Soil Dynamics
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Lecture no. 39
Analysis of Machine Foundations
(Elastic Half Space Method – Part 3)

Hello friends, hope whatever we have discussed in last 3 classes, that is all right to all of us. So, today, we will solve a few, at least one numerical problem and I will explain the other numerical problems also. So, that you can try to solve that.

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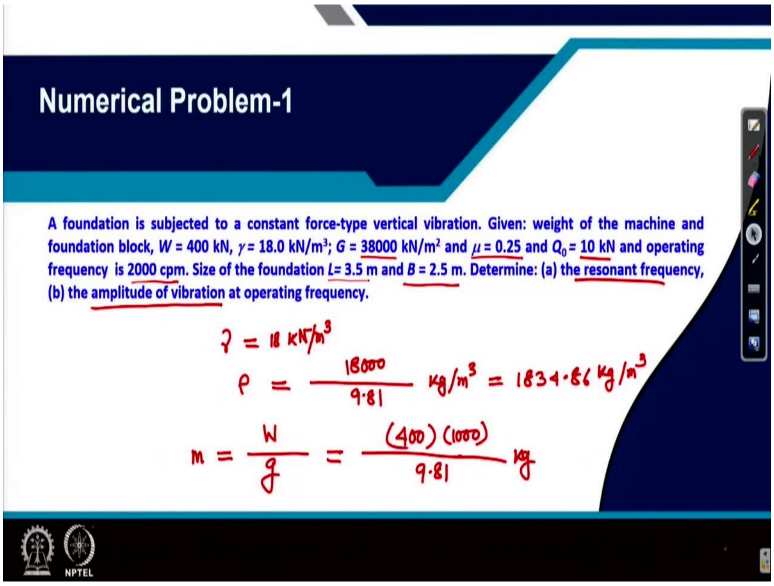

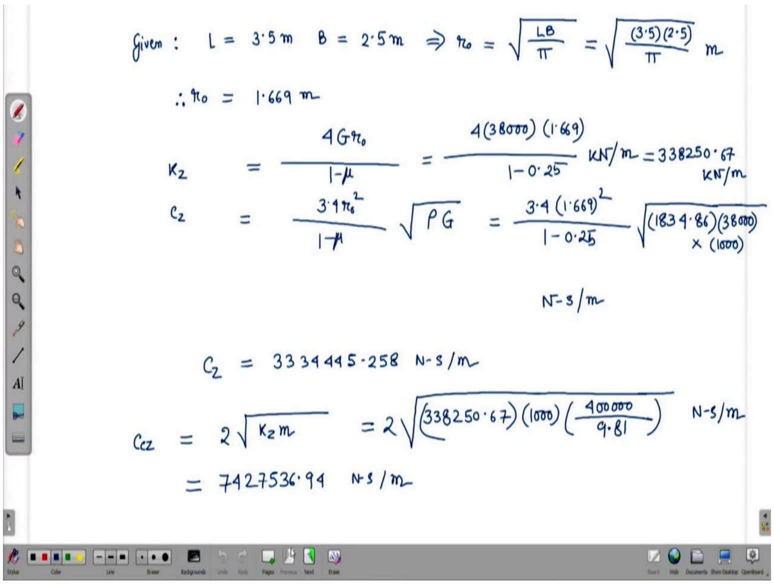

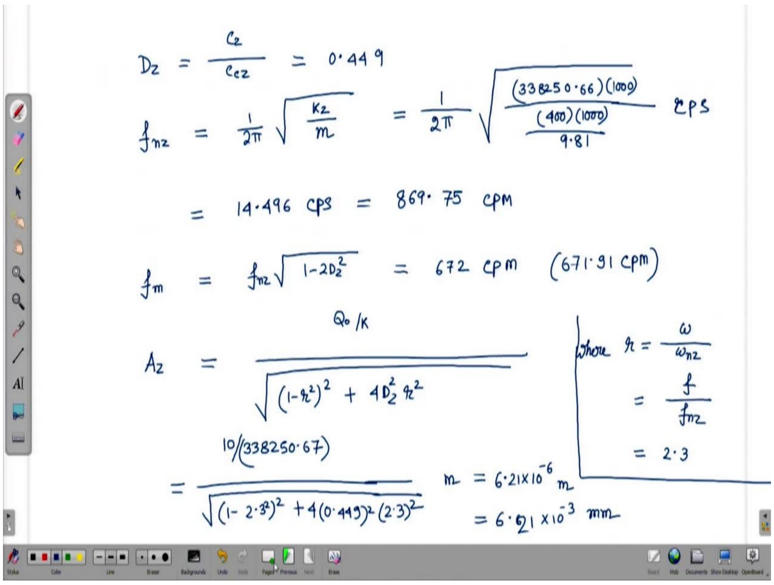

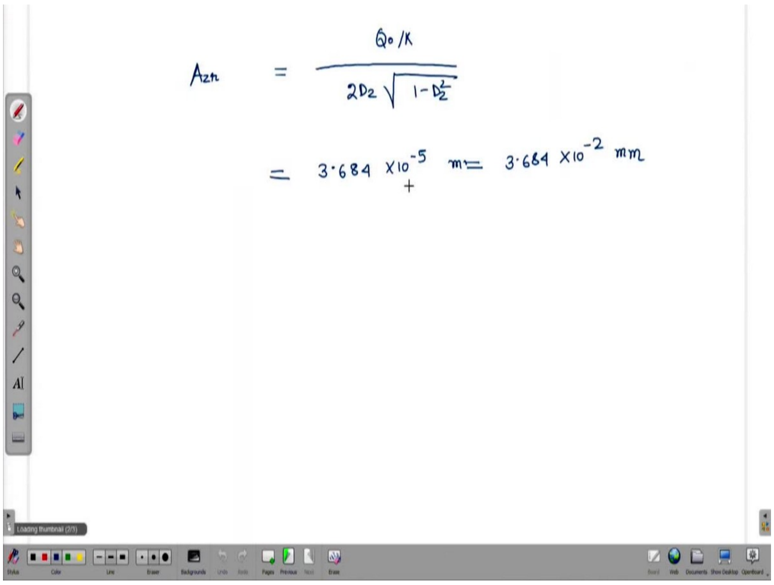

So, let us see our first numerical problem. So, I am first reading the problem statement here a foundation is subjected to a constant force type vertical vibration that means, in this case, foundation is subjected to vertical vibration. Given parameters weight of the machine and the foundation block, which is you can see 400 kilo Newton. Now, gamma, which is the bulk unit weight of the soil that is also mentioned 18 kilo Newton per meter cube G, which is dynamic shear modulus of the soil is given that is 38,000 kilo Newton per meter square, Poisson's ratio mu is 0.25 here, Q 0 which is the amplitude of vertical vibration is 10 kilo Newton and the operating frequency is 2000 cpm cycles per minute.

Also the size of the foundation is provided L is 3.5 meter B is 2.5 meter that means, it is not a circular foundation, but a rectangular foundation. So, what we need to do we need to find out the equivalent radius for the circular foundation. So, that is r 0 here, we are asked to determine the resonant frequency, resonant frequency means f m and the amplitude of vibration at of operating frequency here operating frequency is 2000 cpm.

So, let us start the problem. First I will write what are the parameters given to us, m is given that is 3.5 meter, B is given which is 2.5 meter. So, from this we can calculate r 0, which is equivalent radius for a circular foundation, how we can get it if we equate that area have the circular foundation to the area of the rectangular one, then we can get it. So, that is square root of L B divided by pi which is nothing but 3.5 divided times 2.5 divided by pi in meter.

So, from this what we can get is r 0, r 0 will be how much let me calculate quickly 3.5 into 2.5 divided by pi. So, it is coming approximately 1.6 I can take it as 1.668 or 669 in meter. Next we need to know the value of k z value of c z, k z is the spring constant and c z is dashpot coefficient. So, for k z already we have seen which equation we can use. So I am using this equation 4 times G r 0 divided by 1 minus mu. Already G and mu is given to us you can see here g is 38000 in kilo newton meters square and mu is 0.25. So, 4 times 38,000 times r 0 which is 1.669 divided by 1 minus 0.25 and it should have been unit kilo Newton per meter.

So, how much it will be let me check. So, it is coming, I am getting 338,250 in kilo newton meter, I am writing 338250.67 in kilo Newton per meter, if required, we will convert it in Newton per meter also. Now, let us find out c z. So, for c z it what equation we can use c z it means 3.4 r 0 square divided by 1 minus mu times rho G. So, 3.4 times r 0 square 669 square divided by one minus 0.25 times square root of rho I think bulk unit weight is given.

So, if I know bulk you need to eat which is a 18 kilo Newton per meter cube then from that what I can calculate rho also which is right? This is rho, so, rho is how much then let me check it is coming 1834.86 kg per meter cube you can take instead of 9.81 you may take also 10. So, now, I am writing here the expression full expression so, rho is in 1834.86 times G, G means 38,000 times 1000 to convert it in Newton per meter square so, the unit for c z is Newton second per meter.

So, what is the final value for c z let me check here 669 square divided by 0.75 into square root of 1834.86 times 38000, so, our c z is coming 3334445.258 in Newtons second per meter. Now, we can find out the critical damping c cz so, c cz is 2 times square root of k z times small m here. So, if we see the problem what is small m here that means the mass of the machine and the foundation together we can find out mass is equal to W divided by G which is 4000 kilo Newton we can convert it in Newton now, divided by 9.81 so, that is in kg.

Now, here then I can write c cz is equal to first I need to write the value of k z. In this case I will convert all the units in SI system and we need to make it uniform. I have expressed k z earlier in kilo Newton per meter, but to make the uniformity now I will convert it in Newtons per meter. So, let me do this into 1000. So, now it is in Newton per meter, now, weight of the mass of the system. So, this is the mass of the system. And now it is unities again Newton second per meter. So, how much you are getting let me calculate 338250 338250.67 times thousand.

So, we are getting critical damping 7427536.94 in Newtons second per meter. So, now I have c z and c cz.

So, from that I can calculate damping ratio which is cz divided by c cz. So, how much it will be let me check so, it is coming 0.4489 I can write it approximately 0.449 also. So, D z is now calculated after calculating D z what I need to find out is already what I have found out that let me check I have not determined so, far the natural frequency for the undamped system. So, let me do that first so, f nz which is the natural frequency for the undamped system is calculated using this equation.

So, 1 divided by 2 pi k z it means I can write the expression for k z. So, expression for k z is coming 338250.66 times 1000 divided by 400 times 1000 read by 9.81 and this is in cycles per second. So, how much we are getting I think it is coming to me is 14.496 cycles per second or you can write it also 14.5 directly and if we will express it in cpm that means cycles per meet minute then that will be if we will express 18 cycles per minute we will get 869.75 in cpm.

So, now, I have the information of the natural frequency for the system undamped condition. So, from this I can find out resonance frequency in this problem it is said that it is a subject foundation is subjected to constant force type vertical vibration. So, for the constant force type vibration, resonance frequency is less than the untapped natural frequency of the system. So, f n multiplied with 1 minus 2 D z square. So, a f n or f nz also I can use which is coming how much let me calculate 869.75 into 1 minus 2 times 0.449 square so, it is coming 671.9 or I can write it also as 672 cpm or you can I am also writing the exact value, exact what I got is this one alright.

So, now we are able to calculate the resonant frequency next is to find out A z so, for is it I can use this expression what is r here? r is frequency ratio, frequency ratio means omega divided by omega nz or I can write f divided by f nz alright. So, how much it is coming? It is coming approximately if we will try it is coming 2.3 and D z already calculated, Q 0 I think it is it 10 kilo Newton yes.

So, now A z is 10 divided by k, k is this one 338250.67 this is in kilo Newton per meter Q 0 is also in kilo Newtons, so, I am not changing the unit in this case in numerator and denominator both the places we can see kilo Newton so, they will can cancel each other. Now, divide this thing will be divided by 1 minus 2.3 square whole square plus 4 times 0.449 whole square times 2.3 square and that is in meter.

So, finally, what we are getting that I am trying to write now, I am getting to provide let me check let me calculate divided by 1 minus 2.3 square plus 4 into 0.449 square 2.3 square yes, I get the 6.21 into 10 to the power minus 6 in meter if I will convert it in millimeter then it will be 6 point sorry 6.21 into 10 to the minus 3 millimeter alright.

Now, in addition to this I can also find out the amplitude at resonance frequency I can write it not A r but I can express amplitude that resonance frequency A zr. So, what is the expression for that, for that we can directly write here Q 0 by k 2 D z times 1 minus D z square. So, I am just trying to get it 0.449 is D z square divided by 2 here. Yes, I am not writing all the values that you know already. So, it is coming actually 3.684 into 10 to the power minus 5 in meter. So, I can express it in millimeter which is 3.684 into 10 to the power minus 2 in millimeters.

So, in this way, we can find out the resonant frequency and the amplitude of vibration at operating frequency as well as at resonance frequency and if I show here you can see at resonance frequency this is the amplitude and at operating frequency this is the amplitude. So, obviously, that amplitude that resonance frequency is high that we can see here. Now, let us see the next numerical problem.

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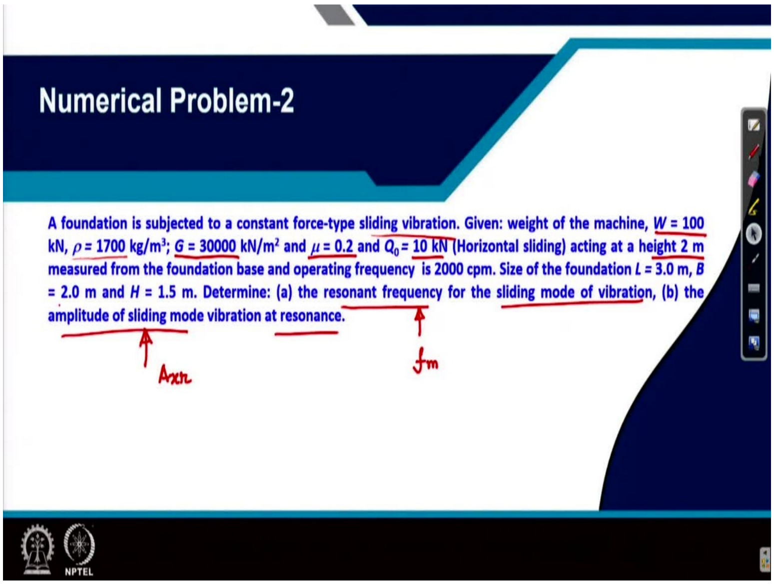

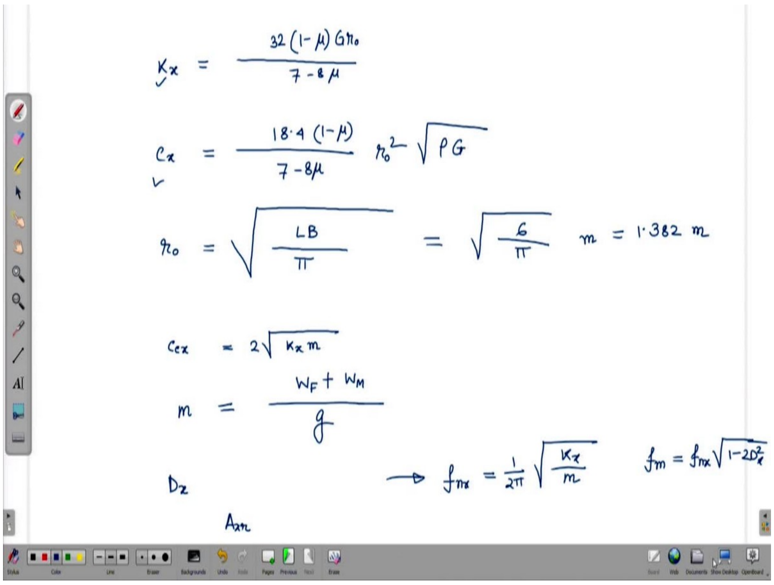

Now, let us see the next numerical problem here is the problem statement for your next numerical problem, what is said here is that a foundation is subjected to a constant force type sliding vibration, weight of the machine is given which is 100 kilo Newton, you can see the density of the soil is given which is 1700 kg per meter cube, dynamic shear modulus G is given that is 30,000 kilo Newton per meter square, Poisson’s ratio also provided and Q 0 which is the amplitude of horizontal sliding is given and it is said that it is acting at a height 2 meter measured from the foundation base and its operating frequencies also given which does not matter probably in this problem, because here only asked to find out the resonant frequency for the sliding mode of vibration and the amplitude of sliding mode vibration at resonance.

So, what is the value of omega that may not be used. So, you need to find out the you are asked to find out f m which is the resonant frequency and you are asked to find out the amplitude of sliding vibration at resonant that means A xr. So, just like the previous problem, you can start.

So, I am just showing you a few steps rest of the things you will try and next class I will tell you the final answer for this problem first you just give a try for this. So, I am demonstrating only the steps here. So, first you will find out k x you know what equation we will use equation is this one which I am writing right now, 32 times 1 minus mu times G r 0 divided by 7 minus 8 mu alright you can find out c x also.

The equation is 18.4 times 1 minus mu divided by again 7 minus 8 mu times r 0 square times square root of rho G. Sorry r 0 square not 0 here r 0 square. Now here you need to know r 0 for that what you will do? The area of the rectangular foundation will be equated to the area of the circular foundation and then you will get this expression.

So, let me check what are the values given to you just I am going back to sorry, I do not need to go back previous slide here 3 and 2 right. So, if it is 6 divided by pi that is in meters so, r 0 you will get 1.382 meter. Now, these r 0 will be used to find out this k x and c x then you will find out c cx which for which you need to use this equation.

Now here how you will calculate m. So, m is the mass of the foundation and soil sorry foundation and the machine. So, weight of the machine is already given you can see that is 100 kilo Newton, what about weight of the foundation you know the volume of the foundation because length, the width and height are provided you know it is made of concrete and for concrete unit weight of concrete you can take 23.5 kilo Newton per meter cube or you can take even 24 kilo Newton per meter cube from that you will get the total weight of the concrete in kilo Newton and that should be added to the weight of the machine itself and that final weight will give you will be used to find out m.

So, in this case m means W F that means weight of foundation plus weight of machine divided by G. I hope with this you will be able to find out cake k x c x, c cx then you will find out damping ratio and from that you will find out f m, before f m you need to find out if f n, f nx which is this one right after finding out f nx what you will find out you will find out f m it is constant force type excitation. So, here also you can use this equation and then you will find out A xr which is amplitude at resonance.

So, today I am not calculating the values I am giving you can exercise next class I will share you the final values of the parameters which are asked to find out. So, with these I am concluding today’s class.

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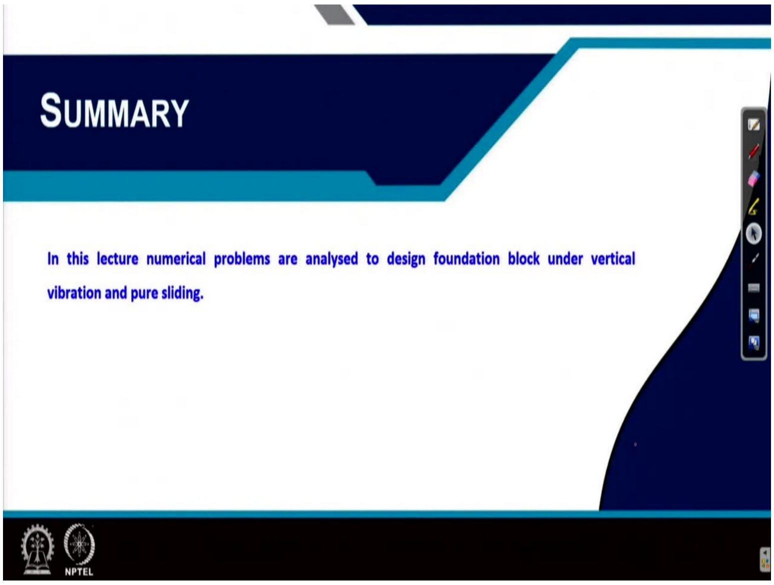

Here is the summary, summaries that we have discussed only the numerical problems and for solving the numerical problems we need to take care of that unit or dimensions of the parameters otherwise, we will not get the correct answer. So, please take care of the unit or dimension of the parameters.

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This is the only reference which I have used today to solve to set these numerical problems and to solve the questions. All right. So, thank you. We will meet once again in next class.