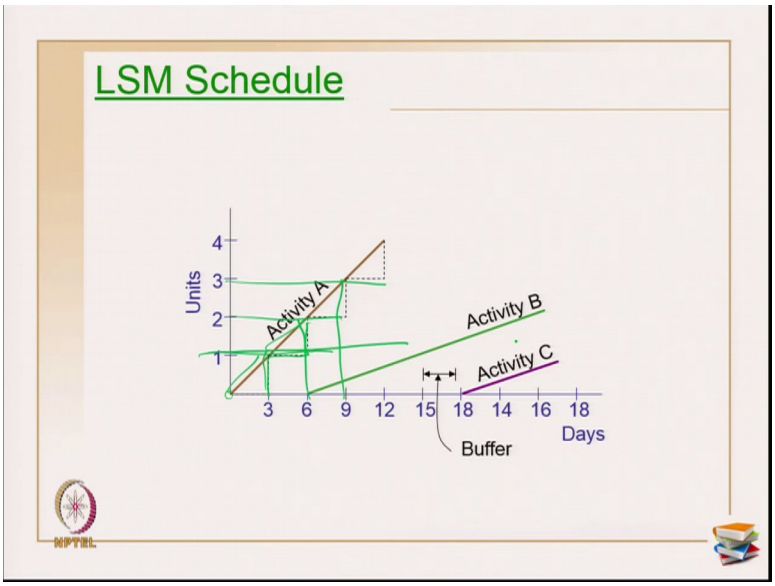

Next is LSM, LSM is linear scheduling method. In the regular class I explained you on line of balance method, line of balance you have to draw 2 bars in order to show the early primarily. The start of the segment and finish on the segment there is nothing called early and late ok, which shows start of unit one finish off unit one, so it shows as a rectangular bar and the entire progress till the last unit is seen here ok. In LSM what happens is, it shows, so primarily this is a network it shows only one horizontal line and with an inclination to the horizontal. So, primarily I have taken 3 activities A B and C and this is a duration of the activities and this shows units 1 2 3 4 and so on ok.

So, I am having an activity, primarily I am having a rectangle here, this shows the time taken with which the first unit is done ok. So, the 1st unit when I am drawing a line it says I am finishing it at 3 days, the 2nd unit I am finishing it at 6 days, 3rd unit I am finishing it at 9 days and so on. So, 0 to 3 ok, 3 to 6 that is how you have to represent or interpret your LSM schedules ok. Now for here, there is a distance buffer also in the earlier LoB also we showed the buffer by means of a start buffer or a end buffer, same case here also we have to show the buffers in LSM .

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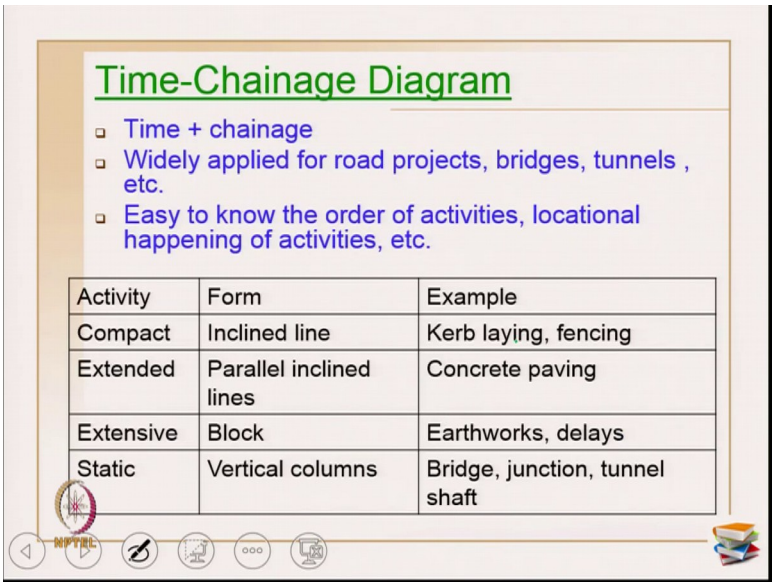

Now what happens is, there are software which are very specific only for repetitive activities. We are just moving into that.

But there can be non-repetitive portions also in a repetitive stretch of an activity completions. This is not a new technique what we call as a time-chainage diagram; this is a very old technique which came in as soon as your LOB was formulated ok. There are so many terminologies came along with this then only the CPM form of a network came in existence. So, these all techniques have come even earlier to CPM schedules ok. So, time-chainage diagram it just talks about time plus chainage, now we are into repetitive activities. So, I have duration as my stretch and I should also know where these activities are going to be done in the whole chainage ok.

I am having a 200 days of my duration and when you are saying excavation it takes for throughout stretch, but you should know on day 60 to day 80. This excavation is happening on which stretch and where is the other activities happening at the particular point of time, so primarily the chainage is the whole segment or distance, I would say along with you are representing your time. It is widely used for all repetitive projects like your road projects, bridges, tunnels and so on and it is easy to know the order of activities, locational happening of activities and etc ok.

Broadly the researcher has classified four types of activity; one is a compact. Compact is generally shown with the incline line ok. These examples I have taken with the help of

earthwork or, maybe kerb laying or fencing ok. Extended lines, I may have parallel inclined lines here; this is primarily to show concrete paving. Maybe there is a duration there and it is like a completely happening an activity. Then extensive activities are shown as blocks for example, earthwork ok.

Earthwork can be done throughout the stretch of your highway construction ok, which you may have to show it as an complete block till the chainage is completed. Static primarily show it in vertical columns. In the entire highway segment, I may have bridge maybe in one or two places only; bridges, junctions or tunnel shafts. So, only in few places I may have the vertical columns coming in and to show the bridge construction, peers, abutments and so on. And with that, I am closing my diagrams ok.

So, these are the main features in non-continuous representations. And there is a specific software which helps to show your repetitive projects ok, what we call it as a TILOS ok.

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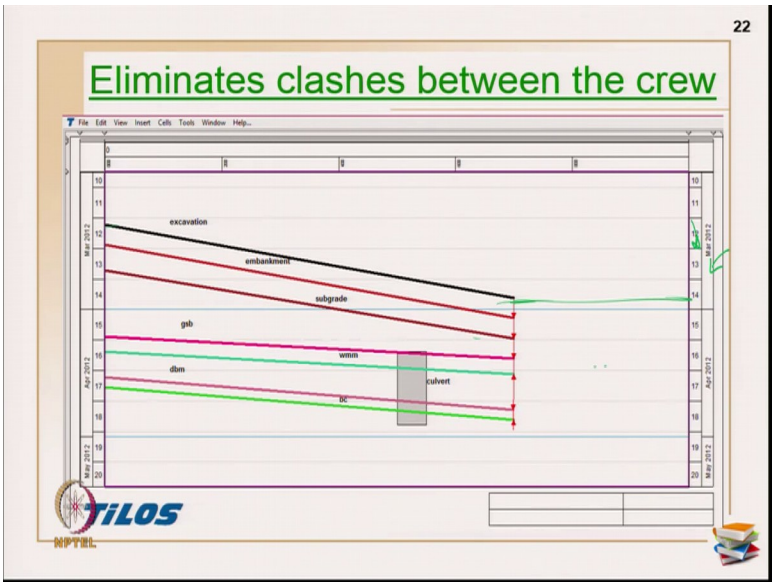

So, TILOS is primarily the time linkage software and here you see, this is the same example what we have discussed the earlier on highway widening project. So, this is a snapshot on TILOS. So, I am having a March ok, April, then May, these are all the weeks ok; I am starting on 10th week is somewhere in March, 11th, 12th, 13th, 14th, 15th and so on. So, these are the weeks and along with the year of representations.

Now the excavation work is starting somewhere in the 12th week of the project. So, which is happening in March and it is finishing in somewhere in close to the 14th week of the project progress, which is supposed to be the end of March towards the end of March. This is the project progress week and this is your month, the relevant month on which this entire work is going on. Then excavation, embankment, these are all parallel inclined lines which shows your regular activities ok. If you see here, compact activities are shown generally by inclines lines, right. So, these are all your compact activities.

So, first excavation, then exists embankment, subgrade, granular sub base, wet macadam mix, then I have my DBM, then this is my bituminous concrete mix ok. So, all these are shown. The crew connectivity is also shown for the next levels and so on, because I am sharing so many resources between the activities, which during the RDM modes we have discussed this also.

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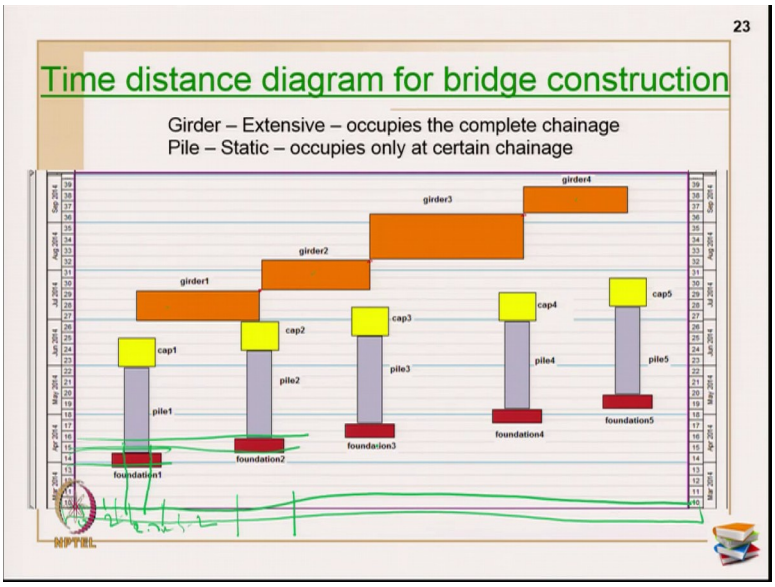

Now, let us move on in to see the time-chainage representations on TILOS. This is again a TILOS snapshot only on the same project, where in I have raised a bridge also to continue with my highway construction ok. So, these are all girders here; the girders are primarily the extensive activities which are shown like blocks and they occupy the complete chainage ok, almost most of the chainage ok.

Suppose if the entire construction is happening on bridge and highways, then you may have to show all these on girders on extensive activities ok. These piles are all static

portions which happens only from this particular segment to this particular segment. Here you will have a chainage also and I have to crop it because I did not have and I could not put it fully.

Ok, below this at the end I may have the chainage also, which shows 0 kilometers, 2 kilometers, 2.7 kilometers, this may be 3.2 kilometers; all these can happen and you will know so this, from this particular distance to this particular distance I am doing my foundation. Foundation is happening from this time to this time, the second foundation is happening from this time to this time and it is happening in the month of April 3rd to 4th week. So, all these you can interpret on seeing the figure only ok. So, it is still a visualization diagram and also an analysis tool on repetitive construction projects. That is all about TILOS ok.

So, now, we are just wrapping up from the beginning. So, first non-network schedules we have seen, network schedule CPM and PDM we have seen earlier. Now we have discussed PERT, GPM, GERT and so on, and then we moved on into repetitive construction projects. LOB we have discussed enough in detail in the regular class. Now I have introduced to you LSM and time chainage charts and this TILOS can help you to know to represent these networks also ok.

MS project or Primavera are very relevant for all your earlier schedules like your CPM, PDM, bar charts and so on. And then, TILOS is very good for LSM. It does it will not show LOB scales. It only use as LSM and time-chainage charts ok. So, in way repetitive projects can be shown on this TILOS.

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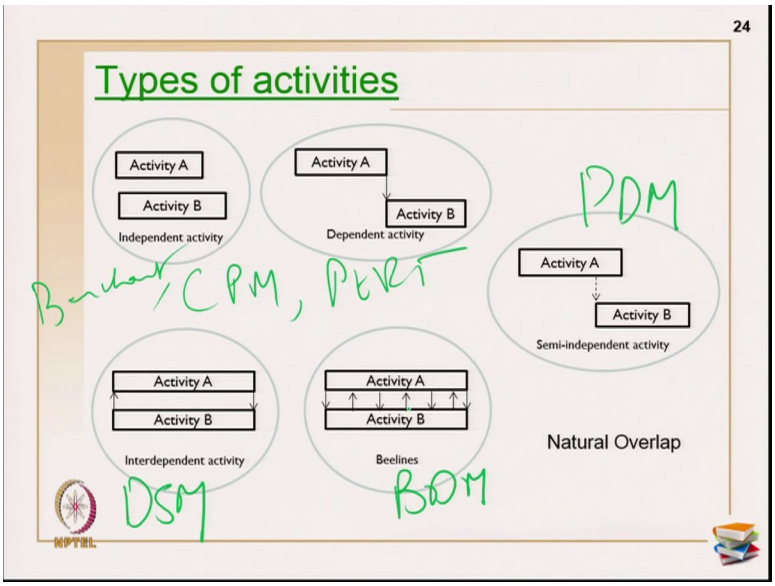

The next is types of activities we are just moving on into types of activities, to show where we are and what all we have discussed so far. So, independent activity, dependent activity we seen, we know what is it. So, your CPM, bar charts whatever you have discussed so far will surely take care of independent and dependent activities.

The next is semi-independent; semi-independent is, you need not wait till the end of a finish to start conversion relationship. If you are ready to send any pass on any information or you are ready to start your work anytime in the midway of your previous predecessor. Then you can use a relationship called semi independence activities ok. Your PDM can really represent the semi-independent activities. This you can use CPM, you can use PERT, or you can use bar charts. So, all these are helpful for that, I am not talking about repetitive activities here ok.

Next is interdependent activity. DSM is a powerful tool for representing interdependent activities we have seen that in very much detail. The next is multiple two way information linkages or beelines and BDM is a very powerful method for introducing and if you want to mix and use repetitions and BDM and so on. Then so, BDM is primarily like point to point and if you want to have continuous relationships on distance, time and so on, then you may have to use what they are, what professor Hajdu has used on continuous and point to point relationships.

So, all these, you know what tools we can use and how to do the scheduling with all these methods ok. But one thing you should understand these are all primarily comes under the classification called natural overlaps; wherein, the information can pass on easily at that time and you are scheduling only with that knowledge ok.

Suppose if you want to know force and activities to release information ahead of something or behind something and then you wanted to schedule a project, then you may have to do forced overlap ok. Forced overlap, I am not going to cover in this particular course ok and interested researchers you may have to go through research articles only on forced overlap.

So, all these are our natural overlaps and we have seen all these techniques right now ok. So now everything has been covered, some in detail, some atleast I gave you an idea. So starting from bar charts, you have all the varieties like milestone chart, fenced bar chart, linked bar chart, hierarchical bar chart and so on. Then time scaled diagrams, network schedules CPM, PERT, PDM, Repetitive projects: LoB, LSM, Time-chainage diagrams. Other techniques like GPM, GERT, BDM, RDM, DSM which are extension.

MSProject and Primevera you can you

TILOS

NetPoint for GPM only

Beeliner Contigous

With this, I am stopping for today's class ok. With that, we will wrap up with the course. Bye.