Foundation Design
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Lecture – 20A
Deep Foundation - Part 4

So, last class I have solved two problems one case of a single pile with a uniform soil deposit in cohesion less soil. So, find it out the bearing capacity of the pile. So, calculated for both base resistance as well as site frictional resistance and from there ultimate bearing capacity got it 2 4 2 4 kilo Newton allowable load is your 9 6 9 kilo Newton.

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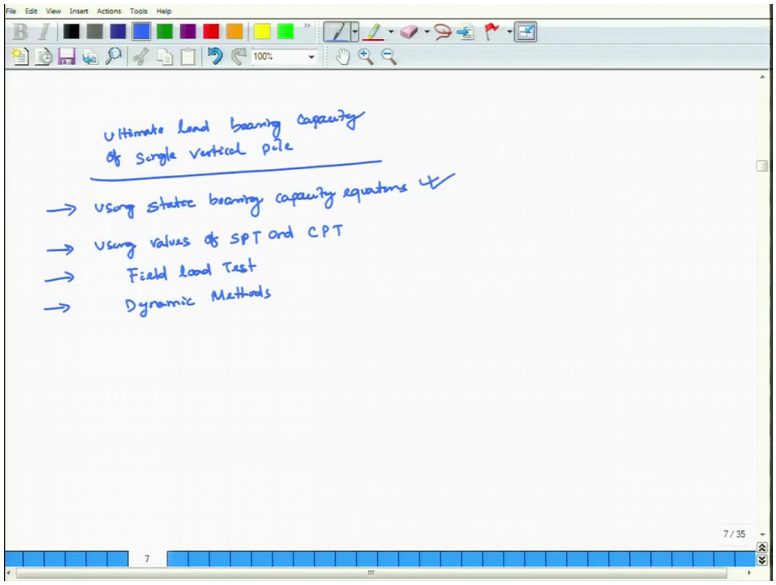

Considering your water table is far away then second case we have considered as if water table is at ground surface. Then second example I have solved for layer soils pile is there diameter is given each layer properties has been given.

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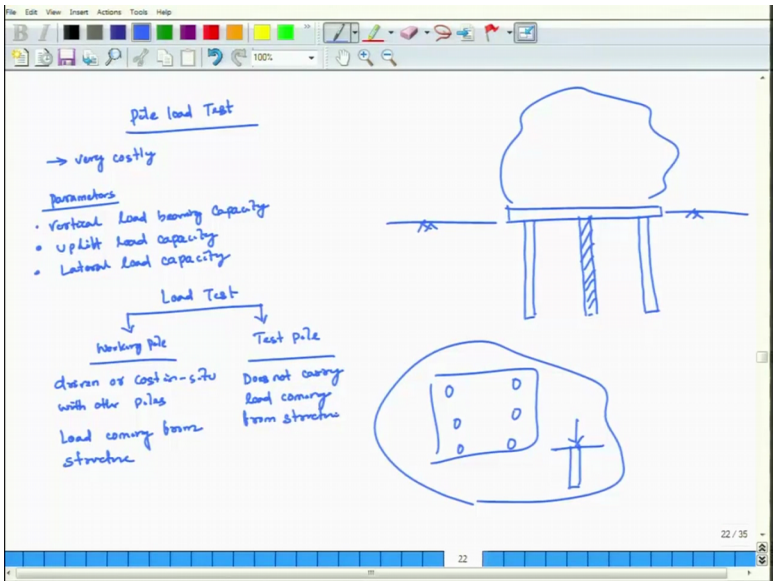

Only property is missing in this case gamma saturated also G. Gamma d is given dry density is given e is given from there we calculate g once you get the g we can calculate gamma saturated and delta has been arrived taking into consideration of two third 5 to 3, fourth 5 and this is for layer case the formula has been used perimeter and submission of q 0 bar k s bar tan delta delta l.

So, q 0 1 is every layer what is the average value for layer 1 layer 2 layer 3 and area at the base perimeter k s all parameter has been calculated, and this steps for layer 1 what is the value of gamma submerged layer 2, what is the value of gamma submerged layer 3 what is the value of gamma submerged then from their I got it Q u and Q a. Now next move to ultimate load on piles driven into cohesive soils; cohesive soils what is the formula Q u is equal to q b A b plus f s A s. Whether it is a cohesive or cohesion less this formula is your base resistance into area of base frictional resistance into surface area.

Then it would be C b N c and A b at the base what is the N c? At the base what is the c and A b plus alpha C u prime A s for layered soil Q u is equal to C b N c A b plus P summation of 0 to L alpha C u prime delta L. So, C b is equal to C b is equal to undrained shear strength of clay at base level of pile undrained shear strength of clay at base level of pile then C u bar which is equal to average shear strength of clay average shear strength of clay under undrained condition along the length of the pile, then alpha is your at average adhesion factor alpha is equal to average adhesion factor then P is your

perimeter of pile, delta L is equal to thickness of layer and N c is equal to your bearing capacity factor generally it is taken as 9. What are the different values of the adhesion factor has been recommended if you look at the adhesion factors, material first part is your material.

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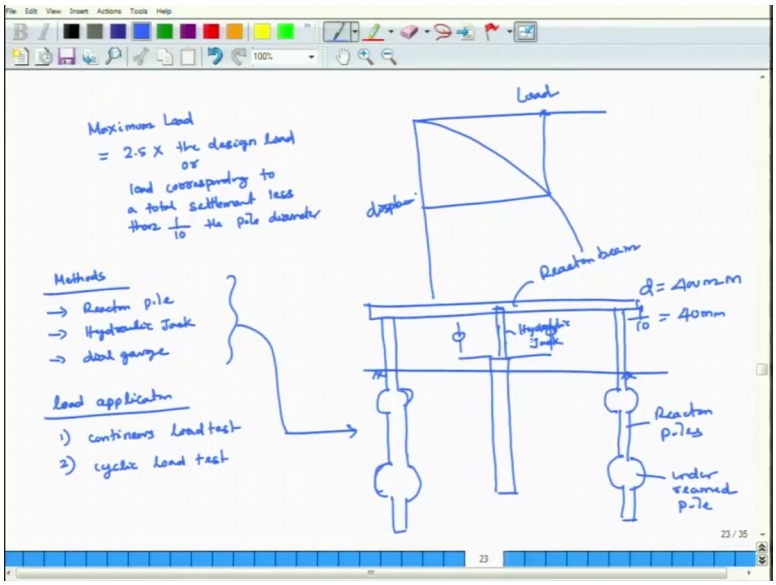

Then second is your consistency third is your cohesive strength; that means, c cohesive strength then is your alpha. Material is your timber and concrete and second is your steel consistency is your soft medium and stiff soft medium and stiff then steel is your soft medium and stiff and cohesive strength if it is kilo Newton per meter square. So, for soft 0 to 37.5 medium 37.5 to 75.0 stiff 75.0 to 150.0, then soft medium and stiff it will be continue same here same here it will continue.

Then alpha value is varying it is between 1 to 0.9 then 0.9 to 0.6 then 0.6 to 0.45 then here it will be 1.0 to 0.80 then 1.0 to 0.5 then less than it is your 0.5. So, for cohesive soil without layer conditions so, this will be base resistance into area of the base frictional resistance into area of side frictional or surface area, in for layer soil it is a perimeter summation of alpha average adhesion factor C u bar average shear strength of clay on under undrained conditions delta is your delta L is your thickness.

Now, will solve one example look at here, this is water table at the ground surface and this is my ground surface, there is a load Q and this is your delta L1 is equal to 8 meter delta L 2 is equal to 6 meter, delta L 3 is equal to 2 meter. So, then this is your 45

centimeter then this is a soft clay C u is equal to 30 kilo Newton per meter square, alpha is equal to 0.90 and this is a medium stiff clay C u bar is equal to is your these are all C u bar average shear strength, which is equal to 58 kilo Newton per meter square, alpha is equal to 0.75 it is a stiff clay where C u bar is equal to 105 kilo Newton per meter square alpha is equal to 0.50.

So, you can take it factor of safety is equal to 2.5, now let us find it out. So, Q u is equal to C b A b N c plus perimeter summation of 0 to L total length this is your L alpha C u bar into delta L. Now perimeter p is equal to 1.429 meter, A b is equal to 0.159 meter square. So, now considering these if I calculate Q u it will be 9 into 105 into 0.159 plus 1.429 into if I consider alpha C u bar delta l alpha is your first layer 0.9 into 30 into delta L is equal to 8 meter plus 0.75 into 50 into 6 plus 0.50 into 105 into 5. So, which is equal to 930.48 kilo Newton, then Q a allowable load is equal to Q u by is your factor of safety who is comes out to be 372 kilo Newton.

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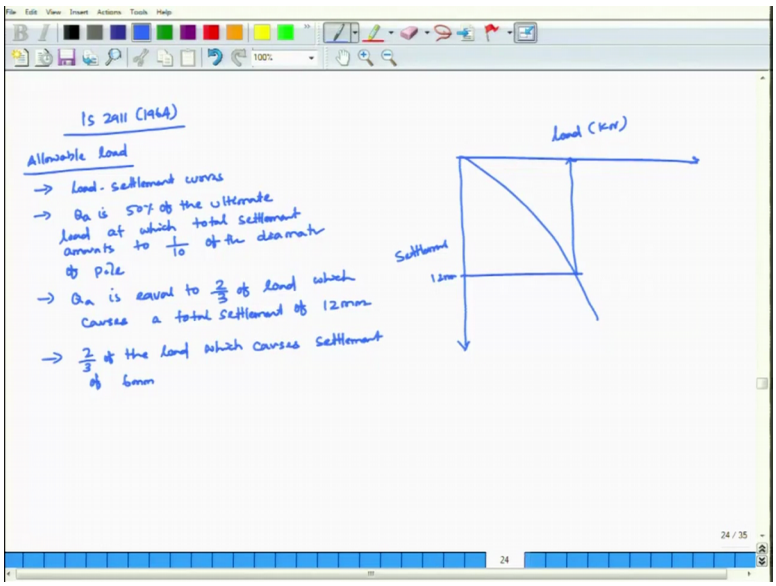

So, this is one example this is one example where I put it instead of giving a homogeneous layer, this is a layer soil water table is at the ground surface. So, for length delta L is equal to 8 meter it is soft clay, delta L is equal to 6 meter it is medium stiff clay, delta l is equal to 2 meter it is stiff clay diameter of the pile has been given 45 centimeter factor of safety is your 2.5.

All value C u average alpha all the values has been given. So, then perimeter and area of the base has been calculated based on that Q u is equal to 930.48 kilo Newton Q a is equal to 372 kilo Newton. This is what the example then I have finished this first part, let me get go back if you look at here first part right now I have finished, using static bearing capacity equations this is at the static bearing capacity equations particularly and then this based on that particularly for cohesion less soil and cohesive soil we have done it then by dynamic methods or dynamic formula second part field load test then values of SPT CPT will be later on.

So, it will be pile bearing capacity from dynamic pile driving formula. So, if I put it a energy relationship if I put it first one is your energy relationship a fast one is your energy relationship; that means, pile driving hammering of the pile, then what will happen w h is equal to Q u into s. So, Q u is equal to w h by s. So, w is equal to weight of the driving hammer and h is equal to height of fall of hammer, h is equal to height of fall of hammer w h is your energy of total w h if I write it this will be energy of hammer blow q u is your ultimate resistance to penetration, s is your pile p penetration pile penetration under one hammer blow.

Q u s resisting energy of pile basically what will happened how this energy relationship there is a pile here.

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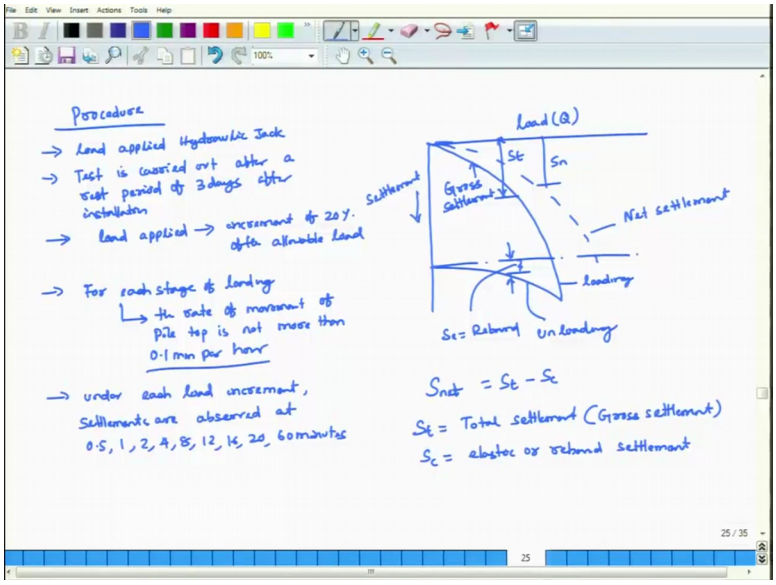

Then by means of hammering this is my weight of the hammer, and it will be fall with a certain height of fall, based on that energy of hammer blow is equal to how much resistance taken by pile into pile penetration under one hammer blow. So, this method gives fairly good result, it gives good result particularly good result for free draining sand, what are the different conditions? Free draining sand and second is your hard clay hard clay where pore water pressure does not develop.

So, cannot be used for submerged or uniform fine sand limitations, this formula or whatever it is their ultimate bearing capacity by driving by putting a hammer, it cannot be used for submerged conditions and uniform fine sands. So, there are different people different formula regard regarding this hammer has been given; first one is your Hileys formula. First one is your by means of energy relationship first one is given by Hileys h i l e y Hileys formula. So, in this case Q u is equal to n h w h by s plus c into 1 plus C r square by plus into R by 1 plus R . So, capital R is equal to w p y w. So, w p is your weight of file, and c is equal to half of the total elastic compression, small c is equal to half of c 1 plus c 2 plus c 3; c 1 is equal to elastics of compression of pile cap c 2 is equal to elastic compression of pile c 3 is equal to elastic compression of soil c r is equal to this is your coefficient of restitution and it h is equal to efficiency of hammer.

Based on the energy relationship will has given a formula n h into eta h into w h divided by s plus c plus 1 plus c r square into r divided by 1 plus r. So, in this case what is the limitation? Pile rest on rock this formula does not valid. So, different how you are going to get it as I said how you are going to get it C 1 C 2 value first one is your c 1. So, it is material then range of driving stress k g per c m square, then range of C 1. Precast concrete pile first one is your precast concrete pile. So, it will be 32 150 and it will be 0.12 to 0.50 timber pile without cap.

So, it will be 32 150 and this will be your 0.05, 0.05 to 0.20, steel H pile it will be 32 150 and it will be 0.04 to 0.16. So, elastic compression C 2 of pile then C 1 you can get it what are the different materials, and range of driving stress how much you are driving how much stress you apply based on that these are all your ranges of your C 1. Now come to c 2. So, generally C 2 is equal to Q u L by a into A E is equal to length of pile A is equal to average cross sectional area of pile E is equal to young's modulus. So, for c 3 generally c 3 is your elastic compression of soil.

Generally it has been taken as 0.1 then come to the pile hammer energy then eta h pile hammer energy what are the different hammer type, what is your eta h? Drop hammer second one is your single acting, third one is your double acting, forth one is your diesel. So, it will be 1.00 0.75 to 0.85 then 0.85 then 1.00. Next part is your c r this parameters why I am writing it sometimes you cannot get it from the books. So, these I am giving in details.

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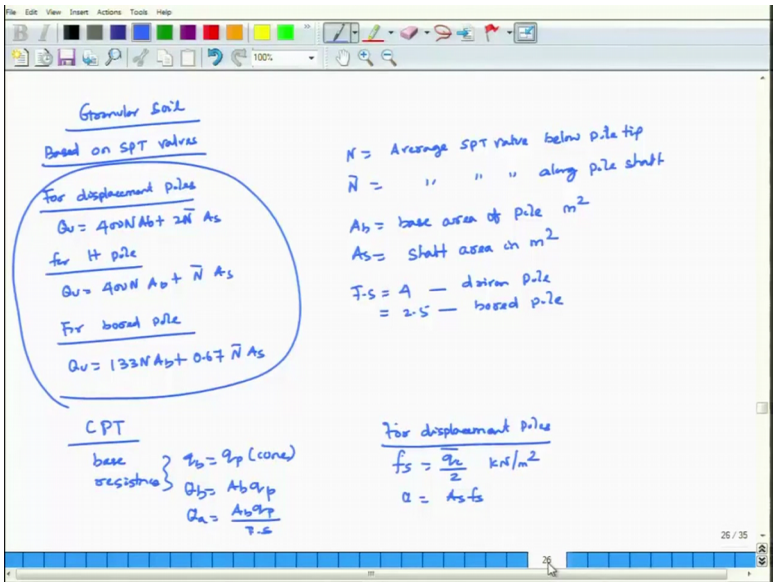

So, a bout there is a drop hammer what should be I needs eta h, then come to the value of c r wooden pile compact wood cushion on steel pile, then C I hammer on concrete then hammer on steel pipe.

So, the value of the c r this is your material, c r will be 0.25 here it will be 0.32 here it will be 0.40 here it will be 0.55. This is how this willey has given for this conditions now come to the next one that is called is your engineering news recorded formula that is your engineering news record ENR formula. In this case Q a is equal to w h by 6 s plus c, in this case what they have taken eta h is equal to 1 c r is equal to 1 and factor of safety they have taken 6. So, Q a is your allowable load in k g or kilo Newton, allowable load in k g or kilo Newton c is equal to they have given c is equal to w h q a is there then s you can said final penetration in centimeter per blow.

Final penetration in centimeter per blow, so, c is your empirical constant, c is equal to empirical constant which is equal to 2.5 centimeter for a drop hammer, then which is

equal to 0.25 centimeter per single and doubling acting hammer, there are also cases for drop hammer a for drop hammer Q a is equal to w h by 6 s plus 2.5, single acting Q a is equal to q h by 6 s plus 0.25 then double acting Q a is equal to w plus a p by 6 into s plus 0.25, a is equal to area of piston p is equal to main effective steam pressure.

Small p is equal to mean effective steam pressure kg per centimeter square. Actually it has been modified by engineering news record formula ENR what they have consider. Eta h they have consider 1 c r coefficient of restitution is equal to 1 factor of safety they have consider 6. So, they have if you compare it with village formula Hileys formula this is ultimate capacity here it is your allowable capacity, the it will be w h divided by 6 s plus c, s is your final penetration in centimeter per blow c j empirical coefficient constant which is equal to 2.5 centimeter for drop hammer, 00.25 centimeter for single and double acting hammer.

Then Q a has been calculated for drop hammer single acting and double acting all the values they have consider. So, what will happen what are the discussions about this two formula? First one is your Hileys formula does not give a consistent result, it gives either higher or lower values the second one is your this formula this dynamic formula has to be used with more confidence. So, you should have worst experience so that while using this formula you should have more confidence about this then only you can able to do it then only you can able to do it.

So, we can solve a problem of this whatever we have discussed we can solve a problem what is the example what problem has been given 40 by 40 centimeter reinforced concrete pile, pile is your forty centimeter by 40 centimeter it is the square pile of RCC reinforced concrete of 20 meter long. It is driven through loose material then into dense gravel to a final set of 3 mm per blow. Using 30 kilo Newton single acting hammer with a stroke of 101.5 meter what is the thing has been used? Single acting hammer of 30 kilo Newton, then stroke 1.5 meter what has been asked? It has been asked ultimate driving resistance of pile find ultimate driving resistance of pile if it is fitted with a helmet b plastic dolly and 50 mm packing.

On the top of the pile the weight of helmet in Delhi weight of helmet is your 4 kilo Newton weight of pile is equal to 74 kilo Newton, weight of hammer is equal to 30 kilo Newton. They typical example pile size of 40 centimeter by 40 centimeter constructed as

a reinforce concrete pile and 20 meter long it has been driven into a lose material then into a dense gravel. How it has been diven? Driven with a hammering in such a way that it is giving a penetration of 3 mm for blow, everyone blow it penetrate with a 3 mm single acting hammer has been used which weight is 30 kilo Newton and a stroke if this is my single acting from here to here this is called one stroke it is your 1.5 meter find it out ultimate driving resistance of the pile fitted with helmet plastic dolly 15 mm packing on the top of the fpile and other perimeter is given weight of helmet weight of pile and weight of hammer.

So, pile hammer efficiency other parameter is given, pile hammer efficiency is equal to 0.60 coefficient of restitution c r is equal to 0.40 c bar is equal to C 1 plus C 2 plus c three is equal to 19.6 mm, c is equal to c bar by 2. Let us solve it first one is your hiley formula which is your Q u is equal to eta h w h by s plus c into 1 plus c r whole square into r by 1 plus r. So, eta h is equal to 0.8, w is equal to 30 kilo Newton, h is equal to 1.5 meter, r is equal to w p by w which is equal to 74 plus 4 by 30 which is equal to 2.6, c r is given 0.4, s is equal to 0.30 centimeter.

Then from this using this formula Q u comes out to be 1105 kilo Newton, then comes to your engineering news formula in this case Q u is equal to 6 Q a, which is equal to w h by s plus 0.25 and which comes out to be let me calculate it into 30 into 100 into 150 into 10 to power minus 3 by 0.3 plus 0.25, which is equal to 818 kilo Newton. Look at the two in Hileys formula ultimate capacity is your 1105 kilo Newton, in engineering new formula ultimate capacity is your 818 kilo Newton. Definitely Hileys formula is giving higher side this is what I have said this is based on drive pile driving formula the pile is there hammer is there, at the top your hammering it then what are how you are going to find it out if this data is are available with you as I solved in the example these are available then how to find it out pile capacity. The next one I will start next class that is your pile load test or it is called field pile load test, this is what I am going to cover in the next class.

Thank you.