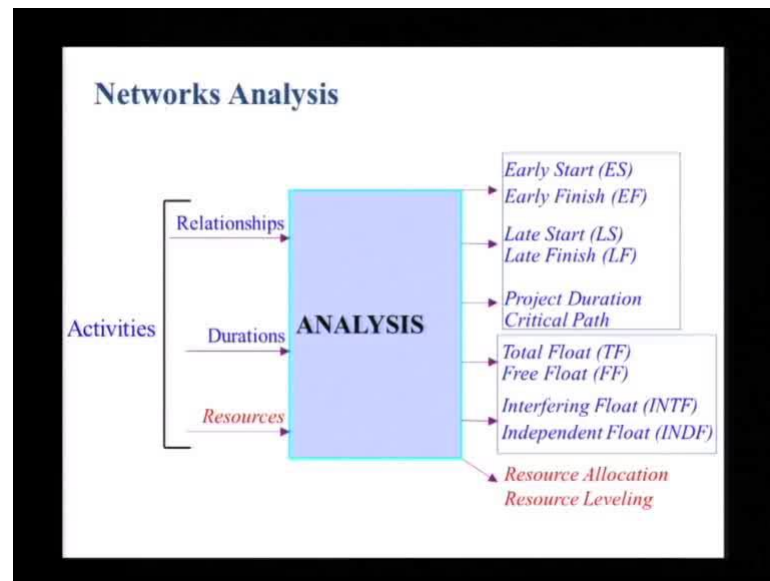


Project Planning & Control
Prof. Koshy Varghese
Department of Civil Engineering
Indian Institute of Technology, Madras

Lecture – 32
Resource Scheduling

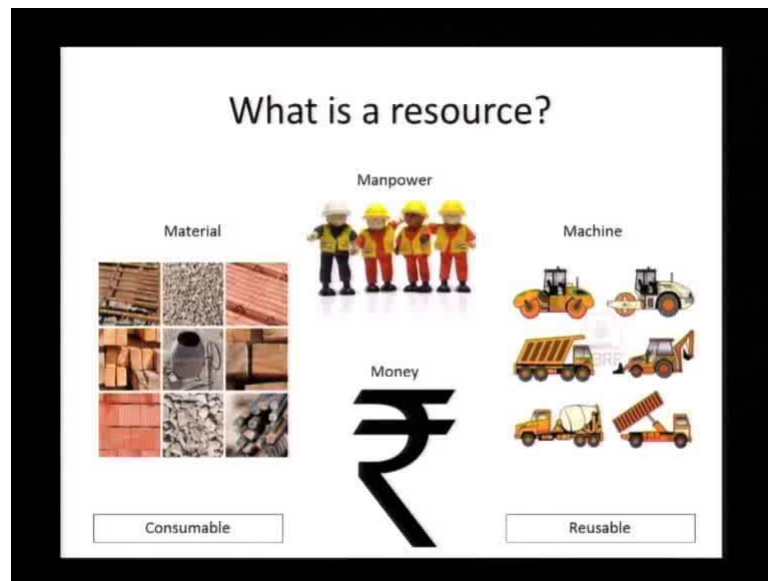
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This lecture we will cover, we will start with this important topic of Resource Scheduling and as you all know, we have looked at this figure before, where we have basically we used it to introduce network analysis, where we had relationships and durations. We did the analysis and all of these outputs you see box; that is early start, early finish, the late start, late finish, project duration, total float, free float, interfering float we have learnt how to calculate.

Now, you would have, we would have we also discussed a little bit about resources earlier and the focus of the next few lectures are on, how do we consider resources as input to the network and what is the kind of allocation and leveling operations we can do with resources.

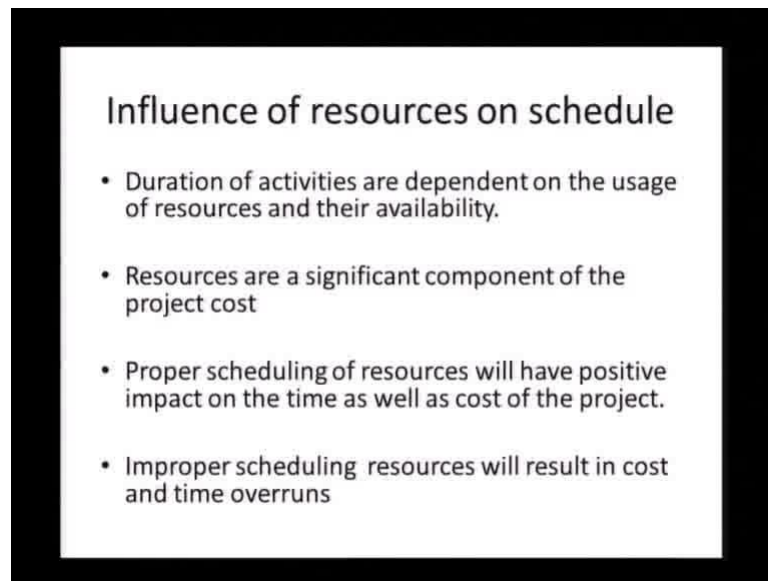
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So, when we use this term resources it is a very common saying in construction that there are all these M's. So, materials, man power, money, machines are all the M's of construction and if you manage these properly, you have a good project and that is really very true, that resource management is the crux of good project management. And if you are able to use resources appropriately, there will be a lot of things which go right on your project.

And you can see in this slide we have two types of resources, one is consumable the other is reusable. So, for example, something like materials is a consumable resource, it gets used up you cannot reuse it, whereas something like man power is a reusable resource or machines are reusable resources. What about money? It gets consumed. So, when you use of money it gets consumed. So, at a later stage it is a kind of important that distinguish whether resource is consumable or reusable.

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So, when we get into resources we see they have very important influence on the schedule. We have, do you recall when we have discussed resources and its influence on the schedule.

Student: ((Refer Time: 02:23))

Yes, when we took up the two span bridge we discussed it, when we talked about duration estimation we talked about the influence of resources and duration. So, here you can see one of the critical influences is duration of activities are dependent on usage of resources and availability. So, when we take construction projects we talk about the usage of the resource, the type of resource and all of it and see. So, we say we have more sophisticated equipment might be the productivity is better, might be the duration can be reduced or if we put more equipment or people, we can reduce duration we talked a little bit about that on the crashing met, which we did in the last sessions.

Now, when we talk about other kinds of project, where people are the resources, skilled man power is a resource; something like availability becomes important. So, let us say you have you wanted to do a design and the designer is not available or his schedule is so tight, that he is not available on that day, then the availability becomes. You cannot put multiple designers and start reducing the duration of the design.

Just that you need that particular person for the designs, so skill and availability become a very important issue and we talk about people human resource and skilled highly skilled human resources. And other very important issue of resources, there are

significant component of the project cost, most of the project cost is derived from resources. So, if you can keep track of resources and you can actually look at, what has happened with the resource, you actually keep track of the project cost or you can even plan, how the project cost is going to vary with time.

So, as we discussed if you schedule resources properly, it will have a positive impact both on the time and on the cost. So, the first influence here is more on the time and the second is on the cost and improper scheduling is the reverse, you are going to really land up with problems and this is one of the most common issues on projects, where the resource management is not proper. So, resource are idle, if resource is idle like people are idle, which means that you are paying them, but no work is getting done and as a result the project will be losing money or even equipment. So, as we say we go to a project and the tower crane is idle, which is a valuable resource it is sitting there and losing money. So, management of resources is very important.

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Now, we discussed this before, so if you take the two span bridge example, what are the resources here, what are the resources you see here.

Student: Casting operation

Yes, for the casting operation you need formwork you need all these forms, you need equipment and mixed concrete, you need people to pour, yes, you have reinforcement. So, you have people resource, we do not see the people here, but people resource you have you know formwork equipment resource, you have material resource like concrete

and reinforcing steel. You have an equipment resource here, you need a truck to transport, you know so you can cast all these beams and keep it there, but if you do not have a truck to transport it, it is I mean you are not going to achieve the objective.

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Two Span Bridge - Cast Beams - Duration

Beams are prefabricated in casting yard set-up on site.
No. Beams required is say 3 for each span- total = 6

No. beams required = 3 + 3	Production Rate— based on No. Forms/Beds
Operation Sequence: 1.0 Reinforcement Fabrication – 2 days 2.0 Casting Beam 2.1 Formwork Assembly – 1 day 2.2 Concrete pouring – 1 day 2.3 Form removal after – 1 day 2.4 Form removal time- 1 day Curing before usage – 28 (14) days regular 3 days steam curing Assume reinforcement fabrication is done in parallel	No. Sets of forms 1 1 beam in 4 days -> 24 days for 6 beams 2 2 beams in 4 days -> 12 days " 3 3 beams in 4 days -> 8 days "

What production rate is required?
Assume 3 sets of forms:
Total Duration= 2 +14 (1st set);
Day 6*14 (2nd set)?

And then, you might recall this calculation where we found the duration of casting beams based on number of resources we mobilized. So, we said if we want to you know reduce the duration; that means we needed more form work. So, if you have more form work, which means your mixing operation has to be a, your concrete output has to be done faster, which means you have to have an appropriate mixing machine to be able to do that. So, if you know all of these matters, so resources really drive the duration.

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What decisions do we need to make
about resources ?

Now, we come to this question, so we understand the importance of resources on a project. What decisions do we need to make about resources? You know, so here as a project manager we understand there is materials, there is man power, there is machinery, there is money, what are the decision we would want to take. We know that we, that resources drive the duration, we know that resources if not used properly will lead to cost overrun, what are the other, so what and then we also seen, so far how we get time as I mean time based output from a network analysis.

Now, if we combine this network analysis and the knowledge of resources, what are the decision we will be able to make.

Student: quantity of resources

Yes, so I will, so for example, when you say quantity of resources if I take a design drawing and I do a quantity take off, I do get quantity of materials for example. Is that what we are talking, what you mean by quantity?

Student: No, no. Yes.

Yes, so I have my total project quantity, is that... That is yes, that is useful, but is that can we get more than that on a project.

Student: Time of entry of resources into the site.

Yes, you can get a weekly resource plan. What is the point you were mentioning?

Student: man power

Yes, same thing. So, I can do either materials or man power on a timed basis, I want to know how much material I need this week. Yes, how much material I need for the whole project is certainly useful information, but I need to time it I need timing wise information and as he mentioned inventory is then becomes important.

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Resource Decisions

- **Materials**
 - Periodic order quantities
 - Storage requirements and locations
 - Quantity discounts – multiple sites
 - Custom equipment ordering & delivery
- **Manpower**
 - Mobilization requirements each period
 - Skill requirements during each period
 - Work planning during non-availability period

So, if you take a look we need periodic order quantities, only if I note time I cannot order all my material in the beginning of the project, it is going to come in periodic lots and I need to know the order quantities. I need to know storage requirements and locations, I might have a specific capacity in my warehouse, I cannot I should be able to know that and if that capacity is exceeded I should have alternate places to store.

You will find that large companies will try to get material requirements from multiple sites, because they will get volume discounts. So, if I am buying 10000 bags of cement versus you know one lakh bag of cement, the cement manufacturer might give me a discount bigger discount on 1 lakh. So, if I can, if a large construction company I rather go with that, if can coordinate between my sites rather by the large one rather than each site buying small one.

So, now, if the sites do not give me when they need what quantity I will be not able to do this. So, again when I put a time line on my resource requirements and say on a weekly basis and here specifically material requirements, I will be able to take those decisions. The next point is custom order and delivery. So, custom equipment is something which is specialized for example, a hospital might have a special MRI machine.

If you know when the MRI is going to be installed as far as your schedule goes, I will know when to make when to give the order. I cannot go an order and MRI within a week or two it, might take a year for delivery. I have to know when it is going to be installed to be able to make that order, sequence it is delivery. I will show you an example.

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So, for example, this is vessel that goes into a power plant, now for something like this it will take quite some time to make it you will have to ship it there has to be received it has to be erected now. So, something like this is what we mean by the long lead time for equipment which we are calling materials here. ((Refer Time: 10:40)) So, this is some forms this is called equipment I have used the term custom equipment it is not the construction equipment it is the equipment that goes into a plant like a boiler or a cracking tower for a petro chemical plant.

So, so only if I can get scheduling information with resource loading I will be able to take all these decision correctly, when we go to man power you said we need mobilization requirement for each period how many workers do I need, what is a skill of workers I need it is not just workers I will need people like welders, I will need masons, I will need carpenters a worker is not just worker.

So, I need to know this kind of skill, skill level I need in this each period of time we need to able to understand I mean if it is highly skilled work like design as such people might not be available of people are not available we need to be able to substitute people or reallocate work during that period in some reasonable form. If we are talking about construction work typically the festival seasons are the time when worker availability is low we should be able to understand that resources well dip man power resources on site will dip during that period and planned work in that kind of a method.

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Resource Decisions

- Machinery
 - When special equipment is needed on site
 - Preparatory works for equipment requirements
 - Sharing equipment with other sites

- Money
 - Cash flow predictions
 - Credit planning
 - Project Profitability
 - Tax planning

So, these are some of the decisions when you go into machinery the equipment that is used for construction there is a lot of specialized equipment requirement. So, for example, you have an image of a crane this is a crane, which was not that easily available I will have to schedule it I will have to say that you know either if it is a company owned crane I will have to tell my plant and machinery people when I need it and when I will release it and or I have we are going to higher it out again I will need to know the crane is available and this is not just crane it is.

So, much specialized equipment today we will have to know went to mobilization in went to demobilize that equipment. Then, preparatory work for example, if we were going to move this into a site you will have to take a look at all the bridges and all the culverts its going to cross and see it if can stand the load, which is going to placed sometimes they will have to put there are there are kind of drains and everything on site and this travels on it, it could just break.

So, a lot of times there are perpetrator works for equipment requirements. So, if you have a heavy lift crane coming into the site I will have to do foundation preparation and to prepare the foundation for the crane it is self is going to take time only, then I my crane can we placed on the foundation and only than the lifting operation can take place. So, you really needs, so these resource based decisions have to be planned carefully.

Now, another one is sharing equipment with other sites, so if you are large company and you have large equipment pool I need to know just has we said material wise a volume

discount on material my equipment sharing is also very important I can not a lot a equipment of one site and keep it there forever I need to specially specialized equipment I need to use it all around when we go to a money this becomes extremely important lot of times not I mean emphasis is not meant not put on the money management of a project.

So, we can have people management you know as a material management you can have a machinery, but you might have heard the term that you know this business is very good, but cash flow was the problem what is that mean.

Student: Input of cash flow during every month or milestone might not have come during the particular stage when expected

So, the sales was good, but sales is usually on a some kind of credit and, so the person is able to sell material, but he is not getting cash for it is. So, he does not have money to buy and or sustain you know pay his salaries and everything else like that. So, then cash flow t's a very simple example of saying where cash flow is a problem.

So, in a project there is cash flow right? if the company buys all of this material everything it has to buy how it is that is cash out flow how is what is inflow, how does cash come in from the client on a periodic basis the client has to pay. So, you have way you have to able to understand. So, if your contractual term has certain inflow conditions you have to make sure that your out flow conditions are in a way that you do not face a cash flow problem. So, that is again it is a question of money and time right.

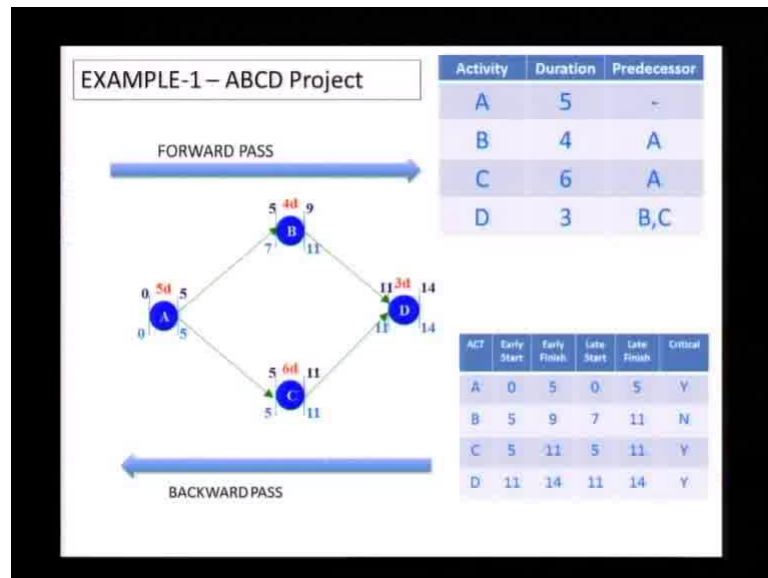
So, how does money flow with respect to time and unless you have an understanding of that on your project you will not be able to you might be doing a very good engineering project, but if you do not know if you have final cash is this is not there to buy materials or other things because you built a lot of it put it into building the for some reason for some contractual reason you are not getting it back from the owner you your project is going to be in trouble.

And if you look at the second point credit planning in some many situations the construction company might be borrowing money to move things forward and there might be a credit limit. So, if my negative flow is more than the credit limit my creditors are not going to give me money I do not want to be in that situation to. So, there are ways I can change my cash flow and this has to do with your network and if you recall we talked about floats. So, when I will see how it is, how can we use floats to vary

equipment and resource loading and cash loading of a project ultimately all these effects profitability even taxes.

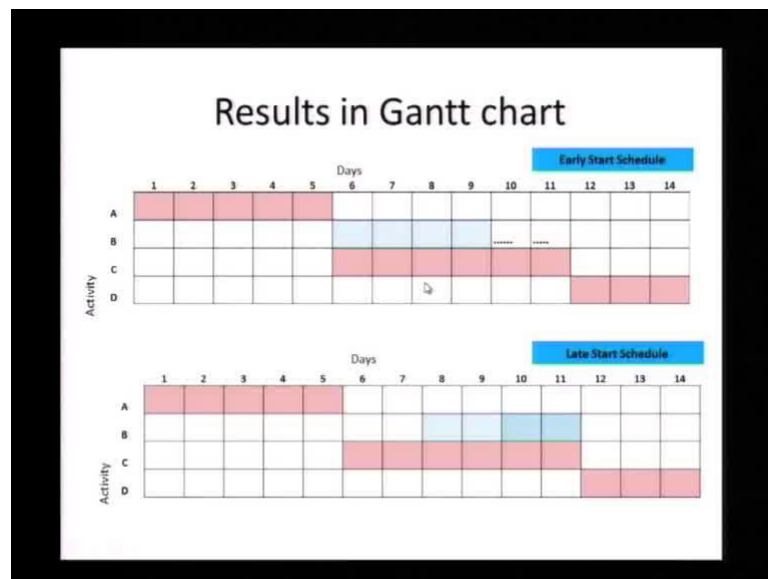
So, in the end we how do you actually pay tax you know on a project you know what is what is billed what is all these kind of when you get a tax break or what you get a tax break tax is also time based right. So, all of these things are very critical and have to be related to the time and hence to the project schedule any questions.

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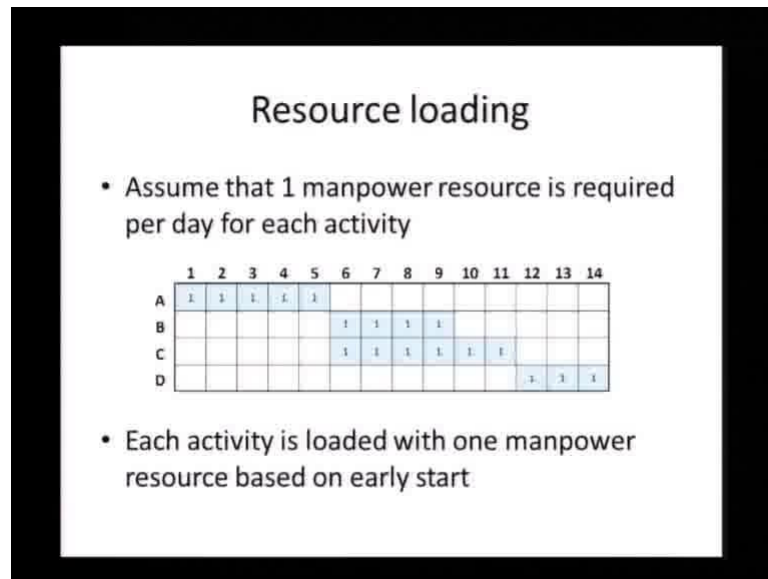
So, we will start with the basics and we take this, this example which we have worked with earlier we you and you very familiar with the, the basic numbers of this for now.

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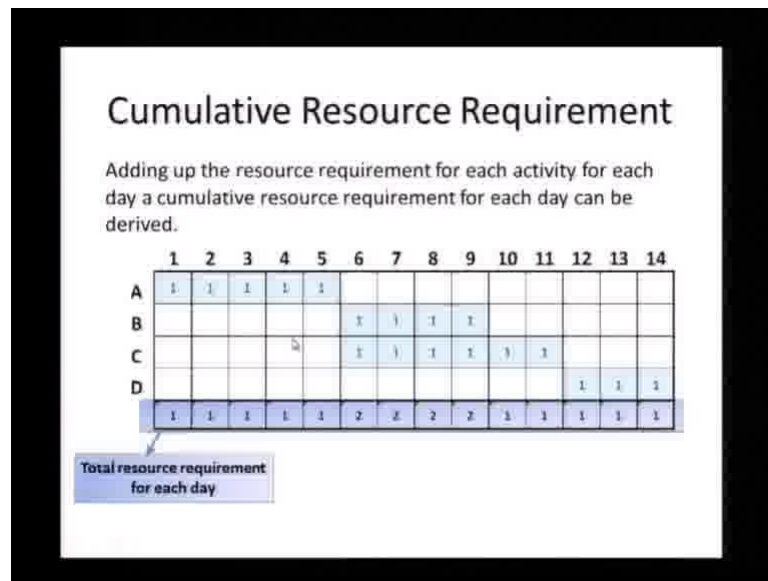
And we have seen the results in this Gantt chart if we recall we had we had the four activities we had ABCD and we said that B has here two days float. So, if I go back to the network diagram this was the a network analysis we did forward pass the backward pass we have 14 day duration and we have the all of the critical path analysis times and this is the resulting early start schedule and late start schedule is that okay. So, when we, we have that A goes on all of these days B is here.

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So, when we load resource load the schedule what we are basically doing is putting. So, in this particular case we have said that one man power resource records per each day we just keeping it very simple to start. So, all we have done here is put the number one in each. So, you can see each activity is loaded with one man power resource based on the early start.

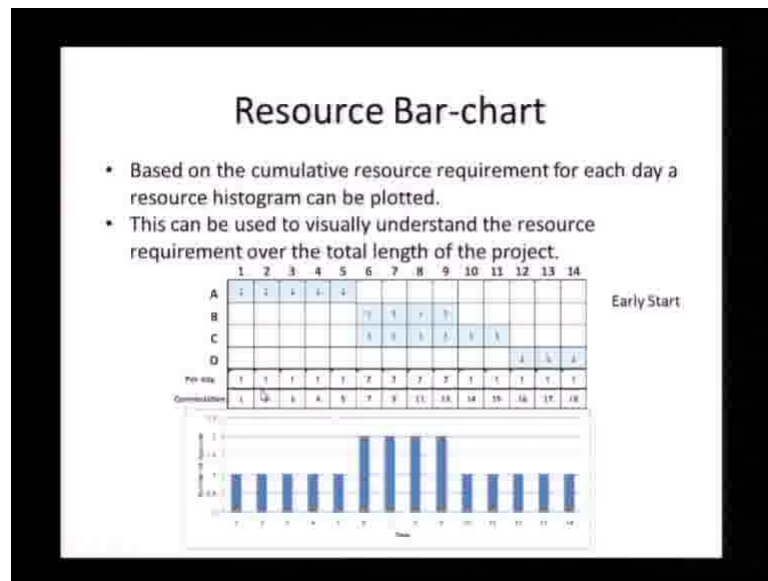
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So, now what it allows as me to do is simply to calculate the total resource for the project and this is a single resource. So, you can see this is going to be, so I can I can take this and put it in the form of a histogram and this is my if what is very simple example this is my man power loading chart for the project. So, I have you can see an all these days one increases to two then goes back to one and you can see the two is because there are two activities each requiring one I can have a cumulative plot.

So, all I am doing is cumulating, so I am just adding keeping a cumulative value as I go and therefore, it mean it just adds up. So, for man power sometime cumulative is not as meaning full as for money, but a lot of time cumulative is done to look at the progress. So, you can also then plot the cumulative.

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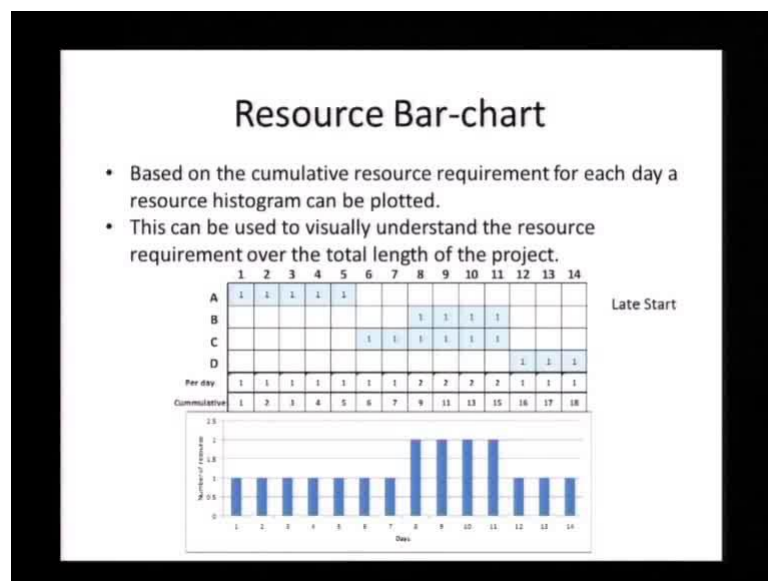


So, these really form the basic or basics of where how we load resources and look at resources from a Bar chart and once we do the CPM analysis. Now, what would be the next variation we want to do?

Student: ((Refer time 19:55))

yes either that or this was remember for the early start. So, so I should be able to now see this.

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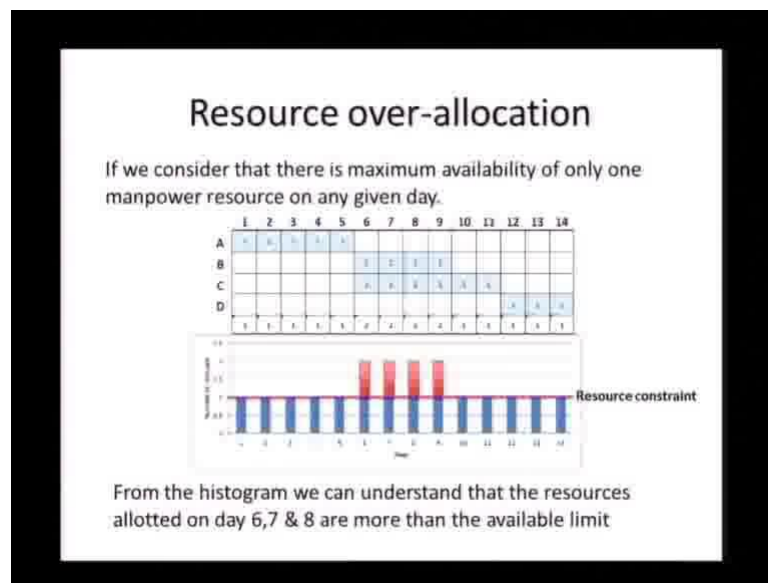


If I move this in late start you can see the profile is changed, so this was the early start profile this is the late start profile, so all I have done. So, for example, if if I went to the

early start profile and said locate. So, here I have two resources you know and these two days have two resources, but people are not going to be available on day six and seven I have I can only mobilize one then I would actually going for a late start and say I will still keep it at one for these two days.

But, the people will come back here on these on day 10 and 11 and I am okay of course, activity B as you know now becomes critical, but I can still finish the project within my original duration. So, this is a little bit of how you use the float of the activity to change your resource profile any questions. So, now, you can see what we have here is the resource cumulative resource taking the early start and the late start. So, you again have an envelope, right now there is probably just one if I move B by 1 I will have a in between point, but again this is the, this is envelope of the extreme points of my resource loading.

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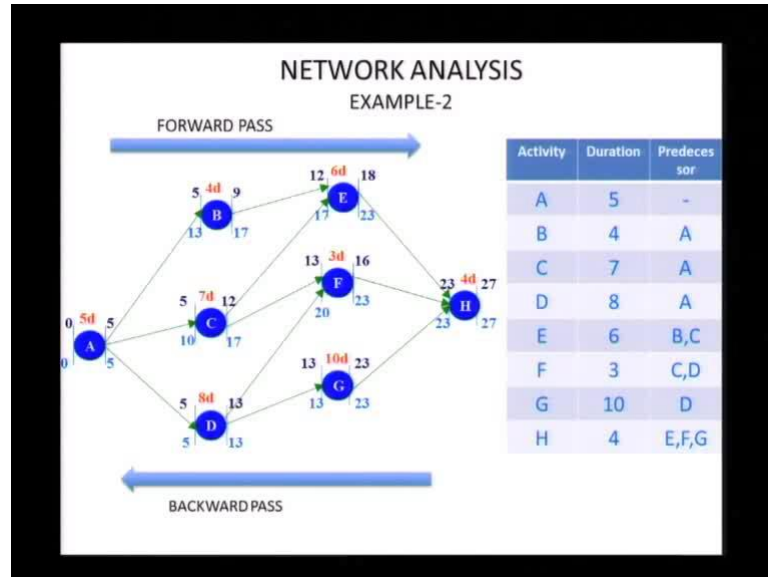
And this is called a banana curve by some in some areas because it will represent a banana another important use of this histogram or of this resource is to understand over allocation. So, here you can see that we are saying that I have only one person available I do not have two I only single person available and that is the maximum resource I can mobilize and immediately we can visually see that that we have over allocated and there is one extra I mean one resource we will need which we will not be able to meet.

So, in this situation what are our options?

Student: The project will get delayed.

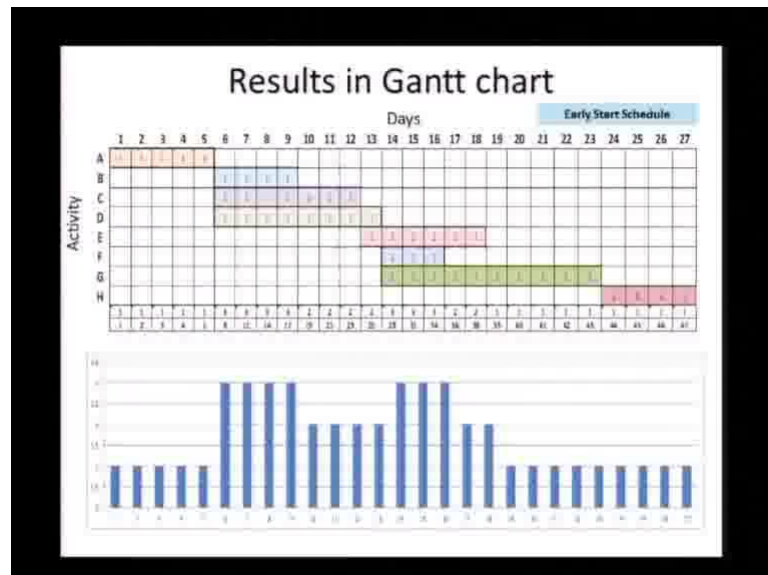
the project will get delayed there is no way I even if I used my late start of B I still need to do B there only way, now is two either do B and then, do C and if I do that I will have to all these 4 days will get it get delay by 4 days.

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So, in some resource, where since some cases when resources are a constraint, there is no other option, but to delay the project.

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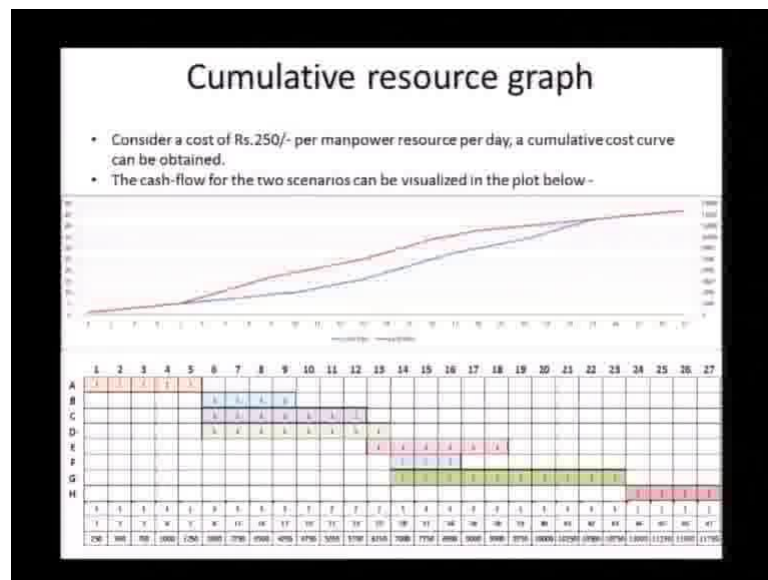


So, we will take another example, so this is also an example we have worked with before and you can see the results in the Bar chart this is for the early start and again it is a single loaded resource it is a slightly larger example and you can see the cumulative the

total resources required for a day in this first row at the bottom here and you can see the result in graph histogram. And, so here we are going to its like as the maximum I need is three, but there is a profile as such and there is also.

So, if I go into the late start this is the profile early start this is the profile and depending on you know what my availability and everything else is I can, then choose between the late and the early.

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Now, in addition to this we are also looking at the now going to add cost to it we are saying that its say two fifty rupees per man power resource per day. So, the minute I put in cost I am able I able to, now take you I will factor in the cost and now this is this what you have below becomes cost its cumulative cost. So, then this becomes a total cost of my man power resource for the project and you can see the line in red is the early start cost curve and the blue is a late start cost curve.

Now, when we say cumulative cost it has a lot of meaning which means if I go on to this day here I should have spent this much money is my as per my plan or my man power resource, which means I should be able to mobilize the I mean I should have mobilized that much money by that period. So, you will find that in some cases people might just from a cash constraint point of view go in for a late not from not from the precedence or from the resources or anything just that I mean resource is a cash is in way that they might decide to delay things, because cash is will be available much a little late any questions on this.