Foundation Engineering
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Lecture - 25
Shallow Foundation – Design V

So, in the last class I have discuss about the Design of a Raft Foundation Resting on Clay and today in that class calculated the bearing capacity and the immediate settlement. Today I will calculate the consideration settlement and before that there is a small change in the value that was given in the last problem. So, what is that? So, this was the problem.

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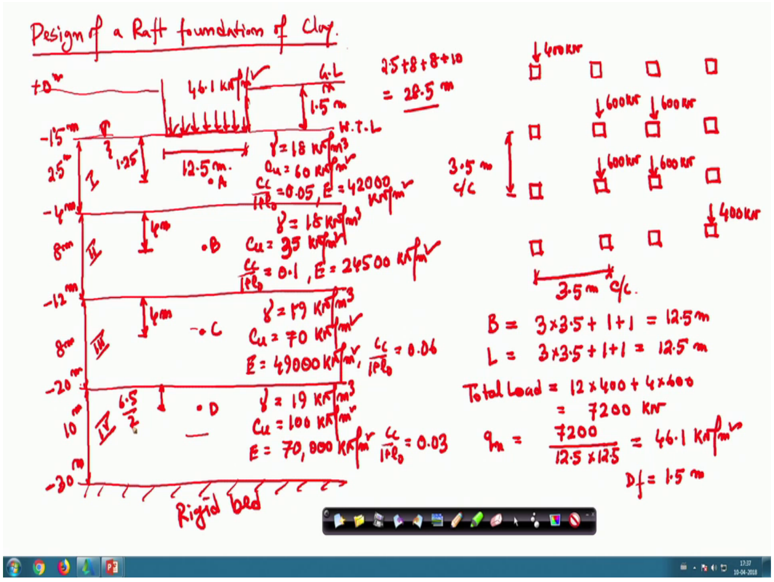

So, the change is that so, this was taken 25 kilo Newton per metre square actually it is 35 kilo Newton per metre square. So, please change that. So, this Cu for the second layer is 35 kilo Newton per metre square ok. So, still that is the lowest Cu that among the all layers. So, these value is 35 kilo Newton per metre square that is the change.

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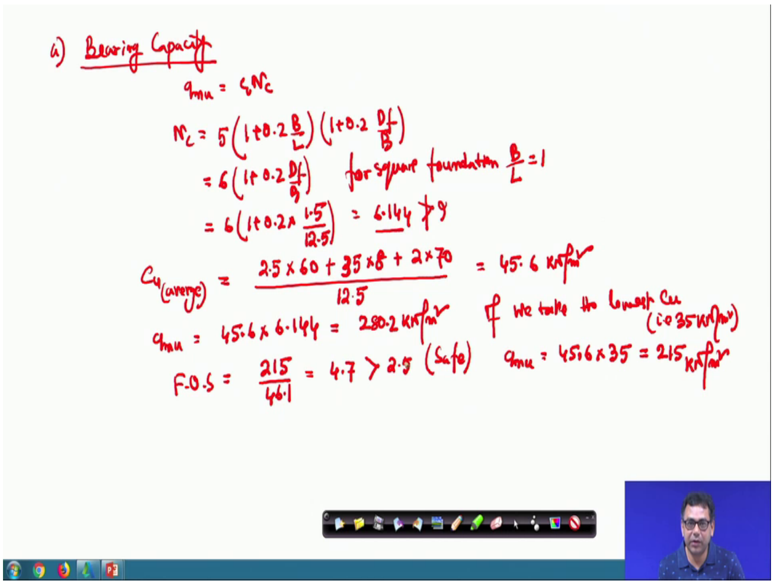

So, that is why during the calculation of Cu average I have taken this will be the 35 kilo Newton per metre square. So, this will be 35 into 8 so, then this value will be 45.6. So, just correct that this will be 35 kilo Newton per meter square and another thing is that that in nq term, if I use 46.7 then this will be also change this will be 280.2 kilo Newton per metre square. So, if I use 46 point 45.6 kilo Newton per metre square, but if I take if we take the lowest Cu that is 35 kilo Newton per metre square then the q n q will be 45.6 into 35 that will be equal to 215 kilo Newton per metre square.

So, here you can see that if I take the lowest Cu value because, that is the maximum zone of the soil that is influenced by this foundation is the second layer which is 8 metre and there Cu is lowest. And that Cu is the 35 kilo Newton per metre square then it will be 215, but if I take the weighted average then it will be 45.6.

So, now if I take the 215 then factor of safety is 4.7 which is quite high. So, and if I take 46; obviously, that will be higher. So, that is why I have taken the lowest value, but because that is safe and then this is greater than 2.5. So, it is safe it is over safe so, but let see whether it is how much safe it is against settlement.

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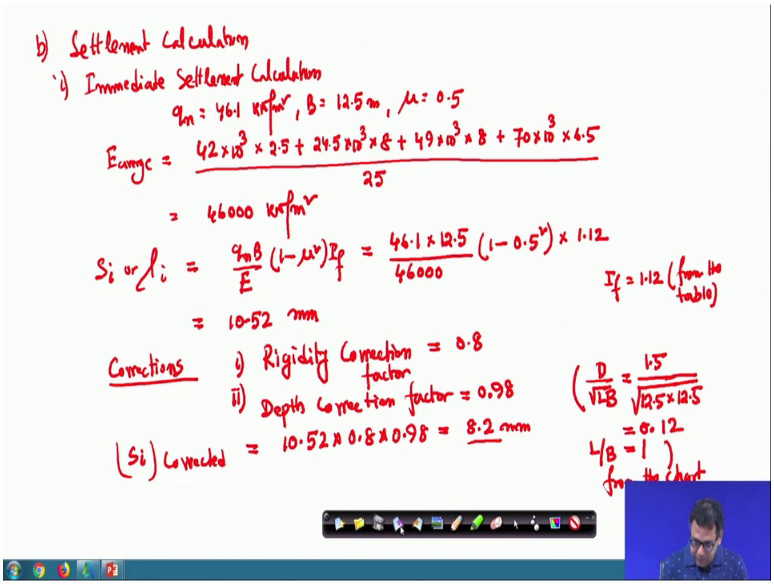

So, that that is why I have calculated the immediate settlement also and immediate settlement is coming out to be 8.2 millimetre and then we will go for the consolidation settlement, that is consolidation settlement ok.

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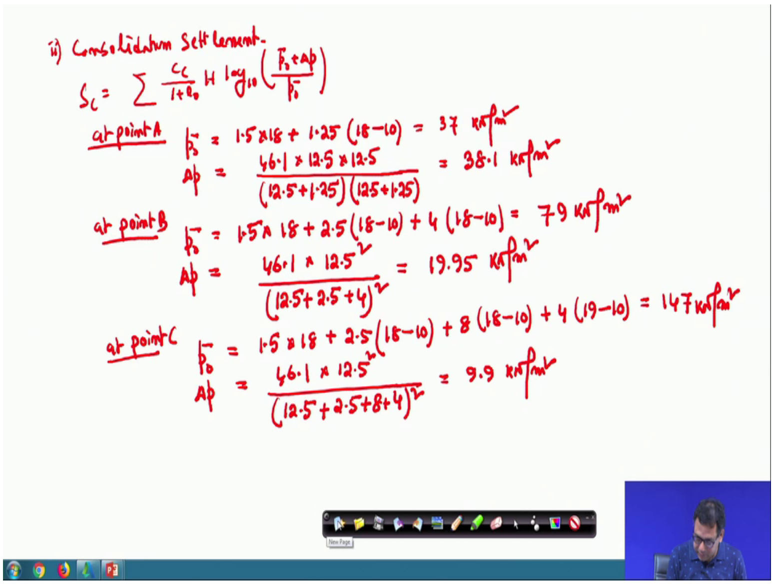

So, in the consolidation settlement what the expression is same that is S c is equal to C c 1 plus e 0 H log 10 p 0 bar plus del p divided by p 0 bar and so, in this problem so, again I am just quickly explaining that we have to take the points middle of this layer. This is A point, this is B point, this is C point and this layer is up to 6.5 so, this is D point ok. So, this point is distance of this point from this centre is 1.25, 1.25 from this base of the footing and this one is 4 metre and this one is also 4 metre, because these are the thickness is 8 metre; here it is 6.5 is the thickness.

So, this will be D is 6.5 divided by 2. So, now similarly I am just calculating the stresses at different point. So, at point A so, the value will be the p 0 value will be your 1.5 into 18 plus 1.25 18 minus 10 ok so, that is equal to 37 kilo Newton per metre square and del p the same process I will use that is 46.1 because my q n is 46.1 into 12.5 cross 12.5 divided by 12.5 plus 1.25, 1.25 into 12.5 plus 1.25 ok. So, that will be equal to 38.1 kilo Newton per metre square.

Similarly, at point B p 0 bar will be 1.5 into 18 plus 2.5 into 18 minus 10 then it is 4 metre so, and unit weight is 18. So, this will be plus 4 into 18 minus 10 that is equal to 79 kilo Newton per metre square and del p is equal to 46.1 into 12.5 square divided by 12.5 plus 2.5 plus 4 that is square; I am taking square because it is a it is a square foundation. So, that is equal to 19.95 kilo Newton per metre square.

And point at point C the value is p 0 bar is equal to 1.5 into 18 plus 2.5 into 18 minus 10 plus this will be the 8 into 18 minus 10, then for the third layer it is up to 4 then 19 minus 10. So, that is equal to 147 kilo Newton per metre square and del p is equal to 46.1 into 12.5 whole square divided by 12.5, then plus 2.5. Then the total thickness will be the C point C point thickness is 2.5 plus 8 plus 4 to C point position. So, 2.5 plus 8 plus 4 and that is square so, that will be 9.9 kilo Newton per metre square.

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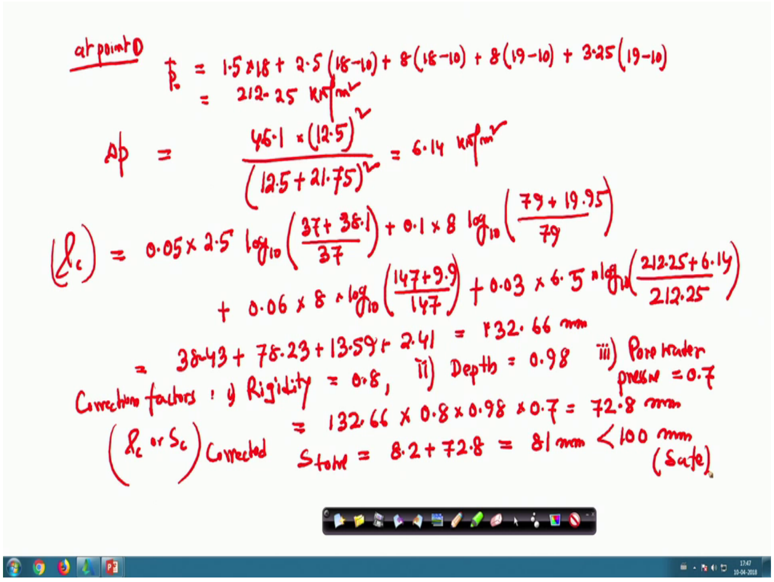

Similarly, I can go for the next layer at point D, the p 0 bar is equal to 1.5 into 18 plus 2.5 into 18 minus 10 plus 8 into 18 minus 10 then plus 8 into 19 minus 10 plus 3.25 into 19 minus 10 3.25 it is the 6.5 divided by 2. So, that is 212.25 kilo Newton per metre square. And similarly, the del p value is 46.1 into 12.5 square divided by 12.5 plus 21.75 square 21.75. How it is coming because the position of D point is 21.75 metre from the base of the foundation, because this is 2.5 8 metre, 8 metre and 3.25 metre.

So, that is total 21.75 meter from the base of the foundation 6.14 kilo Newton per metre square. Now, the p c value uncorrected I can write for the first layer 0.05 and the thickness of the first layer is 2.5, then log 10 this value is p 0 is 70 37 del p is 38.1 divided by 37. Then plus 0.1 for the second layer, second layer thickness is 8 metre then log 10 p 0 is 79 plus 19.95 divided by 79. Then for the third layer it is 0.06, thickness is 8 metre and then log 10 147 plus 9.9 divided by 147.

Then for the third layer 0.03 thickness of that layer up to the influence unit is 6.5, then the log 10 this is 212.25 plus 6.14 divided by 212.25. So, the settlement are 38.43 plus 78.23 plus 13.59 plus 2.41 total is 132.66 millimeter ok. So, and the corrections factors so, the first one is the rigidity. So, the rigidity correction factor is 0.8, then the depth which was taken which was determined as 0.98 and the pore water pressure nothing is mentioned. So, I can take as I mentioned that 0.7 is a reasonable value. So, for the pore water pressure it is 0.7 is taken, it is a normally consolidated clay

So, Q c or S c corrected is equal to 132.66 into rigidity is 0.8, depth correction factor is 0.98 into 0.7. So, that is equal to 72.8 millimeter. So, S total corrected is 8.2 plus 72.8 so, that is equal to 81 millimeter. And the permissible value of the settlement of raft resting on this clay, say this is this type of clay is given as per IS code is 100 millimeter. So, which is less than 100 millimeter and that is safe ok. So, here the dimension that I have chosen and I started with the minimum both side dimension 1 meter, that is required for you design because from the column edge I have taken only up to the 1 metre.

So, and that is a reasonable dimension that I have taken up to the edge of the column foundation from the centre of the edge column to the edge of the foundation I have taken 1 meter. So, further reduction is not recommended and the value settlement value is quite close to 100 millimeter. So, that is why the dimension though it is over safe in the bearing, but the, for settlement the dimension that I have chosen is reasonable. If you look at this settlement value which is 81 is the total settlement which is and the permissible is 10 millimeter so, which is reasonable.

So, this is the total design of a raft foundation again I am talking about the design means, I am saying that design means the dimension and the depth of foundation I am talking. So, here the depth of foundation is 1.5 meter, dimension of the raft is 12.5 cross 12.5 and which is given reasonable value.

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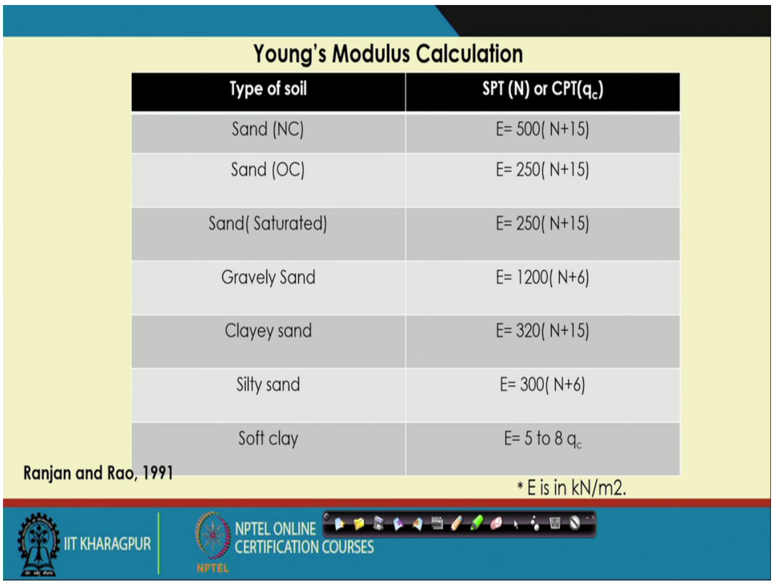

And I have mentioned that if nothing is mentioned, E value is given in if E is value is value is not given in the clay problem, then I can take 700 or 750 Cu for the normally consolidated clay. Similarly, for the sand also I can use this chart, I have given this chart also. So, I can use this chart from where if the SPT value is available from there also I can get this N value. We can use this chart this in a corrected SPT value.

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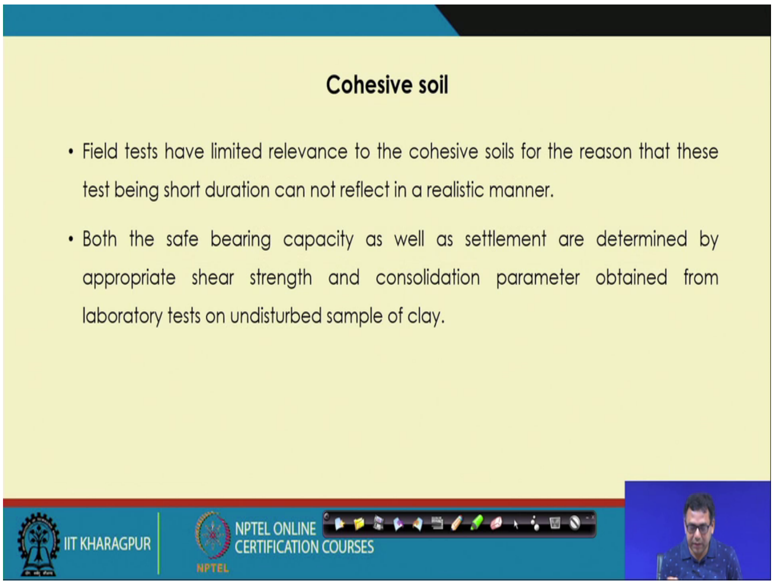

And few things I want to mention that for the sandy soil I can use the in-situ test data because, as I mention they are the in-situ testing that we can do and which is useful for the sandy soil.

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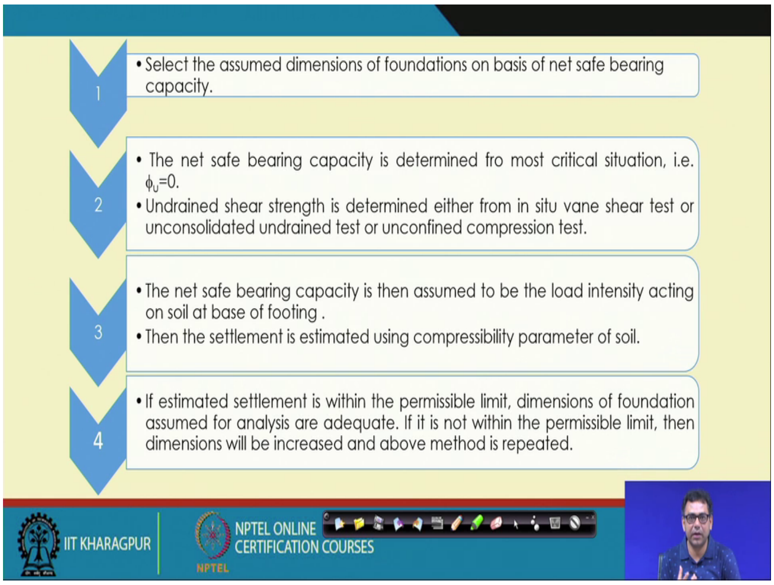

But for the clay soil I can determine the bearing capacity and the settlement based on the properties, that we are get properties of the soil sample that you are getting from the field. Because, the undisturbed soil sample we can collect from the field then you will take it to the lab and then you will do the test as a unconsolidated undrained u test or the unconfined compressive strength in the lab. Or I can do the field vane shear test in the field to get the undrained shear strength and that shear strength I can use to determine the bearing capacity and the settlement calculation.

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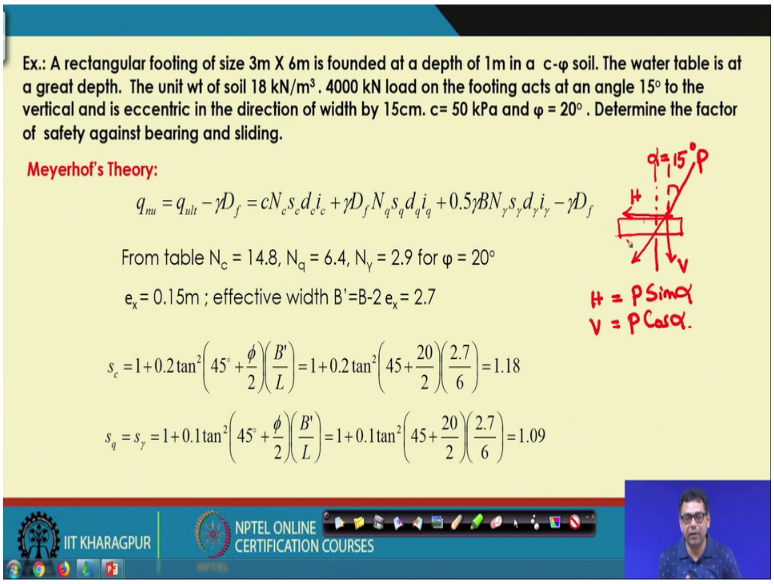

So, next one that I will solve another type of problem that till now I have discussed that your load is not eccentric, not inclined ok. So, the load that you are talking about which is acting on the centre of the footing and which is totally vertical. Now, what will happen if my loading is eccentric as well as inclined or eccentric or inclined either any of them or both ok. So, I have chosen the same problem that I have discussed in lecture 13 during the bearing capacity calculation for the by using various methods.

So, a rectangular footing of size 3 meter cross 6 meter it is depth of foundation is 1 meter it is on c phi soil. The water table at a great depth so, that is why water table effect is not incorporated here. But if the water table is there then you know how to incorporate that becuse I have solve us that water table effect problem also. The unit weight of the soil is 18 kilo Newton per meter cube, 4000 kilo Newton load is acting on the footing with an angle of 15 degree to the vertical and eccentric in the direction of width by 15 centimeter; c is 50 kPa and phi is 20. And determine the factor of safety against bearing and sliding also. So, what is sliding? I will explain that. So, here because your loading is not perfectly vertical it is inclined.

So, a horizontal component will come as in addition to the vertical component. So, vertical components we have to use for the bearing check and horizontal component we have to use for the sliding check. Because, when your safe that this is now in this case your if this is the foundation base, now the loading is this is the centre. So, loading is making an angle 15 degree with the vertical. So, what will happen this load has two components; one is the similar to if this is the loading, one is the horizontal component, one is the vertical component. This is the H horizontal component, this is the V.

So, your H is equal to if this is the P is load is acting P sin alpha, here this angle is this angle is alpha which is equal to 15 degree and V will be equal to P cos alpha ok. So, this V I will use for the bearing capacity check and H I will use for the sliding check. Because, when your there is a horizontal flows force is acting into the foundation so, there is the possibility that this because of this horizontal force foundation can slide along this phase ok.

So, that slide also I have to check. So, I will discuss these things and then what I am doing a an another that I will use the various available bearing capacity expression and see then where I will use B or the total weight, where I will use the effective weight, because all the bearing capacity expression are not giving the same thing. So, we have to be very carefully handle them. So, that is why I have chosen this problem; where it is inclined as well as eccentric. Now, in case of eccentric as I mentioned that if the loading is say eccentric; eccentric means here if I am talking about this is your footing is, if this is the centre then your load is acting here not at the centre.

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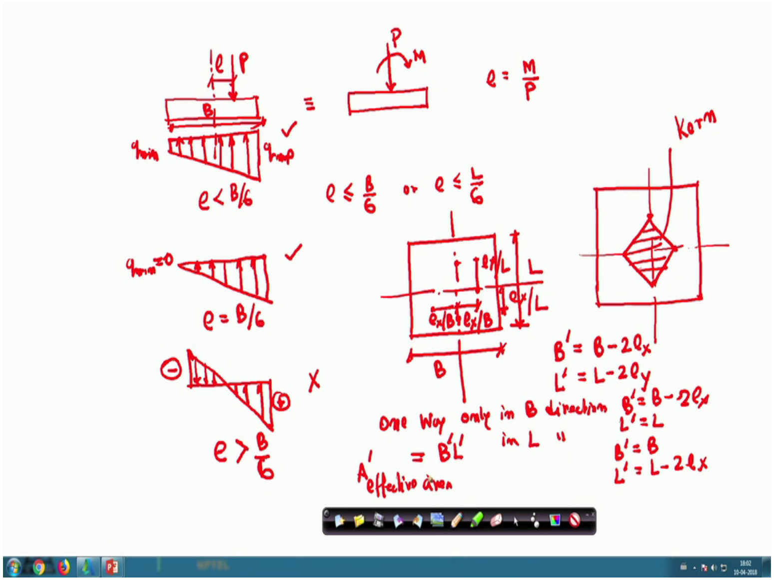

So, this is eccentric say as I say value of e. So, now, there is a one thing that how it can be simulate that if loading is acting here say, but additional to there is a moment is also acting ok; that we can represent by this P e with an eccentric loading and the e value will be M by P. So, now here in this problem directly e value is given, but in another way that your load is given which is acting in the on the foundation vertical load P as well as a moment is also given. In that case we have to convert it to in this form; that means, your e value is moment by the speed so that will be the e value.

And another thing is that so, when you are apply a eccentric load then your distribution of stress below the face of the below the base of the footing is not uniform. It will because, here it is expected as the load is acting this side though your stress at the right side will be more compared to the left side. So, that your stress distribution will be something like this ok and I have mentioned this thing that then there is a possibility that this stress distribution can be negative also and we do not want that negative one. So, that is why you have to keep our e value is less than equal to B by 6 or e value is less than equal to L by 6 ok.

So, if the because here it is mentioned eccentricity in the width direction so; that means, it will be B by 6. If eccentricity in the length direction this will be L by 6 ok. Now, eccentricity can be in the width direction, can be in the length direction or it can be in the both ok. So, that is why if I draw this diagram so, this diagram is valid if your e is less than B by 6 ok. So, if you say this is the width and if I draw this diagram then this diagram is valid for e is equal to B by 6 ok, the stress diagram. So, this is q max, this is q min and here q min is equal to 0.

So; that means, here this is the so, eccentricity 0 and after that we allow. So, now, another condition may occur that it is like this also so; that means, it will in the opposite direction it is. So, this is the positive, this is the negative. So, it is valid if it is happen if e is greater than B by 6, but we will not in this particular design or course we will not consider this one. So, we will design it for either this one or this one ok, but you can design the foundation if the e value is greater than B by 6, but that procedure is not included in this course.

So, this is the part of the advanced foundation engineering, but here in this course we will consider that we will not allow any load beyond this B by 6 or L by 6. So, I will we will consider design under this condition. So, another one if in the plan if it is the one way eccentricity, suppose this is your width direction and this is your length direction ok. So, in the here it is mentioned it is in the length direction, some eccentricity is there sorry width direction. So, with the width direction this will be the value say e x by B; because if I talking about the width direction.

So, this is also a value say e x by B and this direction also a point this will be e y by L and here also some point which is also e y by L ok. So, specifically as I mentioned that I can, if you use within this zone then there will be no negative stress in the foundation within this zone. So, the specifically I can say if you put your foundation, if it is two way eccentricity that this port these two points and so, it is a diamond shape. So, this is this shape is called the kern.

So, if you place your foundation within the kern then there will be no negative force will allow will happen and you can use these expression because, in that case because when you are your loading is eccentric your width and the length of the foundation that will also change. Now, instead of B I will use B dash. So, B dash will be B minus 2 e x and L dash will be L minus 2 e a y. So that means, either if one way eccentricity one way only in B direction then this will be B dash will be equal to B minus 2 e x and L dash will be L.

So, and if it is in L direction then B dash will be equal to B and L dash will be L minus 2 e x. If it is both direction then it will be the expression ok. And finally, our effective area this is called effective area is equal to B dash and L dash. If it is in eccentricity in width direction then it will be B dash into L. If eccentricity in the length direction then it will be B into L dash, if eccentricity in the both direction, it will be B dash into L dash ok. So, this way I can design of foundation.

So, next class I will design this foundation under this load that is mentioned in the problem and I will use all the available bearing capacity expression. And then we will find which method is given what value and how I will implement these things in the correction; that is the shape correction and depth correction eccentricity correction. And because, in the all the methods this application of the eccentricity and the inclined are not same in the correction factor. So, that those things I will explain in detail in the next class.

Thank you.