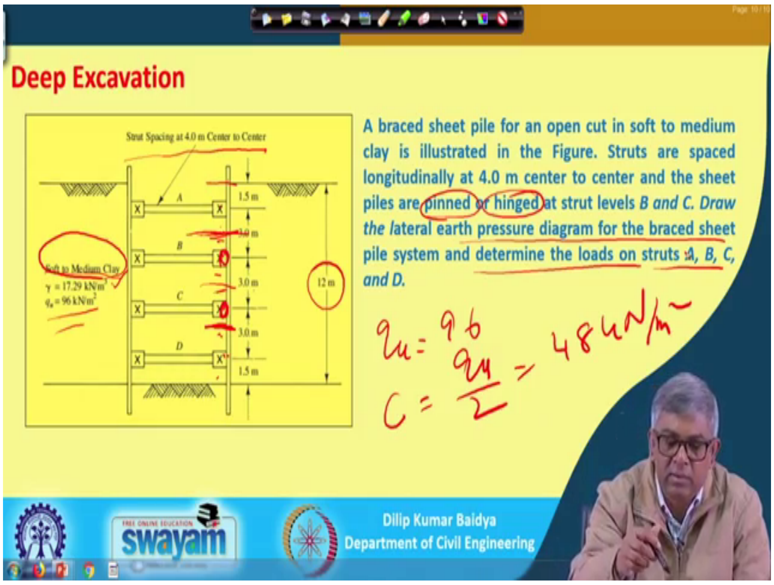
Geotechnical Engineering II / Foundation Engineering
Prof. Dilip Kumar Baidya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture – 52
Deep excavation (Contd.)

Well, in the previous lecture, I have considered various aspects of Deep excavation and the main thing is that to finding out the strut loading and that much we try to do in this course. So, here I have shown how to analyze that and what are the different pressure diagram etcetera and now, I will try to take one numerical problem to show how we can arrive the solution.

(Refer Slide Time: 00:55)



So, so, let us take the problem this is the problem actually shown you can see that is the here actually there are depth of excavation is 12 meter total and there are four struts are given and at a vertical spacing of 3 meter; you can see 3, 3, 3 and top 1.5 bottom 1.5 and one more is the strut spacing at 4 meter center. SO, that means, perpendicular to the board perpendicular to the board if I consider the continuous excavation then this struts at there again another 4 meter intervals.

So, then while calculating load actually influence area you have to consider; that means, I am considering while calculating strut load I will be taking from here to here this much vertically. Similarly, I have to consider horizontally also 4 meter. So, 2 meter from this side, 2 meter from other side, so, 2 meters from this and 2 meter behind.

So, that means, another 4 will come. So, to find out the strut loading this is the thing you have to consider actually. The vertical spacing to consider the; that means, zone from half the zone half the loading will come to this half the zone loading will go to there. Similarly, these half coming here again these half will go there similarly these half will come here and these half will go there again these half these half actually coming here and this part will come here because there is no other support. So, like that vertically we are taking that way; that means, 50 percent this side 50 percent other side.

Similarly, when there is a horizontal that is the spacing is there laterally so, that at 4 meter interval; that means, for each strut will be considered 4 meter width. So, that another 4 will come. So, that one has to keep in mind. So, that these are the things that that is the geometry if I could have done three with three-dimensional then this wall could have been continuous I could have seen perpendicular to the board and soil type given for this problem is actually soft to medium clay and gamma is 17.29 and q u unconfined comprehensive strength actually 96. So, q u actually in our calculation we have seen that C value is required, but you know that q is given.

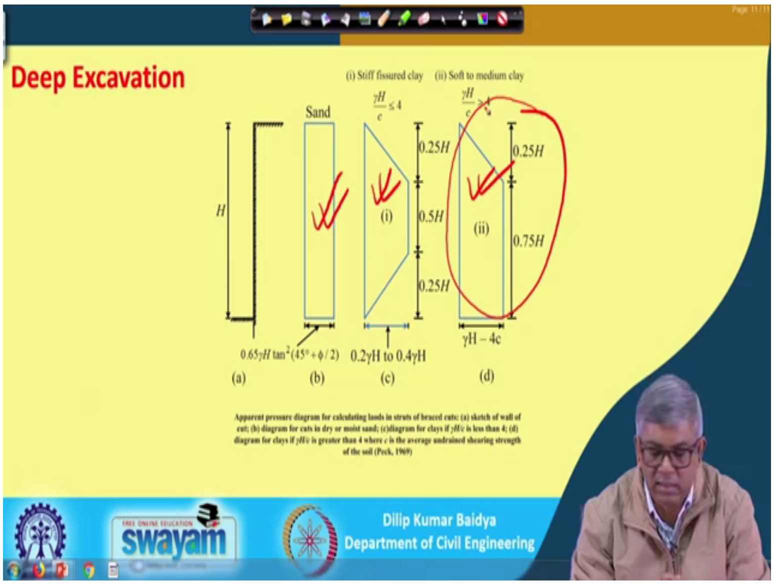
So, when q u is given q u is 96 and relationship between cohesion and q u is C is cohesion q u by 2 so; that means, 48 kilo Newton per meter squared. So, that is one thing is given and soft to medium clay it is mentioned; that means, we have actually shown three different pressure diagram; that means, based on this description we have to choose one of the figure. So, three figures; one is complete rectangle, one is top portion linearly wearing then remaining rectangle then third portion third type actually it is top one fourth is linear and increasing to maximum and bottom one fourth actually from maximum linearly decrease to 0.

So, that three out of the show this description and from this description will be able to pick up the appropriate pressure diagram and you can see that the braced sheet pile wall for an open curve in soft to mediums clay is illustrated in the figure that is the thing I have. So, many once again I have discussed struts up space longitudinally at 4 meters center to center; that means, a vertical spacing is shown longitudinal spacing actually 4 meter and the sheet piles are pinned or hinged at strut levels B and C.

That means, your A, B, C, D already method of analysis I have mentioned that it looks like a continuous beam, but intermediate support can be considered as pinned here itself it is also mentioned here itself that at point B and C we can assume that pinned or hinged that nothing, but what I have already told and draw the lateral earth pressure diagram for the brace sheet pile system and determine the loads on struts A, B and C and D.

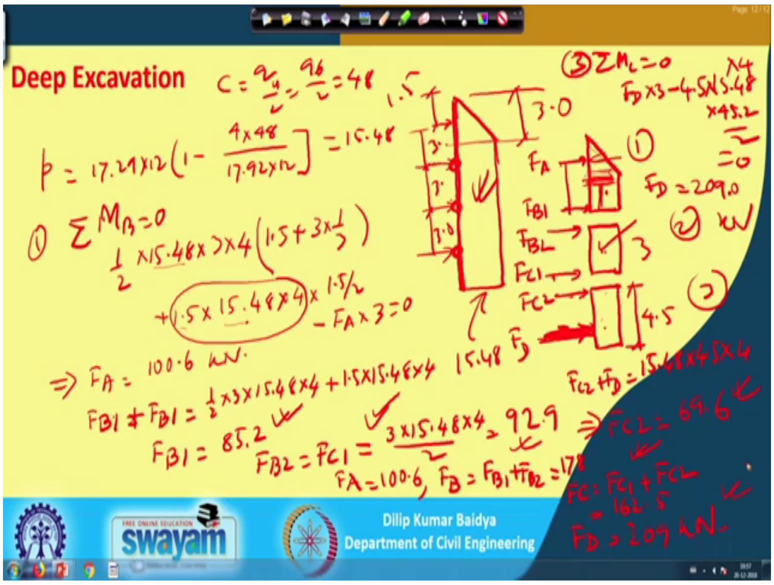
So, this is the problem. So, based on the given description so, let us see first the different types of pressure diagram.

(Refer Slide Time: 05:25)



You can see this pressure diagram we have discussed in the previous lecture and you can see here that for sand this is the one and for stiff clay this is the one and for soft to medium clay this is a diagram; that means, our problem is appropriate to this diagram, ok. So, we have to pick up this and now based on this first of all you have to draw the pressure diagram and then you have to find out the loading in the strut. So, let me go to that next slide.

(Refer Slide Time: 06:01)



So, next slide I have kept blank and in fact, I will draw first and then I will do that you can see here total 12 meter and your one fourth will be. So, this is the diagram and here actually this is 1.5, this is 3, this is 3, this is 3 and this is also 3 and if I consider hinged here, hinged here, hinged here then I can break this the first one; first one will be diagram will be like this and the second one. So, this will be F A and this will be F B1 next will be F B2 and this is F C1 this is F C2 and so, this will be this is suppose F D and this will be actually 4.5 this is 3 and this is 4.5 this is 3 and this is 4.5 so, like this.

So, now I can take actually intensity I have to find out this intensity I have to find out this intensity will be gamma h minus 4 C and C already I have got q u by 2 that mean 96 by 2 actually 48 and p will be equal to 17.29 multiplied by 12 1 minus 4 multiplied by 48 divided by 17.92 multiplied by 12 that gives you a value 15.48. So, that means, this is actually 15.48 and if this is 15.48.

And then if I take moment with respect to B, so, this one for this problem this is the 1, this is 2 and problem 3. For problem 1 if I take sigma M B equal to 0 and then you will get half multiplied by 15.48 multiplied by 3 multiplied by 4 these become actually the total force on this beam this force on this beam and then I have to take moment with respect to this. So, I have to find out I have taken this triangle only first of all I have taken this triangular loading if 2 we can divided two parts; this is 3 meter, this is this triangle is 3 meter.

So, that is what we have taken half multiplied by 3 multiplied by 15.48 multiplied by 4 so, that loading. So, I have to multiply it by the lever arm and that lever arm will be 1.5. This is 1.5 plus this is 3. So, 3 multiplied by 1 by 3 ok. So, this is; that means, it is point of application or somewhere here from here to here actually 1.5, this is this distance is 1.5 which is not shown professionally. So, if these distance is 3, so, half of that actually 1.5. So, this is the lever arm.

And then I have to; then I have to take this diagram. So, this diagram actually plus 1.5 multiplied by 15.48 multiplied by 4 multiplied by that is actually these become loading on that rectangular portion. So, this is 1.5 by 15.48 this is pressure and because of the longitudinal spacing force. So, that I have to taken that total load and then lever arm will be 1.5 by 2. So, it was 1.5, so, it will be from here to here it is half 1.5 by 2.

So, if I do this and then minus actually your F A multiplied by this distance between this is 3. So, that will be 0 and if I based on that I will get F A will be equal to 100.6 kilo Newton and F A if you are getting then I will get F B, F B1 I will get actually. So, F A plus F B1 F A plus F B 1 will be equal to summation of this triangle diagram. So, half multiplied by 3 multiplied by 15.48 multiplied by 4 plus 1.5 multiplied by 15.48 multiplied by 4. So, from here I will get F B1 will be equal to 85.2.

Now, if I go to this and then it will be F B2 and if is F B2 equal to F B2 equal to F C1 and which will be equal to the area of this triangle, but divided by 2. So, this is 3 multiplied by 15.48 multiplied by 4 divided by 2 that is nothing, but 92.9 ok.

And next one for this for this problem for this problem number 3, problem number 3 sigma M C if I take 0; that means, I take moment with respect to; with respect to the this is D actually. So, it will give you F D multiplied by 3 F D multiplied by 3 minus 4.5, this is actually 4 this is like this 4.5. So, 4.5 multiplied by 15.48 multiplied by 4.5 by 2 equal to 0. If you do this then your F D become your F D become 209 point 209 kilo Newton 0 kilo Newton.

So, we have got F A you have got, F D you have got and F A F B1 you have got F B2 also you have got F C1 you have got and F C2 can be obtained and from here actually once you get F D and your F C2 plus F D will be equal to nothing, but your 15.48 multiplied by 4.5 multiplied by 4. Here actually there must be there will be a 4 it has to be multiplied by 4 also there will be 4 also here. So, this if you do from here actually will get F C2 will be equal to 69.6 ok.

So, now, you can see your value of F A your F A become F A already we have got how much 100.6 F B equal to; F B equal to F B1 plus F B2 and if I do that then we are getting 178. Similarly F C will be equal to F C1 plus F C2 and that gives you ultimately 162.5 and F D already known actually you have got here 209.

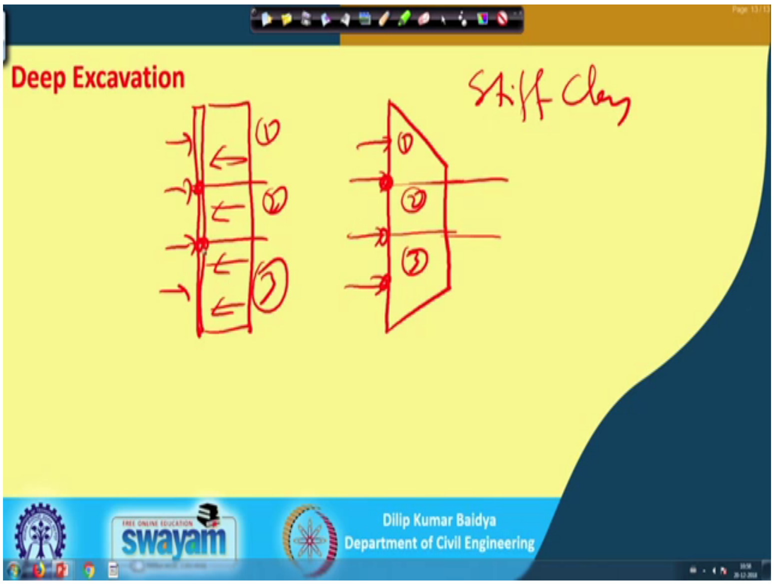
So, this is the actually total the it is a very simple actually based on given pressure diagram based on the given soil type I have to add up the typical pressure diagram and based on the strut location I can divide into three beams like this beam 1, beam 2, beam 3 and beam 1 and 2 actually two unknowns. So, we can take moment with respect to any one of course, but we can take with respect moment with respect to this one then actually will get directly F A. So, that is the thing we have done first.

And once you get F A, F B can be obtained because summation of vertical force equal to external load sorry summation of vertical force will be 0; that means, this reaction plus these loading should be equal to 0 that is done here and from there we got F B2 F B1 and for second beam actually you can see it is a symmetric. So, because of that F B2 and F C1 must be equal and if it is so, then what is their value?

Their value will be total loading divided by 2 that is the thing you have done here and then last beam actually again we have taken moment with respect to C and then moment with respect to C if I take then I will get F D directly and once you get F D then F C1, F C2 plus F D will be the loading here from there you have got the F C2 ok. Somewhere we have done F C2 I have got.

And then as I have shown before F A itself whatever you have got F B will be equal to F B1 plus F B2 that is the thing I have done here and F C equal to F C1 plus F C2 that is the thing I have done here and F D whatever you have got. So, these are the forces in the different struts already obtained. So, this is the way actually problem can be done.

(Refer Slide Time: 18:45)



So, if it is instead of this diagram, if you are if the soil would have been something else like same things, suppose same 12 meter depth and you are if it is sand suppose then we could have done pressure diagram something like this. And your strut location was here and here and then accordingly you have to divide into different parts, this is one part, this is another part and so, part 1, part 2, part 3 or if it is instead of saying this is actually what this actually stiff clay; one is stiff clay.

And, if it is a sand then you could have considered something like this. This is the one and your pressure diagram will be something like this and your strut location something like this. So, pressure diagram like this. So, this is simplest actually we can divide into one part second part and this is the part 1, 2, 3 everywhere same and it is part 1, part 2, part 3 like that one can find out what is and at this point you can consider the hinge, then you can find out what is the loading in the struts ok.

So, with this we have almost at the end of the foundation engineering part or all type of static loading. And in fact, as I have mentioned that I will take some amount of in the in a different examination nowadays in foundation engineering there is a another part is included that is for dynamically loaded foundation. That means, so far whatever we have done actually it is static loads are considered and based on that you have seen bearing capacity calculation we have shown the settlement calculation, we have shown pile foundation, their loading settlement, then we have done for retaining wall also for static loading everywhere we have consider static loading only.

So, now I will be I have another 8 modules actually total lag; that means, 4 hours approximately and try to give some introduction on machine foundation; that means, or some dynamic really loaded foundation and what is the difference from this conventional static loading. And what is the dynamic loading that I will try to highlight and what is the simplest method available for doing some analysis for a dynamic load foundation.

Here actually in static loading condition most important part actually because of the loading how much pressure coming on the soil that is important that we have to find out that maximum allowable pressure should not your loading pressure should not exceed the maximum allowable pressure for the soil.

But, in dynamically loaded foundation; that means, particularly machine foundation what I have discussed mostly they are actually that is not a problem, most of the time pressure will be significantly low. But, another important aspect which has to be taken care that is actually that vibration amplitude.

During dynamic loading and because of this frequency change of frequency that machine will be vibrating at different amplitudes and at lower frequency some, higher frequency some amplitude and there may be some frequency where actually resonance will occur we know that at resonance means where the natural frequency and driving frequency when coincides then that become natural frequency and at natural frequency your amplitude become excessively large.

So, in the dynamic loading condition that is the important most important; that means, you have to limit the amplitude. Like in the static problem we are what is the maximum amount of settlement and that settlement you have seen that it can be of 40 millimeter, 50 millimeters, 75 millimeter like that different codes for different loading or different foundation type is recommended and you have to design in such a way that your settlement remain below that value.

And here actually in the dynamic loaded current condition actually the amplitude is the displacement amplitude during vibration is the important parameter and that amplitude actually it will be much smaller actually it is in the micron level actually sometime not even millimeter; so, the fraction of millimeter.

So, there are different methods are available actually to do the analysis and again loading can dynamic loading can be also different types; sometime it will be vertical dynamic loading, sometime horizontal dynamic loading, sometime rotational dynamic loading and sometime rotting rocking dynamic loading like that will be there. So, because of that there are several parameters will be involved in it for calculating that amplitude and perhaps I will try to very briefly try to introduce that in 4 hours next 4 hours, today, I just end here.

Thank you.