Foundation Design
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Lecture - 15B
Design of Raft Foundation

So, earlier I have started soil design of raft in clay one is your partially compensated raft in clay; that means, particularly for raft foundation as I said there are many number of columns are there.

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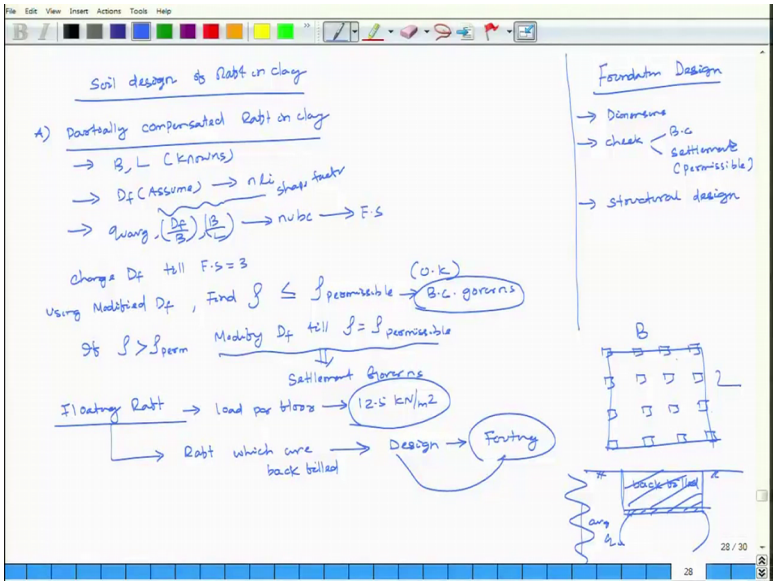

So, B by L is known, B by L is known; so then depending upon your partially compensated raft. So, D f you have to assume depth of the foundation from there you have to find it out net load intensity. Then q average you calculate it will be given every 1.5 meter interval or 2 meter interval then D f by B b by L based on that you find it out your shape factor.

Once you get this shape factor from there you can find it out net ultimate bearing capacity, then net load intensity once you know net ultimate bearing capacity from the soil properties once you know find it out factor of safety. If you are getting a factor of safety of 3, then there is no change in depth of the foundations if factor of safety if you are not getting factor of safety of 3 modified the depth of the foundations, this is what

one. Then part 2 is your find it out your settlement. This settlement calculated it should be less than settlement permissible right.

If you are getting with first part of your depth of the foundation assume with your settlement less, than permissible settlement then your bearing capacity governs; that means, it satisfies settlement as well as bearing capacity; that means, the design criteria completely governs with your bearing capacity. For example, after satisfying your bearing capacity for example, if is your settlement is calculated settlement is greater than your permissible settlement, then you have to again modify your depth of the foundations, till you are getting rho is equal to rho permissible.

Then in that case if rho is greater than rho permissible that is in that case we can say that it is the case where your settlement governs particularly your raft foundations. Then there is a floating raft floating raft generally if load intensity is not given, there are multi story buildings, then load per floor is 12.5 kilo Newton per meter square, raft which are back field that is called your floating raft. And it should be designed as per my earlier one as per your footings as per your footings.

So, if I raft foundation design categorically mention into 3 parts, one is your dimensions, second is your check bearing capacity settlement permissible, then third one is your structural design. Let us go to one example.

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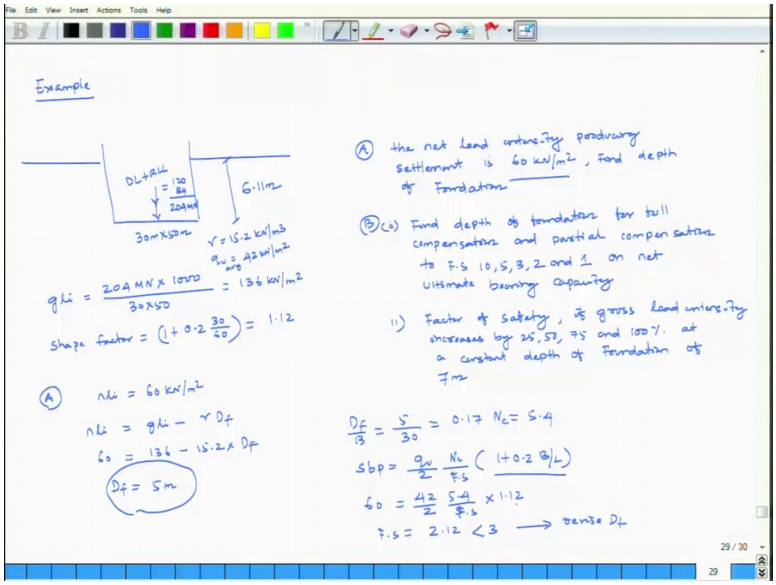

This is a example, in this case I started with a very small one, 6.11 meter. And raft size is 30 meter by 50 meter. And this will be this will be dead load plus reduced live load, dead load is given 120 reduced live load 84 which comes out to be 204 mm. So, what is their? What has to be find it out for the floating raft in clay shown in figure A, what you have to find it out A? The net load intensity producing permissible settlement is, the net load intensity producing settlement is your 60 kilo Newton per meter square, to find depth of foundation simple one I have started with this.

And the B Also determine the depth of foundation for full compensations, there are 2 parts B, find depth of foundation for full compensation and partial compensation to factor of safety of 10 5 3 2 and 1 on net ultimate bearing capacity. Then second part is your simple one as started factor of safety, factor of safety if gross load intensity increases by 25 50 75 and 100 percent at a constant depth of foundation of foundation of 7 meter.

So, very simple the raft size is given 30 meter by 50 meter. And dead load and reduced live load is given 204 mega Newton. First one is the net load intensity producing settlement is 60 kilo Newton per meter square. Find the depth of the foundation and part B there are 2 2 sections, find depth of foundations for full compensation in partial compensations 2 factor of safety is equal to 10 5 3 2 and 1 or on net ultimate bearing capacity. Second factor safety if gross load intensity increases by 250 75 and 100 percent at a constant depth of foundation of constant depth of foundation of 7 meter.

Let us start with gli gross load intensity 204 mega Newton into 1000 divided by 30 into 50, 30 into 50. It comes out to be 136 kilo Newton per meter square. Let us go to the shape factor, shape factor is equal to 1 plus 0.2 30 by 60 which is equal to 1.12. So, start with part 1 A. So, for net load intensity is given what net load intensity is given 60 kilo Newton per meter square.

So, net load intensity if I write it, net load intensity is equal to gross load intensity minus gamma D f the gamma is given, gamma is given here 15.2 kilo Newton per meter cube. And considering this is equal to 60 gross load intensity is equal to 136 minus 15.2 into D f. So, the depth of foundation is equal to 5 meter. So, now, also you consider you consider D f by B how much? D f by B is your 5 by 30 which is equal to 0.17. N c is equal to 5.4, then soil bearing pressure sbp is equal to q u by 2. So, also q u is given q u

average is given 42 kilo Newton per meter square, q u by 2 into N c by factor of safety into 1 plus 0.2 B by l.

So, if this is my shape bearing capacity is 60, then q u is equal to your 42 by 2 and c is equal to 5.4 by factor of safety factor of safety into 1.12. So, factor of safety is equal to 2.12 which is less than 3 then what does it mean revise your D f. So, first one is not satisfying, considering the net load intensity and other part it is not satisfying. If I taking into this if you look at here how I have started for part 1. Gross load intensity calculated, gross load intensity what is the load is given, 204 mega Newton into 1000 it is Newton divided by your area 30 meter by 50 meter it is coming 136 kilo Newton per meter square.

Shape factor is your 1 plus 0.2 B by L it is 1.12. So, net load intensity is given 60 kilo Newton per meter square. So, net load intensity is equal to gross load intensity minus gamma D f from their I am getting D f is equal to 5. At the same time I will have to find it out your soil bearing pressure. Considering soil bearing pressure is equal to 60 q u value is given N c and this is your shape factor then factor of safety is coming less than 3. So, you have to revise this factor of safety.

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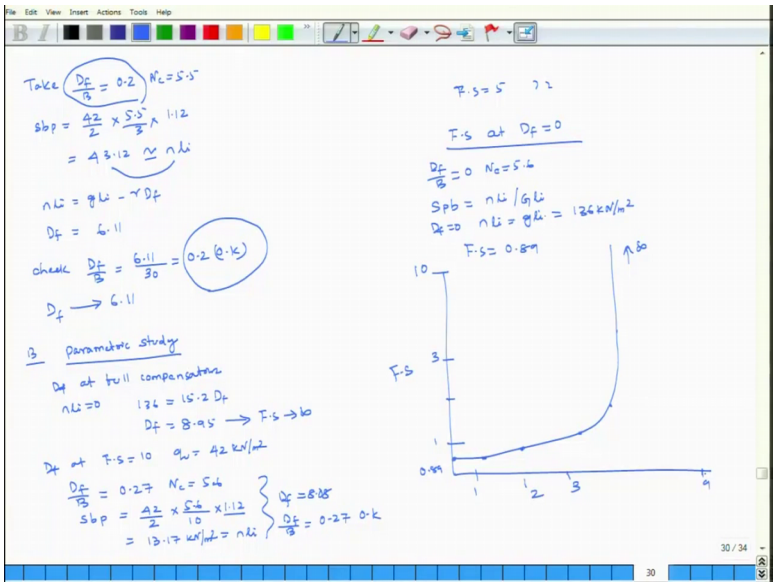

Then you consider take D f by B is equal to 0.2 N c is equal to 5.5.

So, sbp is equal to 42 by 2 into 5.5 by 3 into 1.12 which is equal to 43.12 then you consider this is your net load intensity. So, from there you find it out net load intensity is equal to net load intensity is equal to your gross load intensity gross load intensity minus gamma D f. And there you are getting depth of the foundation is equal to 6.11.

Now, you have to check D f by B is equal to 6.11 by 30 which is equal to 0.2 it is. Now for part 1 adopt D f is equal to 6.11. So, in the first case one taking into depth of the foundation 5 meter it is not satisfying. Our criteria factor of safety is equal to 3. Now considering D f by B is equal to 0.2 N c is equal to 5.67 5.5 soil bearing pressure comes out to be 43.12 this same soil bearing pressure as been assumed as a net load intensity. Providing net load intensity is equal to gross load intensity minus gamma D f. D f is equal to 6.11.

Now, checking D f by B is equal to whether it is satisfying 0.2 because this is our assumption. So, D f by B is coming exactly 0.2 hence depth of the foundation comes out to be 6.11, there is no assumptions it is coming out from the net load intensity and gross load intensity. Now come to the part B, parametric study, D f at full compensation. So, net load intensity is equal to 0 full compensation means there is no back feeling net load intensity is equal to 0.

So, from there I am getting 136 is equal to 15.2 into D f gamma D f. So, D f is coming out to be 8.95 and considering with this D f factor of safety 10ds to infinity. So, depth of the foundation at factor of safety is equal to 10 and q u is equal to 42 kilo Newton per meter square. So, then you have to find it out assume D f by B is equal to 0.27 N c is equal to 5.6 then sbp soil bearing pressure is equal to 42 by 2 into 5.6 by 10 into 1.12 this is your shape factor 1.12. That comes out to be 13.17 kilo Newton per meter square which is equal to net load intensity.

So, considering this your D f, D f is coming to be 8.08 and you can check it D f by B is equal to 0.27 it is. Now depth similarly you can find it out considering factor of safety is equal to 5. And similarly you can get it then factor of safety at D f is equal to 0. So, in this case D f by B is equal to 0 N c is equal to 5.6. So, from there you can calculate sbp is equal to calculate it and D f is equal to 0. Then net load intensity is equal to gross load intensity which is equal to 136 kilo Newton per meter square. Then with considering this

is equal to either net load intensity or gross load intensity, then from there you can find it out factor of safety is equal to 0.89.

If I draw it this is my factor of safety. So, it will be 1 this will be 2 3 and this is completely 10. And this will be starting from 1 and this will be your 9. So, this is your 0.89 and it 10ds to infinity. So, this will be your 1 2 3 and up to the 9. So, this is what this parametric study has been asked for different factor of safety. For different factor of safety you can find it out what is the depth of the foundations, factor of safety is given 10 5 3 2 1 then you can find it out for full compensations. Full compensations means net load intensity is equal to 0, then you can also find it out this part I will leave to you factor of safety gross load intensity increases by 20 percent 50 percent 75 percent and 100 percent; that means, here gross load intensity is given 136 increases 20 percent increase 50 percent increase 75 percent and increase 100 percent, then also you can find it out this part I leave it to you.

Come to a next example, example 2 for raft.

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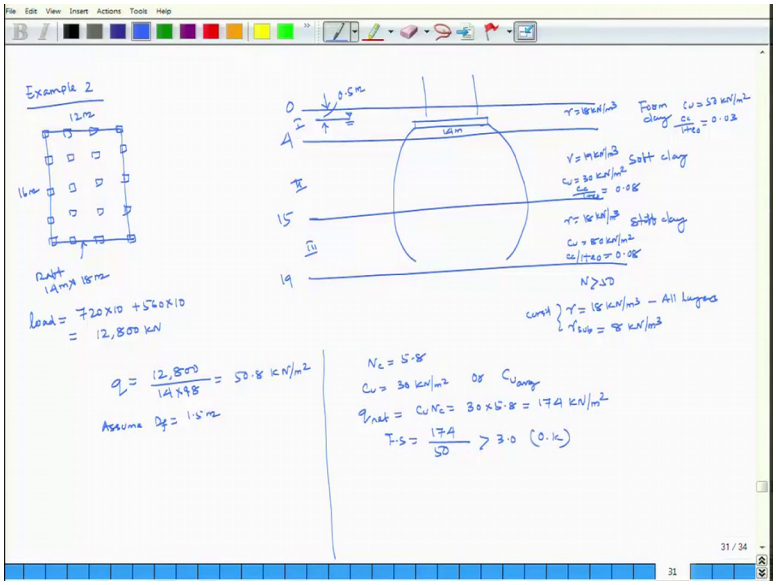

These are the size as been given, column loads also given, this is what it is given this part is your 12 meter, this is your 16 meter and raft is your 14 meter by 18 meter. Raft is 14 meter by 18 meter because here 12 this side will be one meter this side will be one meter that is why it is 14 here 16 this side will be one this side will be one that is why it is 18.

Load is given load is given 720 into 10. How it is 10? 1 2 3 4, 1 2 3 4 5, 5 into 4 it is 20 and here also 20. So, altogether it is given 720 into 10 plus 560 into 10.

So, this comes out to be 12800 kilo Newton. How many number of columns loads are their? 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20; out of the 20 10 column load is 720 kilo Newton, another 10 column load is 560 kilo Newton; that means, interior column load is 560 outer column is 720 kilo Newton is there.

Now, at the same time there is a sub soil profile also given. This is 0, this is 4, this is 15, this is 19. So, and water table is at located, 0.5 meter this is your delta and layer one is your farm clay, layer 2 is your soft clay, layer 3 is your stiff clay and n is greater than 50. Gamma value is given 18 kilo Newton per meter cube, or all 3 layers for all layers. And gamma sub merge is given 8 kilo Newton per meter cube. So, you just consider it though it is given gamma is equal to 18 kilo Newton per meter cube. Here gamma is 19 kilo Newton per meter cube, and then here gamma is 18 kilo Newton per meter cube. And what other values as been given; here in this case C u is given 50 kilo Newton per meter square; c by 1 plus e 0 which is equal to 0.03.

And here C u is equal to 30 kilo Newton per meter square. C c by 1 plus e 0 which is equal to 0.08 then here C u is equal to 80 kilo Newton per meter square and then C c by 1 plus e 0 which is equal to 0.08. This is what your sub soil profile is given. This is your raft there are total 20 column loads are there. And load is given outer periphery it is 720 each column inner interior columns are 560 kilo Newton total load is coming 12800 kilo Newton.

So, from there you can find it out rough size is given 14 meter by 18 meter. So, q load intensity is equal to 12800 divided by 14 into 18 which is equal to 15.8 kilo Newton per meter square. So, initially start with assume value of your depth of the foundations. Assume depth of the foundation is equal to 1.5 meter and check your bearing capacity N c is equal to 5.8. So, if you look at here this is my zone 1, this is my zone 2, this is my zone 3. If I put it here in this way and this is my 14 meter. This is my pressure bulb. Then what will happen? Major person of the pressure bulb raise in zone 1 and zone 2 and if I compare with zone 1 and zone 2 major person lies in zone 2.

So that means, N c is equal to 5 6. So, either you take in case of zone 2 either you take C u is equal to 30 kilo Newton per meter square. Or you can say C u average considering 1

2 as well as 3. As an design engineer I look at major person of the where it is lying it lies in the zone 2 I am considering C u is equal to 30 kilo Newton per meter square. So, q net C u in c which is equal to 30 into 5.8 which is equal to 174 kilo Newton per meter square.

So, factor of safety is equal to 174 divided by 50, which is equal then 3.0 now it is. Bearing capacity has been satisfied. Now go to your immediate settlement, as well as consolidation settlement. Then we will check whether it is satisfying or not. Now if I take it immediate settlement.

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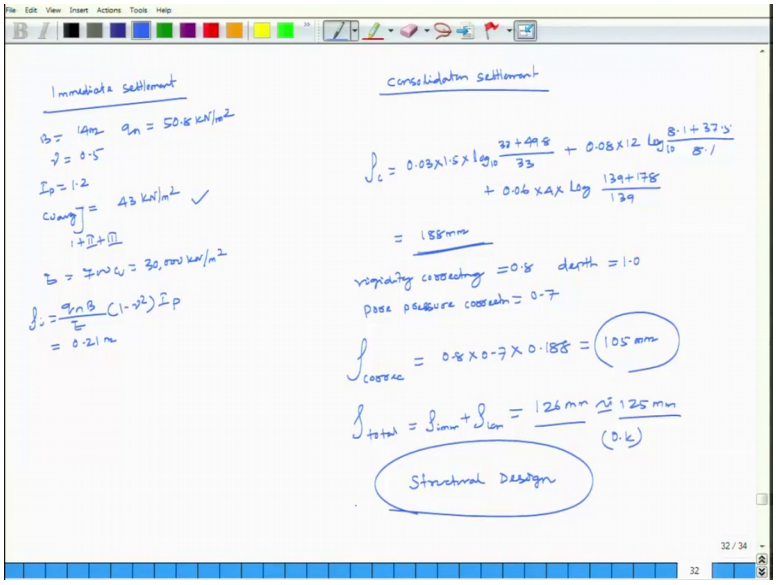

So, B is equal to 14 meter. Q n is equal to 15.8 kilo Newton per meter square. Mu is equal to 0.5 I p is equal to 1.2 C u average considering 3 layers it considering 1 plus 2 plus third layer it comes out to be 43 kilo Newton per meter square.

E is equal to I have considered 700 C u which is equal to 30000 kilo Newton per meter square. So, immediate settlement which comes out to be q n B by e 1 minus mu square into I p which comes out to be 0.21 meter. Similarly if I consider for consolidation settlement first one is your immediate settlement, second is your consolidation settlement. In consolidation settlement this part I leave it you, in consolidation settlement you consider this one a at the middle this is at the B this is at the c.

Consider 3 layers find it out your consolidation settlement. So, I am just you can said this consolidation settlement, I leave it to you, I am just leaving this step. So, it will be 0.03 it is for layer 1, 1.5 into log 10, 33 plus 49.8 divided by 33, plus 0.08 into 12 log 10 8.1 plus 37.5 divided by 8.1, plus 0.06 into 4 into log 139 plus 178 divided by 139, which is equal to 188 mm.

So, there are 2 corrections in your consolidation settlement, one is your rigidity corrections; however, it is rigid it had been taken as 0.8 depth corrections also taken it is 1.0 then pore pressure corrections, pore pressure correction which is equal to 0.7. So, rho corrected consolidation settlement rho corrected is 0.8 into 0.7 into 0.188 which comes out to be 105 mm. So, total settlement total is equal to immediate plus consolidation which is 126 mm. More or less it is same as 125 mm; that means it is ok.

So, this is a case of not fully compensated. When net load intensity is equal to 0 it is a partially compensated. In that case as I explained earlier floating raft it is just case of a floating raft very simple. It will be design like a floating. So, in this case straight forward what I have done it, raft size has been given load has been given load intensity as been calculated. Net load intensity has been calculated, assuming a value of depth of the foundation 1.5. Then net load intensity is coming 174 kilo Newton per meter square. Here considering pressure bulb I found that the zone 2 is most of part of the pressure bulb covering complete zone 2, either you can consider C u considering zone 2 or you can take C u average of zone one zone 2 and zone 3.

So, factor of safety is coming about to be 3.0 which is. Now calculated the immediate settlement immediate settlement calculated. Immediate settlement B is given q net load intensity is given I p is given, C u average has been considering layer 1 layer 2 and layer 3, has been calculated e modulus of elasticity has been taken into 700 C u which is 30000 kilo Newton per meter square. Load immediate settlement is coming out to be 0.21. Consolidation settlement considering 1 2 and 3 this part I have given. Of course, I have given the del detail calculations here is your p 0 plus delta p by p 0 p 0 plus delta p by p 0 it comes out to be 188 mm. There are generally 3 corrections applied, one is your rigidity; how rigidity is?

So, rigidity corrections is your 0.8, then depth corrections depth corrections is your 1. Pore water pressure correction is 0.7 based on that rho corrected is 100 consolidation

particularly consolidation settlement corrections is your 105 mm. Total settlement is comes out to be 126 mm. As for the BS buro of Indian standard code, the permissible settlements require is 125 mm now it is ok.

The size and the depth of the foundation is the last part is your structural design. This part I will solve for one case either for retaining wall or footing. So, you should have some structural design basic knowledge. So, I will solve one problem then it will taken care of everything. So, I will stop it here next class I am suppose to start a new chapter earth pressure or earth pressure theory or may be defoundations.

So thank you all of you, so we will meet in the next class.