Foundation Engineering
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Lecture – 23
Shallow Foundation – Design III

In the last class, I was solving a problem or I was designing a isolated footing which was resting on clay and I did the bearing capacity analysis, now, and it was safe against the bearing. Now today I will check whether that foundation dimension that I have chosen it is safe against settlement or not.

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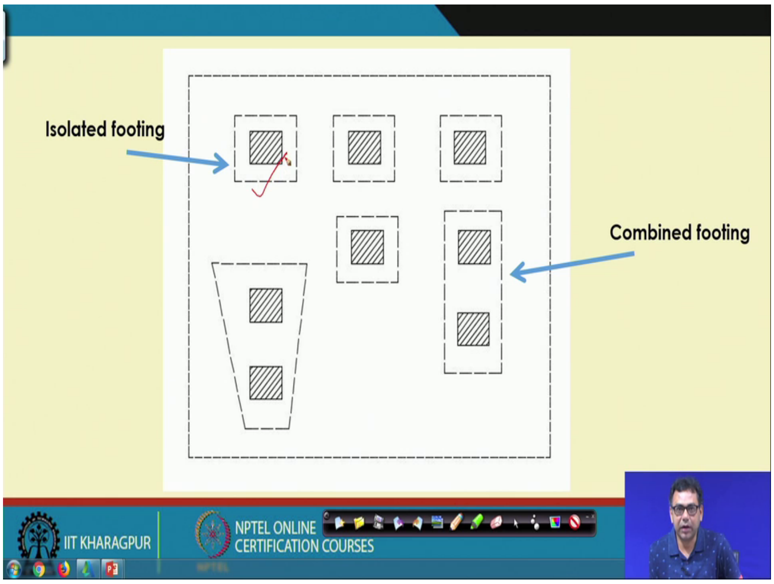

So, as I mention this was the shallow foundation and we are designing a single isolated footing. And the problem was the problem that was taken. So, I am just quickly drawing that problem again.

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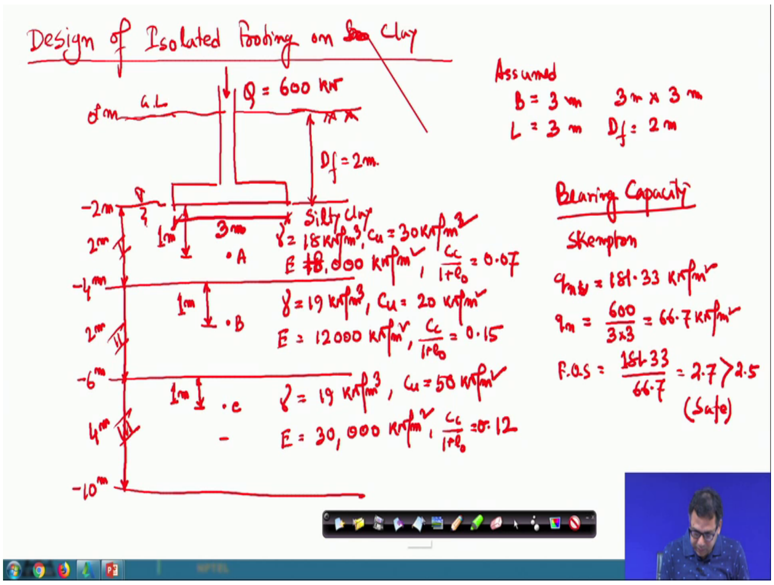

So, this is the ground surface and this was the foundation. So, depth of foundation was chosen as 2 meter. So, this is ground level plus 0 meter this is minus 2-meter water table location was also at 2 meter and there was 3 layer. So, this is layer 1 1 2 and 3 3 layers this is layer 1, this is layer 2 and this is layer 3. And that layer 1 it is silty clay with unit width was 18 kilo newton per meter cube C u value was 30 kilo newton meter square and E value was 18000 kilo newton per meter square. So, this is 18 and the second layer and Cc 1 plus e 0 was 0.07 for this layer 1 and for the layer 2-unit width was 19 kilo newton per meter cube and C u value was 20 kilo newton per meter square E value was 12000 kilo newton per meter square C c 1 plus e 0 was 0.15.

Similarly, for the layer 3-unit weight was 19 kilo newton per meter cube, Cu value was 50 kilo newton per meter square, E value 30000 kilo newton per meter square and Cc by 1 plus e 0 was 0.12. So, this is the problem and the assumed B value was that we assume a B value that is 2; 3 cross and theL value is 3. So, 3 meter. So, it is a 3 meter cross 3 meter foundation or footing and depth of foundation was 2 meter.

So, this was the chosen problem. So, our this width of footing was 3 meter. Now the total load that was coming Q was 600 kilo newton and as I mentioned that this Q is the total load including the self-weight of the foundation. So, if the only weight is given. So, you can add 10 percent of that load as the weight of the foundation. So, here this 600 kilo newton is the load including the foundation load.

So now, when we are checking the bearing capacity we use the Skempton bearing capacity expression and the q net safe was coming out to be or q net ultimate was 181.33 kilo newton per meter square and the q net load or stress that is acting on the base of the footing is 600 divided by 3 cross 3 that is 66.7 kilo newton per meter square and the factor of safety was 181.33 divided by 66.7 it was 2.7 greater than 2.5. So, it is safe the dimension that is chosen it is safe against bearing.

Now, we have to check whether that dimension is safe against settlement or not and the. So, it is a 3-meter width. So, the influence zone for the settlement will be twice of b. So, it will be 6 meter. So, and the this second layer dimension is minus 0.4 meter minus 4 meter then the this layer is 6 meter minus 6 meter this is minus 10 meter. So, the thickness of this portion is 2 meter then the second layer thickness is also 2 meter and the third layer thickness is 4 meter.

So, the influence zone is 6 meter, but total thickness is 4 plus 2 plus 2. So, 8 meter. So, here also the half of the third layer will be in the influence zone for the footing because it is twice b and twice b is 6 meter. So, this is 2 meter then another 2 meter then another 2 meter. So, 6 meter up to this is the influence zone ok. So, we have to take first immediate. So, for the consolidation now settlement calculation you are taking 2 3 points. So, this is B and this is C ABC, A is at this is 2 meter so it will be 1 meter from the base of the footing because it is half of in the middle of the layer. So, B is also 1 meter from this layer and C is also 1 meter from here ok. So, these are the all dimension.

Now, what So, I will take do the immediate settlement calculation. Then, I will do the consolidation settlement calculation and then, I will check whether the total settlement is coming out to be within the permissible limit or not.

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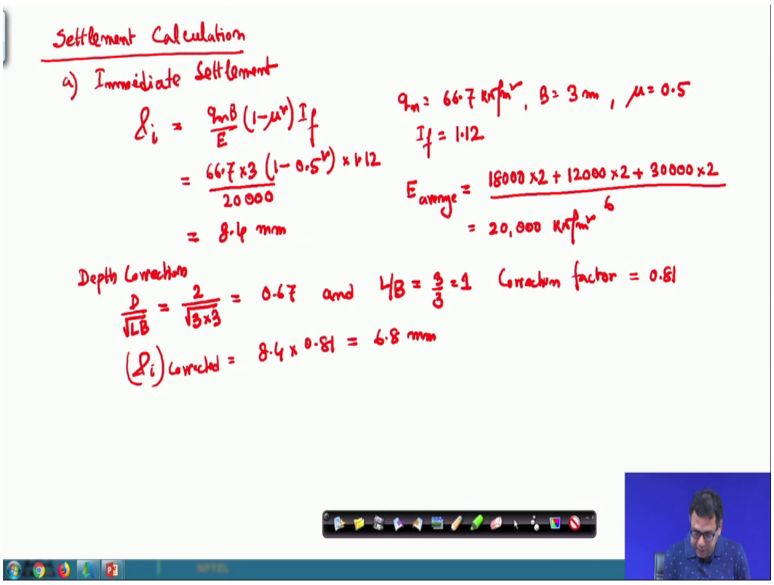

So, next one is the settlement calculation. So, first one is the immediate settlement ok. So, the immediate settlement is q n B by E 1 minus mu square into I f ok.

So, the q n value is given 66.7 kilo newton per meter square and B is equal to 3 meter and for the clay mu value is taken as 0.5 as I mention for the clay we will take the mu value is 0.5 and for the sand we are taking 0.25 to 3 ok. So, last problem I took 0.3. So, the I f value so it is a square footing and the we are taking the center so, the I f value will be.

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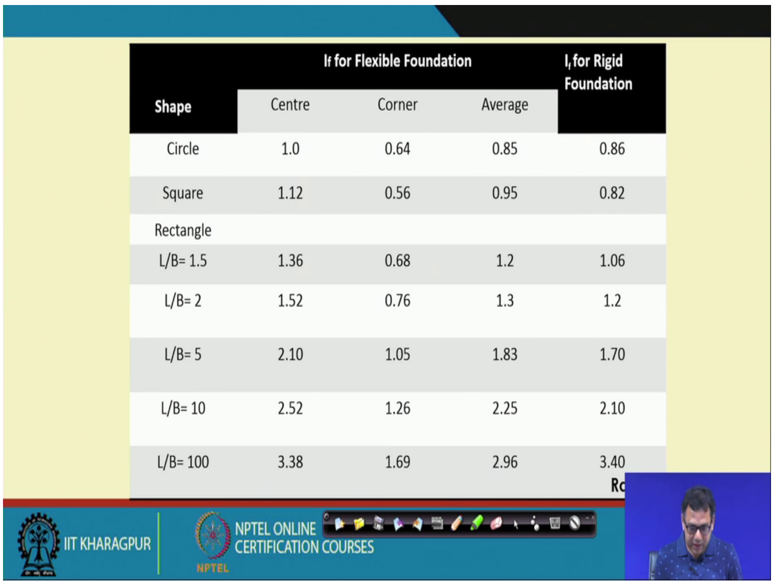

Shape	If for Flexible Foundation			I_f for Rigid Foundation
	Centre	Corner	Average	
Circle	1.0	0.64	0.85	0.86
Square	1.12	0.56	0.95	0.82
Rectangle				
L/B= 1.5	1.36	0.68	1.2	1.06
L/B= 2	1.52	0.76	1.3	1.2
L/B= 5	2.10	1.05	1.83	1.70
L/B= 10	2.52	1.26	2.25	2.10
L/B= 100	3.38	1.69	2.96	3.40

So, from here you can see for the square footing at the center I f value is 1.12 ok.

So, the I f value we are taking from the table is 1.12. So, this table was given so you can use that table. So, the same table I am using this is for the different shape and for the rectangular footing also. So, this is the table for different centre this is corner average and this is for the rigid foundation as I mentioned we are taking the I f value of the centre of the flexible foundation then we apply the rigidity correction as 0.8. So, here also, but it is a isolated footing so, it is a flexible foundation. So, you are taking the centre for the square footing which is one point one 2.

So, next one is that so, q I value will be q n 66.7 b is 31.5 square into 1.12 and for the e value. So, if I go back to the problem so, it is a 6 meter and e value is different for different layers. So, as I mentioned I will take the weighted average of this e value. So, the e value that I am taking e average will be equal to first layer e value 18000 kilo newton per meter square thickness is 2 meter plus 12000 again thickness is 2 meter plus 30000. Again, thickness is 2 meter divided by 6 and that is equal to 20000 kilo newton per meter square.

So, that is 20000, I will use here. So, the calculated value is 8.4 millimeter ok. So now, we have to apply in the in the immediate settlement we have to apply 2 corrections rigidity corrections and the depth correction, but here we will not use the rigidity correction because it is not a rigid footing it is a flexible footing. So, we will apply only the depth correction. So, for the depth correction so, that d by the root over L B. So, D value is 2-meter root over l is 3-meter b is also 3 meter.

So, these value is 0.67 and L by B is equal to 3 by 3 1 ok. So, corresponding correction factor so, we will use the for correction factor and that will get from the fox chart. So, fox chart I have given you and, but still again I can show you.

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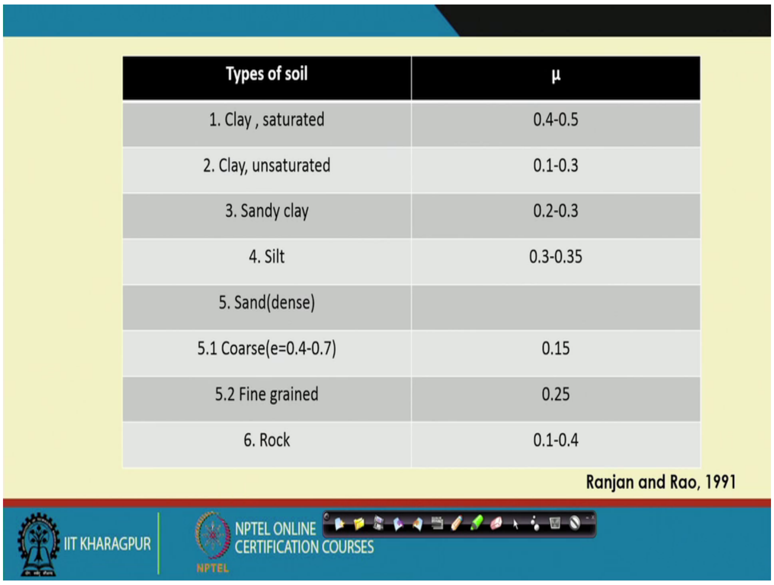

Types of soil	μ
1. Clay , saturated	0.4-0.5
2. Clay, unsaturated	0.1-0.3
3. Sandy clay	0.2-0.3
4. Silt	0.3-0.35
5. Sand(dense)	
5.1 Coarse(e=0.4-0.7)	0.15
5.2 Fine grained	0.25
6. Rock	0.1-0.4

So, this is the this chart also I have given. So, here you can see that for the clay saturated the value of mu is 0.4 to 0.5. So, here that is why I am taking 0.5 for the sand it is around 0.25 1.52 0.25 or you can say take 0.25 to 0.3 also I am taking 0.3.

So, you can take 0.25 also, but I will take 0.25 or 0.23. So, I am taking 0.3.

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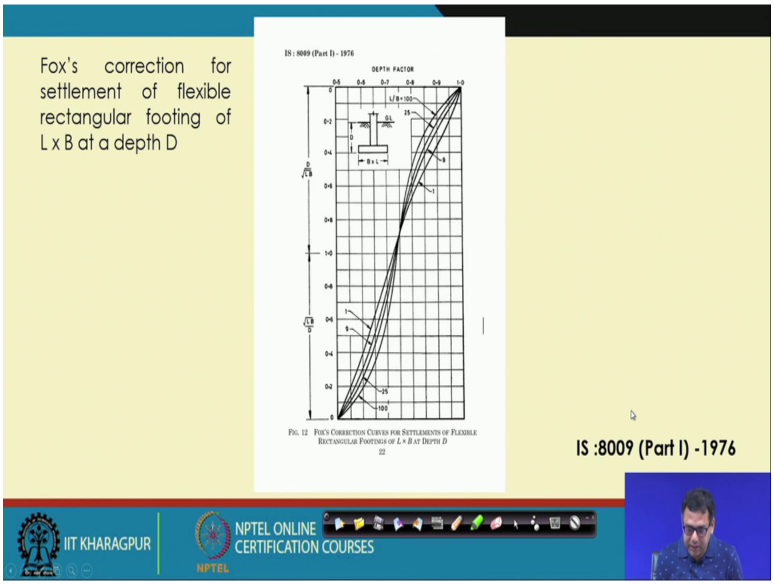

And this is the chart that I will use. So, this is a fox chart so, from here I will get the depth correction. So, the depth correction as it is mentioned you can see that D by root LB. So, this is D by root LB so, that is 0.67 so, 67 will be somewhere here so, corresponding L by D equal to L. So, this is 1 by L by B equal to one this chart line is l by b equal to 1 this is 0.67. So, L by B equal to 1 so, it will take 0.81. So, from this chart I am taking 0.81 this is D root over L by B is 0.67 then this is L by B 1. So, corresponding correction factor is 0.81.

This is the upper portion as I mention in the lower portion, it is root over LB divided by D it is just the opposite. So, that this portion we will use for the shallow foot foundation, this portion will for the deep foundation. Later on, I will use this portion in the problem when we will solve the settlement of a deep foundation or pile foundation. So, so; that means, correction factor is 0.81 ok. So now, the corrected immediate settlement will be 8.4 into 0.81. That is equal to 6.8 millimeter ok. So, corrected immediate settlement is 6.8 millimeter.

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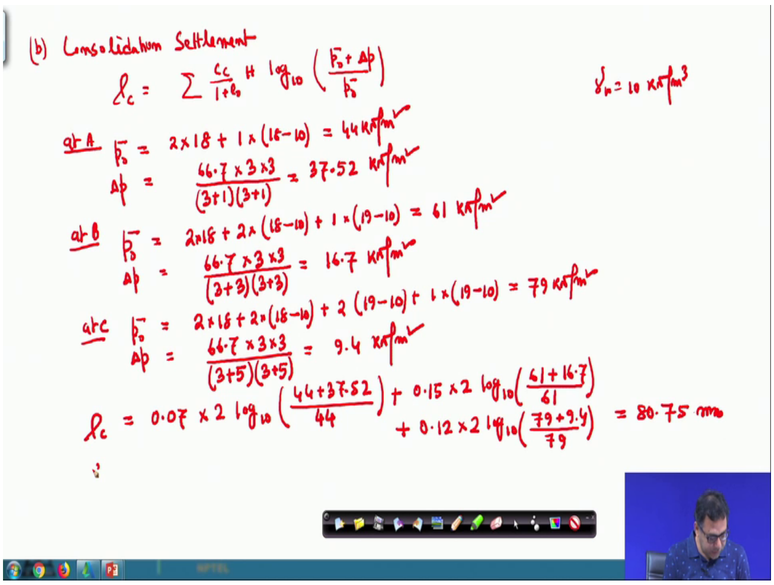

So now, I will do the next part that is consolidation settlement ok. So, the consolidation settlement expression is Cc 1 plus e 0 h log 10 p 0 bar or sigma 0 bar del p divided by p 0 bar. So, I have taken 3 points at the centre of the each layer. So, I will calculate the stresses at point A B and C. So, water table is above is below 2 meter from the ground level. So, this portion I will use the 18 that is the unit weight is given and this portion I will use the sub merge. So, I am taking I will I will take the 18 minus 10 as the unit weight.

So, in this way I can calculate at point a that P0 bar is equal to for the first 2-meter depth 2 into 18 plus. So, if you see the this portion is 2 meter plus 1 meter this is 3 meter from the ground surface. So, this is 2 into 18 plus 1 into this is 18 minus ten. So, here the unit weight of water this is the unit weight of water is taken 10 kilo newton per meter cube; however, you can take 8-point 9.81 also, but all the problems the I am solving I will take unit weight of water 10 kilo newton per meter cube. So, that mean you can take also 9.81 kilo newton per meter cube.

So, this is equal to 44 kilo newton per meter square and del p the same procedure I will use. So, del p will be 66.7 into 3 into 3 divided by 3 plus 3 because 3 plus 1 because it is one meter. So, 3 plus because this depth is one meter from the base of the footing, it will be 3 plus 1 and the other side also 3 plus 1. So, this is equal to 37.52 kilo newton per meter square similarly at b your P 0 bar is equal to 2 into 18 plus 2 into 18 minus 10 plus 1 into 19 minus 10. So, that will be equal to 61 kilo newton per meter square and del p will be 66.7 into 3 into 3 divided by 3 plus 3.

Because now, it is 3 meter from the base of the footing 2 meter plus 1-meter b point is 3 meter from the base of the footing. So, 3 plus 3 into 3 plus 3 so, that is equal to 16.7 kilo newton per meter square. Similarly, at point c P 0 bar is equal to 2 into 18 plus 2 into 18 minus 10 plus 2 into 19 minus 10 plus 1 into 19 minus 10.

So, this is equal to 79 kilo newton per meter square and del p is equal to 66.7 into 3 into 3 divided by 3 plus 5 meter because, now it is 5 meter from the base of the footing plus 5. So, that is equal to 9.4 kilo newton per meter square. So, the settlement value is coming out to be this is for the first layer Cc divided by 1 plus e 0 is 0.07 thickness of the layer is 2 meter and this is log 10 P 0 bar is 44.

Del p is 37.52 divided by 44 then for the second layer it is 0.15 thickness of the layer is 2 meter this is log 10 this is p 0 is 60 1 plus del p is 16.7 divided by 61 for the third layer this is 0.12 thickness of the third layer portion in within the influence zone is 2 meter then log 10 it is 79 plus 9.4 divided by 79. So, the total settlement is 80.75 millimeter so, the correction factor.

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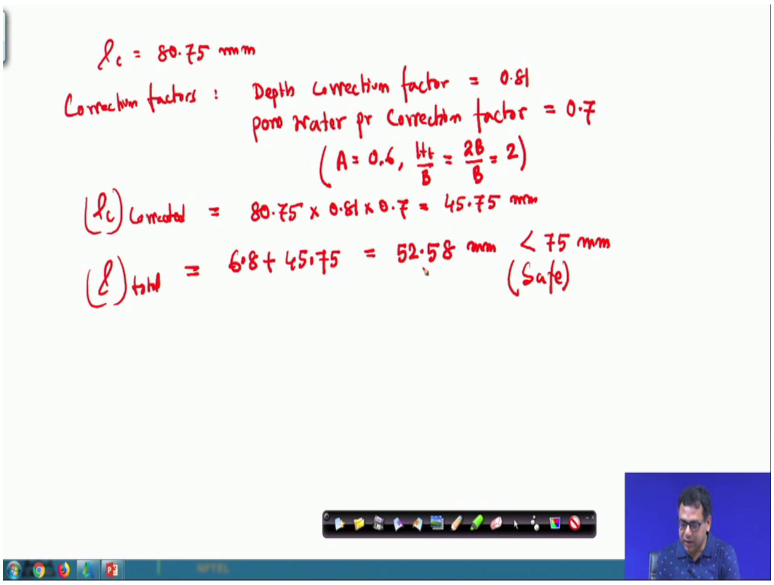

So, next we will calculate the correction factor. So, total uncorrected settlement is 80.75 millimeter and correction factor. So, for the depth correction factor is equal to 0.81 and pore water pressure correction factor is, because we are taking corresponding a value is given as 0.6 and Ht by B Ht by b here Ht is twice B we are taking and B is here.

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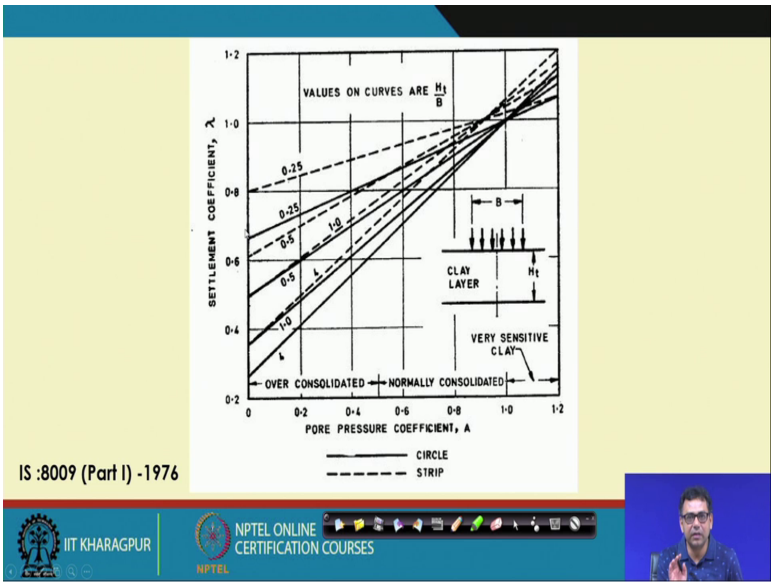

So, it is 2 so now, if I go to the chart then this is the chart where this is the correction factor. And here we are for the circular footing I am using because it is a square footing because here strip for circular is given. So, for that for normally consolidated soil this is a value is point 6 this is the Ht by B of these values. So, this is this is Ht by B equal to 1 this is ht by B equal to 4. So, it is in between that so, 0.6. So, this is the value correction factor is 0.7.

So, the correction factor will be the 0.7. And so, corrected settlement consolidation settlement is 80.75 into 0.81 into 0.7. So, that is equal to 45.75 millimeter. So, the settlement total is equal to 6.8 plus 45.75. So, that is equal to 52.58 millimeter. So, in the permissible settlement part I have given that for the isolated footing rcc on sand permissible settlement is 50 millimeter and for rcc isolated footing on clay or sensitive clay here it is that type of clay where it is soft clay. So, or medium clay thus permissible settlement is 75 millimeter.

So, our settlement is less than the permissible settlement as per the is code. So, our design is safe. So, it is safe against bearing it is safe against settlement also. So, the dimension that I have chosen is safe. And so now, another thing I want to say that sometimes this dimension may be over safe also. So, you have to redesign that, but here it is not over safe because your factor of safety is 2.7, which that limit is 2.5. So, it is it is not over safe we can say in bearing- in terms of bearing, but in terms of settlement it is 50 degree 75 it is slightly you can increase the settlement further by reducing the dimension, but for the bearing purpose you cannot further reduce the dimension.

So, the dimension that I have chosen is almost and safe as well as economical because our in design criteria this is 2 things we have to make this foundation such that it is safe against bearing and settlement as well as it is economical. So, here we can we can choose the this dimension because it is a safe against bearing as well as the settlement. So, this is the isolated footing part and then I want to say few thing that. So, yes so, as I mentioned. So, these tables I have used for the purpose of let me check another thing that I will.

I am coming back on these tables. So, we have done the isolated footing part now similar way you can you can design the combined footing also suppose we have a combined footing of this type where there is the 2 columns and we can use as that combined footing and such that you can design in such that, the load is acting at the centre or the centroid of that footing and then you can take the summation of the all load that is acting on the centre and then you design it as a rectangular foundation or if it is 2 strip on narrow then you can choose as it is a strip footing also ok. So, and the regarding this correction table these are the tables I have used.

So, this is the, for the if value. So, I have taken 1.12 I have used these values and for the flexible square footing. And then as I mentioned we can take the poison ratio of the clay as 0.5 and for that sand it is 0.3, but here it is given the for the fine sand it is 0.25. So, 0.25 to 3 you can choose. So, I have taken 0.3 and then.

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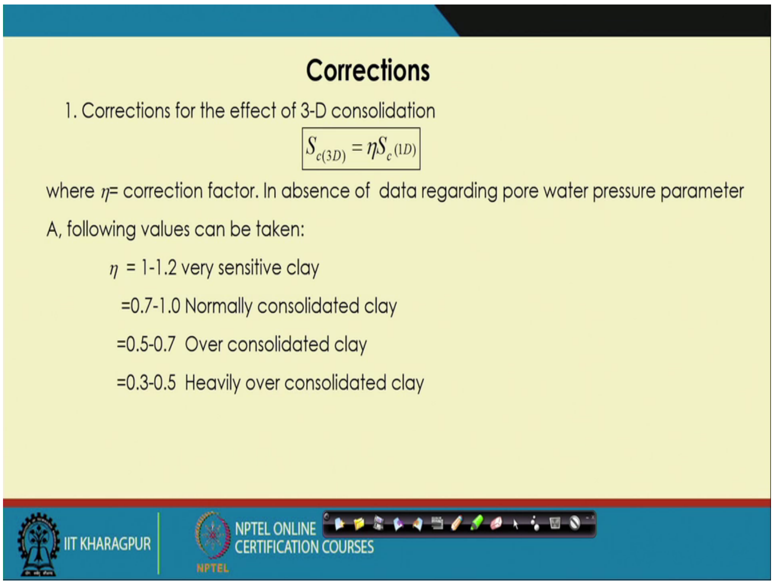

This is the correction factor for the. So now, we are using the 3 correction factors. So, for the depth- one is rigidity correction factor that is always we are taking 0.8 and that is applicable only for the rigid foundation or raft foundation. And another is pore water pressure correction which is applicable for the consolidation settlement and you can see that for a normally consolidation settlement if a value is given is 0.6. So, this point normally consolidation settlement 0.7 a reasonable value. So, that I have used even in the this chart also this is the correction factor.

Ah this connection factor range for the normally consolidated soil is also 0.721. So, that is why if nothing is given. So, so you are a value is not available and ah. So, you can in that case for normally consolidated soil you can take pore water correction factor as 0.7 which is reasonable if a value is not available, but e value a value is available then you have to use the chart that I have used in this problem, but if a value is not available.

So, for normally consolidated soil you can take pore water pressure correction as 0.7 which is a reasonable value and all the designs. Here, I am I am doing on normally consolidated soil and which is the most of the cases we will find the soil is normally consolidated.

So, that is why you can take 0.7 reasonable value if nothing is available and then for the and if the a value is available then you can use this chart that I have used for the determination of pore water pressure correction factor for or it is a pore water pressure correction factor and then next one is that and third correction factor is the depth correction factor.

So, you can use this chart that I have used. So, all the problems I will not show that the chart I will just mention that I am taking from the chart. So, this is the chart that I am using I have explained these things in previous lectures also. So, again I am explaining. So, this is the chart I am using. So, this is the upper portion of this chart is applicable for shallow foundation and lower portion of the chart will be used for the deep foundation settlement calculation. So, this is that just 1 by you can see d root over LB and this is root over LB by D.

So, in few books you may find this is lb root over d which is not correct. So, this is the correct form that you have to use because it is a non-dimensional form ok. So, that that why that is why we are we have to use this chart and then next one is, we are talking about the yes. So, we are talking about now the combined footing so now, in the next class I will discuss how I will choose the dimension of a combined footing then I will design raft foundation resting on clay.

Thank you.