Principles of Construction Management
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Lecture - 09
Discussion on the case study of the boundary wall

[FL] and welcome once again to this course on principles of construction management.

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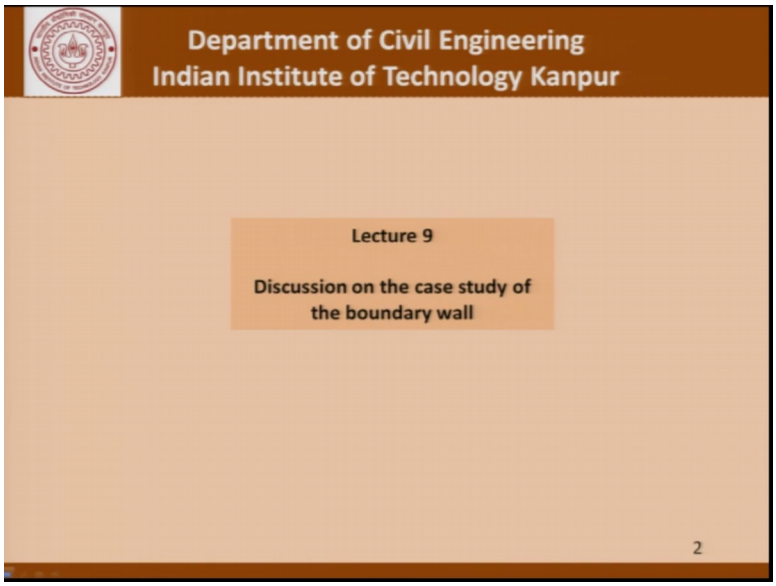

And today in the ninth session that we have, we basically discuss the case study of the boundary wall. What I thought was that before we get into the other modules like accounts or scheduling or safety. It is important for us to go through this example even though it is a very simple example in a little bit of detail. So, that you have a better appreciation of what we are talking about. So, this discussion today will be largely confined to the discussion in the boundary wall and we will look at the whole case in a little bit of detail.

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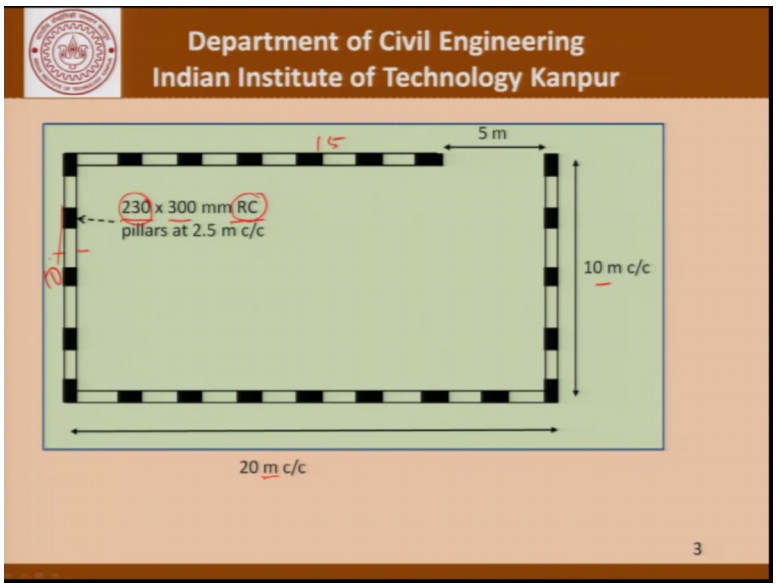

So, now going to the details of that this is what we had used, this was the case study. Here we have a 20 meter and a 15 meter here and 10 meter here and another 10 meters here. So, we had a 55 meter boundary wall with RC pillars; reinforced concrete pillars and the dimension of this RC pillar has been chosen as 230 into 300; 230 having been chosen basically to coincide with the width of this brickwork so that the plastering can be done uniformly on the pillar as well as the wall.

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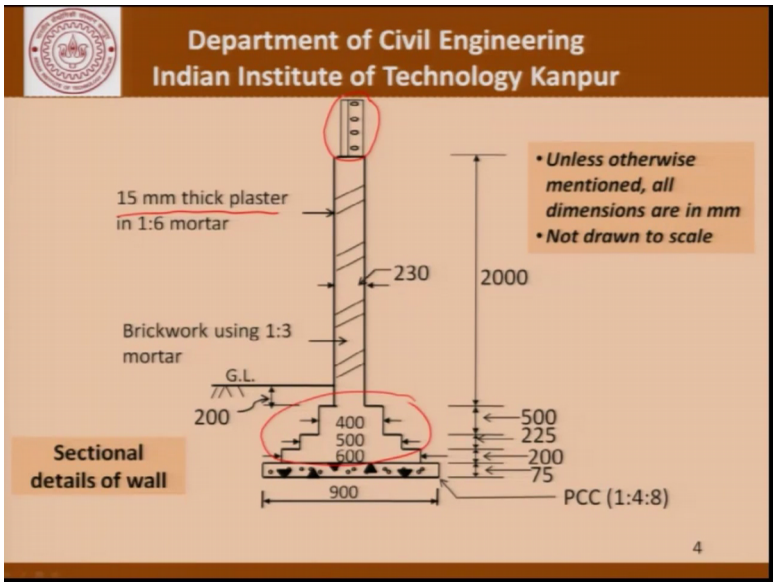

This was the section that we had used for this boundary wall where we had said that there will be a 15 mm thick plaster and this here of course, is only the brickwork, but of course, there will be RC pillars is well at certain locations.

Then we have this offsets in the brickwork, we have this angle which is fixed to the pillars.

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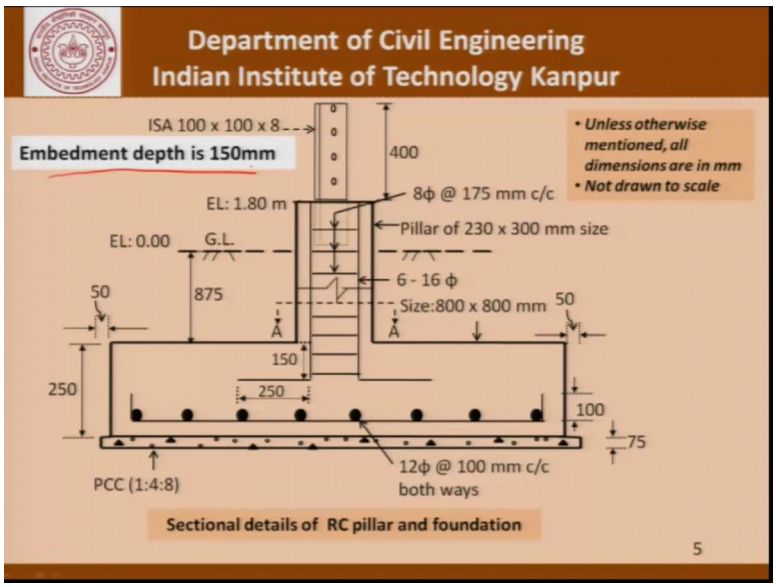

Here we have the details of the RC pillar and the foundation this is what we used to do the quantity estimation and the embedment length used or the depth used was a 150 mm

which was probably not mentioned in the drawing at that time, but it was used in one of the conditions that we give. So, once we understand these drawings a little bit better.

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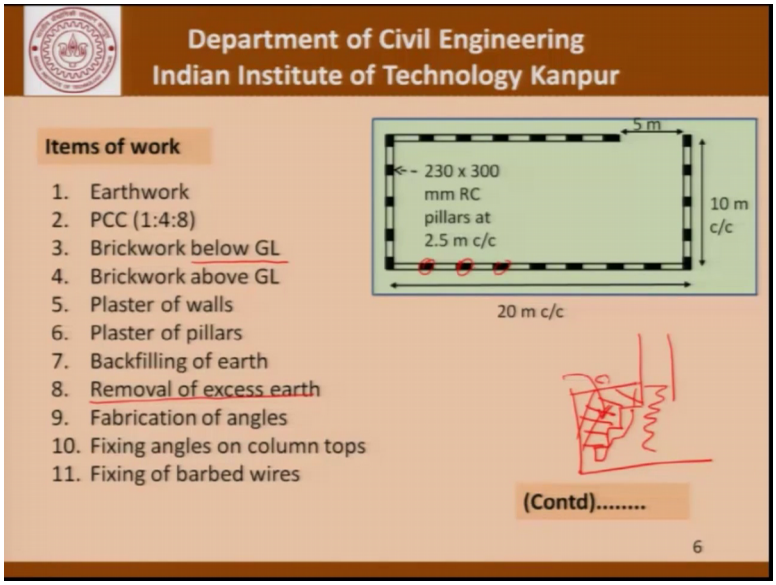

Let us try to understand what are the different items of work that are involved? What are the different activities that will go on in the construction of this boundary wall? We will not talk about the procurement of materials and so on, but we will only talk about the actual activities that go on in order to be able to make this boundary wall.

So, the first thing that we have to do is earth work. So, at the end of it in order to be able to construct the boundary wall, we will have to do some earth work. We will have to remove some earth in order to be able to make the footings or be able to do the offsets of the foundations for the brickwork. Then there is an activity called laying the PCC; the play cement concrete. This has to be done below the brickwork as well as below the RCC footings.

Then we have the brickwork even though when we were estimating the quantities, we used brickwork as a single unit and said all the brickwork can be done together. Let us just get the quantity, but from an operational point of view we are talking of brickwork below the ground level. We will soon see the importance of breaking up the brickwork into below ground level and above ground level, apart from the brickwork there is the plastering on the walls. So, this plastering as you mentioned a few minutes ago has to be done on the walls as well as the pillars. Then there is the back filling of the earth.

Now obviously, if you remember the section of the brick wall, this is what we have. We would have excavated this amount of earth and after completing this brickwork here this earth has to be backfilled. So, there is a back filling activity which is involved which is separate. As far as the payments are concerned or as far as the quantity estimation is concerned we have clubbed the payment for back filling as part of our earthwork. That you will see if you read the description of the earthwork that was given. Then we have removal of excess earth, after all a certain amount of space below ground level has been consumed or has been used by either the brick wall or the column and the footing.

So, that amount of excess earth has to be transported. Now where that has to be transported? Was another matter of discussion, when we talked about the description. We said that that earth if it is to be transported within 500 meter, within a kilometer within 2 kilometers and so on that will have different rates. As far as the construction of the boundary wall is concerned this is a specific item which has to be undertaken. Continuing with that there is this issue of fabrication of angles,; now these angles which we have to fix on top of all these pillars have to be cut, they have to be rounded off and all the kind of shaping has to be done, holes have to be drilled and so on.

So, this is another activity which has to be completed before the boundary wall can be completed. Then we have of course, the fixing of angles on the column tops and fixing of barbed wires, once the angles have been fixed.

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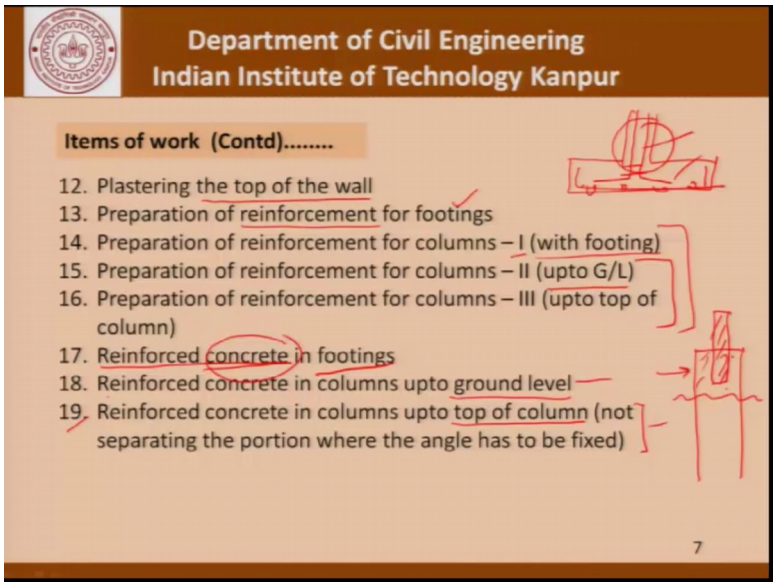

If we continue with this there are other items like plastering the top of the boundary wall. Now this is something which if you recall was not estimated, was not counted when we were doing the estimation of the quantity of plastering in the boundary wall construction, but that is a small amount of plastering and that we will talked about it separately later on in this discussion.

Another entirely different line of activity or a set of activities is preparation of reinforcement for the footings. See what happens is that this reinforcement, that is the reinforcing steel or the bars of different diameters will be ordered and procured they will be brought to site and finally, somebody has to cut them according to the cut lengths and arrange them. So, this I have broken up into the reinforcement for the footings and apart from the footings there is preparation of the reinforcement for columns. And this has been divided into 1, 2 and 3 as we will see and this has to be ready before the footing can itself be cast. For the simple reason, that if you recall the section the footing is like this there is a column here and before you can cast this footing even though the reinforcement for the footing is somewhere here you cannot cast this footing unless at least some amount of reinforcement for the columns here including maybe the links has been buried in the footing.

So, before you can cast the footing you have to be ready with at least this amount of reinforcement for the columns also. Continuing from there, we have the reinforcement for columns up to ground level. Now let me tell you what is the significance of the ground level; if we are able to complete the brickwork and the RC work up to ground level then, we can start doing the back filling because unless that is completed the back filling cannot start. So, one of the reasons actually for doing this exercise today in going through the construction of the boundary wall in more detail is to introduce you these ideas of dependence. The idea that all these activities cannot be taken up together some of them can be because they are independent, but some of them depend on the completion of other activities and so on.

So, this is the second set of reinforcement for the columns and then we have the third set which goes up to the top of the column. Of course, in this particular example the total height is not so large and therefore, maybe we can do this and this together maybe. In fact, we can do all of them together, but the point of breaking them down and discussing them with you like this is to show that in a larger project these are the kind of things,

these are the kind of considerations which operate on your mind when we are trying to manage that project. And then we go to the actual concreting work; that is we are talking of reinforced concrete being placed in footings. You would recall that as far as the PCC is concerned that we have covered already I think it was activity 2 or something just of the earthwork.

Now, we are mentioning placing structural concrete in footings. Similarly we have a structural concrete in columns up to ground level. The reason for choosing the ground level I have already discussed with you just now and then we have reinforced concrete in columns up to the top of column. Now here I have not tried to separate the portion where the angle has to be fixed. There can be a situation where the column is like this, the fact of it remains that we will need to fix the angle here. So, there is a possibility that in a certain situation you may say well we are not ready with the angles yet and therefore, can we do the concreting up to this part and do this part later on once we have been able to fix the angle and then we will pour this.

But in this example I have said no, we will put the angle here and then from the ground level up to the top of column we will club it as a single activity.

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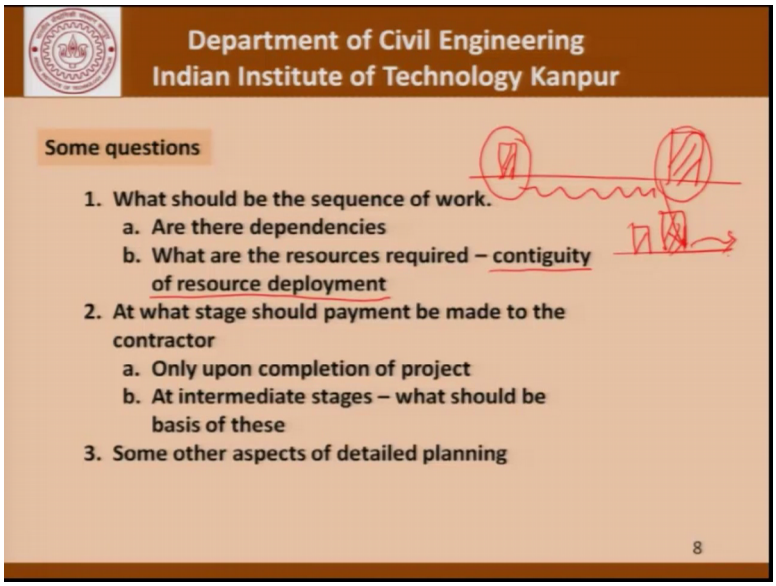

So now, let us try to talk about some questions; what should be the sequence of work? What should be the order in which the activities are to be taken up? Now obviously, you can see from the list of activities that we have considered some of them are independent

and some of them depend on previous activities or other activities to be completed. So, that is what the sequence of activities is. So now, what governs the sequence of work is what we will see in the discussion subsequently. Are there any dependencies? That is number 1.

The second thing is, what are the resources required? What we would like to do is ensure contiguity of resource deployment? See each activity requires certain resources in terms of manpower, equipment, maybe material and we would not like to have a situation that over a period of time a one resource is required here and then it is required here. So, during this period the resource will be idling at site, otherwise we will have to bring the resource here and then bring it again here. So, it would be easier and perhaps operationally a lot better if these two activities could be scheduled in a manner that once this activity is done the resource is used again here and then the resources returned possibly for use in another site; an entirely independent thing. At what stage should payment be made to the contractor?

We must remember that at the end of it the whole idea of doing the estimation exercise was that if we want to construct this boundary wall, how much is the contract are going to be paid? Now at what stage should the payment be made? Should it be made only upon the completion of the project? That is only after the entire boundary wall has been made, the payment is made in a single installment or there could be intermediate stages and then if there are intermediate stages, what should be the basis of making the payment? We must remember that in making payments, one has to be careful to make sure that the process is transparent and reasonable.

We must make sure that the contractor has enough resources to continue with the work, but at the same time he has not been overpaid; that is he has not been paid for an activity which has not been completed or the client should still have funds which are owed to him and not to the contractor. Now apart from this there are some other aspects of detailed planning which we will investigate in our discussion today.

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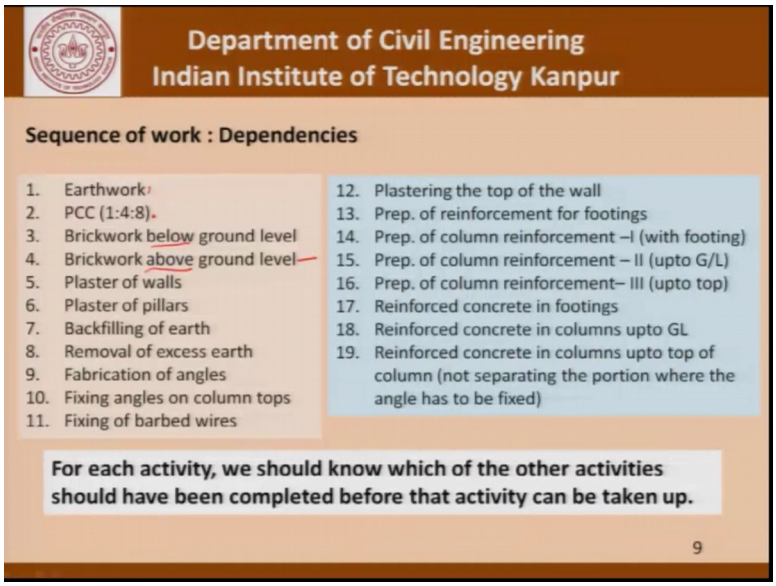

So now, far as the first part is concerned, that is the sequence of activities in terms of dependencies this is the list of 19 activities that we talked about.

Now, some of these dependencies and the absence of those dependencies is very clear and for each activity we would really like to know which of the other activity should have been completed before that activity can be taken up. For example, we cannot do the PCC unless the earthwork has been completed. Now the question is, whether the entire 55 meter of earth work should be completed before the PCC can be started? That is not really true, but you need a certain amount of reasonable front. So, that the PCC operation can start similarly, you cannot do the brickwork above ground level unless you have completed the brickwork below ground level.

So, some of these things are very obvious.

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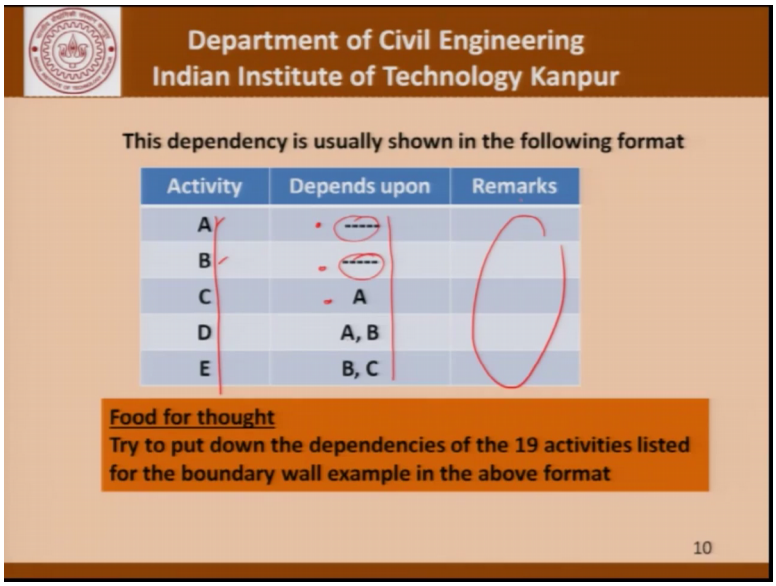

And usually, the dependency is shown in the following format. We have a list of activities A, B, C, D, E and so on and we would list here in this column, on what other activities does this particular activity depend? For example, the way I have shown it here A and C do not depend upon anything whereas, C depends on A, D depends on A and B, E depends on B and C and so on. So, this of course, a remarks column and we want to write something we can say something here, but what I would like you to do is to try to put down the dependencies of the 19 activities listed for the boundary wall construction in the above format.

So, what you do is you go back to this 19 activities and try to complete this, in this format. You list the 19 activities here and list on which activities they depend. Please remember that there is no unique solution to some of these things. There is no reason why only these 19 activities are important or the project can be broken up into 19 activities and not 18, why it should be not 21? That would depend for example; on in how many lifts do we want to talk about brickwork? Whether we want to do the plastering before or after the completion of the brickwork and the reinforce concrete work? Or you would like to do the plastering of concrete as it is completed and then do the plastering for brickwork and so on.

There is no unique solution to that and that is something which we have to see.

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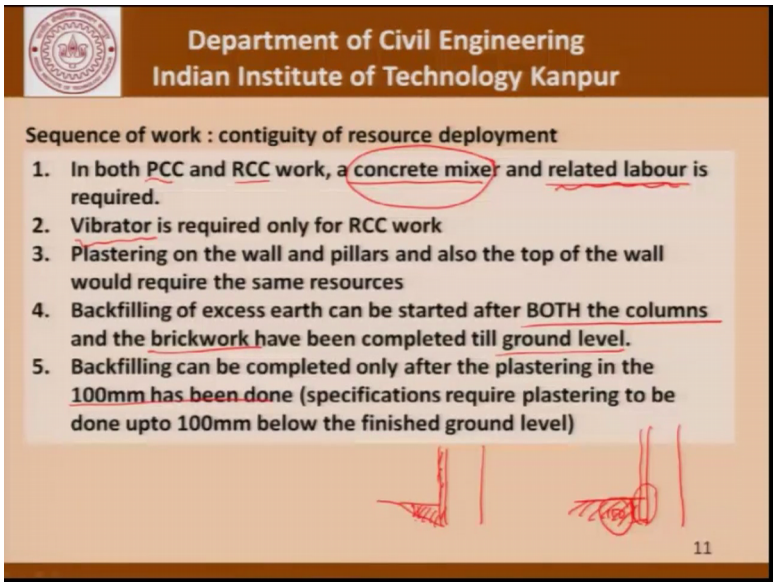

Let us look at the sequencing of work from the point of view of contiguity of resource deployment. In both the PCC; that is a plain cement concrete and the reinforce cement concrete work a concrete mixer is required and related labor is required. So, there is a set of skills in the labor that we want as far as concrete work is concerned. And therefore, it will help us in completing the project if the PCC and the RCC work are taken up together to the extent that they can be and are completed in a manner that the concrete mixer can be returned or transferred to another site and the related labor can also be released.

The vibrator for example, is required only for the RCC work. So, when will we start the RCC work we should endeavor to schedule the RCC work in a manner that it is continuous. So, that the vibrator which has been brought to site can also be used and then returned. We have talked about the plastering before as well; plastering on the wall and the pillars and also the top of the wall would require the same resources and therefore, we would like to start the plastering once a lot of things are ready so that the group of people the labor which is engaged in the plastering work can have work continuously.

We have talked about backfilling of excess earth and that also can be started after both the columns and the brickwork have been completed till the ground level. Of course, there is an option depending on the distance between the concrete pillars we may hold back the back filling in one or the other side; that is we may do the back filling for the brickwork and not do it for the RC footings or do it for the RC footings and not do it for

the brickwork, but that is something which relates to the discussion we were having earlier that there is no unique solution. There is no unique activity that it can be assigned, but as a project manager or a manager at the site you have to understand that whether you want to break it up the more activities you want to break it up or complicated your network becomes then more complicated your thought process becomes.

So, we should try to make it simple, but at the same time it should not be made simple beyond a point. Continuing with this discussion on backfilling, backfilling can be completed only after the plastering in the 100 millimeters has been done because what we have is that here is the wall this is where the ground has to be finished, but what we have said is that the plastering should extend a 100 mm below ground level. So, this back filling here can be completed only after this plastering has been completed.

So, that is something which we need to keep at the back of our mind. We may say that well we will do most of the back filling, but let the ground be like this. So, that once we do the plastering we complete the plastering here and then do this small amount of back filling later on. So, these are small things which as a manager at a site you can always do.

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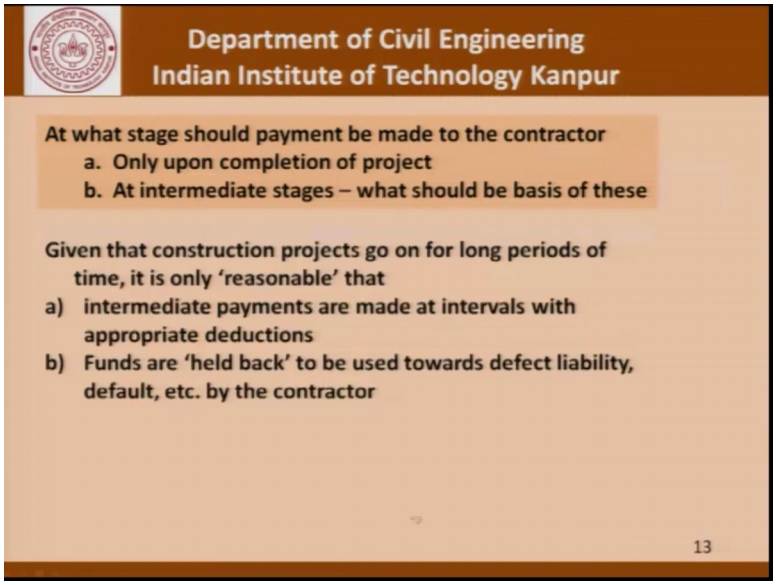

Now continuing that discussion what are the other considerations that could determine the sequence of work, before the final left of the column is caused the angles for supporting the barbed wires have to be in place I explained this to you earlier as well.

Even at the time of casting of the footings the reinforcement in the first lift of the columns has to be in place this also I have discussed with you earlier.

So, now we come to this discussion on what stage the payment should be made? Given that the construction project goes on for long periods of time it is only reasonable that intermediate payments are made to contractors at intervals with appropriate deductions. So, whatever the deductions that are admissible they have to be made as we go along. It cannot happen that we make the payments without making the deductions and think or push all the deductions to be made towards the final bill. Funds are held back to be used towards defect liability, default, etcetera by the contractor I went over this a little while ago.

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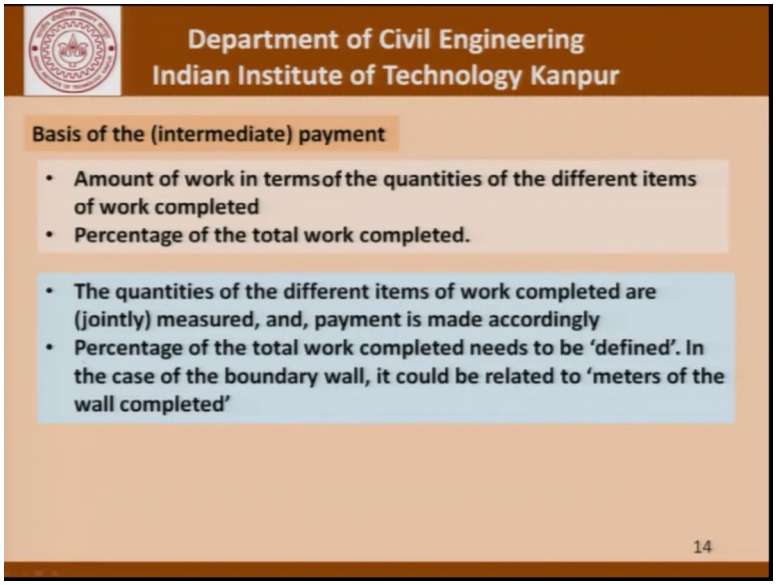

And as far as the basis of intermediate payment is concerned, the amount of work in terms of the quantities of the different items of work completed or it can be done in terms of the percentage of total work completed.

What it means effectively is that if the boundary wall has a contract value of 15 lakhs then an intermediate payment can be made either depending on the amount of work completed for the different items which means that they have to be measured; earthwork, brickwork, PCC, RCC and so on and so forth or in terms of the total length of the boundary wall and that is exactly what is being said here, when it comes to the first part it is the quantities of the different items of work completed and they have to be jointly

agreed between the contractor and the client and payments are made accordingly because for each of the items there is a certain rate which has been agreed upon.

So, we can always make a judgment as to how much is the value of the total work completed at a given point in time when we are making the intermediate payment. Now as far as the percentage of total work is concerned this has to be defined. In the case of the boundary wall, it could be related to the meters of the wall completed. So, we can say that well if the 55 meter boundary wall costs 15 lakhs and 15 meters has been completed therefore, a certain fraction of that has been completed and we make a payment for that. But please remember that, if we adopt the latter part that is we are going by the percentages then the wall has to be completed in all respects for those 15 meters, that is right up to the fixing of the angle and possibly even the barbed wire.

So, one has to be careful as to what is the kind of contract that we deal with and that is something which we will probably go into at a later stage in this course; the types of contract and the relationship with the schedule of payments, Now let me give you some homework.

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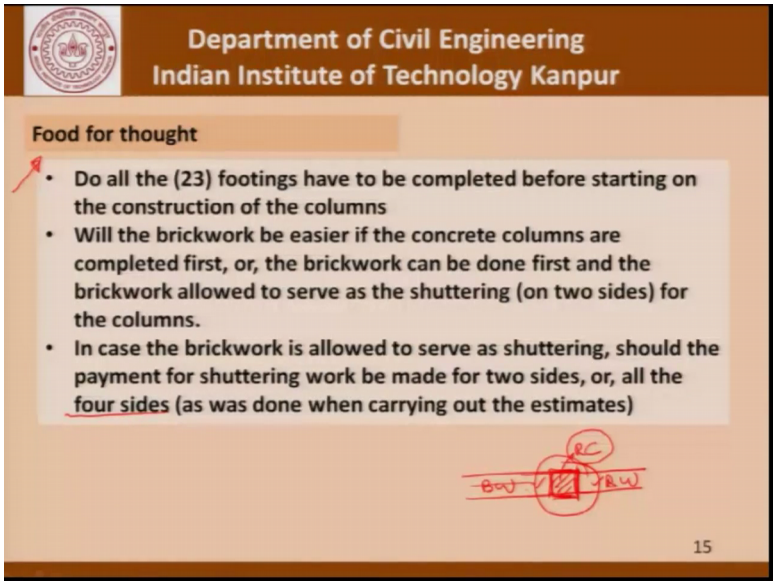

Just to think about it; do all the 23 footings have to be completed before starting on the construction of the columns? The answer is obviously no; we can complete a certain amount of footings and start casting those columns so that at least the other things can carry on.

Similarly, will the brickwork be easier if the concrete columns are completed first or the brickwork can be done first and the brickwork allowed to serve as the shuttering on two sides for the columns. What is being said here is that we have brickwork here on both sides and we have the RC pillar. So, one way to do things would be to complete the RC pillar first and then do the brickwork or we could do the brickwork first and then do the RC pillar. Now if you bring the brickwork all the way up to here then there is no place to put the shuttering plate. In fact, this brickwork will serve as the shuttering for these two sides and as far as the RC pillar is concerned we need to put shuttering only on the two sides.

Now, in case the brickwork is allowed to serve a shuttering, should the payment for the shuttering be made for two sides or for all the four sides? When we were calculating the amount of shuttering required for these columns, we have assumed that all the four sides will have a shuttering. Now if we find it convenient to do the brickwork and let the brickwork serve as the shuttering for the concrete. So, be it the issue is whether the payment should be made or not, I am not commenting about it right now. We will probably talk about it sometime later and that is why these questions are food for thought.

There is no real specific answer; there is no true answer to some of these questions. They are open ended and one has to be making a judgment at site at a lot of times and those judgments have to be made in accordance with the principles and the rules formally laid down in the contract. So, we have not gone into the contract, the details of the contract; what we have said is that what is legitimately done is to be paid. So, in this case if only two sides of the shuttering has been used it makes sense to say that well we will make payment only for the two sides. What the implications of that is in terms of the overall contract is something which we talk about separately.

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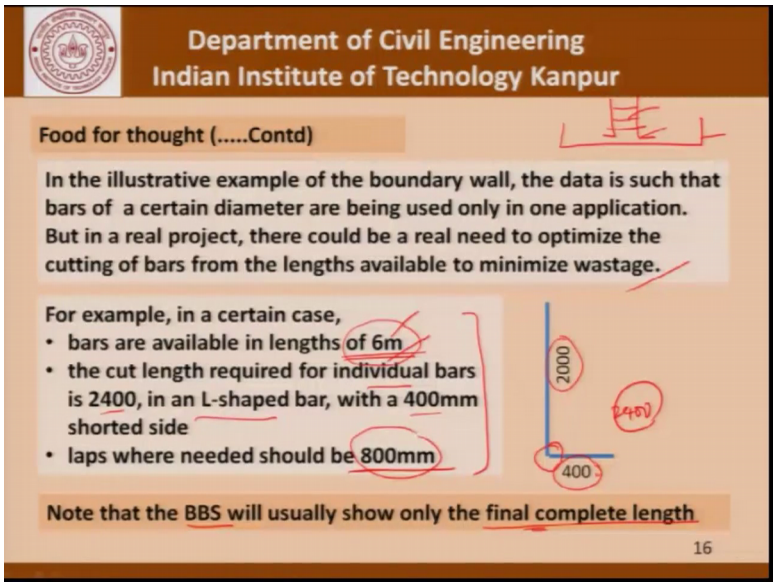

Now, let us continue with the discussion on the homework. In the illustrative example of the boundary wall the data is such that bars of a certain diameter are being used only in one application. So, we have bars which are going to be used like this that is the footing, then we have the column reinforcement and we have the links. So, in this case the diameters for these three applications was all different, but of course, in a real project there could be a real need to optimize the cutting of bars from the lens available to minimize the wastage; not only the wastage, but also see that well if we have a certain amount of reinforcement available for one application should it be not diverted to another application which also uses bars of the same diameter.

So, for example, in a certain case bars are available in lengths of 6 meters. Now I leave it to you to think, what governs the length of bars available at site? They are to be procured from the market and what governs the total length of the bars which is available in the market? Now the cut length for example, for individual bars is 2,400, in an L shaped bar with a 400 mm shorter side. So, we are talking of a situation where the 2,000 is the longer length, the 400 is the shorter length and the cut length for this is 2,400 not counting for any kind of changes that may happen on account of the bend.

Now, it is also given that the laps where needed is 800 mm. Those of you who are familiar with principles of reinforced concrete design would know that there is something called a lap length and if suppose it is given that the lap should be at least 800

mm then the question is, how do we optimize the bars the availability is 6 meters? The cut lengths is given other conditions like the lap lengths is given and we need to find out how best to use the bars? Please note that the bar bending schedule will usually show only the final completed length. The bar bending schedules often do not show the location of laps or how many laps to be provided and so on and that is left to the judgment of the site engineer.

So, now given that the bars are available in 6 meter lengths and the cut length is 2,400, what we do is we make one bar out of this.

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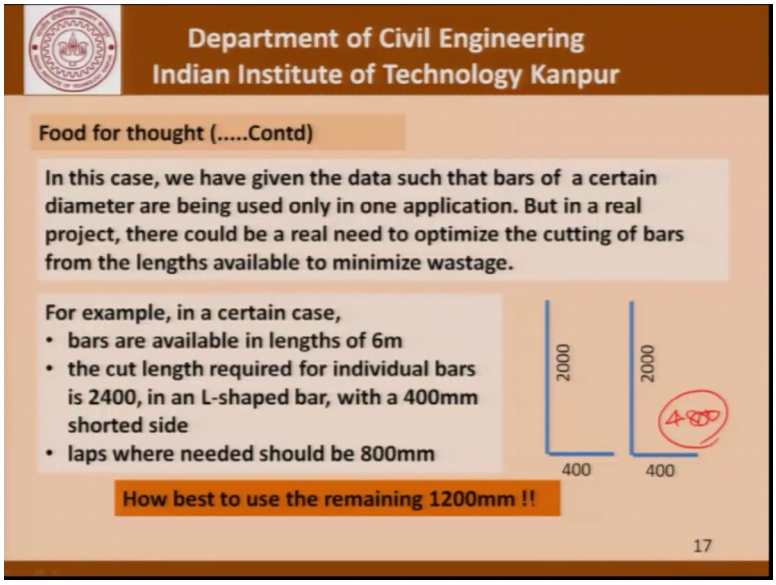

And we make another bar out of this so that makes the two bars having a length of 4,800 mm and the question is, how best to use the remaining 1,200 millimeters of the bar?

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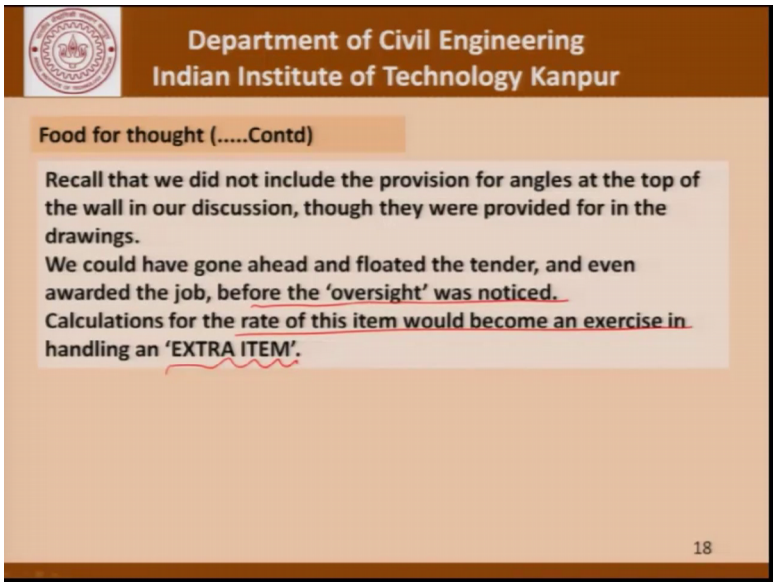

Now continuing, let us talk of something very very different. Recall that we did not include the provision for the angles at the top of the wall in our discussion though they were provided for in the drawing. This was something which I had left out and said that you can do it on your own.

Now, if this happens in a real case what do we do? We could have gone ahead and floated the tender and even avoided the job before this oversight was discovered. So that means, we would have draw up the estimate, awarded the contract without having the item for providing the angles. Now calculations for the rate of this item would then become what is called an extra item and we would need to do the rate analysis as we have discussed in a previous class as to what is a reasonable rate for providing these angles.

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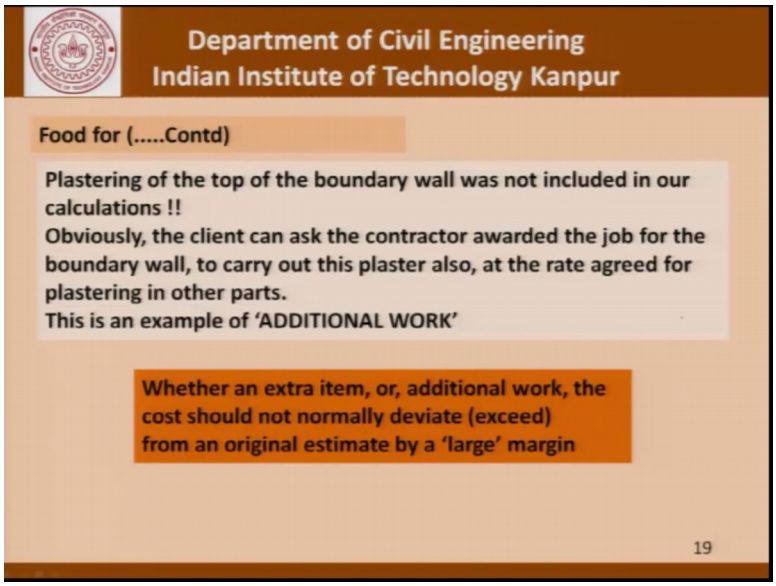

Similarly plastering on the top of the boundary walls was not included in our calculations of the estimate. Obviously, the client can ask the contractor awarded the job for the boundary wall to carry out this plaster also at the rate agreed for plastering in the other parts. This is an example of additional work; what we had in the case of the angle was an extra item which was not provided for in the contract and we are asking the contractor to do it. In this case we are asking the contractor to do additional work in terms of providing plaster at the agreed rate at a location which was not indicated in the drawing.

In short whether an extra item or additional work the cost should not normally deviate or exceed from the original estimate by a large margin. So, this is the bottom line that in most contracts there will be some extra items there will be some additional items, but what has to be ensured is that the total cost of the project does not deviate from the contract value by a large amount. Now how much is that large amount is something which may vary from organization to organization.

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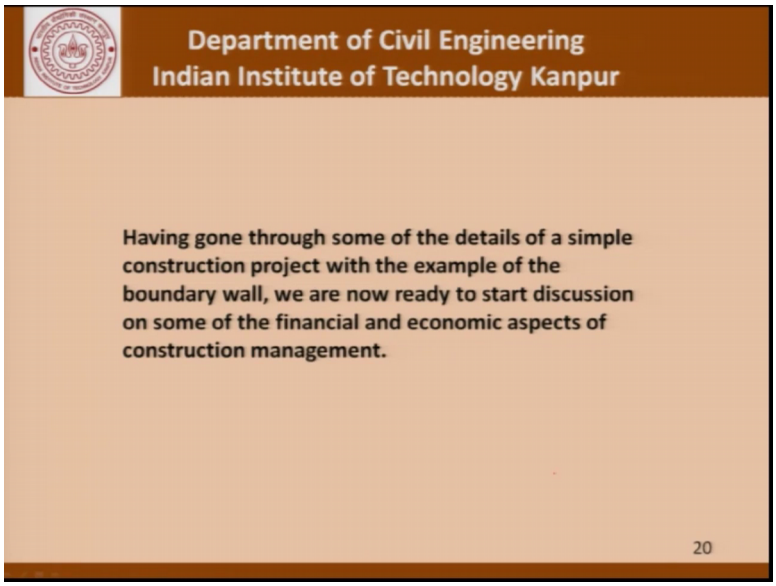

Now, in this discussion coming to an end having gone through some of the details of a simple construction project with the example of the boundary wall, we are now ready to start discussion of some of the financial and economic aspects of construction management. With this example I hope you understand the details of the work, the dependencies the fact that all the work does not have to be started at the same time, the contractors have to be paid periodically and this periodic payment can be made on the basis of the work completed and so on. So, with this discussion we are ready to get started with more detailed discussion on aspects relating to finance and economics.

Thank you.