Foundation Design
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Lecture - 7A
Bearing Capacity of Shallow Foundation- Part 5

Last class we have finished up to scale effect on bearing capacity, earlier we have finished bearing capacity theories based on Terzaghi's, Meyrhof's and as well as Vesic's and also we discussed scale effect on bearing capacity.

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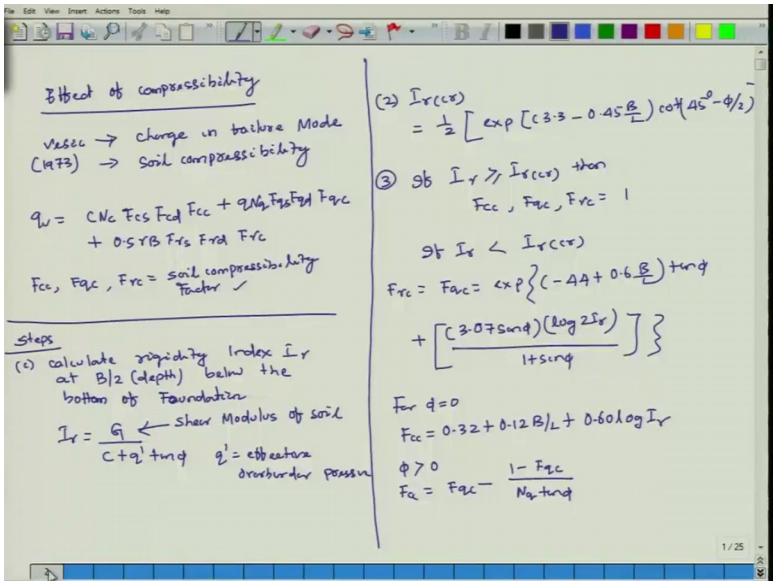

Then effect of compressibility; these are different theories and generally I allow students to bring the formulas its examinations many many charts formulas are there particularly foundation designs. So, it will be difficult to memorize all. However, few like Terzaghi's bearing capacity theory C Nc gamma DFNQ 0.5 gamma bn gamma it should be you should at least remember and this is a common formula generally used.

So, effect of compressibility. So, what Vesic says change in failure mode change in failure mode is due to it is due to your soil compressibility it is due to your soil compressibility and Vesic 1973 proposed relationship considering your soil compressibility. So, ultimate bearing capacity qu is equal to C Nc, F cs, F cd, F cc shape factor plus depth factor and he added one more factor that is your compressibility factors. So, then QNQ FQS FQD Fqc plus 0.5 gamma b F gamma s F gamma d F gamma c now

this is what he has given considering into your soil compressibility now if i write it F cc F qc F gamma c this is your soil compressibility factor soil compressibility factor. So, how you are going to follow this steps this steps are how you are going to calculate taking into consideration of soil compressibility these are all your steps calculate your rigidity index I calculate rigidity index I of soil at a depth b by 2, this is your depth below the bottom of the foundation below the bottom of foundation.

So, compress a rigidity index generally I or I r index i for index r for rigidity I r is equal to g by c plus q prime tan phi g is your shear modulus of soil shear modulus of soil and q is your effective q prime q prime is your effective overburden pressure now critical rigidity index. So, second one is your I r c r; I r c r is your critical rigidity index which is equal to half exponential 3.3 minus 0.45 b by l cot 45 degree minus phi by 2.

So, step three they have given few conditions if rigidity index i r greater than equal to critical rigidity index I r c r then your F cc Fqc F gamma c is equal to 1 if I r is less than rigidity index is less than critical rigidity index then F gamma c is equal to F qc which is equal to exponential minus 44 plus 0.6 b by l tan phi plus 3.07 sin phi into log 2 I r divided by 1 plus sin phi. So, this is what they have given these are all kind of empirical in nature doing very few test calculating few test and this relationship has come up.

So, Vesic asked why there is a change in failure mode; that means, from local shear to general shear failure why it is happening. So, he has a make it in to because it is happening because of your compressibility and effect of compressibility instead of putting it like Terzaghi's if general shear failure is there condition is phi should be greater than equal to 36 degree local shear failure phi is less than equal to 26 degree instead of giving that conditions rather he added three factors F cc; Fqc F gamma c that is your soil compressibility factors and what are the steps calculate rigidity index I r based on your shear modulus of soil c and q prime tan phi q prime is your effective overburden pressure and this rigidity index I r has been calculated at b by 2 depth below your bottom of foundations then second is your I r c r. That means, critical rigidity index he has given expressions and compare with a critical rigidity index with your rigidity index and if a rigidity index is greater than critical rigidity index then F cc, Fqc and F gamma c is equal to 1.

If rigidity index is less than your critical rigidity index then find it out F gamma c and Fqc and then for F cc for phi is equal to 0 he has proposed F cc is equal to 0.32 plus 0.12 b by l plus 0.6 0 log I r for phi greater than 0 F cc is equal to Fqc minus 1 minus F qc divided by nq tan phi this is what he has given taken example

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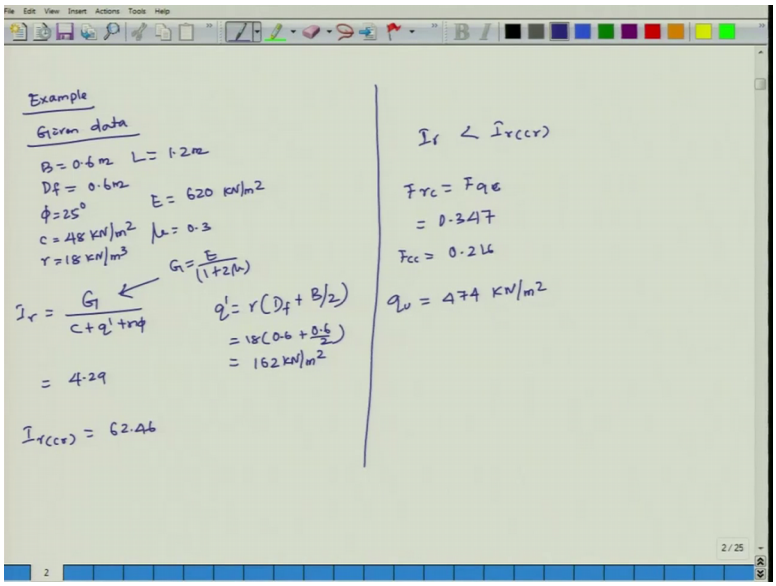

So, given data one example given data what are your given data given data is your b is equal to 0.6 meter l is equal to 0.2 meter foundation size depth of foundation is 0.6 meter phi is equal to 25 degree c is equal to 48 kilonewton per meter square gamma is equal to 18 kilonewton per meter cube then e value modulus of elasticity has been given 620 kilonewton per meter square and Poisson's ratio mu is equal to 0.3 it has been given this values with a size 0.6 and 0.2 depth of the foundation is 0.6 phi is given c is given gamma is given e is equal to given mu is equal to given then find it out rigidity index I r which is equal to g by c plus q prime tan phi you can calculate g where g is equal to e by 1 plus 2 mu and from there also you can calculate q prime effective overburden which is equal to gamma depth of the foundation plus b by 2 if you look at here it has been consider up to a depth equal to b by 2 width of the foundation by your 2.

So, from there you find it out it should be 18 into 0.6 plus 0.6 by 2 which is equal to 162 kilonewton per meter square and now I r you can calculate which is equal to 4.29 then you calculate this value this is your rigidity index critical rigidity index you have to compare. So, I r c r critical rigidity index you calculate this value is coming about to be

62.46. So, now, what will happen from this what you are getting I r rigidity index I r is less than I r c r. Now once, it is less than then you calculate Frc which is equal to F qc based on your suggestions a the empirical relations has been given from there it is coming 0.347 then you calculate F cc which is equal to also because it is phi is greater than 0 phi is 25 degree F cc is coming about to be 0.216 then ultimate bearing capacity you can calculate considering shape factor as well as depth factor compressibility factor all you consider it then this shape and depth will be as usual for your basics theory same it will come there only here only compressibility factor will come into picture. So, it is coming about to be ultimate bearing capacity is coming about to be 474 kilonewton per meter square kilonewton per meter square. So, this is what about your effect of compressibility.

Now, come to the next what are the bearing capacity recommended by I scope bureau of Indian standard generally people say I is generally you can write it BIS; BIS is your bureau of Indian standards what is its recommendation for your bearing capacity.

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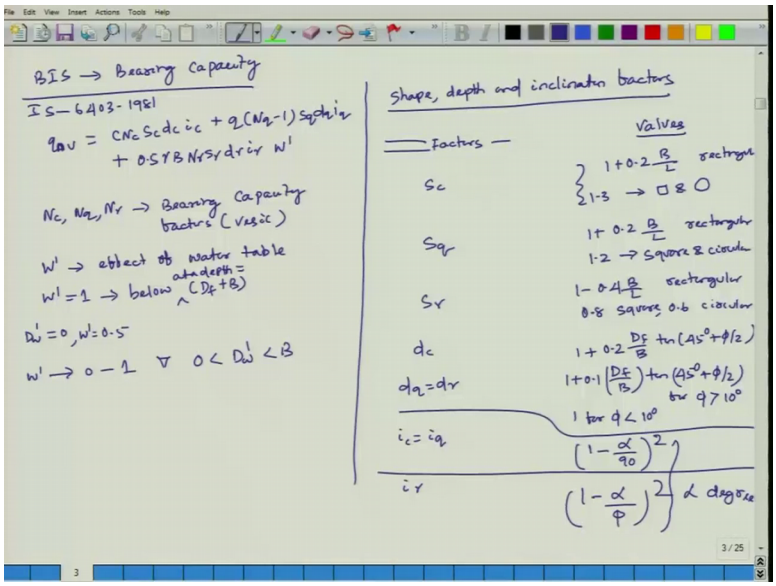

So, bureau of Indian standard they have given qnu they have not given qu q Nu is your net ultimate bearing capacity which is equal to C Nc sc dc ic plus q into Nq minus 1 sq dq iq plus 0.5 gamma b N gamma s gamma d gamma I gamma w prime w prime. So, this particularly this is your bureau of Indian standard the number you can note it is 6403 1981, it has been revised.

So, it will be is 6403 you can download from your library if it is accessible. So, what they say in this term. So, q Nu they have given a net ultimate bearing capacity and they also suggested Nc Nq and N gamma it will be as per this is your bearing capacity factors as suggested by Vesic bearing capacity factors as suggested by Vesic's there are three cases one is your Terzaghi, other is your Meyerhof, third one is your Vesic's considering shape depth factors from there you take it then w is your water table water table effect w prime w prime is nothing, but is your factor takes into account effect of water table effect of water table. So, if w prime is equal to 1; 1 what does it mean? So, water table is below a depth or at the base of foundations of below at a depth which is equal to df plus b below at a depth which is equal to df plus b.

So, then they have given the water table corrections they have given the water table corrections varying from varying from 0 to 0.5 if it is fully submerged fully submerged case then it will be 0.5; that means, depth of the water table is at i can say depth of the water table at the ground surface; that means, dw prime is at the surface at the 0 then w prime is equal to 0.5 which are also we have earlier discussed why it will be 0.5 in this term gamma bulk you need to get will be converted to submerged unit weight once it is a submerged unit weight half of the part will be reduced. So, automatically the relation factor will be 0.5. So, it will be it will be linearly interpolated in between in between 0 to 1 0, to 1 and w prime can be interpolated between 0 to 1 if water table water table is located 0 dw prime less than b this is what i have already said water table corrections earlier.

So, they have given different factors for different cases sc sq s gamma dc dq d gamma ic and i gamma. So, these are the cases they have given. So, shape depth and inclination factors shape depth and inclination factors. So, if I start with this Bureau of Indian standard they have given this is your factor and these are only a values you can download this code. So, they have given sc sq s gamma then dc then dq is equal to d gamma ic is equal to iq then i gamma they have given the value. So, particularly they have given 1 plus 0.2 b by l for rectangular bureau of Indian standards. So, then 1.3 it will be for square and circular foundations.

Similarly, sq; sq will be 1 plus 0.2 b by l it will be for rectangular then 0.2; 0.2 for square and circular similarly s gamma s gamma bureau of Indian standard has been proposed 1 minus 0.4 b by l then it will be for your rectangular then 0.8; 0.8 for square and 0.6 for

circular dc is equal to 1 plus 0.2 df by b tan 45 degree plus phi by 2 then dq is equal to d gamma dq is equal to d gamma it would be 1 plus 0.1 df by b tan 45 degree plus phi by 2 for phi greater than 10 degree and one for phi less than 10 degree then for ic ic is equal to iq inclination factor for c and q, it will be a 1 minus alpha by 90 whole square and i gamma will be 1 minus alpha by phi whole square.

Why I have written this code you could have download it from bureau of Indian standard size or maybe from your college library, but many colleges private institutions they may not have this codes. So, that is why these values I have written. So, you can note it down and prepare a chart for your examinations. So, sometimes it has been asked design based on your bureau of Indian standards.

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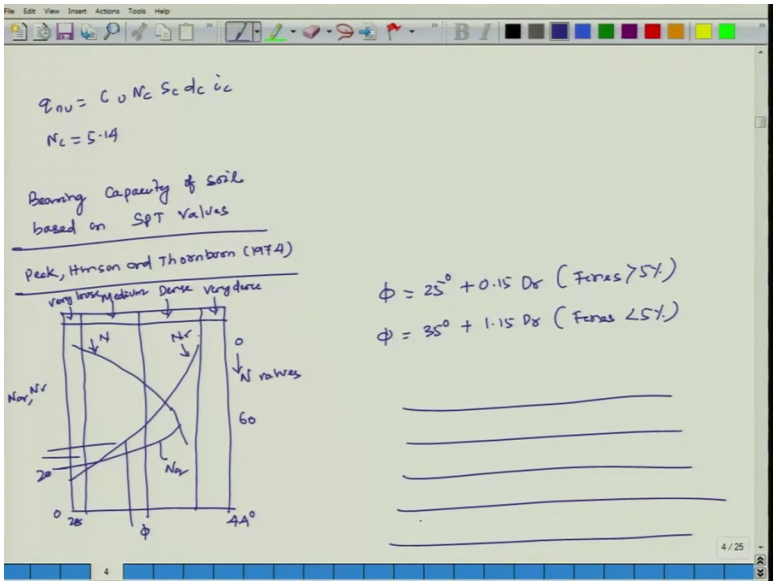

Here, in this case alpha is in degree this is particularly your cohesion less soils this is particularly your cohesion less soils for cohesive soils purely cohesive soils bureau of Indian standard qnu net ultimate bearing capacity is its C u Nc Sc dc ic. So, nc is your 5.14 and Sc dc ic is your shape depth and inclination factor as it is given.

Now, come to next part that is your bearing capacity of soil based on your standard penetration values bearing capacity of soil based on SPT values earlier in subsoil investigations standard penetration test; I have explained in standard penetration test what you are supposed to get you are supposed to get n values for last 30 centimeter of your penetrations from n value what we are supposed to get it there are correlations from

n value you are supposed to get your phi once you get the value of phi from there you are suppose to get you are supposed to get a your bearing capacities.

So, peak particularly this has been given by Peak Hanson and Thornborn 1974 they have given it you can get it from the book this chart you can take it out for your examinations this is your angle of shearing resistance phi it varies us between 28 degree to 44 degree then this is your bearing capacity factor Nq and N gamma then here they are made it this is your vary loads this is your medium this is your dense this is very dense and here is your n values this side also n values they have given this values starting from 0 to up to N is equal to 60. So, here this kind of graphs they have given this is the variation of your N 0 20 this value is your n gamma this is your Nq.

Now, if you look at here once you have a penetration value n this n value is there from n value is there from n value you can calculate your phi once you know the phi from there this has been extended suppose phi is varying from 28 degree 44 degree you extend it where it cut it from there you can find it out Nc Nq sorry Nq and N gamma Nq and N gamma this is what they have given you to find it out nq and n gamma and this chart has been widely used. So, 2 correlations they have given one is your phi is equal to 25 degree plus 0.1 phi dr finds greater than 5 percent then phi is equal to 35 degree plus 1.15 dr. So, finds less than 5 percent dr is your degree of compactions or relative density relative density based on your n value you can calculate whether it is a loose state medium state what is the relative density from there also you can find it out the value of your phis.

So, this is based on your SPT standard penetration values. So, next is your based on your cone penetration values and some of the cases has been given by some formula given by tan then next will be bearing capacity of footings particularly on layer soils right now whatever we have discussed that is a single soil it may be possible it may be possible it is always it is always happen in the field every 2 meter; 2 meter interval or every 1.5 meter intervals subsoil profile is changing it is not necessarily 1.5 to 2 it may be 0 to 5 meter and 5 to 10 meter another subsoil profile if there is a layer soil how to calculate bearing capacity that part will.

I will discuss in the next class once it is over I will go for your settlement calculations immediate as well as consolidation settlement particularly in sand as well as in clays once it is over then we will go for foundation design.

Thank you.