Advanced Foundation Engineering
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Lecture – 38
Design of Shallow Foundation – III

So, last class we are discussing one example problem that where the SPT values are given with the depth for a particular site and then we have a foundation of 2 m × 2 m square foundation, then we have to determine the allowable bearing capacity of that foundation or that soil.

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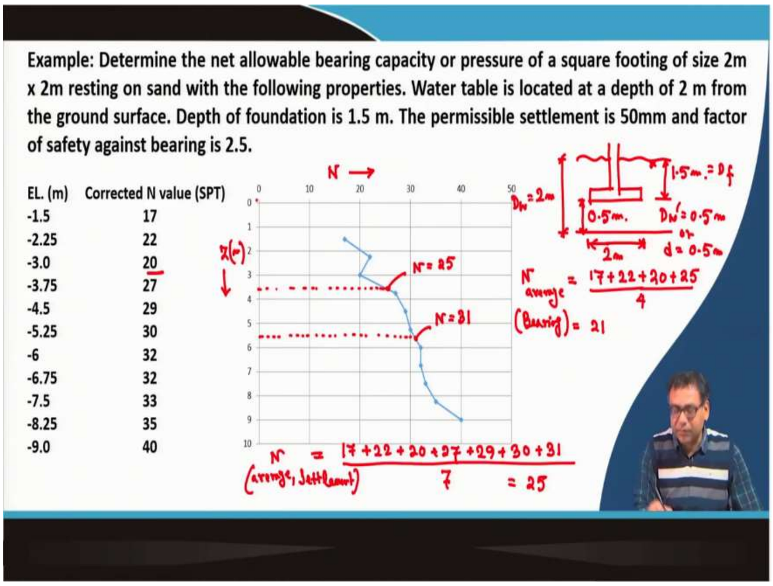

Now, this is the problem where this is a variation of the depth and the depth of foundation is 1.5 m and the water table position is 2 m below the foundation. So, the permissible settlement is 50 mm and the factor of safety in bearing is 2.5 because the permissible settlement while it is taken 50 mm because as per IS code isolated footing on sand the permissible settlement is 50 mm. So, that I have discussed in the last class. So, that is why I am taking the permissible settlement as 50 mm.

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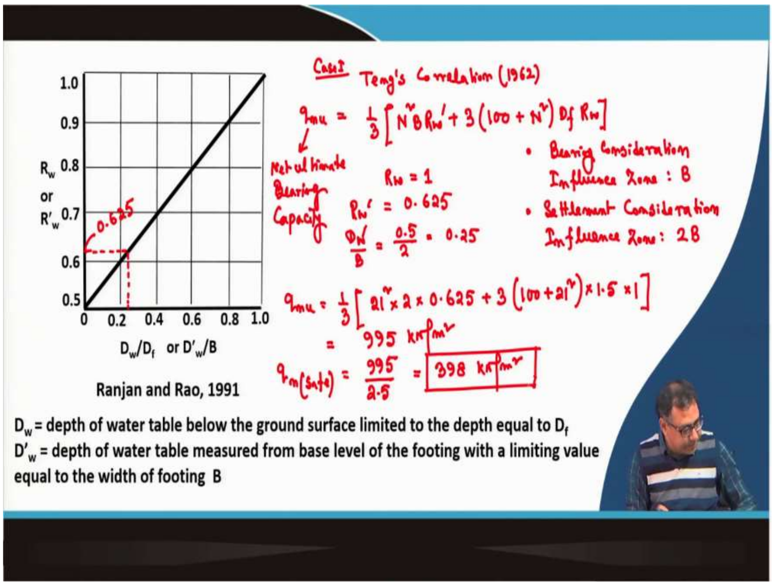

So, now, first case, we; have used Teng's correlations. Now, here this is the correlations now, we have to use the influence zone for bearing. So, this information is also very important that for bearing capacity consideration the influence zone is B width of the foundation from the base of the foundation and for settlement consideration the influence zone is $2B$ below the base of the foundation.

So, that means when you consider only bearing, then you will consider the influence zone of the foundation as B from the base of the foundation and we will consider the settlement then the influence zone is $2B$ from the base of the foundation. So, Teng's correlation is only considering the bearing capacity consideration. So, our influence zone will be B below the foundation and for allowable bearing capacity where the permissible settlement is given.

So, if the settlement is involved, then the influence zone will be $2B$ remember that. So, now, this case correlations if the influence zone is B. So, that means B is 2 m from base of the foundation. So, influence zone will be 2 m + 1.5 m = 3.5 m from the surface, because B = 2 m and depth of foundation is 1.5 m. So, influence zone will be 3.5 m from the surface. So, for bearing consideration influence zone will be 3.5 m.

Now, for settlement consideration the influence zone will be $2B$ so, this will be 4 m + 1.5 m. So, this will be 5.5 m from the surface. So, influence zone from the surface is 3.5 m for bearing consideration and 5.5 m for settlement consideration. Now, so that means we have to calculate the $N_{average}$. So, what is the $N_{average}$ for bearing consideration?

So, we have 3.5 m influence zone so it is in between these so, this is 3 m 3.75 m it is the 3.5 m. So, corresponding to 3.5 m this *N* value is around 25 so this is 20 this is 30 this will be 25. And corresponding to this 5.5 the *N* value is equal to 31 so this is 30, 40, 31. So, we are taking these values. So, now we will add these values for example for 1.5 m.

You have 17 + 2.25 m 22 + 3 m it is 20 + 3.5 m 0.5 also we have taken so it is 25 so the average value this is 4 we are taken four readings so average value is 4 and all four readings are below the base of foundation for example suppose you have a reading of 0.75 m which is above the base of foundation. So, that reading is not required when you calculate this bearing capacity equation. So, we will consider only below the base of the foundation.

So, now this average value is if I take this the average value only bearing consideration is 21 similarly N_{average} for settlement consideration. So, this *N* value is we have again 17 + 22 + 20 +27, 27 then at 4.5 m it is 29 then at 5.25 m it is 30 then it is actually at 5.5 m. So, we are taking 31 also and then we are taking the average 1 2 3 4 5 6 7 readings so average is divided by 7 and that average value is coming out to be 25 so N_{average} value for bearing consideration is 21 and N_{average} value for settlement consideration is 25.

So, we will use these values so now N_{average} value we got now we have to determine the R'_w and R_w and water table position is below the base of foundation. So, as I mentioned that our R_w will be 1 because in that case $D_w = D_f$. So that is equal to 1 so corresponding R_w is 1, because water table is below the base of foundation but R'_w we have to calculate.

So, for that calculation you have to know the $\frac{D'_w}{B} = \frac{0.5}{2} = 0.25$ so if it is 0.25 on here so corresponding to 0.25 the R'_w is 0.625. So, now we can calculate net ultimate bearing capacity N^2 is 21^2, B is 2, R_w is 1, R'_w is 0.625 then + $3(100 + 21^2) \times D_f$ is 1.5. So, this value is coming out to be 995 kN/m^2.

But this is ultimate we have to calculate the safe bearing capacity so $q_{n(\text{safe})}$ is 995 divided by the factor of safety and that factor of safety is given as 2.5 so this value is kN/m^2 so considering only bearing capacity the safe load this footing can take is 398 kN/m^2.

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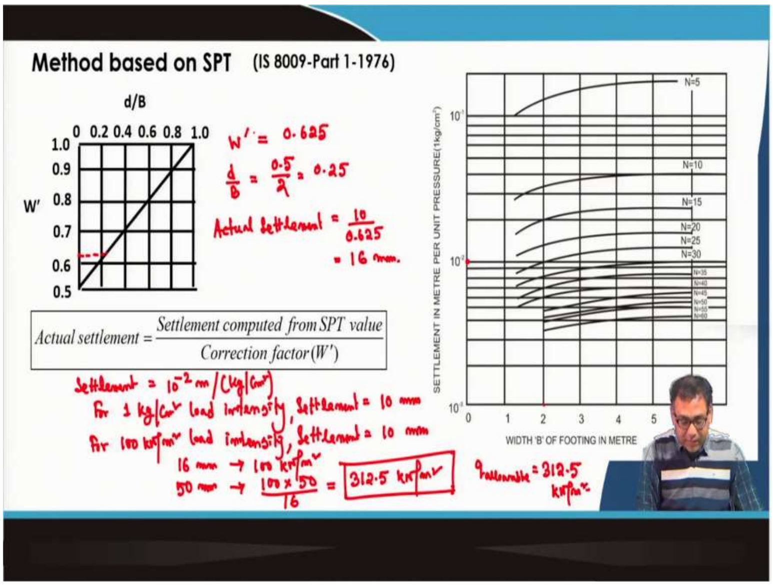

So, now we will use the settlement consideration, we have used only the bearing capacity consideration. Now we will use the settlement consideration because as I mentioned during the design we have discussed the bearing capacity then we have discussed the settlement and then allowable is considering both a minimum of the safe load or the load which the footing can take considering settlement and bearing. So, we have considered the bearing capacity now we will consider the settlement.

So, settlement we use the IS method that I have discussed for settlement calculation in granular soil and I have discussed five methods. So, the plate load test, SPT, SCPT, then the semi-empirical method and the influence factor method. So, here I will use the SPT based method as for the IS 8009 where the settlement curve chart is here. So, settlement value our width of foundation is 2 m and *N* value is 25 so the settlement value will be this one.

So the settlement that we are getting is 10^{-2} m per kg/cm^2. So, for 1 kg/cm^2 loading intensity the amount of settlement is 10^{-2} m from the chart we are getting because width of foundation is 2 m and this is *N* value is 25 this is the 25 line *N* value is 25 so we will get a settlement of 10^{-2} m.

So, we will get for 1 kg/cm^2 load intensity the settlement is 10 mm. So, now if we apply 1 kg/cm^2 load intensity on that foundation I will get a settlement of 10 mm. So, our permissible settlement is 50 mm but in this settlement we have not considered the water table effect.

So that water table effect we have to consider so here also that for 1 kg/cm^2 so this 1 kg/cm^2 actually is 100 kN/m^2 so I can write for 100 kN/m^2 load intensity settlement is 10 mm because 1 kg/cm^2 = 100 kN/m^2. But this 10 mm is not the settlement considering water table effect.

We have to consider the water table a correction factor because the settlement we are getting 10 mm, the actual settlement will be more than that. So, actual settlement first we will calculate the water table correction factor. So, that correction factor is W' so how we will get that, we will get $\frac{d}{B}$ value. What is the *d* value? *d* value is the water table position from the base of the foundation. So, here we can write *d* = 0.5 m.

So, *d* = 0.5 m, B is 2 m, so $\frac{d}{B}$ is 0.25. So, W' will be the same correction factor because this is 0.25 this is 0.2. So, this is 0.25. So, this is the value which is again 0.625. So, W' is 0.625. So, this correction factor chart is as per IS code, where if the water table is at the base or above it then it will be 0.5. So, here or remember that when you design something.

So, we have to consider worst condition and worst condition the correction factor is 0.5 because bearing capacity you can reduce by 50% or settlement you can increase by 2 times, but here it is not 0.5 it is 0.625. So, that means, if you are very sure about the position of the water table, then you use that position of the water table but if one not here, then when you design any foundation, you consider the worst condition.

That means, you consider water table effect is at the base of foundation for this case or at the surface because at the surface you will get the worst condition for the water table position. So, if you are very sure about the position of the water table, then you consider that water table position otherwise you consider it at the ground surface, but here the water table position is specifically mentioned. So, that is why you have taken this position.

So, that means the water table position. So, water correction factor is 0.625. So, actual settlement will be 10 mm divided by 0.625. So, this will be 16 mm. So, after correcting for the water table, we can get that 16 mm settlement we can get for 100 kN/m^2 loading intensity. So, and the permissible settlement is 50 mm. So, 50 mm will get for how much load intensity, so and that will be $100 \times \frac{50}{16}$ and that is 312.5 kN/m^2.

So, settlement consideration the load or the stress that a foundation can take such that your settlement of the foundation will be within the permissible limit is 312.5 kN/m^2. So, here the factor safety we will not apply because this is based on the permissible settlement. So, from bearing consideration, your safe load is 398 kN/m^2 and for the settlement consideration your stress is 312.5 kN/m^2.

So, minimum of these two will be the allowable bearing capacity. So, $q_{\text{allowable}}$ will be 312.5 kN/m^2. So, to cross check that now, you use another correlation. So, that we can determine the allowable bearing capacity directly because here in this case we have determined the bearing capacity we have determined the safe load considering bearing capacity and considering settlements separately and then a minimum of these two will be the allowable bearing capacity. But if I used another correlation where directly we can get the allowable bearing capacity.

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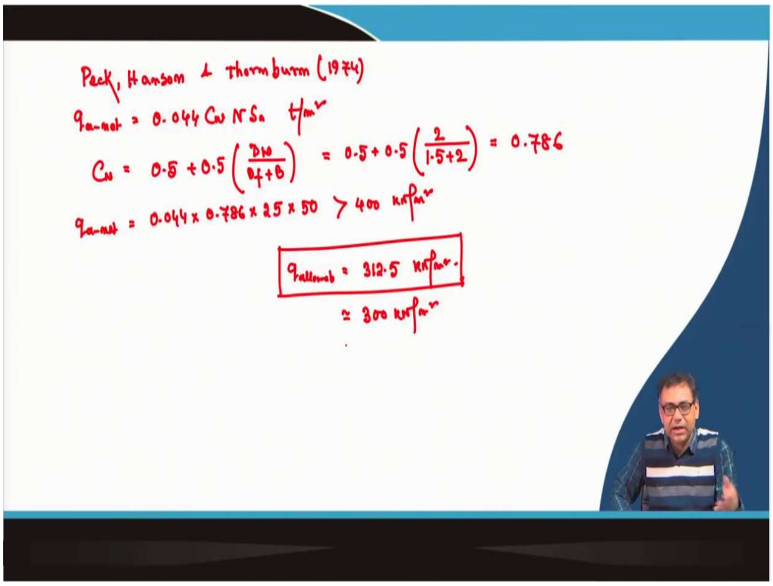

So, that correlations are given by Peck, Hansen and Thornburn in 1974. So, few correlations are available. So, I am using this one where directly the $q_{\text{allowable}}$ we will get and that correlation is $0.044C_wNS_a$ and that is in t/m^2. Now, $C_w = 0.5 + 0.5\left(\frac{D_w}{D_f+B}\right)$ where now the D_w is this position that means up from the surface position of the water table from the surface.

So, $D_w = 2$ m. So, I can write $0.5 + 0.5\left(\frac{2}{1.5+2}\right)$. So, that is 0.786. So, you can see based on the different correlations we are also using the correction factor different because sometimes you are taking it from the base of the foundation sometimes we are taking it from the ground surface. So, what are the recommendations you have to use that recommendation as far as the correlations that you are using.

So, this is 0.786. So, all this is same things you have to use if you are very sure about the position of the water table otherwise, for all the cases you consider the position of the water table is at the ground surface. So, now, it is because here the settlement is the permissible settlement and previous case also permissible settlement is or settlement is there. So, influence zone will be $2B$ and the N value will be 25, because for settlement consideration N value is 25.

So, $q_{\text{allowable(net)}} = 0.044 \times 0.786 \times N$ is 25×50. So, this value we are getting around 400 + because it will be more than 400 or something. So, that means here the allowable bearing capacity that we are taking. So, that we are proposing is 312.5 kN/m^2 is correct, because when we are cross checking it by using Peck, Hansen and Thornburn equation that is given more than 400 or close to the 400 kN/m^2.

So, that which is more than 312.5 kN/m^2. So, we have discussed the three methods, one is the bearing consideration, one is the settlement consideration and another one directly the $q_{\text{allowable(net)}}$ we are getting. So, but among these three the settlement consideration is giving the lowest value. So, that is why this will be the allowable bearing capacity and that we will use for our design.

So, now you check the dimension of your footing that you have considered is sufficient or not to take this much of allowable bearing capacity or this is your foundation you can apply this much of allowable bearing capacity that is sufficient or not the load which is coming from the superstructure. If the load which is coming on the foundation is more than this allowable bearing capacity. Then you have to redesign it or so what here it is only to calculate there is no checking option is available.

So, all you have to calculate this allowable bearing capacity. So, that is why this allowable bearing capacity we recommend by 312.5 kN/m^2 or if you want to put it in a round figure you can put it is 300 kN/m^2. So, and if you know that the load which is coming on the foundation the amount of load then you can check whether that load which is coming from the superstructure can be taken by this foundation or not, but here this load is not given.

So, you can only propose the allowable bearing capacity of that foundation under these 2 × 2 cross sections and this is the value if you know how much load is coming. Then you can also compare also that with that load that this much of load this foundation can take, if it is not sufficient this dimension then you have to change the dimension for the next graph. So, this is the way we can determine the allowable bearing capacity based on N value.

So, in the next class I will discuss that how we can design a shallow foundation on the clay soil. Because here I have discussed both the cases, I mean for SPT and then for plate load test for sandy soil. So, next class I will discuss the how we can design the foundation on clay soil.