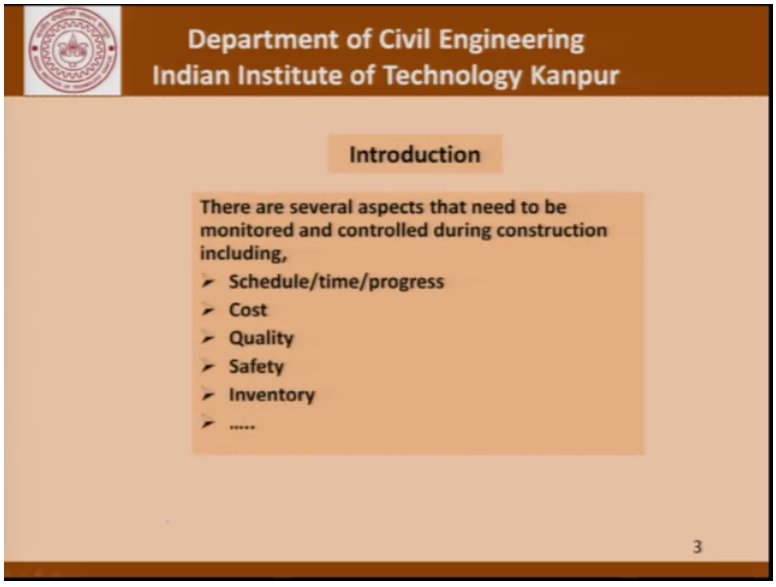
Principles of Construction Management
Prof. Sudhir Misra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture – 18
Project Monitoring and Control System

[FL] and welcome once again to the series of lectures on Principles of Construction Management. And we have been talking about project planning and scheduling in the last couple of classes and we continue our discussion on that, and today the focus is project monitoring and control systems.

What we done so far is try to look at a project broken it down into activities, try to schedule the different activities at different points in time, depending on the precedences, you also try to dilate our discussions to concepts like cash flow and so on. And what is important now is to see how do we monitor a project, how do we control the project as it is progressing so that we are able to do any mid course correction and so that we are able to access the need for a mid course correction if required.

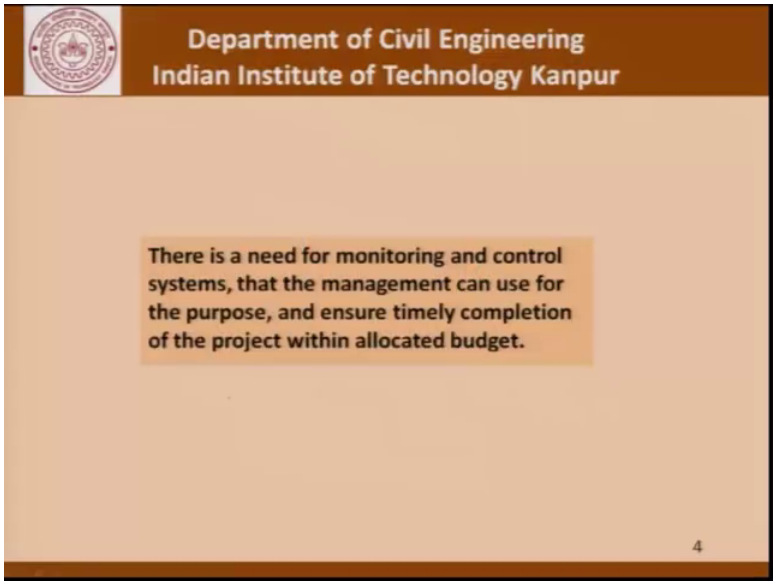
(Refer Slide Time: 01:07)



Now, there are several aspects in a project that need to be monitored and controlled during construction, and these aspects include the scheduling time and progress, cost, quality, safety, inventory and so on. All these aspects required if you will recall in a planning class we had said that plans need to be drawn up for all these items we have to

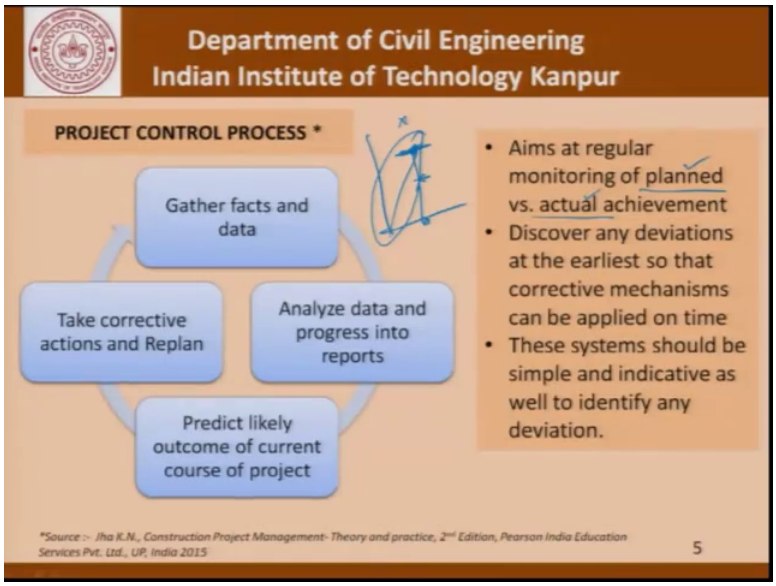
have a plan for the schedule, the time, the progress the manpower deployment the cost involved the cash flow, the quality plan, safety plan, the inventory plan and so on. So, it is not only required to the plan be there, but also whether that plan needs any mid course correction. So, today's focus is on those aspects of mid course correction as far as the time schedule is concerned.

(Refer Slide Time: 02:05)



So, there is a need for monitoring and control systems that the management can use for the purpose and ensure timely completion of the project within allocated budget. So, what happens is that if in the middle of the project we find that we are slipping somewhere, then we try to look at it and see what additional resources can be deployed, how the resources can be diverted from one activity to another to ensure that the project is completed in time without any additional resources in terms of the overall budget.

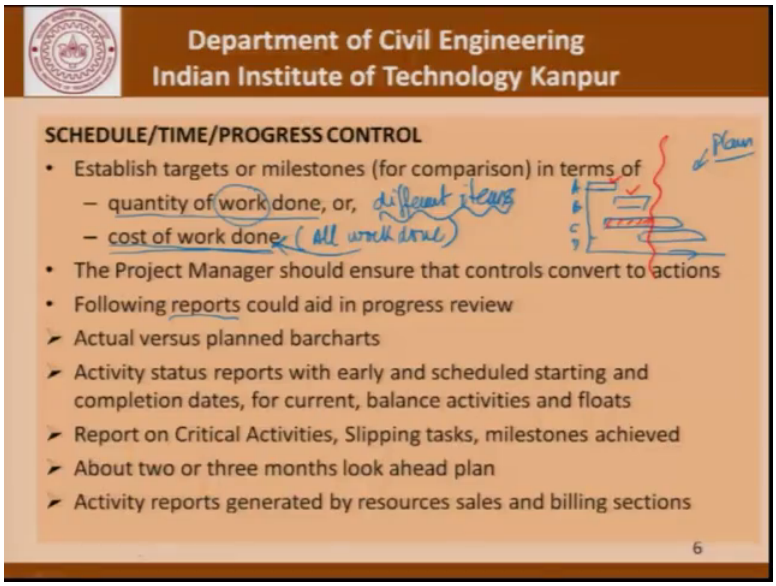
(Refer Slide Time: 02:37)



Now, the project control process as it is involves gathering facts and data analyze the data and progress into reports, predict likely outcome of current course of the project take corrective actions and replan, and once the replan has been done we go back and try to find out whether that is working. So, we once again gather the facts and data and this cycle goes on.

So, basically the idea of a project control system or a project control processes that it aims to regularly monitor the planned versus actual achievement. So, in a graph if you wanted to be somewhere here at a particular point and time, the idea is that have you reached this point or we slipping or we are ahead of schedule. The basic idea of monitoring is to have this reference line or reference point and compare to this reference point where are we. So, this planned versus actual achievement is the backbone of the project control process. It discovers any deviations at the earliest so that corrective mechanisms can be applied on time and these system should be simple and indicative as well to identify any deviation. So, what we need to have is parameters which can be easily identified and monitored. So, once that is done then project monitoring systems are very useful and very handy.

(Refer Slide Time: 04:06)



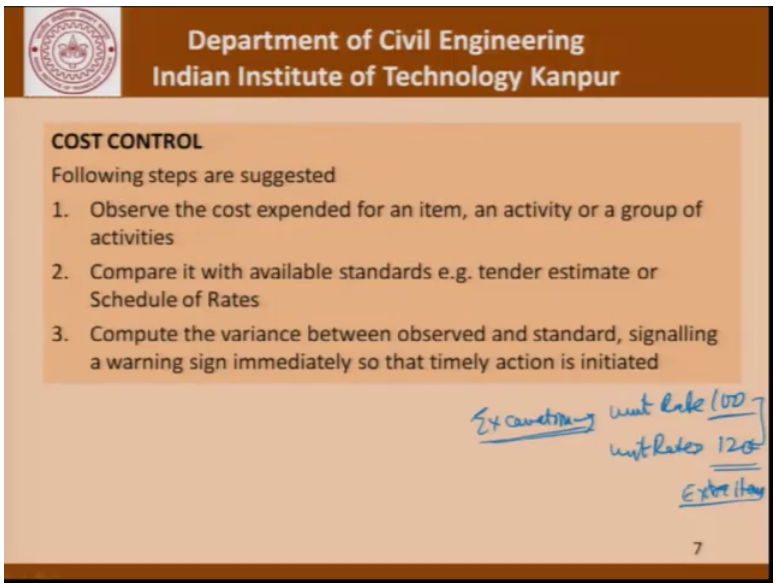
As far as the schedule time progress control is concerned, it establishes targets or milestones for comparison in terms of either it is the quantity of work done or it could be the cost of work done. So, the difference between quantity of work done and the cost of work done is something which we will discuss a lot as far as the discussion today is concerned. We must remember that the quantity of work done would depend on different items. So, we can have different items in the project and different quantities of work will be done at different points and time.

Whereas when it comes to the cost of the work done, all work done can be reduced to the total cost that is the advantage of working with cost and that is something which we will discuss a little bit more as we go along in a illustrative examples and so on. The project manager should and should that controls convert to actions, the following reports could aid in progress review. It is very important that periodic reports are generated from the data that is what was being talked about earlier that we find the data and then we try to analyze it and create a report from that. So, the reports could be in terms of actual versus planned bar charts. So, we know what a bar chart is a bar chart basically plots activities A B C D whatever they are on the time axis as to, when we would like to undertake different activities. And then we could use these activities as a matter of a plan and on this bar chart say at a given point in time suppose you monitoring here whether we have really finished B or not whether we have achieved the percentage progress on C or not

and so on and so forth. So, this is what we mean to say when we say actual versus planned bar charts.

Activity status reports with early and scheduled starting of completion dates for current and balance activities and the floats involved there in report of critical activities slipping tasks, milestones achieved about 2 or 3 months look ahead plan and activity reports generated by the source sales and billing sections. We must remember that report generation is an important task of the project management team; these reports are circulated to all concerned and as we have seen there are different people who are not at the construction site, but are equally involved and are equally concerned about the progress at site. These could include the people in the head office of the client the contractor the regulators and other stakeholders for example, even the users. So, they would like to be kept a best of what is happening, where is the slippage, what are the steps being taken to control that slippage and bring the project back on track.

(Refer Slide Time: 07:08)



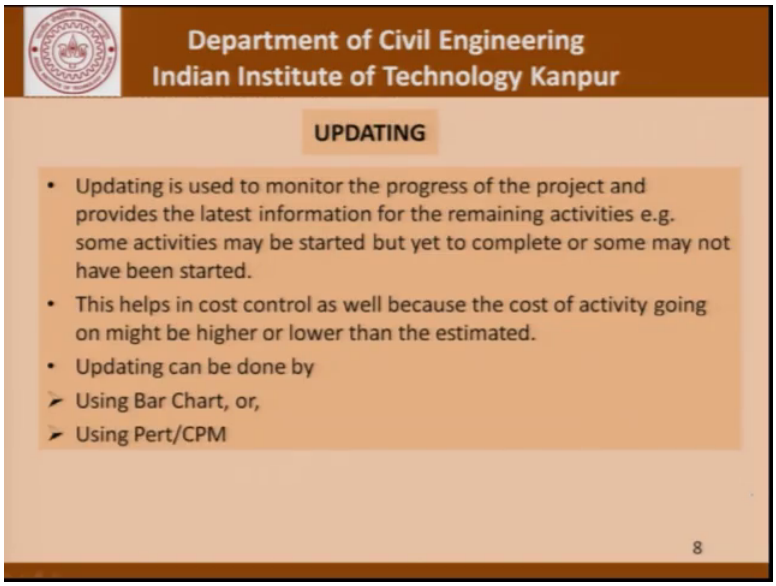
As far as cost control is concerned the following steps could be suggested; observe the cost expended for an item an activity or a group of activities, compare it with available standards tender estimates or schedule of rates and compute the variance between observed and standard signalling a warning sign immediately so that timely action is initiated. So, basically what is being said is that as far as contractor is concerned effort

should be made to monitor the cost being actually incurred for each activity and compare it with what was foreseen at the time of tendering.

So, for example, in an excavation it was forcing that the unit rate would be a 100 and this 100 we do not bother about whether the contract is profit was included or not, if we keep track of the excavation at site and we find that the actual expenditure being incurred is 120. We must understand from a contractors point of view within the contractor organization that why is there this deviation. It is possible that something like dewatering has not being accounted for and therefore, expenditure being incurred as far as dewatering pumps is considered is now getting built into the excavation process, but then the question will be why it was not foreseen; whether this expenditure can be sited as an extra item and so on.

So, this continuous analysis of whatever the cost is being incurred at site for practically every item is something which is very very important exercise not only for that project, but this data becomes the basis for future bidding as far as that company is concerned and that is why it should be taken very very seriously and is a part of the monitoring exercise that goes on as the project progresses.

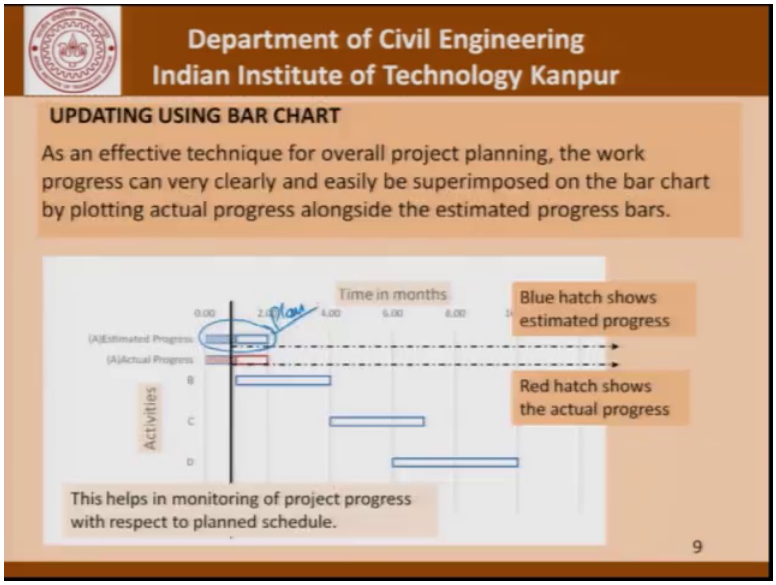
(Refer Slide Time: 08:57)



Then it comes to updating, updating is used to monitor the progress of the project and provides the latest information for the remaining activities that is for example, some activities may be started, but yet to complete or some may not even have started. We

have to keep updating our bar charts the CPM charts and so on. It helps in cost control as well because the cost of activity going on might be higher or lower than that estimated and this updating can be done through bar charts or on the CPM or pert network. So, in this discussion today we would largely focus on using bar charts for the purpose of updating.

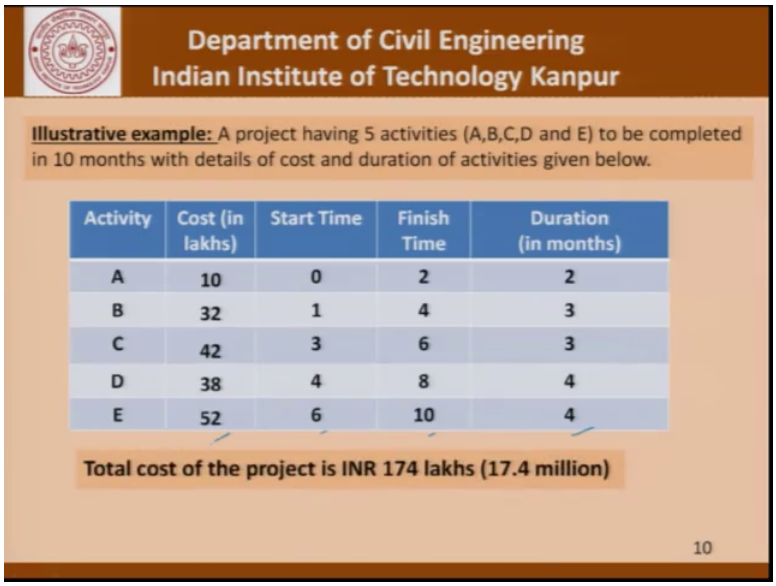
(Refer Slide Time: 09:35)



So, basically to show what we are trying to say is something like this.

Now, how to use a bar chart for updating? The picture here shows how it is done the blue hatch shows the estimated progress. So, this is our plan, this is what we think we will achieve and compared to that the red hatch shows the actual progress. This is a very effective technique for overall project planning the work progress can be very easily and clearly superimposed on the bar chart by plotting the actual progress alongside the estimated progress bars. This also graphical in a very easy to understand method as we will see then we look at some of the illustrative examples.

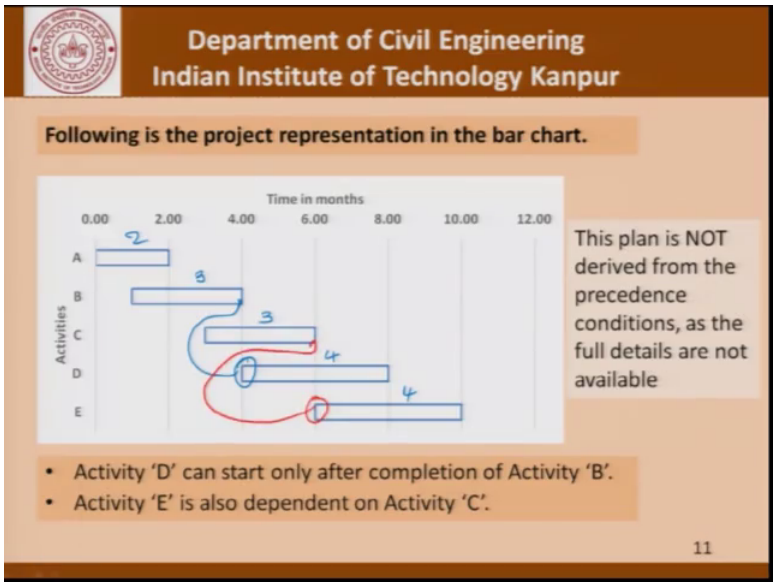
(Refer Slide Time: 10:22)



Let us look at an example where the project has 5 activities A B C D and E to be completed in 10 months, and the details of the cost and duration of the activity is given here. So, this table shows that cost in lakhs for 5 activities their starting times finish times and therefore, the durations activity A takes 2 months, B and C take 3 months and, D and E take 4 months each. And the cost information tells us that the total cost of the project is 174 lakhs which is 17.4 million.

So, now converting this information to a bar chart we probably will lose the cost information, but we will know what activity should be going on at what time.

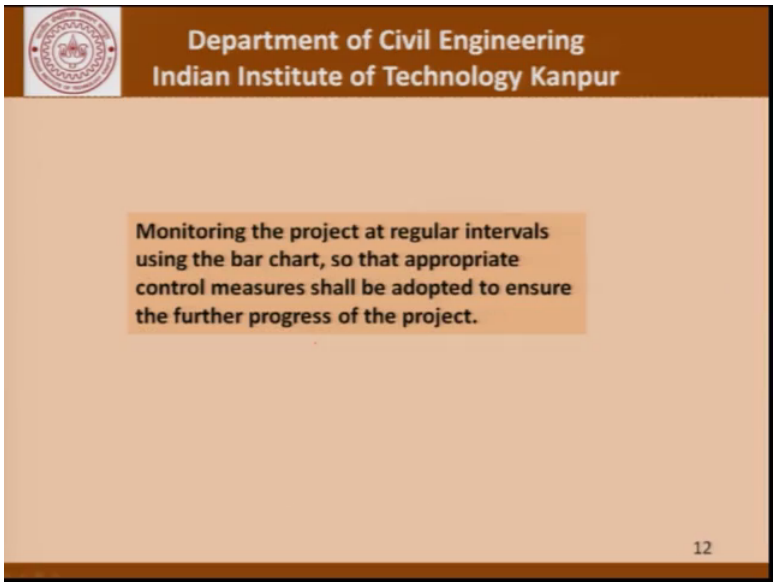
(Refer Slide Time: 11:10)



So, this is the bar chart representation of the 5 activities - A starts at 0 goes for to two which is 2 months, B starts at 1 and goes on till 4 which is 4 months and C is also 3 months D and E are 4 months each. So, what we are showing here is that this project completion is in 10 months.

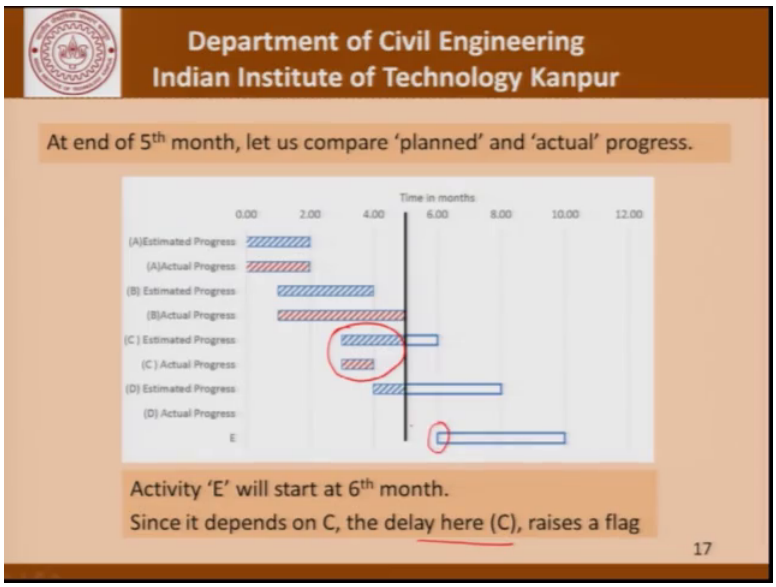
Please remember that this plan is not derived from the precedence conditions as the full details are not available. So, this is just a representation to illustrate the use of bar charts for progress monitoring. Now if we further assume or it is given that the activity D can start only after the completion of activity B and activity E is also dependent on activity C. So, what we are saying is that D can start only after B has been completed and E can start only after C has been completed. So, with this information we move forward and try to see how to monitor this project.

(Refer Slide Time: 12:10)



Monitoring the project regular intervals using bar charts so that the appropriate control measures can be adopted to ensure the further progress of project, we come here.

(Refer Slide Time: 12:20)



So, for example, we say that at the end of 5 months let us compare the planned and actual progress. So, we are doing this exercise at the end of 5 months. What we will do is we will look at what we have actually achieved at different activities. So, we find that as far as the activity A is concerned the progress was as per schedule it started at 0 was

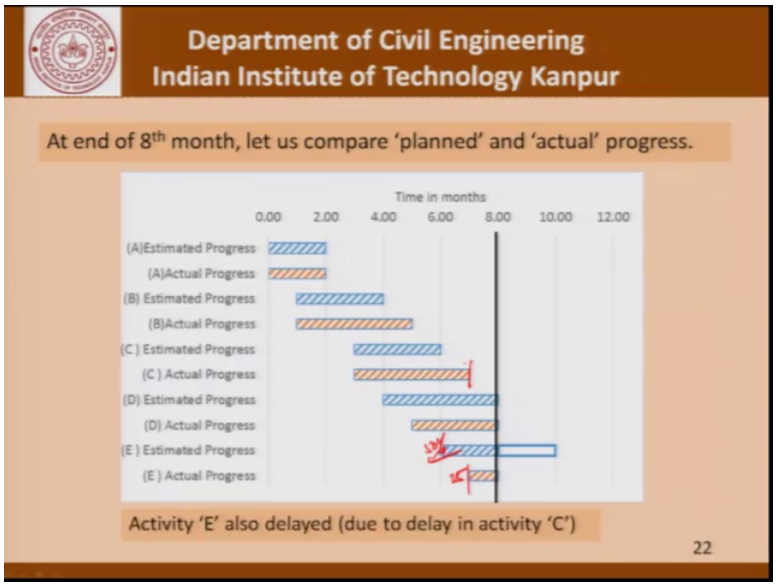
supposed to finish end 2 it actually started at 0 and finished at 2. So, this here the red hash is the actual progress and the blue hash is what the estimated progress was.

Now continuing with this if we go to B, we find that though B started at the schedule time of 1 it has slipped instead of 3 months it has taken 4 months to complete we of course, say that at the end of 5 months we has been completed. So, activity B has actually slipped instead of completion at 4 months it has completed at month 5 continue with this for activity C we find that activity C has also slipped activity C has slipped because at month 5 it was suppose to be 66 percent complete this is a 3 month activity and assumingly in your progress in 2 months we should have finished 66 percent of the activity whereas, we have completed only 33 percent. So, C has also slipped and that is what is written here. The actual progress of activity C is also not as planned instead of two-thirds expected level of completion only one-third is complete.

Then we go to activity D and remember that we are talking at the end of 5 months and this line here is drawn for 5 months we find that activity D is concerned there is a delay because D cannot start unless B has been completed and since B has just been completed at month 5 this 25 percent that is we are supposed to have D over 4 months. So, it should have been 25 percent complete and it has actually not even started it will probably just about start at month 5 after B has been completed and that is what is given here in the text.

So, if we move forward and try to see what is E, as far as E is concerned of course, E will start in the six month, but we have a caution we have a flag which is raised in this case because we are concerned with the fact that C is not doing too well. Since there is a delay in C we have to be careful as to what will happen to activity E it is not showing, even though at this point in time it shows that well E need not have started and has in D not started.

(Refer Slide Time: 15:16)



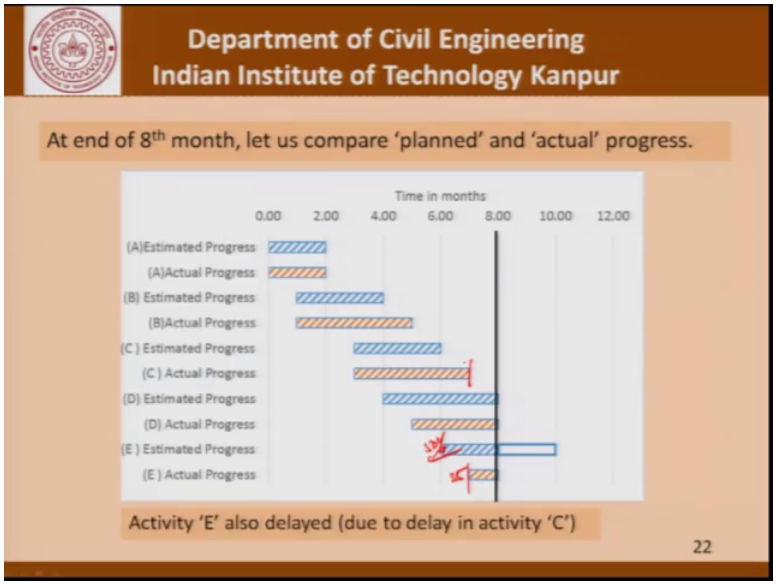
Now, if you do this exercise once again this time at the end of the eighth month. So, please remember that monitoring is a continuous process. So, what we went through just now was an exercise where we looked at all the 5 activities A B C D and E at 5 month now we are doing it at 8 month it depending on how rigorously we do our project management we could do this exercise every month and try to make mid course corrections.

A of course, at the end of eighth month has been completed we have discussed this before, we have talked about B also we said that B is delayed by a month and instead of completing in 3 months it is been completed in 4 months. Activity C was delayed at month 5 and it has been completed in 4 months as compared to 3 as planned. As far as D is concerned the actual progress shows 100 percent so in fact, it is sometimes a good idea to actually write down the percentage of progress against each activity. So, that it is clear that these activities are actually finished. So, this is 100, this is 100, this is 100 and this is become 100.

Now, what this shows is that activity D which was delayed by one month due to the completion of activity B remember that D was depending on B to finish and only then it could start and since D started a month later, but somehow this 4 month could be compressed to 3 months through corrective action. So, because we had an idea at the month 5 that activity B is delayed and we may require additional resources to be able to

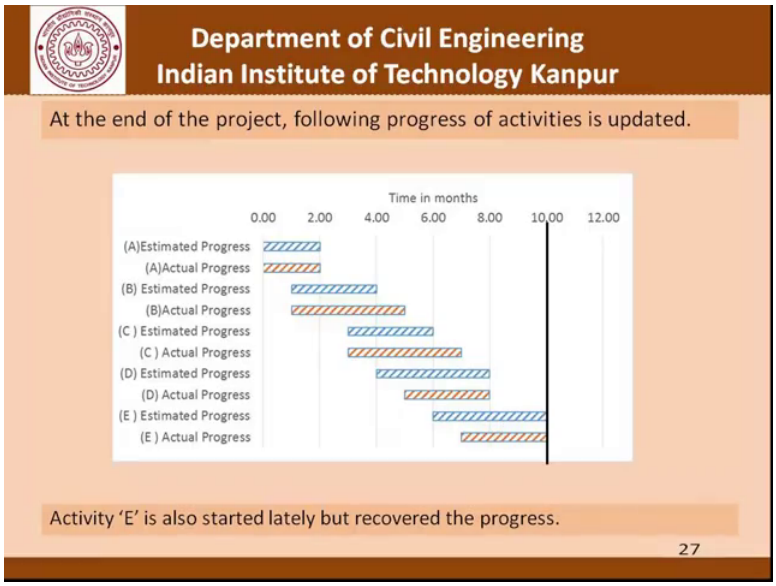
complete D in time that is the kind of planning that was probably done and the activity D was completed as scheduled as far as month A it is concerned. As far as activity E is concerned we can see that it is lagging this should have been 50 percent complete and it is only 25 percent complete because it is started a month later because of the delay again in completing C which was the preceding activity for E.

(Refer Slide Time: 17:31)



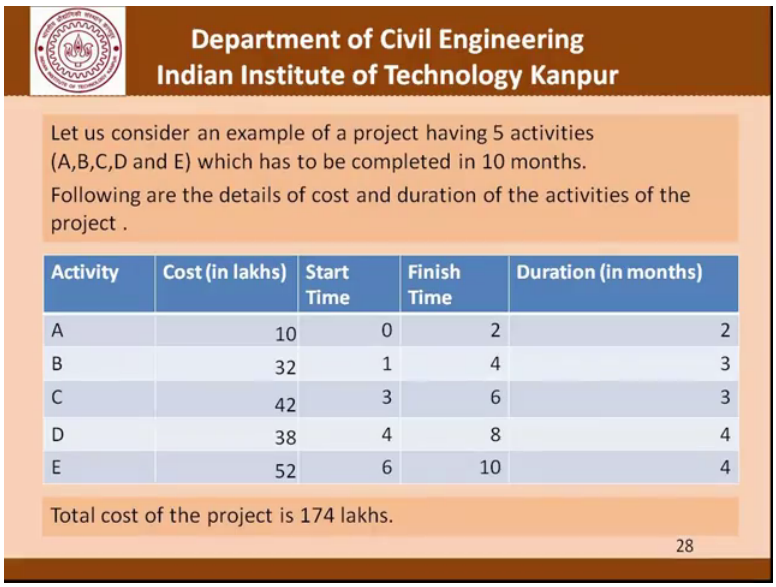
Now as far as this illustrative example is concerned let us try to take it to the logical conclusion and do this whole exercise at the end of the project let us say month 10 and we would find that these things have all been discussed when we talking about the progress at month 8 what we find is that even for activity E which was showing a lag when we did the monitoring at month 8 that has also been completed in time.

(Refer Slide Time: 17:30)



So, instead of taking 4 months this whole activity has been completed in 3 months, again by using additional resources or whatever it is.

(Refer Slide Time: 18:01)

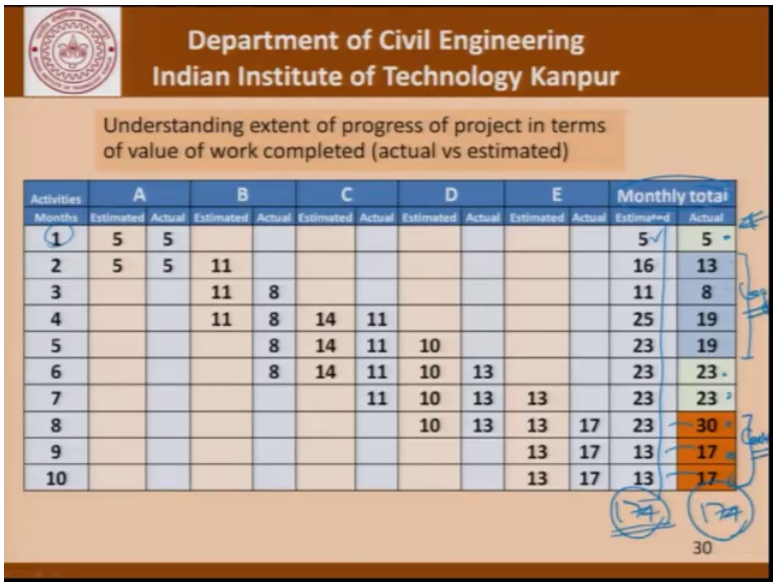


Now, let us look at this representation of progress in a different way. Now we will try to look at the value of the work done in the different activities, recall that this is the table that we had started with. Apart from the durations that were shown here which we used to calculate the progress or estimate the progress every month since we were doing the

monitoring at month 5, month 8 and so on what we will do now is to use this number that is the cost of each of these activities as they were going on at different points and time.

What we will assume is this activity a which is completed in two months, activity B which is completed in three months and so on the actual work completed for each of these activities in those months can now be converted into a monetary value That is we can write a chart like this which says that as far as activity A is concerned in month 1 and month 2 let say its 5 and 5. So, these numbers in grey these are the estimated values that is the numbers as far is the plan is concerned and in the blue columns we have the actual value of the work done. So, what this chart really shows is that at different months which is this column what are the activities which are planned to be happening and what actually happened, what was the value of the work that was generated.

(Refer Slide Time: 18:54)



Activities	A		B		C		D		E		Monthly total	
Months	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual	Estimated	Actual
1	5	5									5	5
2	5	5	11								16	13
3			11	8							11	8
4			11	8	14	11					25	19
5				8	14	11	10				23	19
6				8	14	11	10	13			23	23
7						11	10	13	13		23	23
8							10	13	13	17	23	30
9									13	17	13	17
10									13	17	13	17

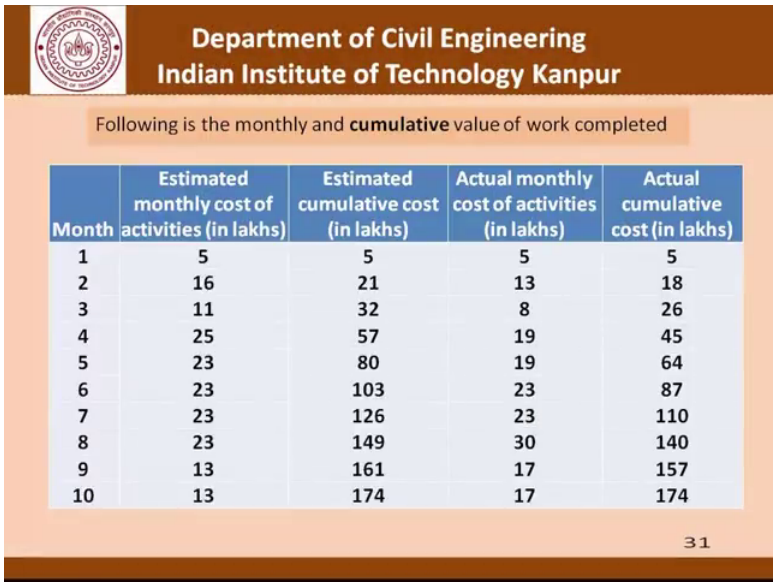
So, if that is done what we will get is something like this what it says is that the monthly total for the different months 1 2 3 4 5 6 and so on is this. What we expect is that the 174 which is the total cost of the project is getting distributed over the 10 months in a manner that is shown here. So, it is 5 to begin with then it goes to 16 11 25 23 and so on and so forth. So, this is something which now tells us an overall picture of the project completion so in fact, the idea behind this discussion is to see what happens if we try to represent the progress whether it is planned or actual in terms of the value of the work done at a certain point and time. For that we should know what was the panned value of

work done at that point and time and then we can compare it with the actual work done at that point and time.

So, what we see from this chart here is we have already seen what were the different activities going on at different points and times as far as the bar charts are concerned. So, we know that what was the actual value of the work done. So, we find that in these 4 months the value of work done actually was lower than the estimated work. In these three months it was at power and finally, in these 3 months the value of the work done exceeded the value of the estimated work in those months.

So, it really shows that the project was lagging at this point in time, but it covered up at this point in time so that the total of 174 that is the total cost of the project was a still accomplished in the desired time of 10 months.

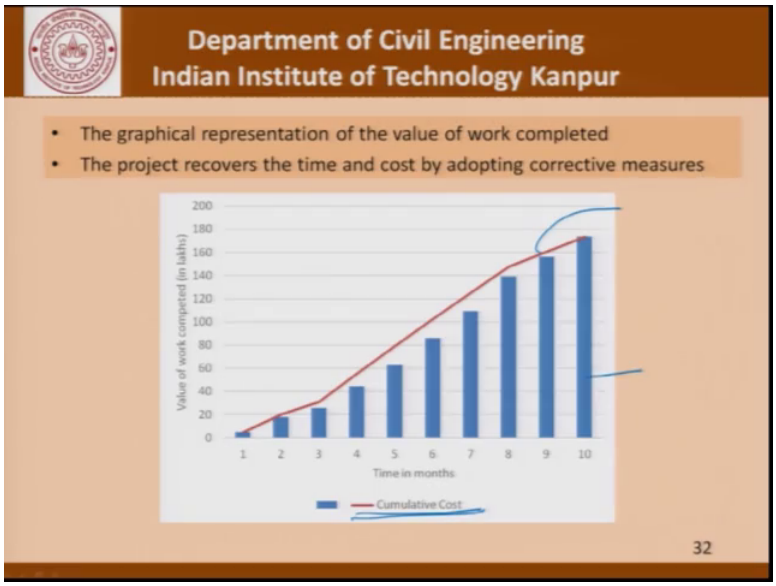
(Refer Slide Time: 21:34)



Month	Estimated monthly cost of activities (in lakhs)	Estimated cumulative cost (in lakhs)	Actual monthly cost of activities (in lakhs)	Actual cumulative cost (in lakhs)
1	5	5	5	5
2	16	21	13	18
3	11	32	8	26
4	25	57	19	45
5	23	80	19	64
6	23	103	23	87
7	23	126	23	110
8	23	149	30	140
9	13	161	17	157
10	13	174	17	174

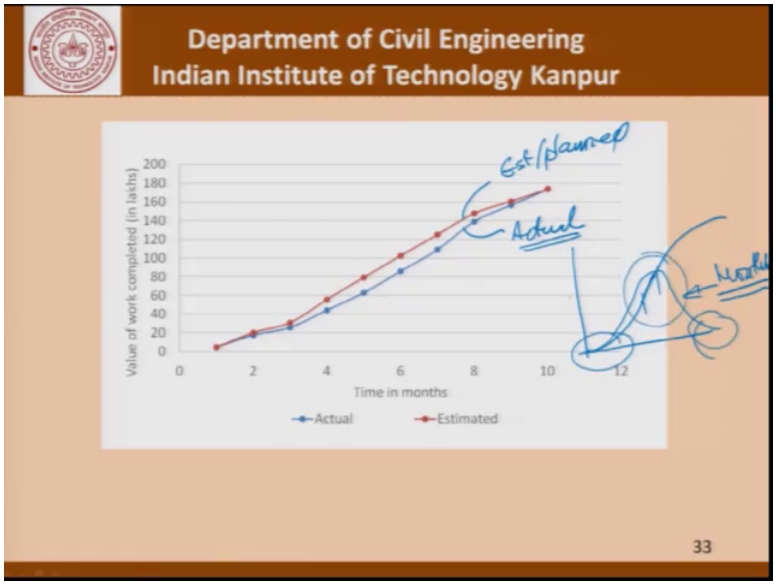
And this is often represented as a (Refer Time: 21:33) and for that what we need is the cumulative value of the work done at the different points in time and this table here shows the estimated monthly value and the estimated cumulative value that is finally, growing to 174 and in this case we have the actual value of the work done which was shown in the column to the rightmost in the previous slide and this is the 174 that we have at the end of the project actually completed. This is often graphically represented as shown here.

(Refer Slide Time: 22:07)



This is the estimated or planned cumulative cost and these bar charts here they show the actual values of the cumulative work till that point in time or at that point in time.

(Refer Slide Time: 22:22)

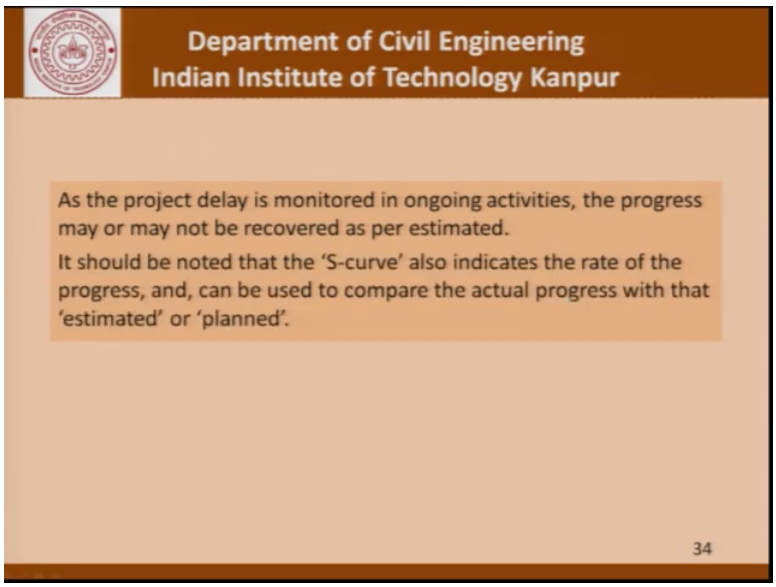


This is often represented like this where this line here is the estimate as shown estimate or planned and what we have here is the actual value of the work done.

We must remember that this S-curve has this characteristic and the derivative of this is basically something like this that is this gives us the monthly rate, that is what is the derivative of this what is the rate at which the work was being done at that point in time.

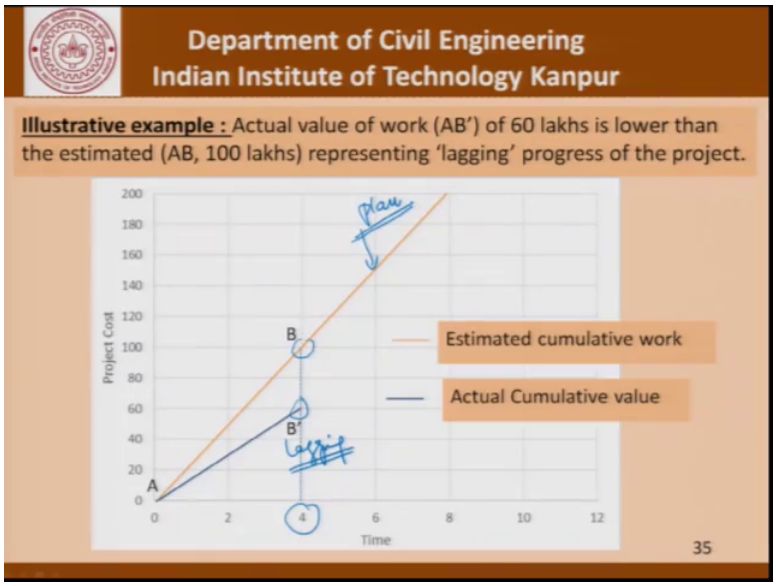
So, we can see from here that this has the characteristic that its initially slow, later on also it is slow, but there is the peak in the middle. Of course, that is the characteristic which we did not see particularly in the previous example because we found that a lot of work was being done at the end of the project. Now as an a site or as a corollary to this s curve and the discussion that arises out of that let us try to understand how we interpret our position on the s curve and that something which we will go through an example and see.

(Refer Slide Time: 23:21)



As the project delays monitored in ongoing activities the progress may or may not be recovered as planned. So, it should be noted that the S-curve also indicates the rate of the progress and can be used to compare the actual progress with that estimated or planned.

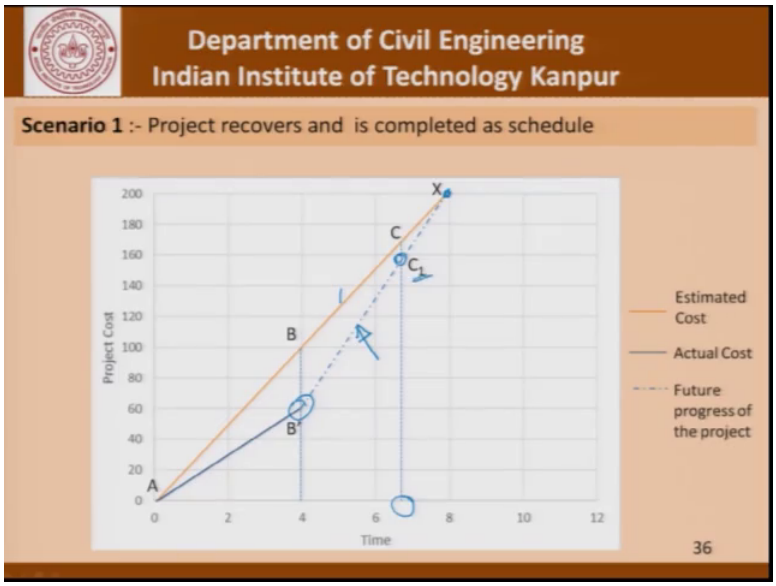
(Refer Slide Time: 23:45)



Now, if we have a situation something like this it is an illustrative example once again and we find that there is a project where at a particular point in time we want the planned cumulative work to be somewhere here having a 100 units of value of work done. Now once we actually monitor the project we tried to find out what is the actual extent of work we find that we are at B dash which is let say 60. So, what it is being shown is that we are lagging as far this project is concerned.

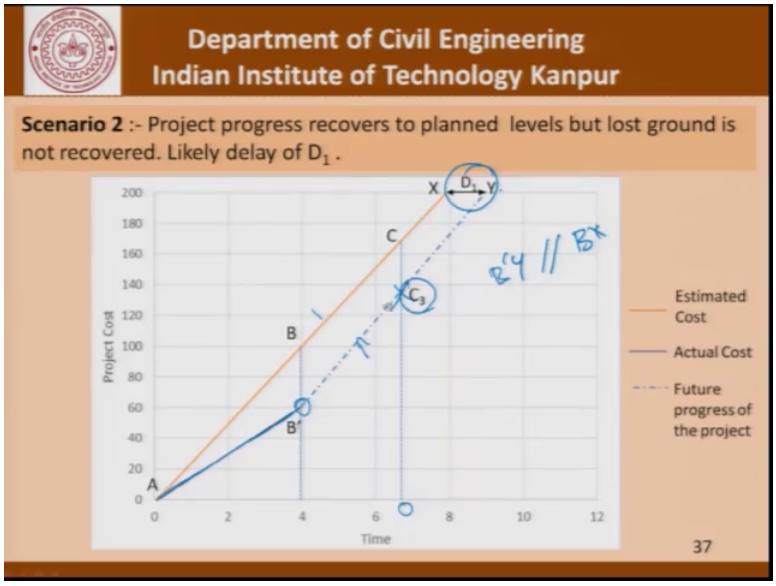
Now, what are the possible outcomes of this discussion? Let us look at this illustrative example where we say that this is our plan we want this project to proceed in a manner that this becomes our value of work done at different points in time and this project is going to be completed in say about 8 months. Now at this point in time we carry out a monitoring exercise and we find that instead of this we are at B dash so we are lagging, instead of having completed 100 lags of work we have actually completed only 60. So, this becomes a wakeup call for us and we have to figure out what we need to do there are different options or there are different implications of this.

(Refer Slide Time: 25:10)



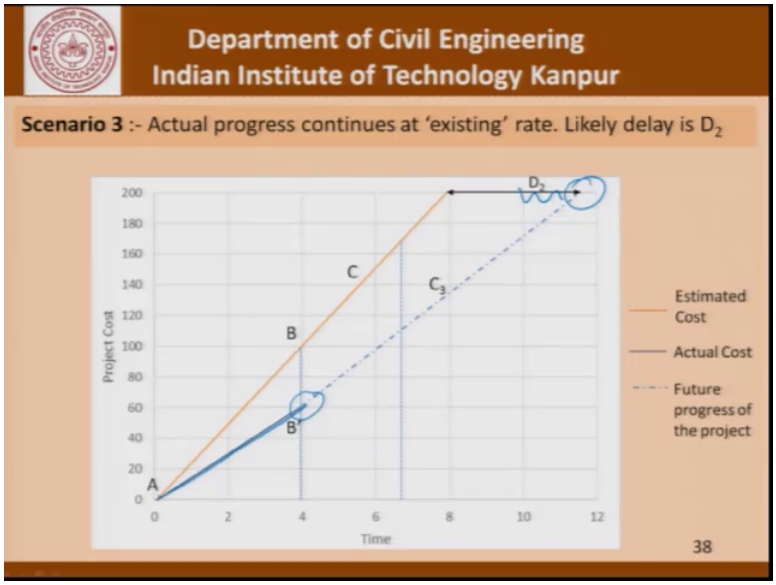
The first scenario is that the project recovers and it is completed as scheduled which means that from this B dash we try to get to this 100 percent project completion or 200 lakhs or whatever that value is in a manner which is connected by this. So, instead of this; obviously, now this becomes the line against which we should be watching further progress. So, if we are carrying out an exercise at this point in time we should be comparing ourselves with respect to C 1 have we will achieve the kind of value that we needed with respect to C 1. So, that will indicate that we are heading to complete the project in time.

(Refer Slide Time: 25:54)



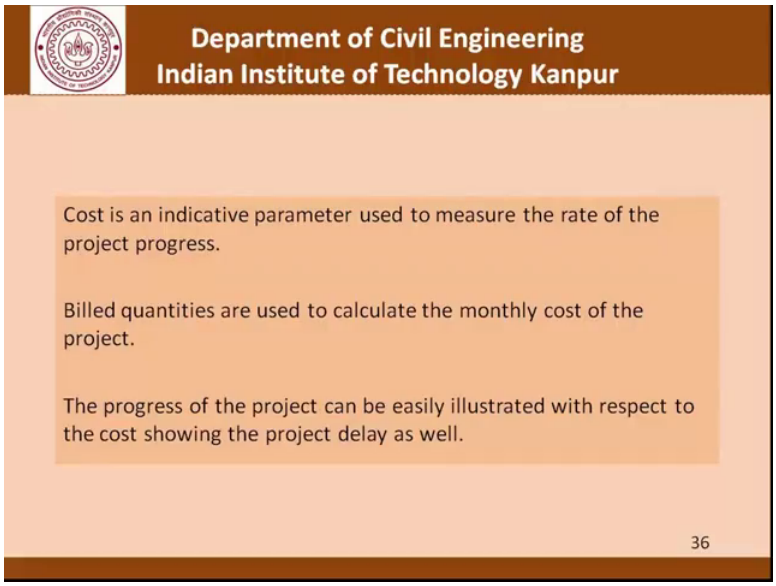
Instead of that if you are working in a manner that well the progress at the initial parts was lower than what was planned, but from this point onwards we will come back to a slope which is the same as this in another words B dash Y is parallel to B X then what we are looking at is a delay of D 1 and in that case at the same point of monitoring we are working against a value of C 3.

(Refer Slide Time: 26:25)



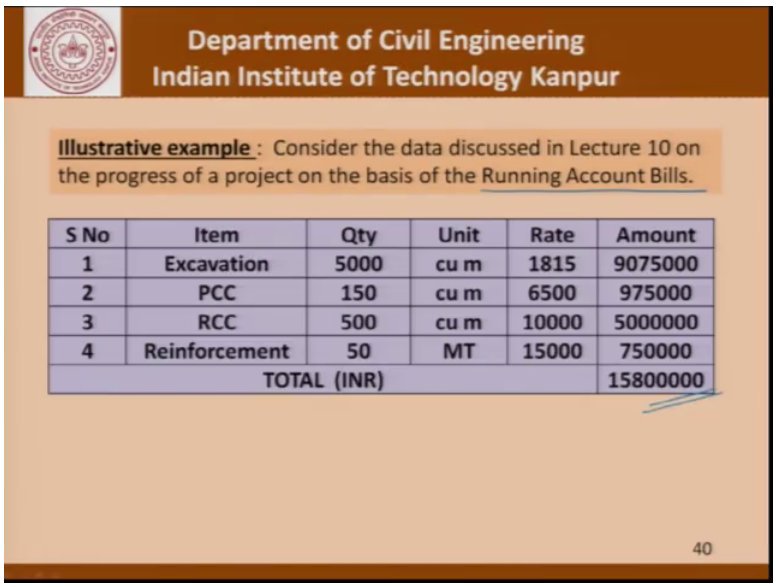
The worst case scenario is that we do not do anything and we continue at this place let say and then we will land up somewhere here leading to a much more increased delay in the completion of this project. So, this is how we try to understand the S-curve and the cumulative progress and so on as far as our monitoring exercise is concerned.

(Refer Slide Time: 26:49)



So, value of work done is an indicative parameter used to measure the rate of the project progress billed quantities that is the work completed used to calculate the value of the work done on a monthly or a cumulative manner and the progress of the project can easily be illustrated with respect to the cost or the value of work done showing and it also shows the delay if it is occurring in that project.

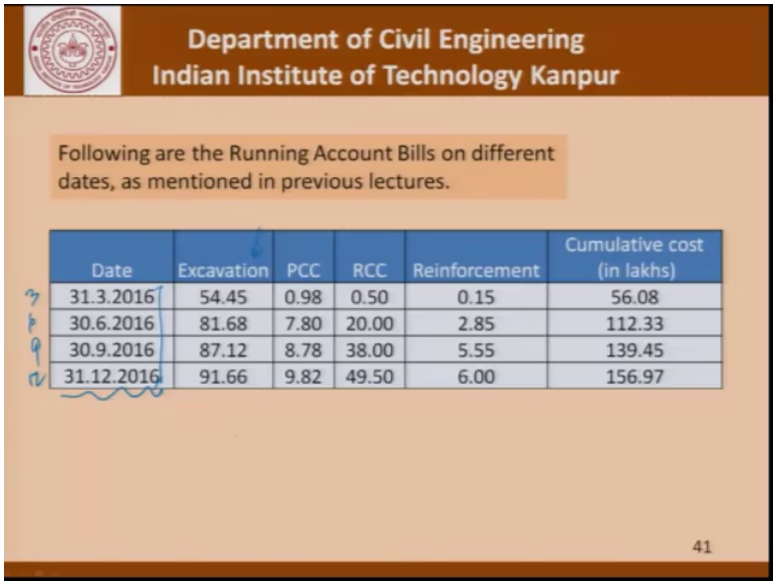
(Refer Slide Time: 27:16)



Let us go back and recall this example that we did long ago when we were talking about running account bills, you will recall that we had a project an imaginary project of

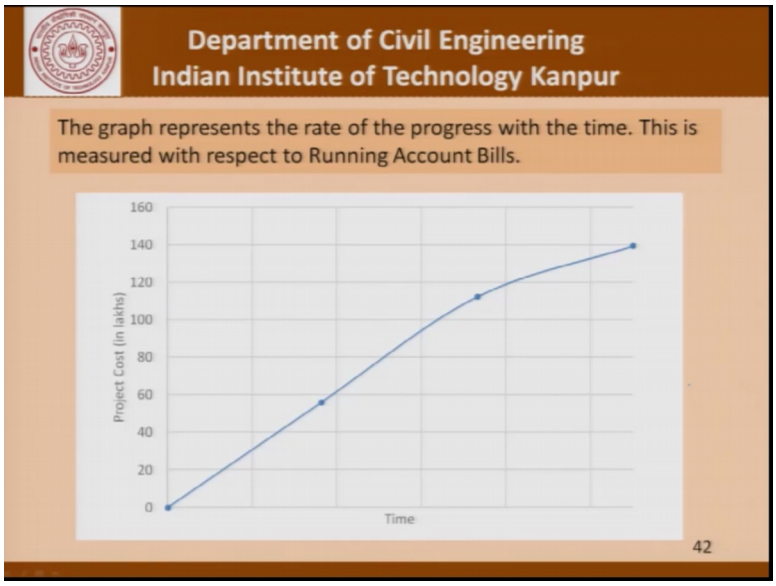
course, having 4 activities excavation, PCC, RCC and reinforcement at a total cost of so much.

(Refer Slide Time: 27:36)



Now, in addition to this total cost we also had information about the work that had been completed at the end of 3 months, 6 months, 9 months and 12 months and this was indeed the completion of this project and the value of the excavation, PCC, RCC and the reinforcement work which had been arrived from the quantities of the work done at the different points and time. So, now, this was the cumulative cost of billing or the cumulative value of the work at different points in time.

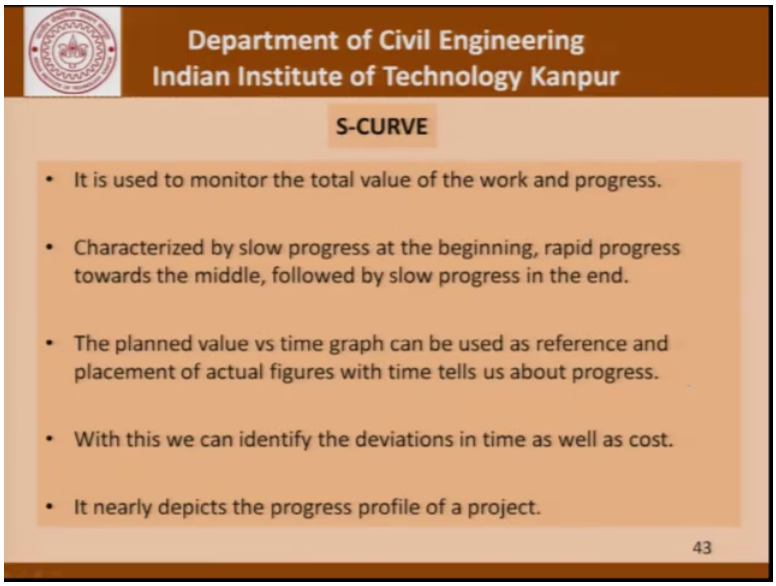
(Refer Slide Time: 28:07)



So, if this now was to be plotted on a graph we will get a curve something like this which is precisely the S-curve that is precisely the plot of the project which shows how the total value of work done has changed with time. This picture of course, does not really show the characteristics of the S-curve except towards the end and in the initial part we find that the value of the work done is much higher.

I am leaving it to you with the thought as to what are the kinds of considerations which will go into pushing this value to a higher value at that point in time early in the project. Let me give you end we have talked about front loading and this is possibly an illustration of that idea that is the excavation was carried out with full figure and therefore, we do not see the initial lag in the progress.

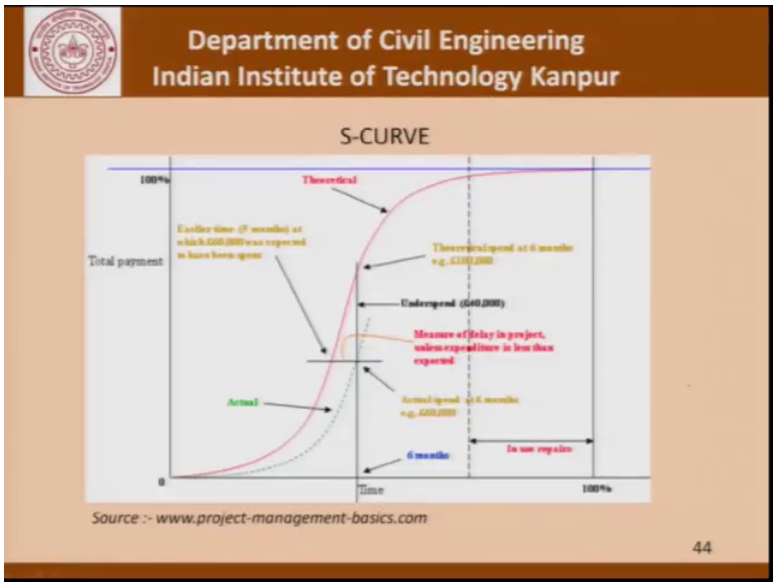
(Refer Slide Time: 29:11)



Now, continuing with our discussion on the s curve it is used to monitor the total value of the work and the progress it is characterized by slow progress in the beginning, rapid progress towards the middle, followed by slow progress in the end and the planned value versus time graph can be used as a reference and the placement of actual figures with time tells us the actual progress at the project and with this we can identify the deviations in time as well as cost and it nearly depicts the progress profile of a project.

Having pushed so far an agenda which said that it is good to represent the total progress of a project in terms of the money spent, let me also say that there are it falls in this thought process for example, there was a project which involved equipment direction. So, at some point in time there would be an expenditure incurred towards buying the equipment which has not yet been installed now whether that expenditure should be counted towards the project progress or not remains an open question because at the end of it the project is complete only after the equipment has been installed and has been tested the facility is working. So, whether the expenditure incurred in purchase of that equipment contributes 100 percent towards project progress is something which is an open question, but that is something which we all understand as far as the profession is concerned and we take all this progress data with a pinch of salt.

(Refer Slide Time: 30:48)



So, this picture here gives a more theoretical treatment of the s curve and I will leave it to you to more or less understand this and we will possibly post a small document explaining some of these aspects of the s curve which we have already covered as far as the discussion today's concern. So, with this we come to an end of our discussion today on project monitoring and control here are the list of references and there are so many other books which could help you better understand the subject and I look forward to see you once again.

Thank you.