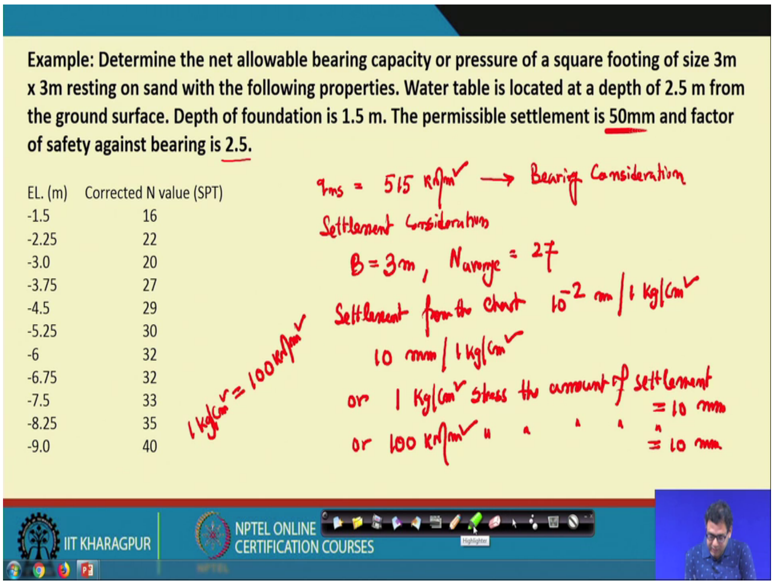
Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 22
Shallow Foundation – Design II

So, last class I have discussed that how I will design a isolated footing on sand and based on the N values for different depth that was given.

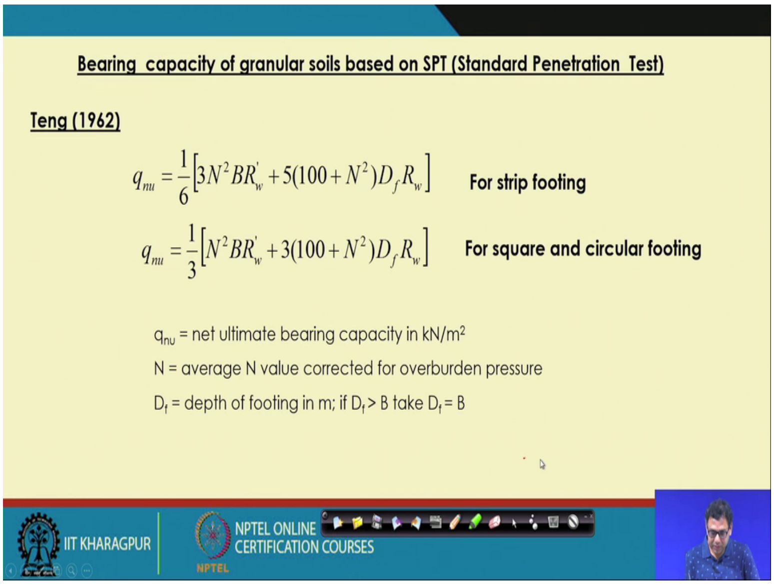
(Refer Slide Time: 00:32)



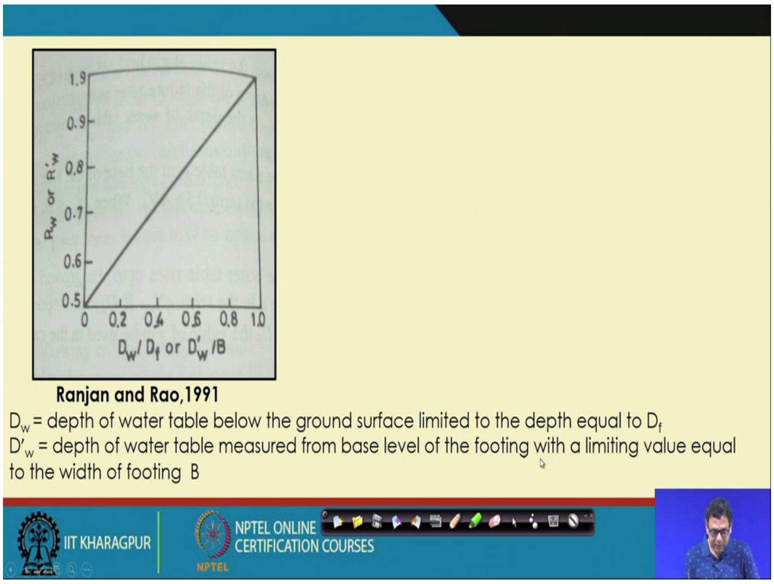
So, this so this is the problem; that was given the determine the net allowable bearing capacity or pressure of the square footing of size 3 meter cross 3 meter resting on sand with the following properties and water table location was 2.5 meter from the ground surface, depth of foundation was 1.5 meter, permissible settlement was 50 millimeter and the factor of safety against bearing was 2.5 and this is the N values were given.

So, from the from the bearing capacity consideration, we got net safe bearing capacity was 515 kilo Newton per meter square. So, that was the net safe bearing capacity we are getting. And we got and this is in terms of bearing consideration bearing capacity or bearing consideration and for the settlement consideration, so we are getting that for the width of foundation is equal to 3 meter and we have the N average is 27 and corresponding settlement so, from the chart was 10 to the power minus 2 meter for 1 kg per centimeter square ok. So, or we can write in terms of millimeter 10 millimeter for 1 kg per centimeter square or I can write that for 1 kg per centimeter stress the amount of settlement is equal to 10 millimeter or I can write for 100 kilo Newton per meter square that is for 1 kg per centimeter square is equal to 100 kilo Newton per meter square; stress the amount of settlement is 10 millimeter square ok. So, this was the case we finish in the last class.

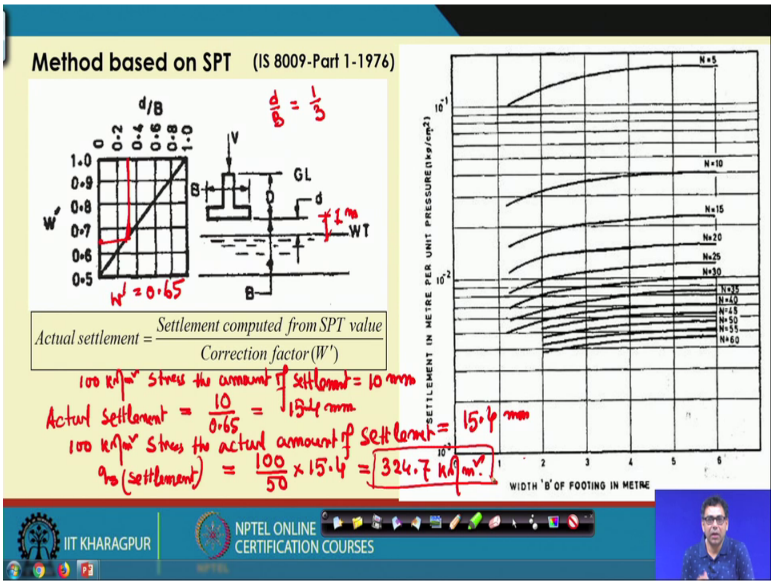
(Refer Slide Time: 03:27)



(Refer Slide Time: 03:28)



(Refer Slide Time: 03:30)



So, now from here we will start the other things and then what we will do that we will go for this chart. So, this chart we know and from this chart, so our it is given that for 100 kilo Newton per meter square stress, the amount of settlement is 10 millimeter ok, but there water table affect was not introduced; but here water table is 1 meter, so water table is 1 meter. If this is the water table so, water table is 1 meter below the ground surface because water table one no not below the ground surface, water table is 1 meter below the base of the footing or 2.5 meter below the ground surface.

So, 1 meter below the base of the footing so, here you can see. So, you have to use this chart. So, here there is a term d by B; so d is that water table depth from the base of the footing, in other case we are using d w dash. So, that d w dash here d both are same.

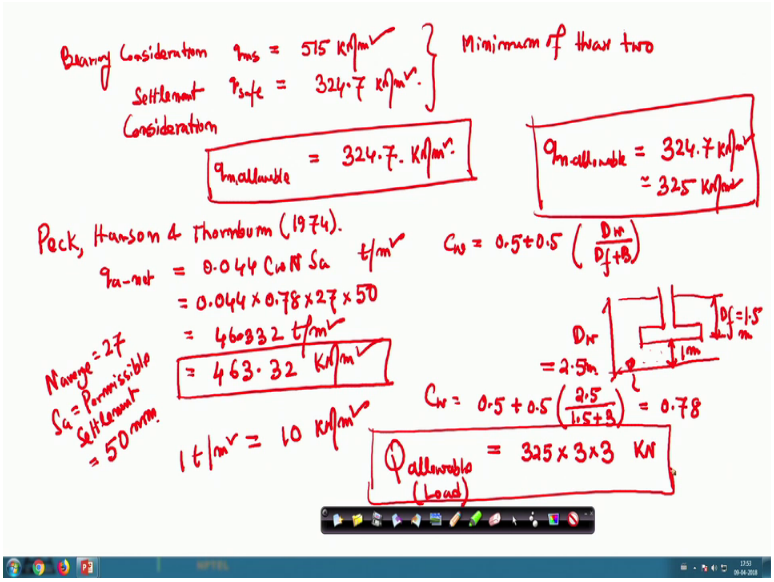
So, remember that in this problems we are using different notation in different cases and because these are the chart this is been developed this way. So, we have to use those notations only. But I am explaining that what is the similarity of the notations, what are the difference between these notations. So, here d or d W dash both are same. So, if this is the d by B, so we have to use this chart. So, here d value is 1, B value is 3. So, again from here, so if this is again this value is coming out to be again this is 0.65; so, W dash is 0.65 ok. So, this is the similar chart we used for the bearing capacity purpose also. So, but here it is given the similar kind of chart in different way it is been represented; so but we have to use them and you should know, what are the meaning of different notations.

So, similar chart here also it is 0.65, previously also it is 0.65 that r W dash was 0.65 for the bearing consideration here W dash because there r W dash here W dash both are same so, but you have to use you should know how it is been used because in different way it is been used. So, that mean this is the W dash is given 0.65. So now, your actual settlement because this is the settlement computed from the SPT value. So, the actual settlement will be settlement computed from the SPT value is 10 meter millimeter and the correction factor is 0.65. So, as I mentioned for the settlement, you have to divide with the correction factor because then it will increase the settlement because in the settlement water will always create a negative effect. So, and for the bearing, you have to multiply with this correction factor because bearing capacity will be reduced because of the water table rise.

So, this is the 10 so; that means, the our settlement is 15 point actual settlement 4 millimeter. So, for 100 kilo Newton per meter square stress, the actual amount of settlement is actually 15.4 millimeter so, but your permissible settlement is 50 millimeter. So, you are getting 15.4 millimeter settlement for 100 kilo Newton per meter square stress, then my the question is what would be the stress for which you will get the 50 millimeter settlement? So, that stress will be your allowable stress in terms of or safe bearing capacity in terms of settlement because we I am getting we are getting 15.4 millimeter settlement for 100 kilo Newton per meter square stress. So, what would be the stress? I will get a 50 millimeter settlement. So, that stress will give me the safe bearing capacity in terms of settlement.

So, the q ultimate or q safe in terms of settlement will be equal to that we are getting for 15.4 millimeter settlement for 100 stress kilo Newton per meter square stress, then 50 millimeter settlement for which stress? So, you will get this is 100 divided by 50 into 15.4. So, that is given 324.7 kilo Newton per meter square ok. So, this is the stress safe bearing capacity that I am getting in from the settlement consideration so; that means, we have two stresses now; one is from the settlement consideration, one is from the bearing consideration.

(Refer Slide Time: 10:07)



So, if I so if I now go for this our problem that for the bearing consideration q net safe is 515 kilo Newton per meter square and q safe for settlement consideration is coming out to be 3247 kilo Newton per meter square. So, minimum of these two these two because this is the maximum stress the foundation can take in or soil can take in terms of settle a bearing capacity and this is the maximum stress foundation can take in terms of settlement consideration. So, minimum of these two will give you q net allowable. So, this q net allowable will be 324.7ok kilo Newton per meter square. So, this is the net q allowable.

Now one thing is that; so, this is we have considered the bearing and settlement separately, then based on that we calculate this things. Now as I mentioned in the last class that we can use directly the N value to calculate the net allowable bearing capacity directly. Here we are getting the net allowable bearing capacity based on settlement and the bearing consideration, but directly we can also get the net allowable bearing capacity by using the expressions based on the N value.

So, I am so I have given three expressions. So, I am using the first one, let us see what is the because those values are given. So, if I use the Peck Thornburn and Hanson and Thornburn expression. So, that will be given so, I can use if pick Peck, Hanson and Thornburn which is given 1974, their expression is q allowable net or net allowable is equal to point 0.44 C w N S a ok. So, this is in ton per meter square [noise;] n is the average N value, S is the permissible settlement and c W is given is equal to 0.5 plus 0.5 into d w divided by d f plus B. What is d W? Again I am writing that this is the position of the water table which is 1 meter below the base of the footing, this is d W which is 1.5 meter and so, the d f this is d f 1.5 meter, this is d W sorry the d W is from the ground surface.

So, d W value is from the ground surface so, d W will be equal to 2.5 meter. So, I can get c W is equal to 0.5 plus 0.5 into d W is 2.5, d f is 1.5 plus b is 3 meter. So, this is 0.78. So, now, if I put this value here this is 0.044 c W is 0.78 and here which one you will consider? Here I will consider the twice B part because here both settlement and the bearing is considered. So, you have to take the influence zone as a twice B. So, if the influence zone is twice B, then my n average value is 27. So, you have to take the 27 and the permissible settlement because my N average is 27 and a is the permissible settlement is equal to 50 millimeter ok. So, I can write this is 50. So, this value is 46.332 ton per meter square, this is 46 point or it is 463.32 kilo Newton per meter square because your 1 ton per meter square is equal to 10 kilo Newton per meter square.

So, if I use if I directly calculate this thing, so it is given 463. So, now, you compare these two, directly you are getting 463 and from the settlement consideration, we are getting 324.7 here also it is here 2 different approaches we are using. So, now, so from here, the ultimately I will use this is my load carrying capacity or the net allowable bearing capacity because that is giving the lowest ok. Now and the so; that means, that finally, I will provide the q net allowable will be equal to 324.7 kilo Newton meter square or 325 kilo Newton per meter square. So, this is the final recommendation based on we are getting ok.

So, here based on the available data we have used the spt value correlations those are given. So, based on I have directly I have calculated, I have calculated in terms of bearing, I calculated in terms of settlement there formed their the minimum value I am getting. So, in the assignment or your exam it will be given that whether you use the directly this expression or nothing is mention, then you use all these methods and then, get the allowable bearing pressure ok. So, this is the so now, based on that now it is this is your dimension of the foundation, now you can get what would be the amount of load will come. So, finally, the I can say that q allowable this is the load. So, this will be your 325 into the area is given 3 cross 3, this is the 3 cross 3. So, that is the kilo Newton will be your the q allowable. This is the load, the foundation can take.

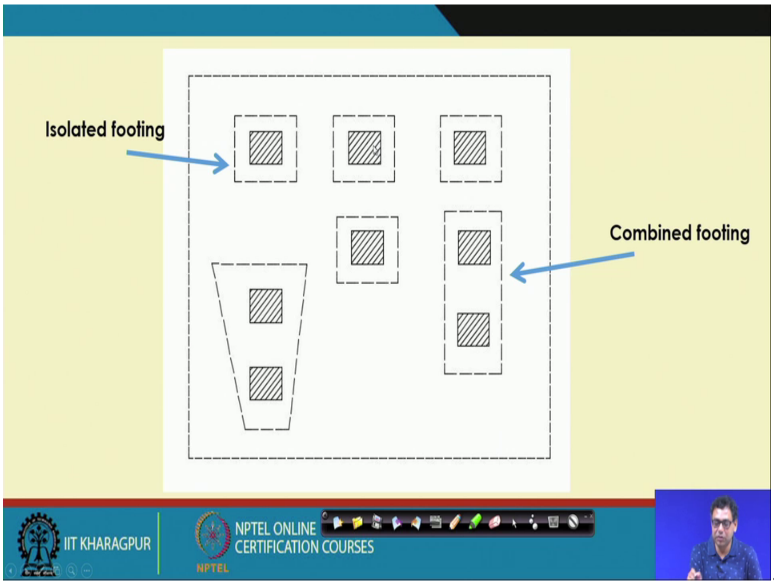
So, your foundation this foundation can take this much of kilo Newton load that is why your bearing will be, there will be no bearing capacity failure and the settlement is also within the permissible limit. So, this is the final recommendation that are given. So, you this is the design load that you have to design your foundation. So, you have design your foundation. So, this is the maximum load you can apply as a design load on the foundation. So; that means, we are here we have first fix the dimension, then we recommend a design. In other way also you can do it that you have the load is given, you can choose the dimension because in this the in that case it will be a trial and error process because first trial you choose a dimension. If it is satisfying all the criteria's fine, then you go for the next; if it is not satisfied, then you go for the next dimension.

So, here as I mentioned so I will give you the how to you will calculate the dimension of foundation or depth of foundation. so, in your design part ok. So, this is the design of a isolated footing resting on sand and we have designed it based on the N value because in most of the and it is on the sand. So, based on the N value we have designed it.

So, in the next part that I will discuss I will design isolated footing which is resting on clay, here it is on sand next one I will go for a isolated footing which is be resting on clay and then, I will design a raft foundation which will be also resting on clay ok.

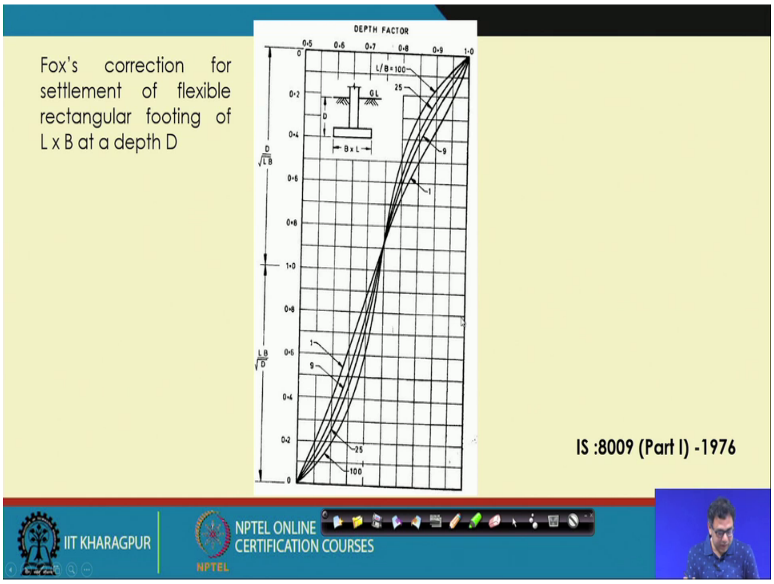
So, here also if it is a raft foundation, then also you can do it for the sand, but here I am 50 why I have I have been written 50 because for the rcc in the permissible value RCC on sand or hard clay the isolated footing the permissible settlement value is 50 millimeter. So, that is why I have taken permissible settlement value as a 50 millimeter.

(Refer Slide Time: 20:53)



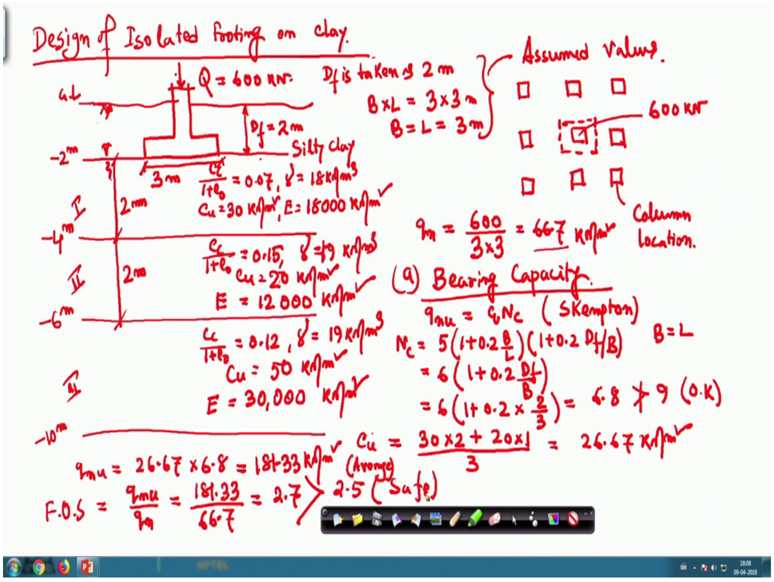
So, the next problem that I will discuss that foundation isolated footing on a on a on a clay. So, these are typical columns of a total building. So, what is isolated footing, if I if I if I design a foundation for a individual footing. So, there is a possibility that two footings may overlap.

(Refer Slide Time: 21:14)



So, in that part, I will go for the combined foundation. So, combined foundation can be rectangular, combined foundation can be trapezoidal depending upon the requirement and if I take all the columns in one foundation, then that will be the raft foundation.

(Refer Slide Time: 21:52)



So, first problem that I will go for it is for the problem. So, design of isolated footing which is resting on clay ok. So, we are designing suppose I have as mentioned that we have say, this is the location of column of a building. This is the column location. So, we are going for a single footing for each column and we are say and we are getting that this is sufficient because there is no overlap. Suppose first we try it and then see whether there will be overlap or not; if there is a overlap, then we have to go for the raft foundation.

So, first we are getting central column we are getting where the load is coming say 600. So, in the center column load is coming 600 kilo Newton ok, so that load is coming. So, we are going for a isolated we have decided that we will go for a isolated footing ok. So, let us the footing for each column. So, what we are doing that I do not know, here in the last problem that I have solved on sand. There we knew the dimension of the footing and the based on that we recommended what will be the permissible load on the foundation, but here we are doing the other way. You can do that you can solve that problem also in other way, but it is in different way I am I am showing that so, can so can so, that you can do it in different way also.

Here I know that load and I have to design the foundation according to that load and based on the available soil properties, but it is on the clay. So, that the in the amount of load that is acting is Q is 600 kilo Newton and we are assuming that these load because these 600 kilo Newton is including the footing weight. If the footing weight is not given it is only the load coming from the superstructure, then you have to the weight of the footing also you have to add ok. But here we assume that this Q is including the footing weight ok.

So, now this is the this is the G L, ground level. So, this is ground level and the depth of footing I do not know because we have to decide and the so, the location of water table is at minus 2 meter. This is the location of water table 2 meter below the foundation, 2meter below the ground level and we have three layer soil system.

So, this is the first layer which is minus 4 meter, then the next layer which is minus 6 meter, this is the another layer which is minus 10 meter and this is the depth of foundation I do not I do not know, but for the first trial what I have taken that I will place the foundation at 2 meter below the ground level. So, for the first trial I have taken. So, D f is taken or chosen as 2 meter because what so that all the soil is the Silty clay ok, all the soils are silty clay with different properties.

So, properties are given the C c 1 plus e 0 is equal to given 0.7, then unit weight of water is given kilo Newton per meter cube 18 kiloNewton per meter, cube C u value is given 30 kilo Newton per meter square and E value is given elastic modulus of the soil 18,000 kilo Newton per meter square. This is for the layer one.

So, layer two again C c plus one plus e 0 is 0.15, then unit weight of the soil is 19 kilo Newton per meter cube, this is 19, C u value is given 50 kiloNewton per meter square sorry, this is u value is given here it is 30, S u value is given 20 kilo Newton per meter square and E value is given 12,000 kilo Newton per meter square.

For the third layer, C c 1 plus e 0 is given 0.12, unit weight is given again 19 kilo Newton per meter cube, C u value is 50 kilo Newton per meter square and E value is given 30,000 kilo Newton per meter square ok. So, here I have decided for the first trial that I will take the D f as 2 meter and the dimension of the isolated footing is taken 3 cross 3 meters. So, it is a square footing where B is equal to L equal to 3 meter ok. So, this is the trial one.

So, let us see whether it is safe or not ok. So, so; that means, here this is these are these 3 are assumed value for the first trial. So, the 600 so 600 kilo Newton is the total load including the footing weight. So, mine q net load that is acting on the on the foundation is will be 600 in divided by 3 cross 3. So, this will be 66.7 kilo Newton per meter square. So, first we will do the bearing capacity calculation. So, first we have to see whether it is safe in bearing capacity or not. So, we are doing bearing capacity bearing capacity.

So, as these foundation is resting on clay only. So, we have discussed about number of bearing capacity expressions, we have discussed Terzaghis bearing capacity expression, Meyerhof bearing capacity expression, Hansen, Vesic and is code and, but we have also discuss a bearing capacity expression which is Skempton bearing capacity expression which is specifically you can be used for the clay.

So, I will use the Skempton bearing capacity expression here, but you can use the other bearing capacity expressions also you can use the Terzaghi, but here I will use the Skempton because it is specifically proposed for the clay and this is the only clay soil. So, the Skempton bearing capacity q net ultimate is C N c or the C u N c. This is the Skempton bearing capacity expression ok. So, N c value I will get by for the for the rectangular footing is 1 plus 0.2 b by l into 1 plus 0.2 D f by B.

So, that can be converted per square footing if you put B equal to l. So, here B is equal to l. So, if you put B equal to l, so this expression becomes 6 into 1 plus 0.2 D f by B. So, which is the expression for the square footing and so; that means, here we are taking that 6 1 plus 0.2 D f is taken as 2 meter and B is 3 meter. So, it is coming out to be 6.8 and 6.8; so which is not greater than 9, so it is because that value should not be greater than 9 for the square footing it is recommended. So, it is not greater than the 9, so it is.

So, now, what we will do say that that C u value, we are taking as the average C u value because here 3 layer soil system and for this is for the first here is 3 meter. So, for the bearing we are talking about for the bearing the influence zone will be 3 meter. So, influence zone will be 3 meter for the first layer thickness is this is 2 meter below the base of the foundation, it is 2 meter, this is also 2 meter ok, but our influence zone is up to 3 meter only. So, for the bearing so C u average C u value or weighed average C u value will be that your first layer 30 into 2 meter plus second layer 20 into 1 meter because influence zone is up to 3 second layer and this is divided by 3. So, C u value is coming out to be 26.67 kilo Newton per meter square.

So, finally, q net ultimate that we are getting is C u is 26.67 and N c is 6.8 so, that value will be equal to 181.33 kilo Newton per meter square. So, this is the net allowable and net ultimate bearing capacity and the stress is coming is 66.7 kilo Newton per meter square ok. So, the factor of safety will be the q net ultimate divided by q net stress that is acting, so 131. 33 divided by 66.7 which is equal to 2.7 ok. So, which is greater than 2.5. So, my design is safe ok.

So, this is safe against bearing, but we have to check whether this is safe against settlement or not ok. So, we have checked it and the dimension that I have taken. So, it is so these dimension footing it is safe against bearing, but we have to check it whether it is safe against settlement or not.

So, in the next class I will see I will check these dimension whether it is safe against settlement or not and then we will provide the final recommendation of these dimension of these shallow foundation.

Thank you.