Principles of Construction Management
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Lecture – 06
Estimating Quantities

[FL]. And welcome to these series of lectures under the course Principles of Construction Management and today we will talk about estimating quantities from a drawing.

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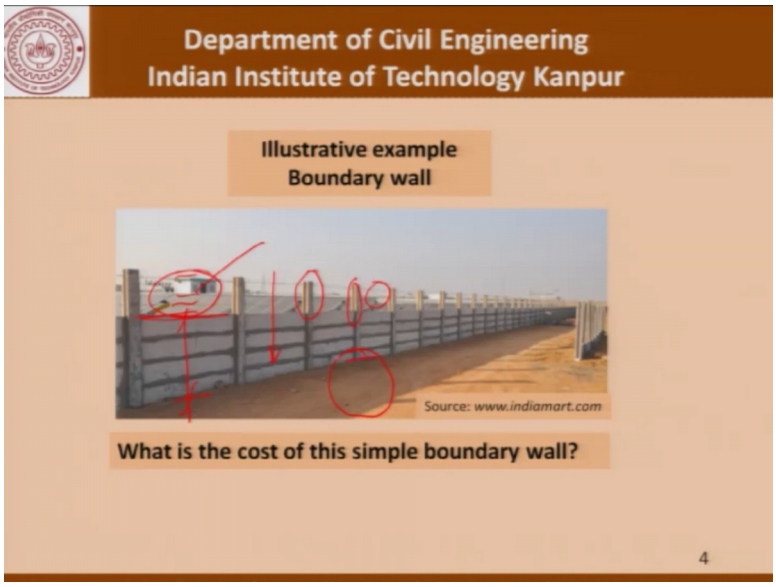

Basically if you look at this simple example let us say boundary wall now our objective is to calculate what is the cost of this simple boundary wall. So, once we understand the principals involved and the method of doing it you can extend it to more complicated projects. So, if you look at this boundary wall what are the components of this wall. There are these piers which we can see or pillars then there is this wall which is there in between these pillars, we have these barbed wires which are running through the pillars above a certain height.

So, from the ground level to this level we have the wall and then there are these barbed wires which are running at a certain distance. Obviously, we must imagine that the wall does not stop here. There is some kind of a foundation which has been dug below the ground. So, this gives us an idea as to what goes on in the construction of this simple boundary wall.

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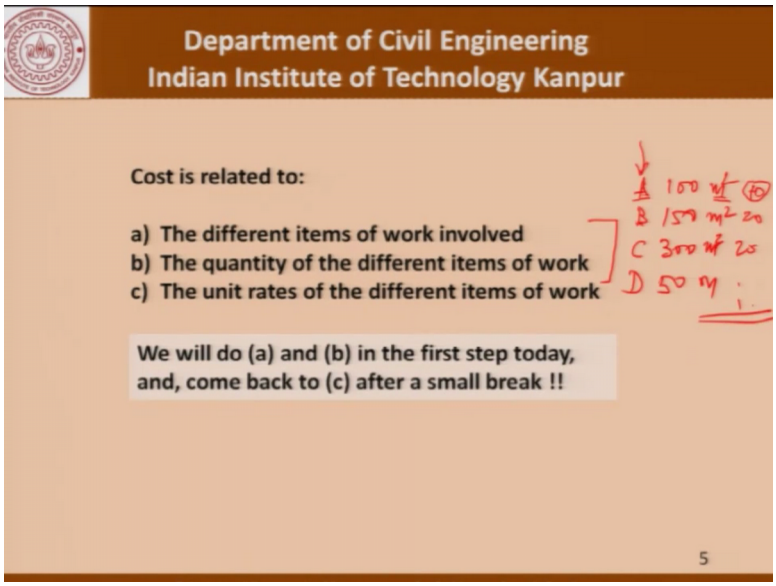

So, now in order to estimate its cost we should know what the cost is related to. So, the first thing that comes to mind is what are the different items of work involved, then what is the quantity of the different items involved and finally, what is the unit rate of the different items. So, what we will do today is look at a and b of this outline first and then come back to c which is the unit rates after a small break.

Basically what we are trying to say here is the following. That if there are items a b c and d first of all we have to make a list of these items what are the items involved, then what is the quantity of these items maybe 100 square meters, 150 square meters, 300 cubic meters, 50 running meters and so on. So, there has to be the square meters, square meters, cubic meters maybe meters and so on and then finally, we will have to have what is the unit rate for a. So, for example, A might cost 10 rupees, B might cost 20, C might cost 25 and so on.

So, once we have this picture then we will be able to figure out what is the total cost of this project. So, now, let us move on and try to take a look at using appropriate drawings and trying to find out the items and the quantities of the various items for a boundary wall.

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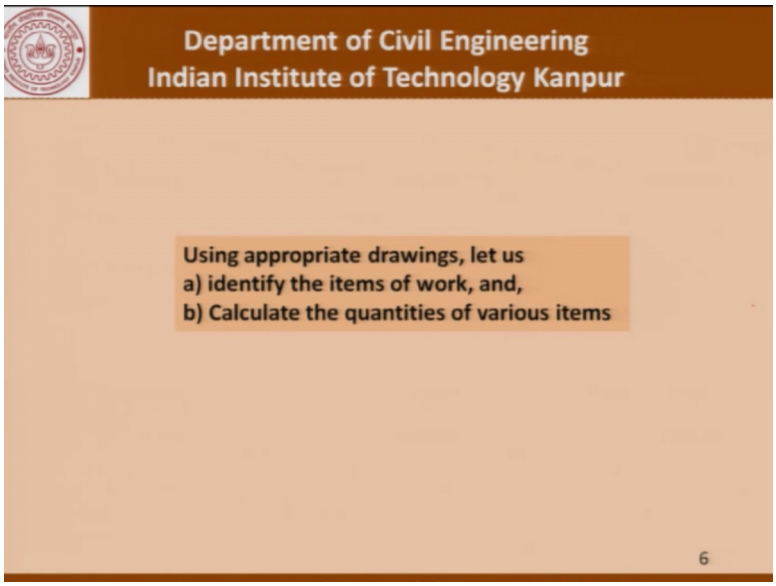

So, now, here is the boundary wall that we talk about.

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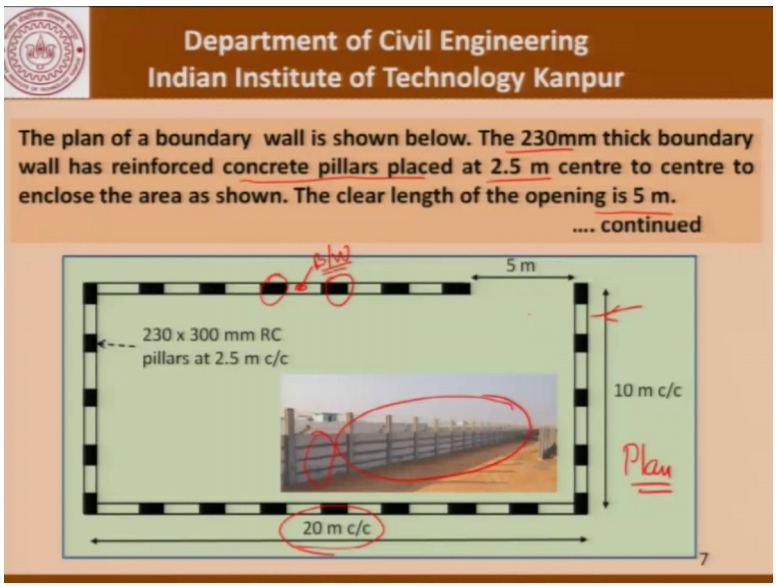

I have included this picture just to give you an illustration as to how this picture which is not to scale which is just a photograph as a matter of fact gets translated to what is called the planned view. So, this is the planned view of a boundary wall that we are going to do the quantitate machine for and what it says is that there is a 230 mm thick boundary wall has reinforced concrete pillars placed at 2.5 meters center to center. So, these are the pillars that we are talking about in between here we have the brickwork.

So, what is happening here is that instead of these kind of panels being used in the wall we are using brickwork and the length of the opening is 5 meters. So, we have a 20 meter center to center distance here, a 10 meter center to center distance on the other side and we have a 5 meter opening which could possibly be used to install a gate and so on at some point in time. So, the gate is not really part of our discussion today.

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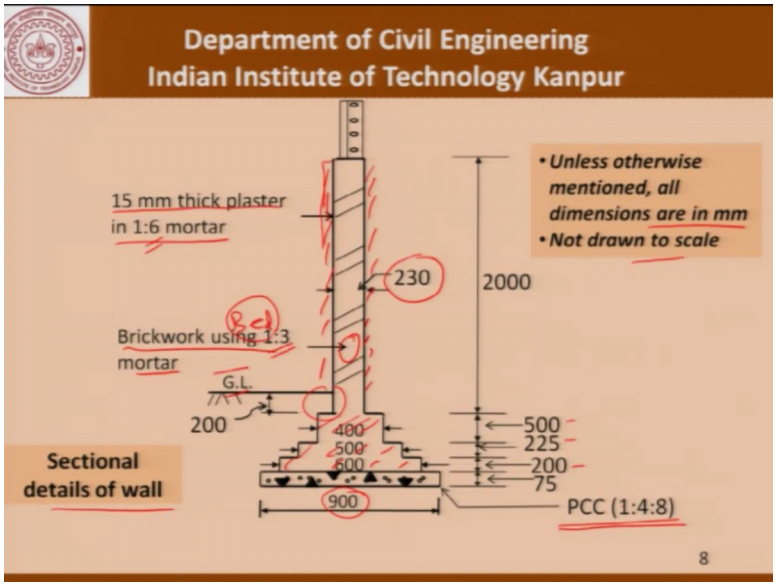

So, now if you look at more drawings related to this to get an idea of what actually the work entails here are the details of the wall. So, this is a 230 thick wall which we are talking about there is a ground level, we must remember that these dimensions at all in millimeters and the drawing is; obviously, not to scale. We also say that there is a 15 mm thick plaster in 1 is to 6 mortar. So, there is a mortar which is specified and the thickness of a plaster which we apply on the brickwork, whether it is on both sides or one side that remains to be seen that depends on what the kind of instructions we have.

Then there is this brick working 1 is to 3 mortar. So, so this is the brickwork in the boundary wall and in the bed joints we will use 1 is to 3 mortar and in the plaster we will use 1 is to 6 and this wall which is 230 thick as far as the portion above the surface and a small portion here which is below the surface is concerned it is supported by a 400 thick here and a 500 thick here and a 600 thick support or an offset for different heights and this entire brick structure is placed on a 900 wide PCC which is plain cement concrete made with 1 is to 4 is to 8.

So, some of these terminologies are taken as prerequisites to this course we would expect that you have done some basic course in concrete construction of concrete materials before you come to this course on management and I would leave it at that.

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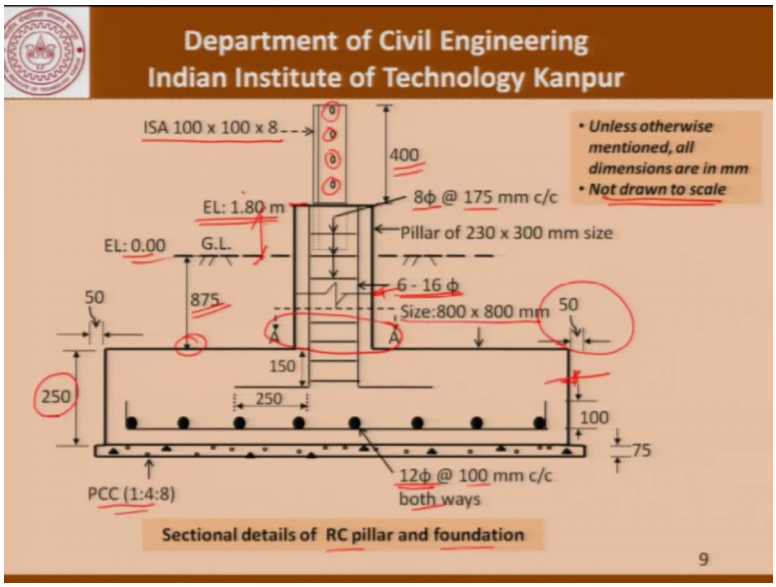

Now, continuing from here if we look at the details of the RC pillar and the foundations. So, now, as far as the RC pillar is concerned the best place to see would be this section A, A which is given here.

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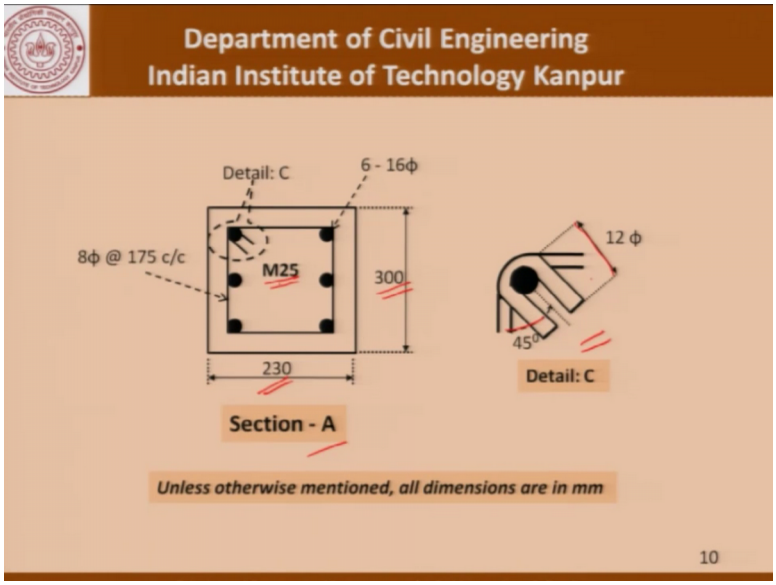

So, this is 230 by 300 thick in M25 concrete and we come back to this. So, the pillar is a reinforced concrete pillar which has 6 of 16 mm bars and then there are stirrups which are 8 mm diameter placed at 175 center to center. So, this how this drawing looks like.

So, now this pillar which is basically a small column is cast into this footing which is also made with M25 concrete and measures 800 by 800 I think that is what is given here. As far as the reinforcement of the footing is concerned it is given to be 12 millimeter bars placed at 100 mm center to center both ways and this is the same PCC that we talked about and we see here that the offset from PCC to the RCC is 50 mm.

The thickness of this footing is given is 250, so basically the idea of going through this drawing in some detail is to take you through the steps of how to find out the relevant details from the drawing. So, it is basically simple exercising reading the drawing. Please understand that since it is not to scale which is obvious from the fact that this point here which is the top of the footing is shown as 875 and the top of the pillar here is at 1.8 meter from this 0. So, this distance is given as 1.8 meter, whereas this distance is shown to be 875 so obviously, this drawing is not to scale.

Now, as far as the RC pillar is concerned there is another small addition to this which is this ISA 100 100 8. This is the angle with holes here to support the barbed wires which are going to run all along the boundary wall. So, these angle projects 400 and the drawing does not show the embedment, but let us read something else. So, moving on from this embedment there is a section A which we have already done now there is this detail C which we can see here which shows how a is stirrup should be bent. It tells you the angle, it tells you the length and all these kind of details which will become very relevant when we talk about it at a later point in this discussion.

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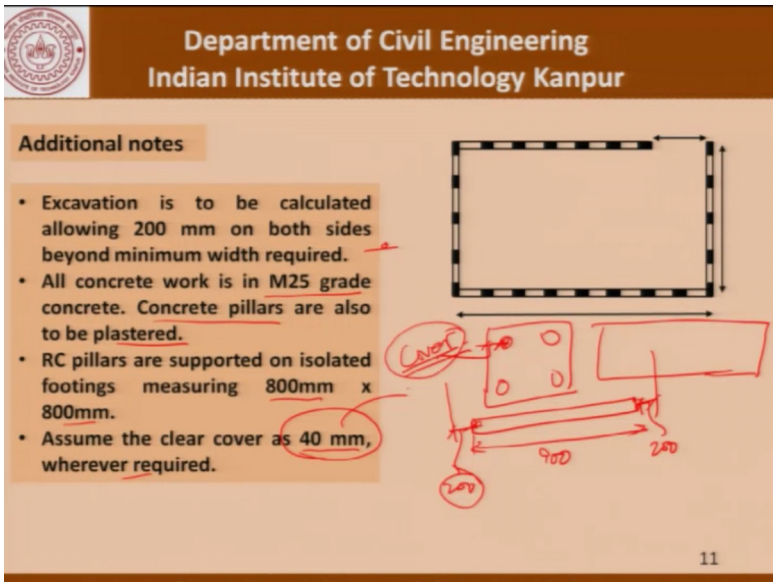

So, moving forward let us take a look at some additional nodes excavation is to be calculated allowing 200 millimeters on both sides beyond the minimum width required. So, what it really means is that suppose there was PCC which had a width of 900 somewhere now what we are allowing here through this provision is that the excavation should be carried out which is 200 millimeters beyond this point, in order to facilitate the construction work. So, when you are calculating the earthwork quantities as we will at a later point in time this 200 millimeter is the extra which we are allowing. This kind of an allowance is made to facilitate the construction.

All concrete is in M25 grade concrete, concrete pillars are also to be plastered RC pillars are supported on isolated footings measuring 800 by 800 square footings, there is a clear cover of 40 mm wherever required. So, cover those of you who have done courses in reinforced concrete design would know that whenever we have a column or we have a beam and we provide steel reinforcement in it there is this minimum distance which has to be provided for in order to protect the reinforcement from the environment and also ensure appropriate structural action and this cover has been is specified to be 40 mm in this case.

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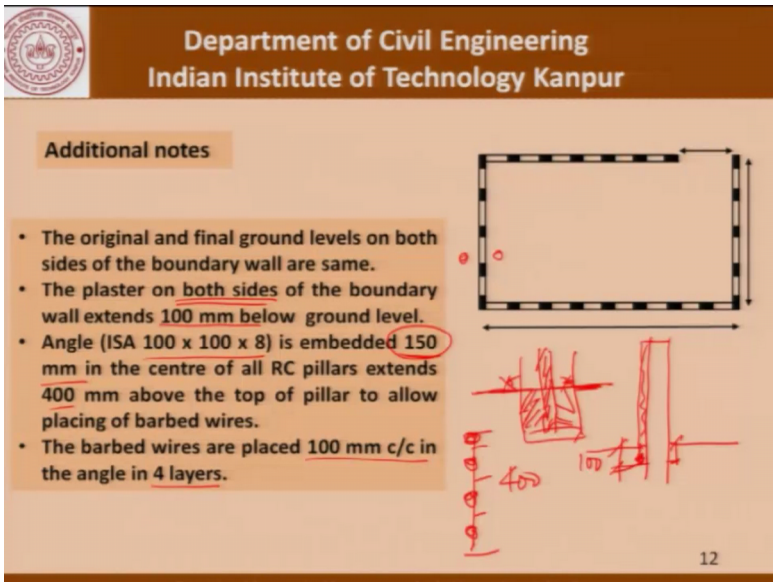

Carrying on with the nodes this picture is there just to illustrate that this is what we are talking about. The original and the final grounds on both sides of the boundary wall are the same, so basically what we are saying is that there is a ground here we are going to make an excavation here to make PCC or whatever it is finally, there will be the wall that will come out and this part if the wall has been come. So, if the wall has been constructed. So, this part will be what is called backfilled and the ground level restored to the original level which is the same on both sides of the boundary walls. So, this is our boundary wall to begin with and also at the end of the construction operation the ground levels are the same on both sides.

The plaster on both sides of the wall extends 100 millimeters below ground level. So, if we have the wall which is something like this and the ground level is somewhere here then what we are saying is that the plaster which is applied here does not end here, but extends 100 millimeters below the ground level. So, this distance here is given to be a 100 and this is done on both sides of the boundary wall the angle which is ISA 100 100 8 is embedded 150 millimeters in the center of the RC pillar and extends 400 millimeters above the top of pillar to allow the placing of barbed wires.

So, the depth of embedment is given here in the node and can be included in the drawing as well. So, this is given to be a 150 millimeters. The barbed wires are placed at 100 mm

centered centre in the angle in 4 layers. So, if we have a 400 mm length we are talking about 4 layers of barbed wires being placed with one layer being at the top.

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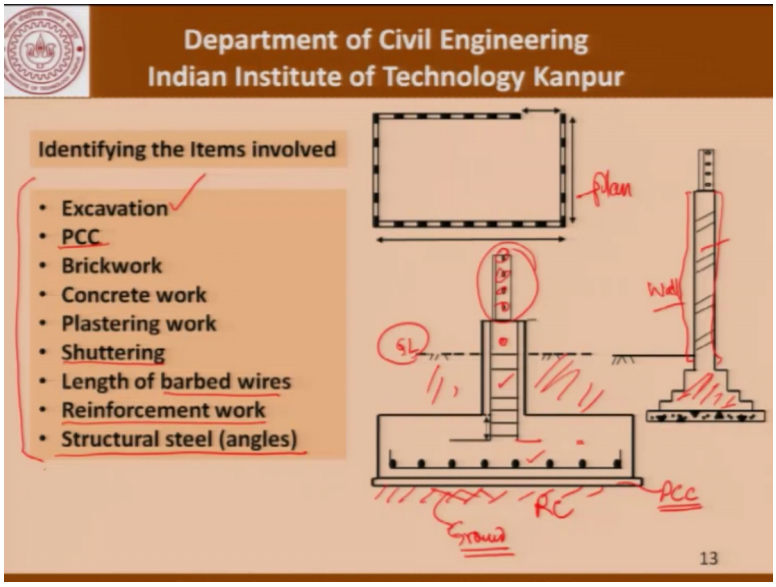

So, having completed that now let us try to see if we have understood the sequence of operations and the kind of operations involved we should be able to identify the quantities which are involved in the construction of this boundary wall. We have the plan we have the RC footing details and we have gone through the wall details. So, once we know all this the items involved would be excavation. Excavation is removal of earth and possibly back filling. So, this is my ground level originally we are going to have to remove certain amount of soil in order to be able to carry out this construction and then this part here will need to be backfilled. So, this exercise is what is called excavation.

Then we have what is called the PCC that is this is the PCC that is the plain cement concrete which will have to be placed at the bottom of the RC footing as well as the brick wall. A question that I am leaving for you is why do we need to have PCC why we cannot cast NRC footing or for that matter just start the brickwork also on ground that is a question which I am leaving for you to answer of course, below the PCC we have normal ground and how this ground is to be handled is something which we will see in the next class.

And moving on with our discussion today we have the brickwork which is in the wall here and in the offset portion below the ground we have the concrete work which means

we are covering the concrete in the pillars as well as in the foundation. We are plastering which we talked about plastering is in the wall extending a 100 millimeters below the wall on both sides. Then we have shuttering which is required to be able to place the concrete we have the length of barbed wires. So, the barbed wires have to be placed here after the barbed wires there is reinforcement work because we know that our column as well as our footing is reinforced with steel.

And finally, we have structural steel which is providing these angles. So, this here essentially is a list of the items that are required to be completed in order to be able to construct this boundary wall.

The next step is; what is the quantity of each of these items.

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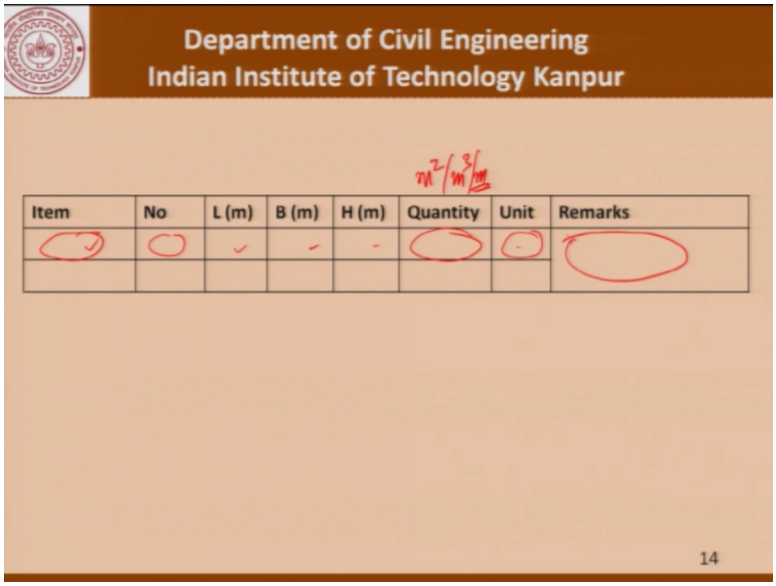

Now, when we start calculating quantities here is a very standard format that we use. Now this standard format helps us write the item how many numbers of that item are required the length, breadth and height or whatever if the quantities are and finally, calculate maybe the square meter or the cubic meter or whatever the meter for this particular item and that unit has to be specifically mentioned here and then in the remarks columns we can always show the details of the working as we will see in some of our subsequent slides.

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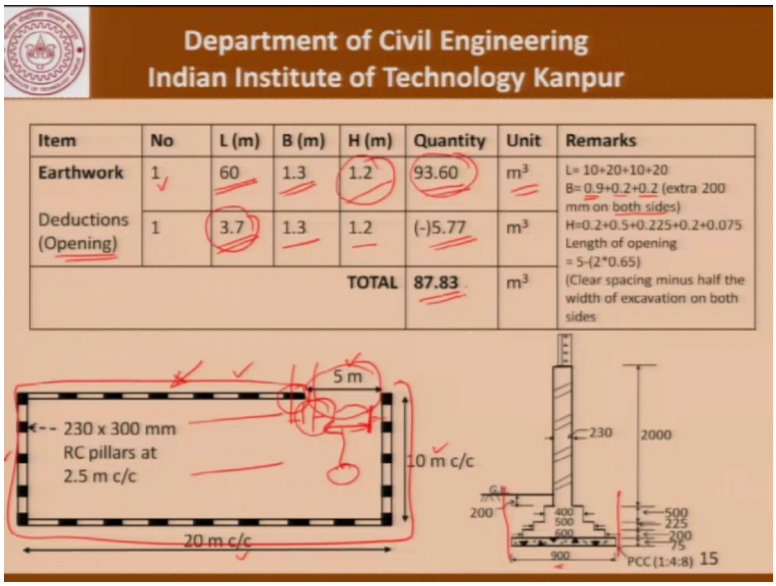

So, now the first item that we go about calculating let us say is the earthwork involved as far as this particular boundary wall is concerned. Now in the earthwork we are talking about the earthwork for this portion here. So, along this portion we will have to do what is more or less like a trench. So, we will have to create a trench which will like this all along the length of this boundary wall. So, there is only one length which is involved that overall length let us say we are talking about a 60 meter. So, 60 meter basically means 20 here 20 here 10 here and 10 here.

Please remember that we have taken the entire 60 here the brick is taken as 1.3 which is coming from the 900 plus 0.2 and 0.2 which is the extra which has been allowed as we mentioned in a previous discussion so that makes it 1.3 and the height of excavation is 1.2 this I am leaving to you to read from the drawings that have already been presented and we will get a quantity like this which is in cubic meters.

So, basically what it says is that 93.6 cubic meters of earth work is involved, but now what happens to the earth work that has been counted here for that we will deduct we will show it as a deduction. And how much is a deduction? If the breadth and the height does not change, but the length is not 5 meters as is shown here because here will be a pillar and once we have the pillar. So, the excavation will extend a little bit beyond the boundary wall and this extension here and the similar extension here will have to be

excavated and only this portion here will not be excavated and how much is this length - that I am leaving to you to read and confirm that it is indeed 3.7 meters.

Now, if that is what happens then 5.77 cubic meters of earth work will not happen and therefore, the total quantity of earth work required is about 87.83 cubic meters. So, if we go through this kind of an exercise in detail with a certain amount of precision we know exactly the kind of quantities which are involved and the more accurate this exercise is the more accurate will be our cost estimates.

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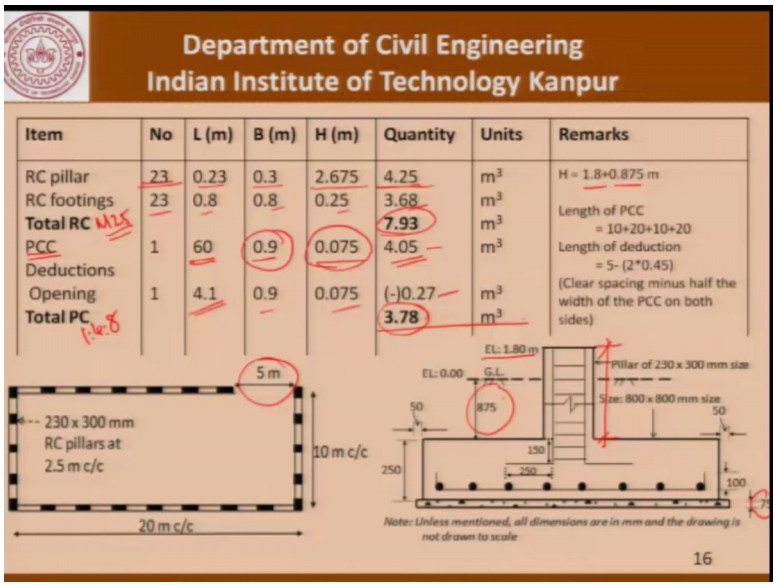

Now moving forward let us talk of the quantities involved in the RC pillars and footings. So, I am leaving it to you to conform from the dimensions that there will be 23 pillars involved the size is 0.3 into 0.2 3 which is given to you and the height is 2.675 now. How does this 2.675 come? Because the elevation is 1.8 and we are going point 8 seven 5 below ground level, from this point to this point is what we have taken the height of the pillar. So, if we take the height to be 2.675 the concrete involved as far as the pillars is concerned is 4.25 cubic meters.

Similarly, for the footings the dimensions are 0.8 into 0.8 and 250 thick. So, we have this quantity here. So, the total amount of RC which is given to be M25 grade is 7.93 cubic meters, in this case there are no deductions. So, as far as PCC is concerned we can more or less follow the same dimensions as given for the earthwork except that the breadth will be 0.9 here because there is no extra 200 mm to be considered and the height is 75

mm which is given in the drawing. So, once we have that we know the quantity of PCC, but again in PCC as well there will be a deduction. So, in this case the deduction will be 4.1 because the PCC does not extend to the extra 200 mm on both sides.

So, this becomes 4.1 0.9 and 0.075. So, we deduct this much from here and we get this number. So, 3.78 cubic meters of PCC in 1 is to 4 is to 8 concrete this is what is our quantity of PCC involved in this project.

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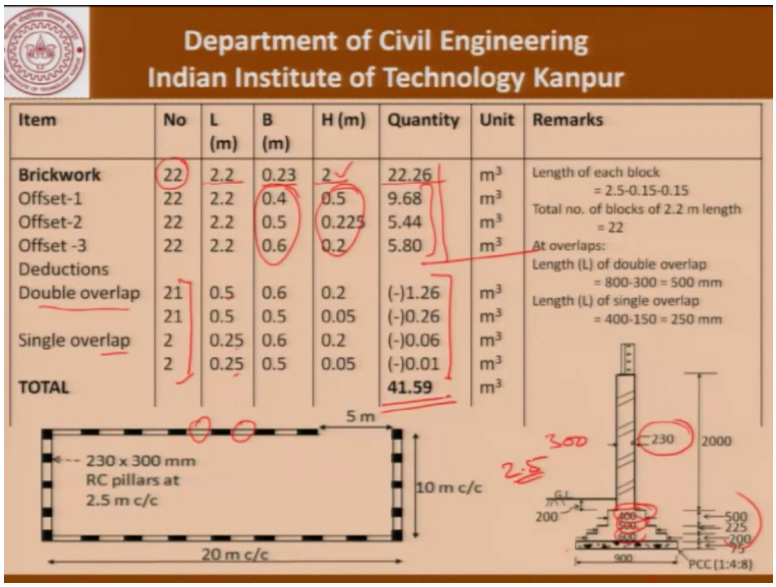

So, moving further from here let us talk of quantities of brickwork these have been estimated using 22 units these are the 22 units that we are talking about. That is the unit from or in between one RC pillar to another. Now this length is 2.2 the center to center distance between pillars is given to be 2.5 meters and since it is 300 wide half of that goes on either side and we get 2.2 as the clear distance for the brickwork the breadth and the height is 2.

Now, how this height is 2 is something which I am leaning to you to figure out from the details given in the drawings. So, we basically get 22.26 cubic meters of brickwork involved which has a width of 230 mm. Then we have offset of 0.4, 0.5 and 0.6 as given in the drawing and this is what we are talking about 0.4, 0.5 and 0.6 in the drawing the heights are also taken from here in the drawing and we get these quantities.

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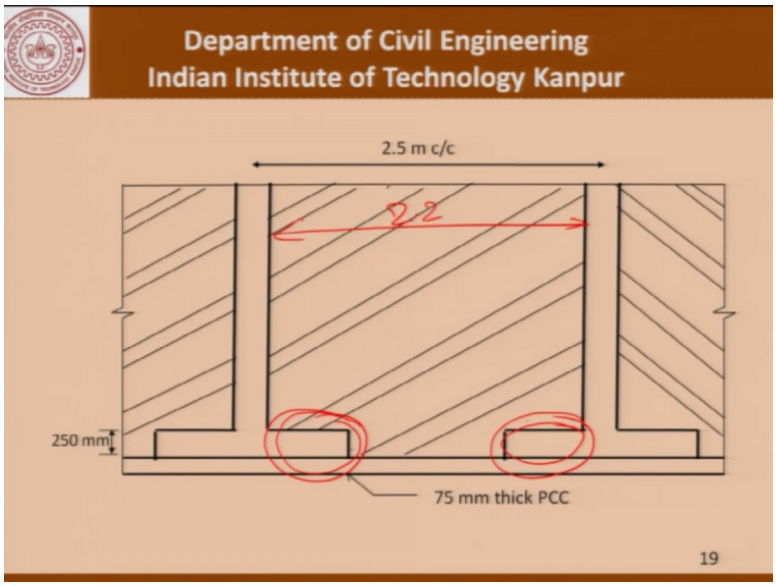

So, if we sum them up we will get a total amount of brickwork involved, but is that all. That is where we will need to understand that when we do the brickwork here what happens to the portions here. When we have taken 2.2 we have said that this is the 2.2 this portion needs to be deducted that is that portion where the brickwork is being done on the foundations or on the footings that amount has to be deducted and that is exactly what is being done here what is being called a double overlap where the overlap was on both sides and then there is a single overlap these details I am leaving to you to understand on your own its 0.5, 0.5, 0.25, 0.25 and so on.

So, if we do this deduction here we will get a total brickwork involved of 41.49 cubic meters.

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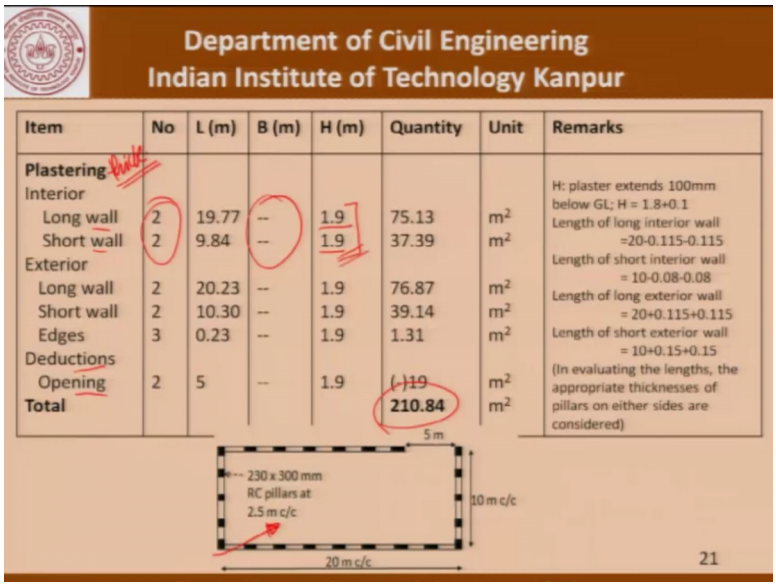

Moving further down we go to plastering I am not going into the detail calculations like I did for the previous slides I am sure you understand how it is done. There is a long wall and there is a short wall then we will deduct for the opening that is why we have taken the complete lengths and we will calculate the height as 1.9, 1.9 because 1.8 is the clear distance which is available to you beyond the ground level and it is also required that the plaster extent a 100 millimeters below ground level. So, that is why it becomes 1.9. Please remember that in the case of plastering there is no breadth if the thickness of plaster is usually specified with the description of the item for plastering and that is something which we will see in the next class.

So, once we do this kind of a calculation we find that this boundary wall measuring 20 meters by 10 meters with a 5 meter opening 1.8 meters high we get a total of 210.84 square meters of plastering involved.

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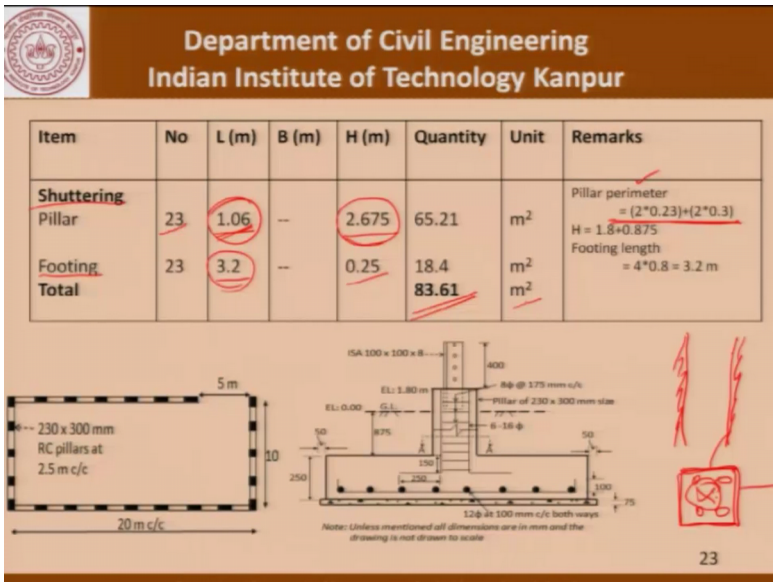

Now, let us come to shuttering, what is shuttering? Shuttering is the support that is placed or required to be able to cast fresh concrete. So, now, once you are costing a concrete in a column what we need to do is to prepare what is called the shuttering across on all the 4 sides have the reinforcing bars here and then pour the concrete and after this concrete has hardened we remove the shuttling. So, that is the principle of it of course, in order to support the shuttering we need to do a lot of other things which is something which is beyond the scope of this course we are sticking to estimation of quantities involved.

So, since we talked of 23 number of RC pillars we have the 23 numbers where a total length of 1.06 for the shuttering is involved having a height of 2.675 this height of 2675 you would recall is the same as the height of the concrete pillar. And the length is 1.06 because we are talking of the shuttering being placed on all the 4 sites basically we are looking at the pillar parameter which is 2 into 0.23 and 2 into 0.3.

Similarly, for the footings we will require shuttering along the perimeter of the footing and a height of 0.25. So, we get a total of 83.61 square meters of shuttering involved in this project.

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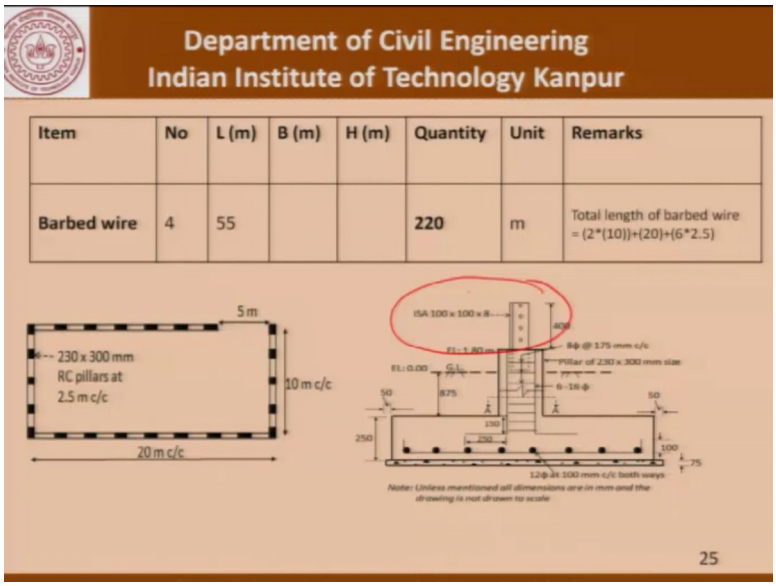

As far as the barbed wire is concerned we have 4 lengths of 55 meters and therefore, we need 220 meters of barbed wire required. So, with this we more or less complete the description of all the items that we listed except the item for is structural steel which is the ISA 100 100 8. I am leaving it as an assignment to you to be able to calculate the quantity of the structural steel angle which is there in the drawing which is this one. So, this is something which are not covered here in the class. And I think I would like you to complete that exercise on your own.

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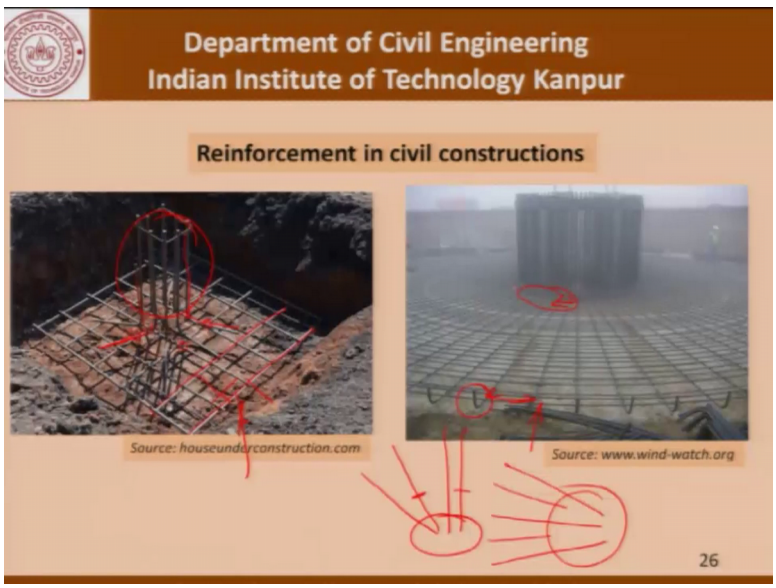

Now, continuing from here there is another is small aspect which we would like to discuss which is related to the reinforcement. In fact, reinforcement has not yet been calculated what is the total amount of reinforcement in the footings and the column. So, that also is an item which is still not done. So, now, before we get into the calculation of the quantities of reinforcement let us understand and how do we actually calculate the quantity of reinforcement.

So, this picture here of this picture here has been shown as an illustration of what the actual reinforcement as placed at site looks like. So, this here is a typical structure of the reinforcing cage which is very similar to what we have put in our drawing we have some bars which are at a certain distance enter the center on both sides and we have this pillar or column which is going to be coming out of the footing. So, basically we are also talking of something similar to this.

Now if we look at this closely we realize that while these bars are straight these bars are not straight they are actually bent and tied at different places. So, these bars cannot be straight they need to be bent for different reasons including being able to have them fixed at that particular location. So, there is the shape of the bars which is very important. Further we must remember that these bars do not come in these lengths what comes from the factory is long bars which could be 6 meter, 7 meters, 8 meters. In fact, the length of the bars as delivered to the site is largely governed by the size of the trucks and the trailers by which the bars are transported and those bars have to be cut to size depending on what is the requirement. So, we need to determine what is the cut length for what length how many bars what shape once we understand that then we are able to calculate the actual quantities involved and all this exercise happens after the drawings are available.

So, making the drawing is perhaps a structural engineer's job, designer's job, but moving from there is something which has to be done at site or now of course, there are software and computer programs which will help you do that kind of estimation. The situation here is something a little more complicated because as you can see it is a radial placement of reinforcement and therefore, this distance here will become much smaller as we approach the center. So, what designers often do is in order to avoid the congestion here they will curtail some bars at a certain distance.

So, what you will have is a bar going here, the next bar going up to this point, the third bar going here, the next bar being curtail in the 4th while going here. So, we should know exactly the kind of lengths of these bars and here you can see there are bent at one side I am not. So, sure it in this picture it is not clear whether they are bent on the other side or not. So, these are the kind of details which have to be read from the drawing and appropriate instruction is given. So, that the bars can be cut and bent.

So, with this background let us try to understand some of this standard shapes that are given in codes.

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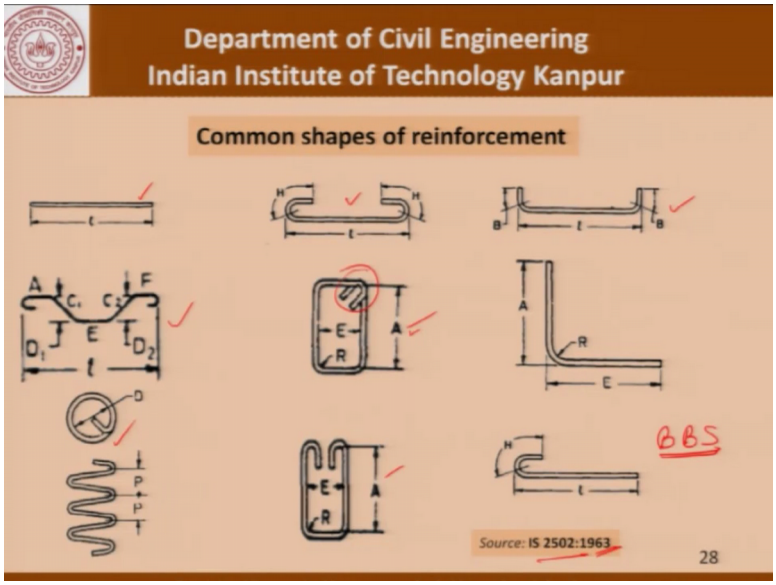

So, this of course, is a straight bar here is a hook this is a simply a bent 190 degree bend those of you who are familiar with reinforced concrete design would understand where these kind of bars are used these are the standard stirrups and from our details see or whatever it was in one of these earlier discussions today we know how this hook has to be provided and this exactly is a helical reinforcement which we use in the columns.

So, once we have this background and IS 2502 is the source for this kind of discussion and you can imagine that this was published in 1963. So, the shape has not changed how to provide those reinforcements how much to provide how much not to provide is all right, but this was something which has been understood the importance of this kind of thing is understood and what we prepare is what is called the bar bending schedule.

So, this bar bending schedule exactly gives you for each diameter of the bar, what is the shape, what is the length and what is the requirement for that kind of steel.

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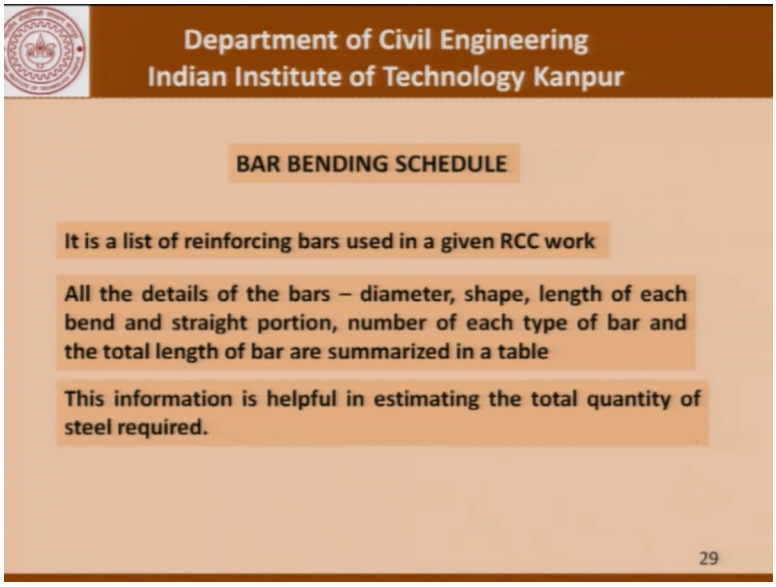

So, now the bar bending schedule list the reinforcing bars used in a given RCC work and also all the details of the bar including the diameter, shape length of each bend and straight portion, the number of each type of bar and the total length of bars are summarized in a tabular form. So, this information is helpful in estimating the total quantity of steel required in NRC work. And now let us quickly run through the steel requirement for in the RC pillars and footings as far as we are concerned in this example.

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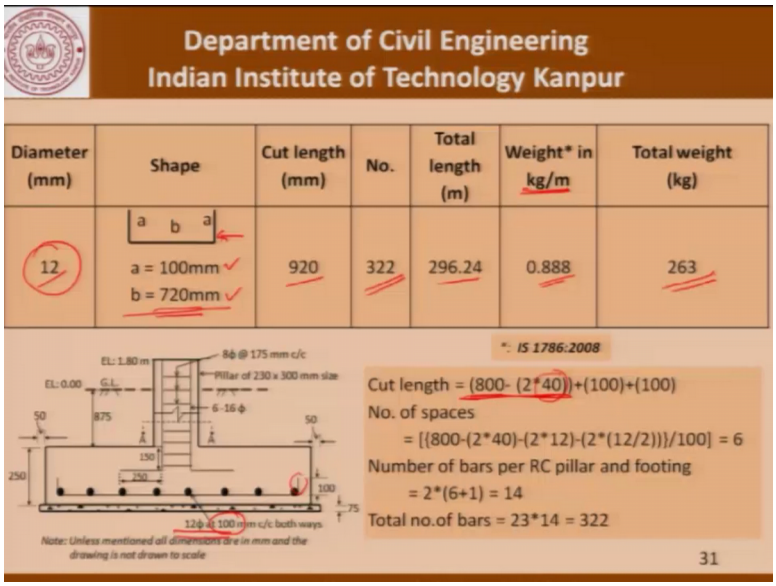

So, the first thing that we take up is the 12 millimeter bars which are to be placed in the footing. So, this is a 12 millimeter bar which we are talking about this is to be placed at 100 mm center to center and this is shown to be in this shape with a and b. So, a is given to be 100, b is determined to be 720. So, this 720 is basically the 800 which is the size of the footing minus 2 times the cover. So, we have given that the cover in this case is 40 mm and therefore, this becomes my straight portion. So, please remember that here we are talking about centerline lengths not extreme lengths and we are going to ignore any effect that is going to come out of bending.

So, if we do that then we have 100 and 720. So, we get a cut length of 920 which is 2 of this plus this then the total number required I am leaving to you to verify is 322. So, the total length of 12 millimeter bars required for the footing is 296 meters this weight which is given in kgs per meter turns out to be 0.888 tones. So, this standard weight which is given in kgs per meter turns out that 263 kgs of 12 mm diameter bars are required.

Now on this you might add 1 percent or half a percent of wastage which will be incurred. You will recall that in one of the lectures we said that the material is not interchangeable. So, if we have 12 millimeter bars in spare those bars may or may not be useful in the pillars. What is given in the footing is 12 millimeter bars here we have 16 millimeter bars 6 of them and we will see how they are placed, but they are in principle not

interchangeable of you want to interchange them yes they will have to be a procedure which you will have to follow.

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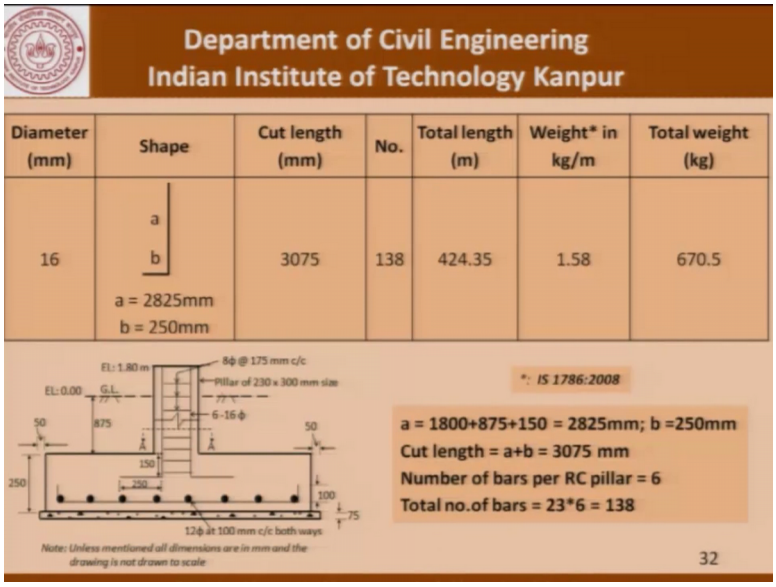

So, coming to the 16 millimeter bars this distance is given to be 250 and we can calculate the length as 2825. So, as far as 138 is concerned you know the number of pillars and the number of bars required for each pillars. So, this gives you the total length of bars required for 16 millimeter bars given their unit weight we know that 670.5 kgs of 16 mm bars will be required.

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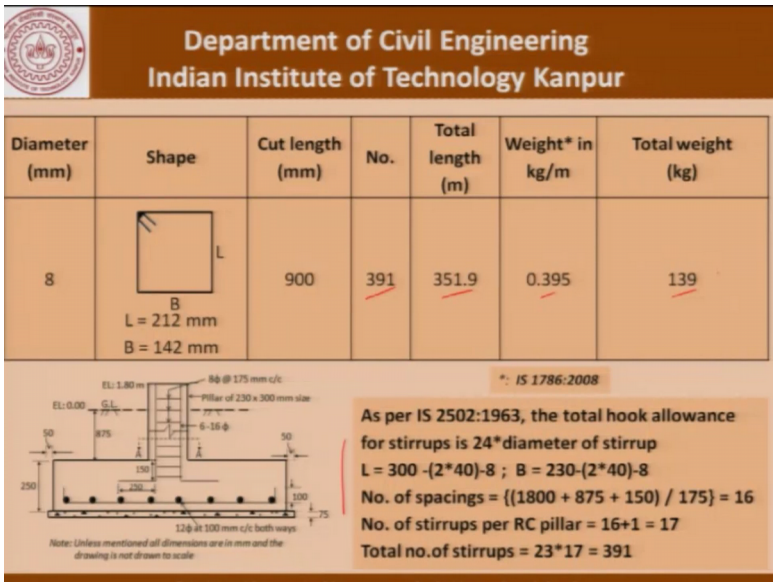

Similarly, if you look at the requirement as far as stirrups are concerned you calculate the length and the breadth from the drawings find out the cut length include the hooks as is given here. And you get the total number of stirrups the total length required from the unit weight you know 139 kgs of 8 mm parts are required.

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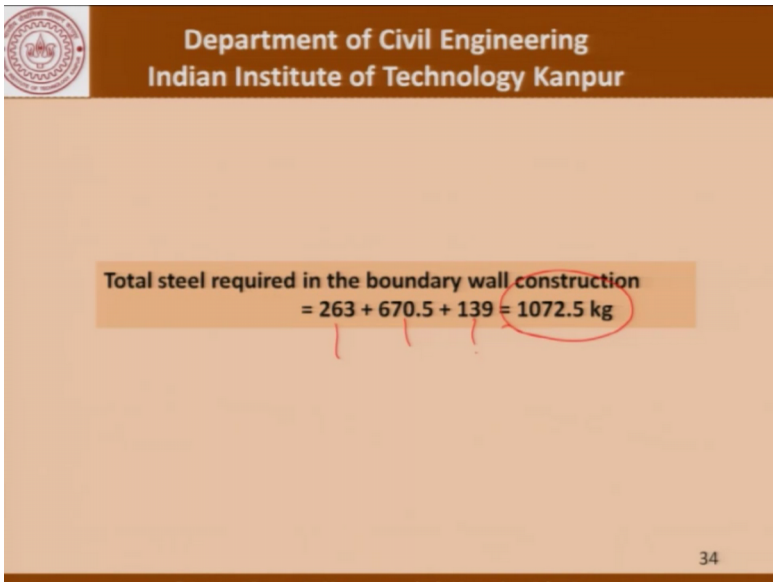

So, once you do that exercise the total steel required in the boundary wall construction is a 1073 kgs. Now on this you may add a few kgs to account for wastages and so on and please remember that unless we have these quantities of the different diameters it will be difficult to complete the boundary wall.

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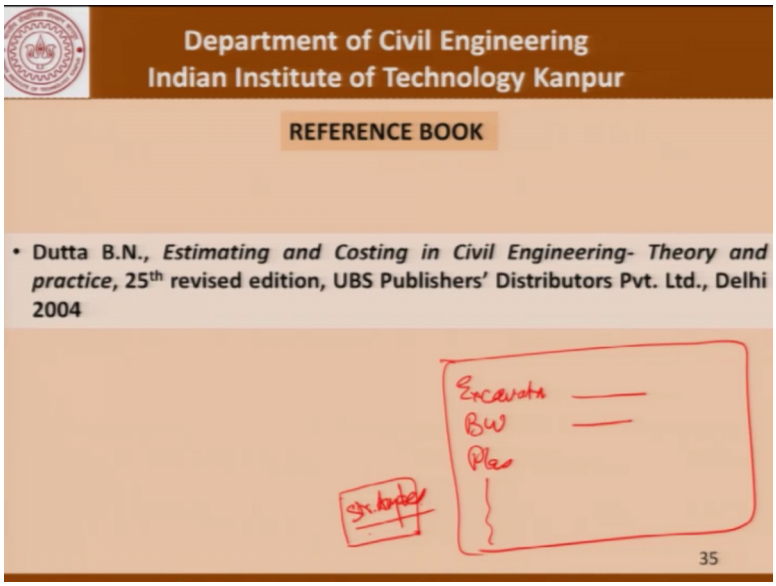

Now, as far as the reference material is concerned for this part of the discussion you can refer to B N Dutta the estimating costing and civil engineering this book is in the 25th revised edition this is just one of the books you can read any other literature and another assignment that I am giving to you is to actually complete the table that ok for this particular project what was the total excavation involved, what is the brickwork involved, what is the plastering involved and so on.

We have calculated all these quantities in the class today and I would like you to complete this table for your own understanding and of course, just recall that there was an assignment on the structural angles, the structural the steel in the form of angles to be provided on the RC pillars.

With this we come to close for the discussion today where we have actually gone through an exercise of a simple boundary wall and calculated the quantities involved.

Thank you.