Soil Dynamics
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Lecture - 38
Soil Dynamics - Quiz

Welcome to the evaluation part of soil dynamics course. Today, we will start with quiz for the soil dynamics course. This quiz can be taken or you can appear for this quiz or this test after completion of the module, which describes about the machine foundations. So, let us see the questions which are asked in this evaluation or test or quiz. Let us look at this slide here. So, soil dynamics quiz full marks can be assigned about 100 and duration is 1 hour to solve the number of questions which has been set for this quiz. It is also mentioned answer all questions and assume reasonable data if necessary, if it is not required of course, all the data have been provided in this question paper set. So, let us look at the question paper set first.

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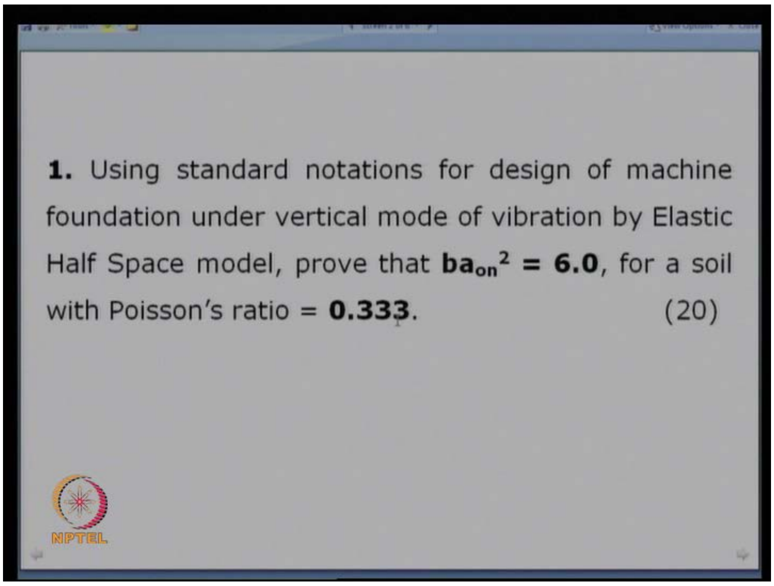

This is the first question which says, using standard notations for design of machine foundation under vertical mode of vibration by elastic half space model, prove that b times a naught n square is equals to 6, numerical value of 6 for a soil which is having Poisson’s ratio of 0.333. So, the marks assigned for this first question if we look at the slide again is 20 marks.

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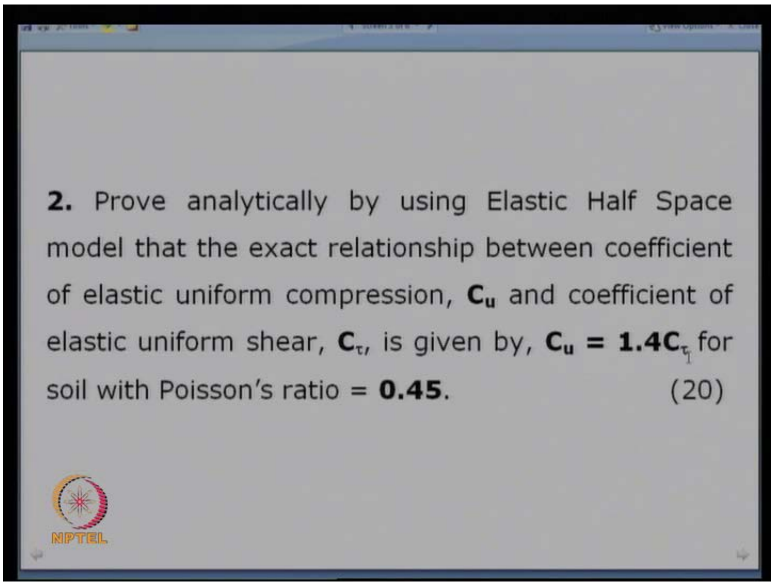

Let us move to the second question which says, prove analytically by using elastic half space model that the exact relationship between coefficient of elastic uniform compression, which generally we express by using the symbols C suffix u and coefficient of elastic uniform shear, which we generally express using the symbol C suffix tau is given by C u equals to 1.4 times C tau for a soil which is having Poisson's ratio of 0.45. So, for this question also about 20 marks can be given. Let us look at the next question.

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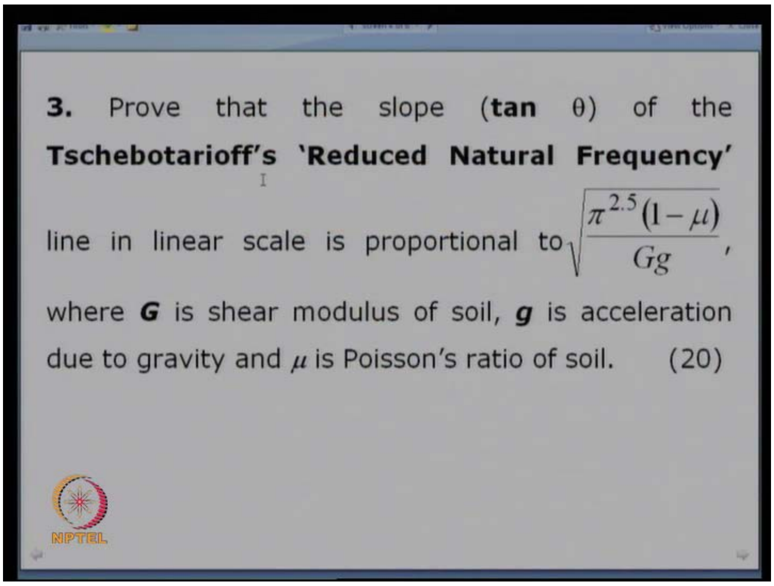

The question number 3 is, prove that the slope that is the tan theta of the Tschebotarioff's 'reduced natural frequency' line in the linear scale. The graph, which we have described in the theory part of this course so the same Tschebotarioff's design chart we want to find out what is the slope inclination analytically. So, that is what we are asking here, that prove that the slope of that line, when we are using the Tschebotarioff's design chart in linear scale; not the log log one, it is in the linear scale is proportional to this term where, this capital G is nothing but the shear modulus of the soil small g is acceleration due to gravity and this mu is Poisson's ratio of the soil, pi is of course, pi parameter 22 by 7. So, marks for this question also can be set as 20 marks. Let us see the last question, which can be set for this quiz or for this test, question number 4.

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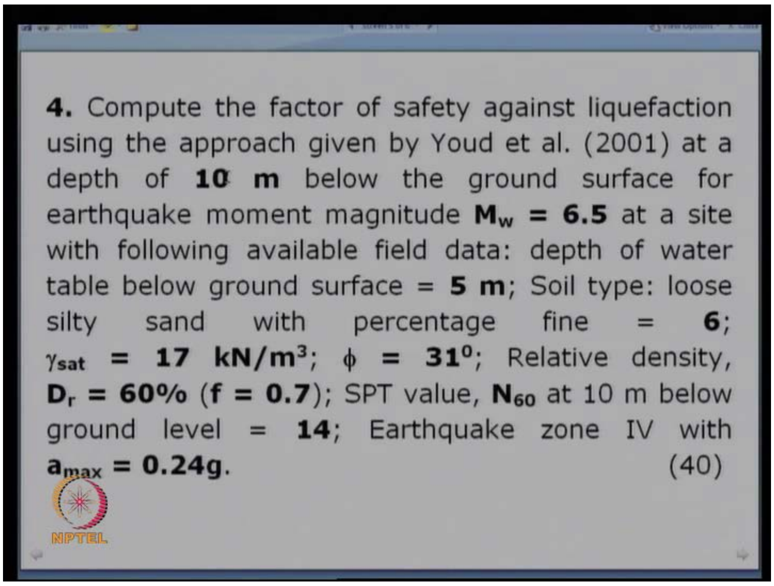

Question number 4, it is asking that compute the factor of safety against liquefaction using the approach proposed by or given by Youd et al 2001 the paper which we have described or which we have discussed thoroughly in our course curriculum of this soil dynamics course. At a depth of 10 meter below the ground surface for earth quake moment below the ground surface, for earth quake moment magnitude M w equals to 6.5 at a site with following available field data. What are those data? Like depth of water table below the ground surface which is 5 meter, soil type is loose silty sand, with percentage fine is 6 percent, saturated unit w8 of the soil is 17 kilo Newton per meter cube, friction angle of the soil phi is 31 degree, relative density of the soil D r is 60 percent, corresponding to that we know the factor f which needs to be used for a correction factor later on for solving this problem that f is 0.7, SPT value n 60 at 10 meter below the ground level is given as 14. Let us note here that, the value of SPT n value given here is corrected using the energy correction.

So, that is why the symbol used here is n suffix 60 that is related to 60 percent of energy input. So, we need not to carry out any energy correction for this value of n 60 which is supplied to us or given to us in this question paper. So, n 60 at 10 meter depth below the ground level is set as 14 earth, quake zone is given as zone 4 as per our Indian earth quake code is 1 8 9 3 with the value of a max which can be considered as 0.24 times g. The marks for this question can be kept as 40 marks. So, total of 100 marks for this test with this 4 questions. Now, let us see how the solution of these 4 questions can be done with steps and details. What is the possible set of solution we can have for this quiz.

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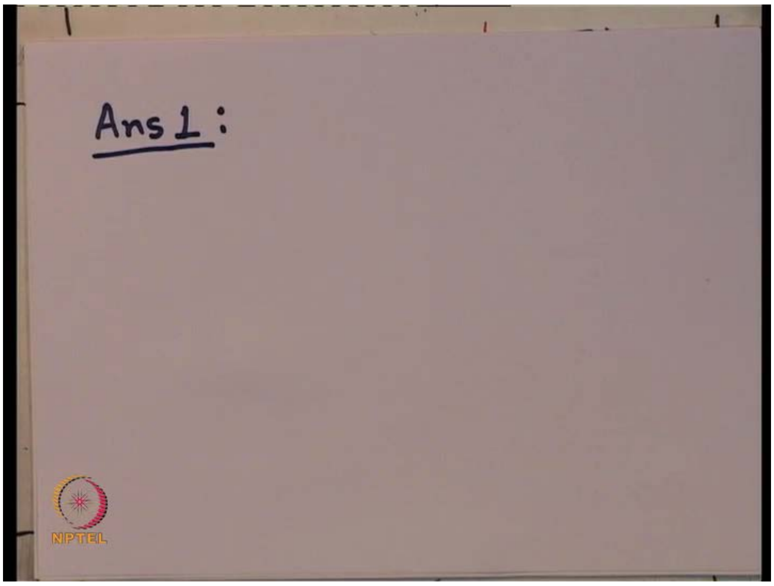

For the first question, let us write down the answer.

So, let me keep in this slide here, the question number 1 so that we can easily write down the solution. It says standard notations for b and a naught n needs to be used.

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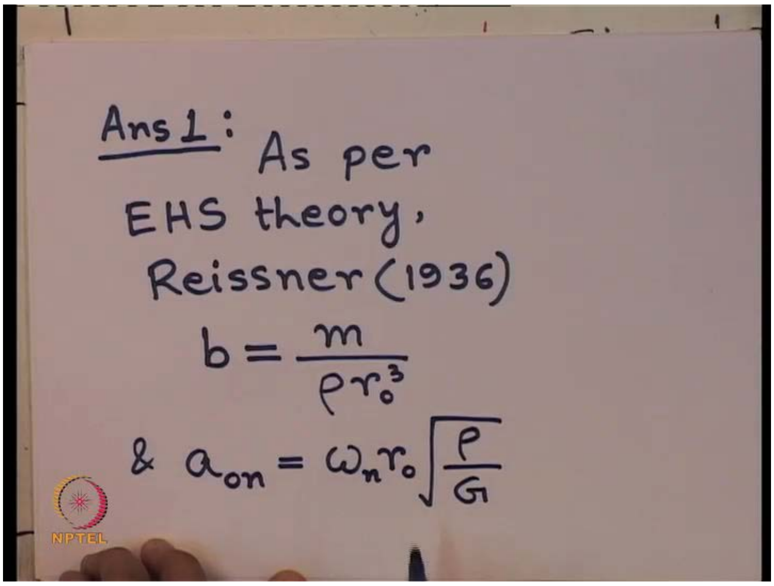

So, using elastic half space model as we know as per elastic half space theory or elastic half space model as given by Reissner in 1936: The expression for the non-dimensional parameter mass ratio is given by b small b which is equals to m by rho r naught cube that we know already. And the non dimensional frequency parameter a naught n is given as omega n r naught times root over rho by g. Now, in this we know for this parameter b, m is the mass, rho is density not the unit w8 it is density, r naught is the equivalent radius of the rigid circular footing or machine foundation which is designed and this a naught n expression, omega n is natural frequency of the system, r naught already I have defined, rho I have already defined and g is shear modulus of the soil. So, now we need to prove in the next step. Let us put it here.

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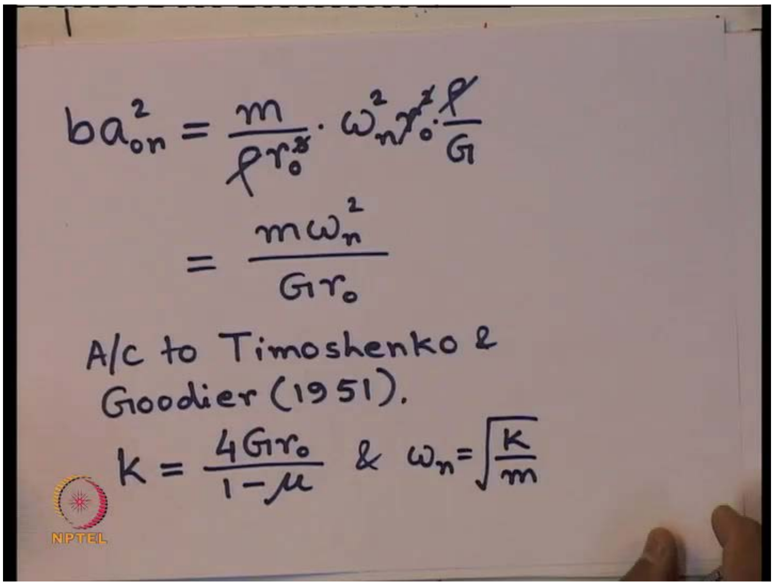

The parameter b a naught n square; so, we need to compute this term. Let us see on simplification what we get from this term. So, this will be the expression of b times a naught n square. Now, in this case this gets cancelled, I have only one r naught, rho rho gets cancelled. So, what we can write further? It is equals to m omega n square by g times r naught. Now, let us see if we know any other expressions to simplify it further. So, according to Timoshenko and Goodier 1951, the expression for the stiffness of the system for vertical mode of vibration k can be expressed as 4 G r naught by 1 minus mu. We already know this, when we had discussed the theory of machine foundation. Here all the parameters are known; g shear modulus of soil, r naught is equivalent radius of the circular rigid foundation subjected to vertical mode of vibration, mu is Poisson’s ratio of the soil. And we know omega n that is, natural frequency is expressed as root over k by m. So, using this known expressions let us see what further simplification of this parameter b a naught n square we can bring.

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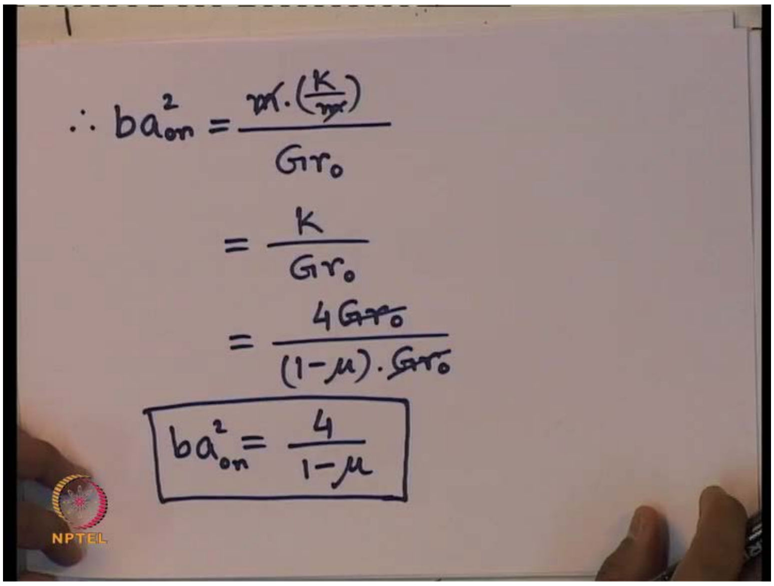

Therefore, b a naught n square on further simplification it becomes m times k by m because it was omega n square which we can write as k by m divided by G r naught. Now, this m m gets cancelled. So, what I can write? This becomes k by G r naught. Now, what is the expression of k? Just now we have seen for vertical mode of vibration is 4 G r naught by 1 minus mu. So, this this get cancelled. So, 4 by 1 minus mu. So, b times a naught n square can be expressed by this expression that is, 4 by 1 minus mu. This is a very good expression which shows that the product of this non dimensional mass ratio and the square of the non dimensional frequency parameter is dependent on the soil property only and that too on the Poisson's ratio of the soil which is simplified by this expression.

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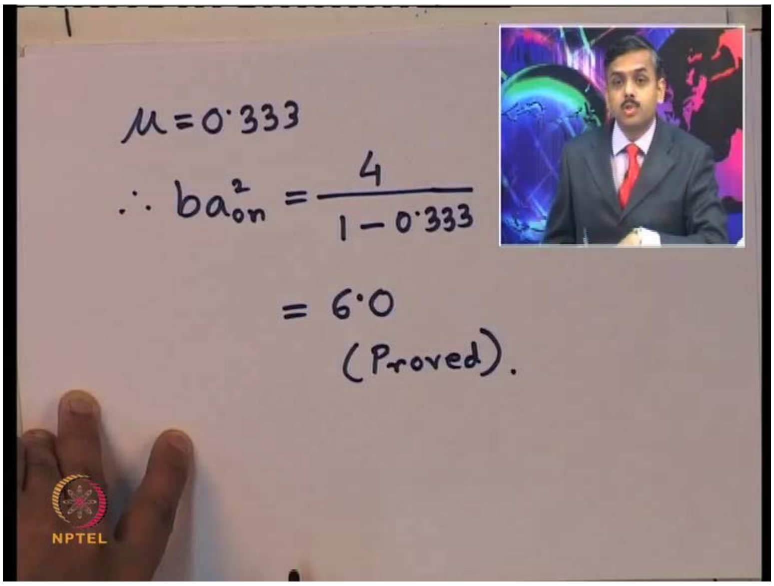

So, now in our question it was asked that, if the Poisson's ratio of the soil is given as mu as 0.333. Then, what should be the value of this term b a naught n square? Then, let us put in the expression the value of mu this will give us the solution b a naught n square equals to 6 so, proved. That was the question which was asked in our first question. If we look at the slide here it says, prove that b times a naught n square is equals to 6 for a soil with Poisson's ratio of 0.333. So, that is what we established here, this is equals to 6. That completes the problem number 1.

Next let us move to problem number 2. Let us see what was problem number 2 in the slide? Let us keep it here. We need to prove analytically that using elastic half space model the relationship between C u and C tau the exact relationship is given by this, if the Poisson's ratio of the soil is 0.45. Let us see what we can find out or how we can prove this expression.

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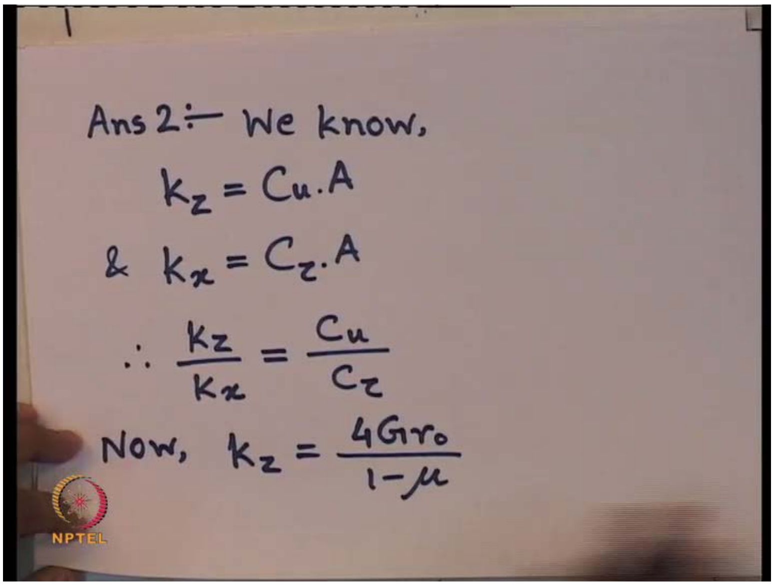

So, answer of question number 2 now, we are writing. What we already know from the theory which has been covered for this course soil dynamics that, k z is given by C u times a. What is k z? k z is nothing but, the spring constant for vertical mode of vibrations of a machine foundation system. And C u is already defined as coefficient of elastic uniform compression and A is the cross sectional area on which the vibration is subjected to for the mode of vertical vibration. And for horizontal mode of vibration this k x is given as C tau times A. So, k x is the spring constant in the case of horizontal mode of vibrations for a rigid machine foundation, block type machine foundation which is expressed as C tau. C tau is nothing but, coefficient of elastic uniform shear and A is the cross sectional area of the foundation which participate in this shearing process. So, if we know these 2 expressions, what we can write? Their ratio that is k z by k x that is vertical mode of vibration to horizontal mode of vibration can be simply written as C u by C tau because the cross sectional area involved in both the cases are same.

Now, just now we have discussed we have known expression of k z which is 4 G r naught by 1 minus mu as per Timoshenko and Goodier 1951. For vertical mode of vibration: G is shear modulus of the soil, r naught is effective radius of the equivalent circular foundation mu is Poisson’s ratio. Similarly, let us see what is the expression for a parameter k x.

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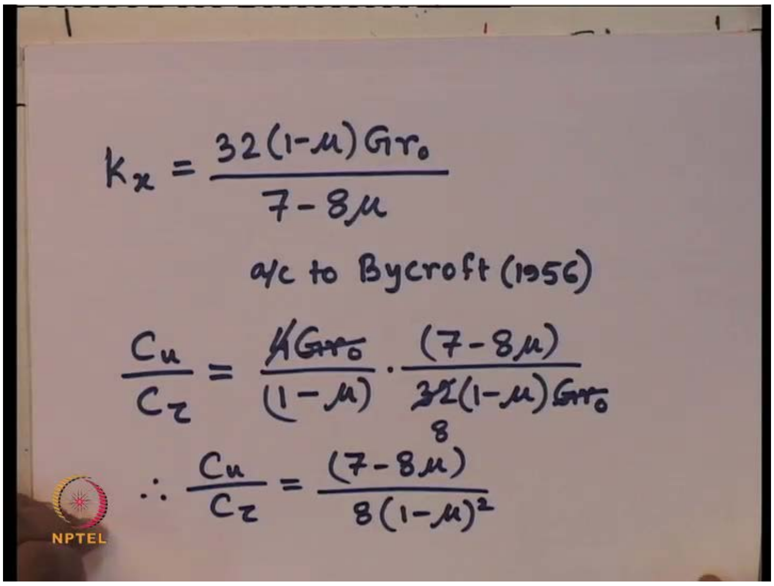

Now, k x can be written as 32 times 1 minus mu g r naught by 7 minus 8 times mu. This is according to Bycroft as proposed in 1956, we have discussed also in our theory course. So, if we know the expression of these 2 terms k z and k x then, automatically in the expression of C u by C tau we can put them and simplify it further. Let us see how it can be. So, 4 G r naught by 1 minus mu times 7 minus 8 mu by 32 times 1 minus mu into G r naught. So, G r naught G r naught gets cancelled 4 8. Therefore, this C u by C tau becomes 7 minus 8 mu by 8 times 1 minus mu whole square, that is the expression. So, in this expression now, it is given in the question for mu equals to 0.45 we need to find out the exact relationship.

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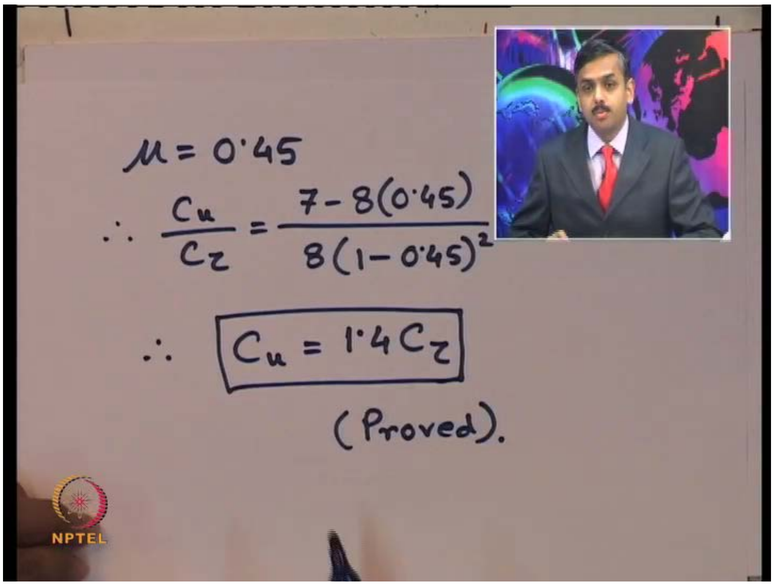

So, let us put the value of mu equals to 0.45. So, mu Poisson's ratio is given as 0.45. Therefore, this C u by C tau becomes 7 minus 8 mu by 8 times 1 minus mu whole square. Therefore, C u equals to 1.4 C tau. Hence proved. So, this shows that for a particular value of Poisson's ratio there is an exact solution or exact expression or relationship exist between these 2 parameters C u and C tau which is established here or proved here.

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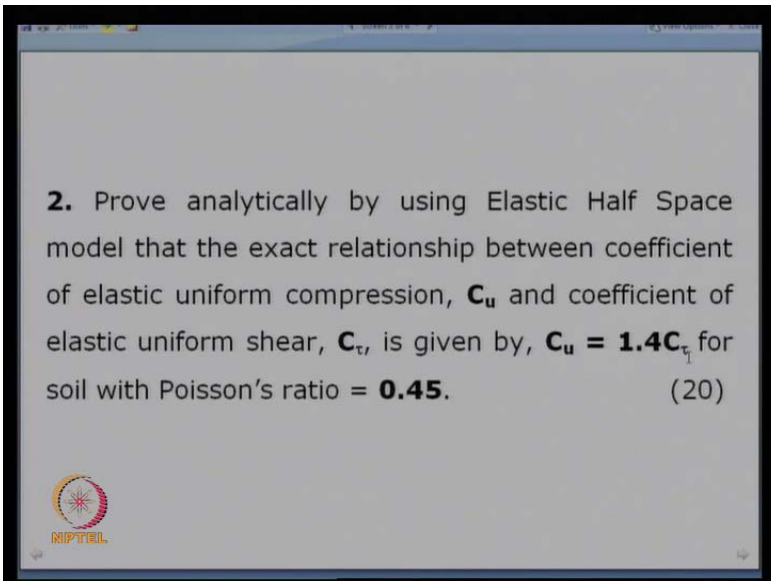

So, this is proved already. That is the solution of question number 2.

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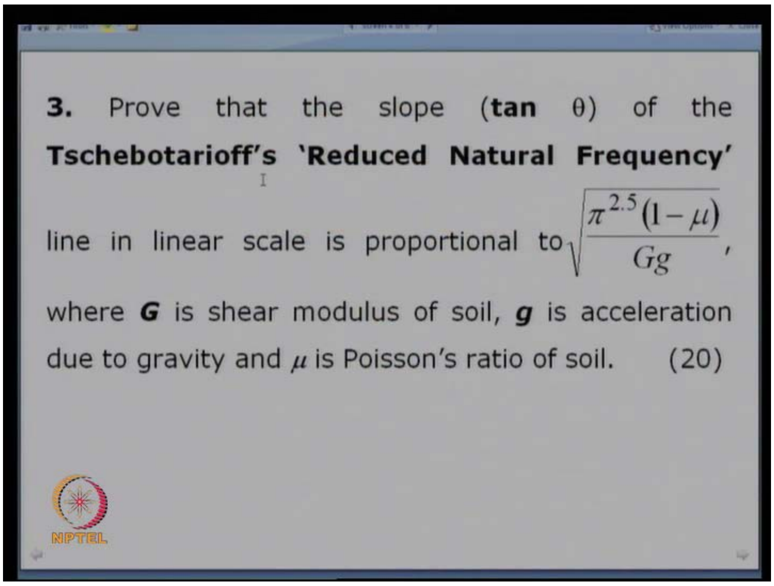

Let us see, what is there in question 3. Question 3 said prove that the slope of Tschebotarioff's design chart in linear scale the reduced natural frequency slope is proportional to this parameter. Now let us see how we can establish this solution or how we can prove it.

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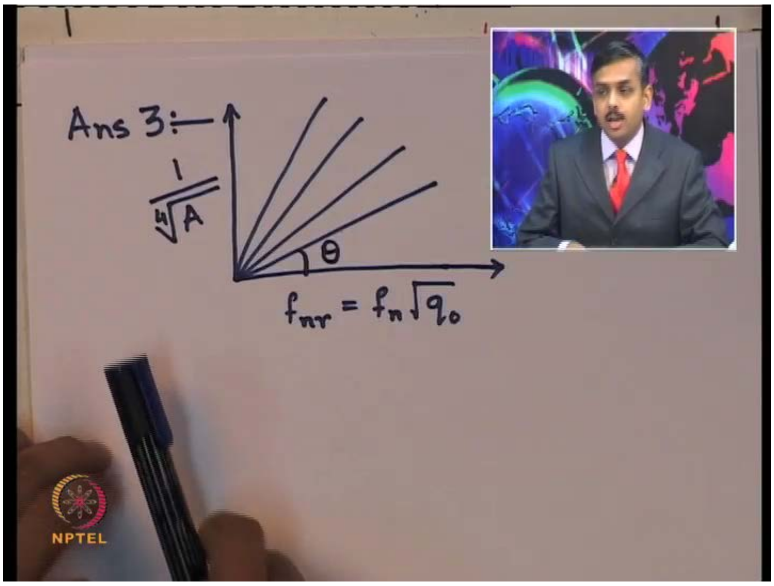

So, answer of the third questions we are now trying to find out. As we have already discussed in the theory class for this soil dynamics course. This is a typical chart in linear scale as proposed by Tschebotarioff for f n r in the x axis and in the y axis we have 1 by

4th root of area A. So, that is the linear scale as proposed by Tschebotarioff. This is reduced natural frequency in x axis which is nothing but the natural frequency times root over q naught, q naught is uniform pressure below the machine foundation and A is the cross sectional area of the machine foundation, 1 by 4th root of that A in linear scale is in the y axis. Now, for different types of soil as we have seen earlier, there are different lines given by or proposed by Tschebotarioff for the design chart. So, this angle if it is theta, it is asked in this question that prove this tan theta for any particular type of soil.

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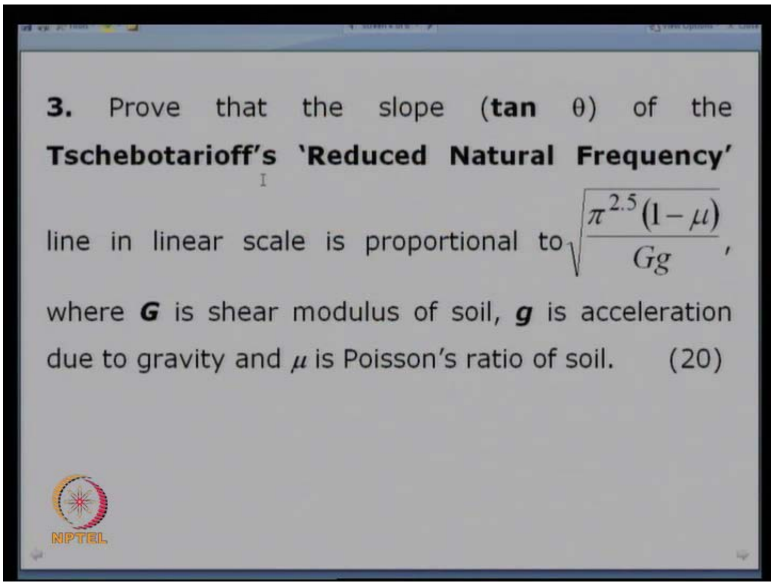

If we look at the slide here again it says this tan theta the slope of that line will be proportional to this parameter. So, let us see how we can prove that.

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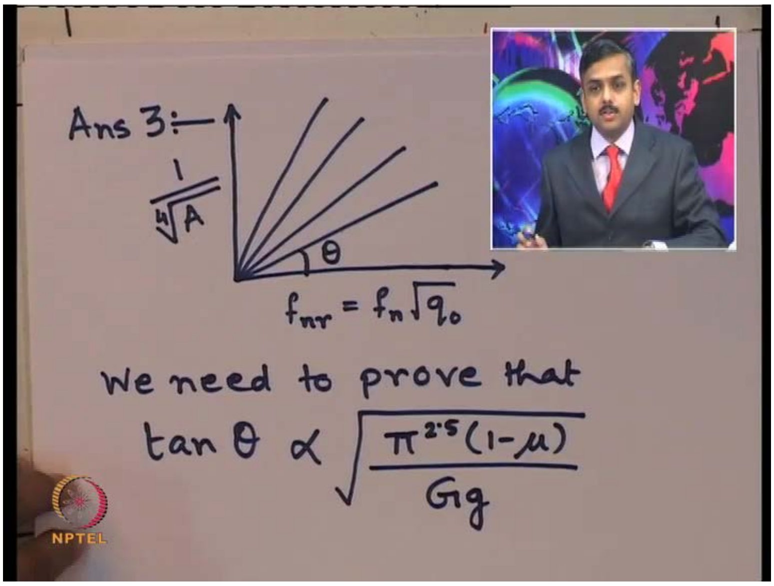

So, we need to prove we need to prove that, tan theta is proportional to the parameter which is given is pi to the power 2.5 times 1 minus mu, mu is Poisson’s ratio of the soil by G g, capital g is shear modulus of the soil, small g is acceleration due to gravity. So, we need to prove this. Let us see how we can proceed further.

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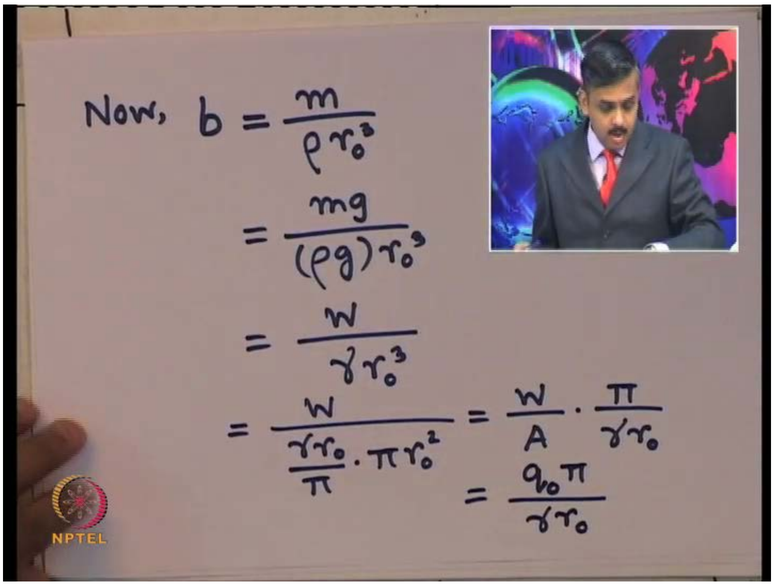

If we see the expression of non dimensional mass ratio b which we have also discussed in our previous problem number 1, just now. So, b equals to m by rho r naught cube which I can rewrite as m g rho g times r naught cube which is nothing but w by gamma r naught cube, where, w is the weight of the machine plus foundation system and gamma is the unit weight of the soil.

So, on further simplification we can write it as w by gamma r naught by pi into pi r naught square. Now, what it can be further reduce to w by a times pi by gamma r naught because pi r naught square is nothing but the cross sectional area A, that is why we can write w by A. Now, pi goes up pi by gamma r naught. Now, what is this w by A? w by a is nothing but, as per Tschebotarioff's expression this is q naught, q naught times pi by gamma r naught that is, equal to this b.

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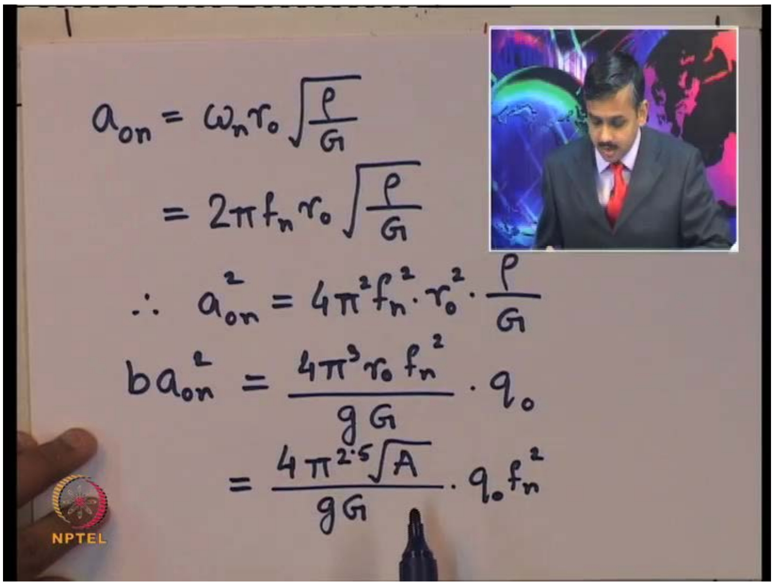

Now, let us see what other simplifications we can make from our known expressions. So, a naught n is expressed as omega n r naught root over rho by G that we have already used. This omega n we can write as 2 pi f n r naught root over rho by G. Therefore, a naught n square will be 4 pi square f n square r naught square times rho by G. So, if we simplify the expression of b a naught n square in this case, what we will get?

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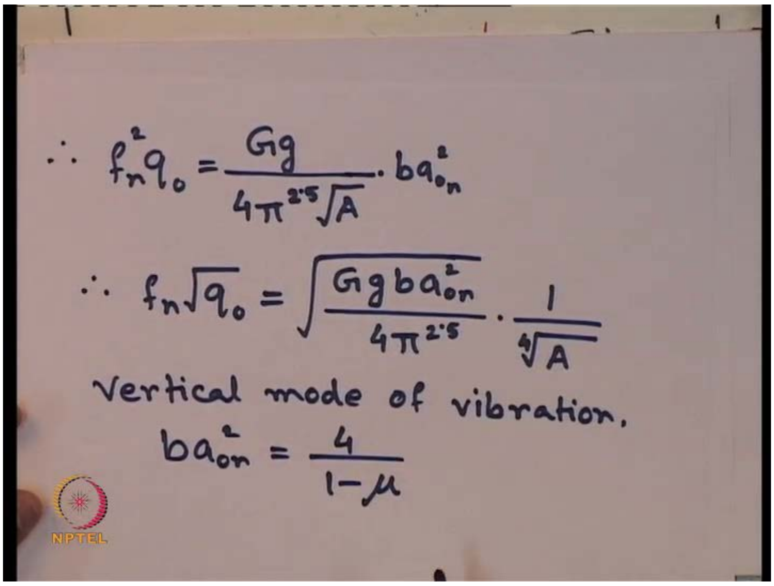

4 pi cube r naught f n square by G g into q naught, by putting the expression of b. Therefore, on further simplification we can write as 4 pi to the power 2.5 root over A by G g into q naught f n square. So, I have taken out root A which is nothing but pi to the power 0.5 times r naught. Is it correct? Next, what I can mention in this case that f n square times q naught is nothing but, G g by 4 pi to the power 2.5 root over A times b a naught n square. Just I have taken b a naught n this side and this parameter on the other side. Therefore, the Tschebotarioff's design chart in the x axis which is f n root over q naught, can be written as root of G g b a naught n square by 4 pi to the power 2.5 times 1 by fourth root of A. This can be written from here easily by taking root from both the sides. Now, for vertical mode of vibrations, for vertical mode of vibration b a naught n square is can be simplified and written as 4 by 1 minus mu. That we have seen in our problem number 1 also. So, what further simplification we can do for this expression? Let us see.

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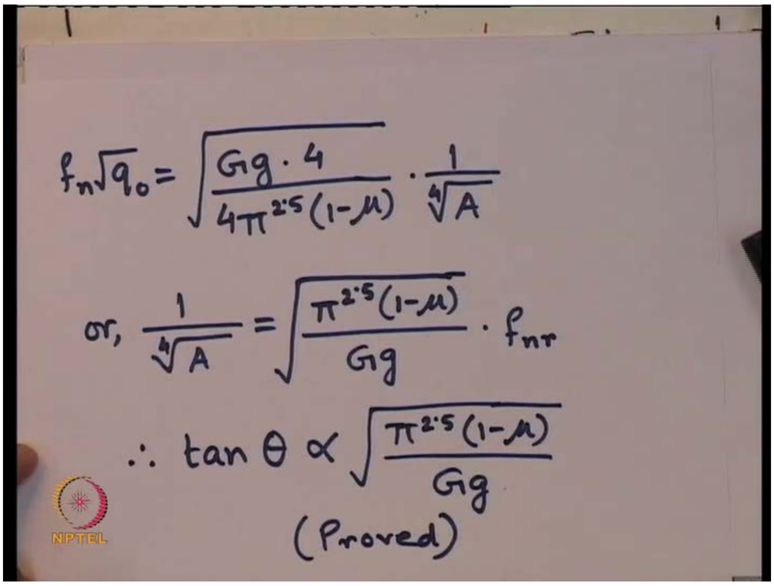

So, f n times root over q naught can be expressed as root G g times 4 4 pi to the power 2.5 into 1 minus mu times 1 by fourth root of A or 1 by fourth root of A is equals to root over pi to the power 2.5 1 minus mu by G g into f n r. By taking this term over there we can write like this. This one is nothing but our tan theta. Therefore, in the plot of this y versus x in Tschebotarioff's plot, that tan theta is nothing but proportional to this term pi to the power 2.5 times 1 minus mu by G g, which is proved.

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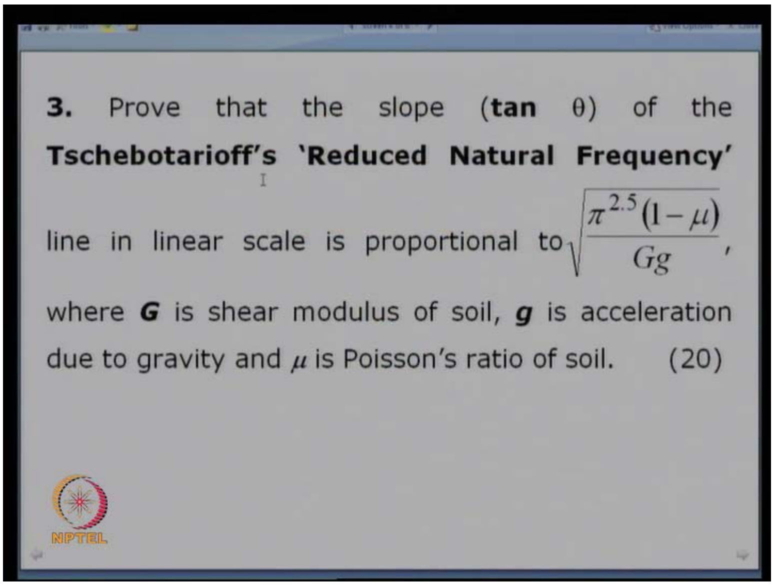

So, if we look at the slide what it was asked here that, tan theta is proportional to pi to the power 2.5 into 1 minus mu by G g, which we have established through the analytical solution. So, that completes the answer of this question number 3.

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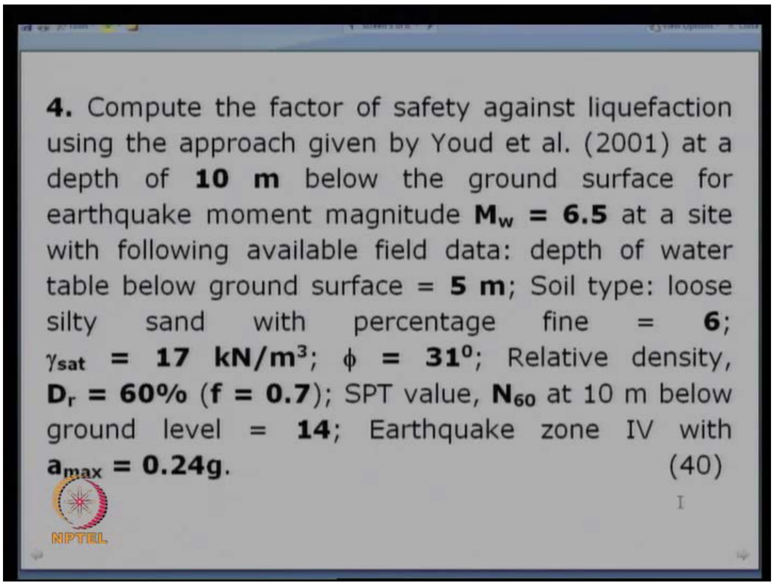

Now, let us move to the next problem, problem number 4. Question 4 says, compute the factor of safety against liquefaction using the approach proposed by or given in the paper of Youd et al 2001 which we have discussed in this course while discussing the theory part.

At a depth of 10 meters below the ground surface for earth quake moment magnitude m w equals to 6.5, at a site with following available field data that is, depth of water table below ground surface is 5 meter, soil type loose silty sand with percentage fine is 6 percent, gamma saturated is 17 kilo Newton per meter cube, friction angle of soil phi is 31 degree, relative density D r is 60 percent with the factor f equals to 0.7 which we need to use for some correction later on I will describe, the SPT value standard penetration test value given to us is n 60 that is it is corrected with respect to the energy correction n 60 at 10 meter depth below the ground level is given as 14 and earth quake zone IV as per our Indian seismic code of IS 1 8 9 3 with a max value given as 0.24 g. Let us see how we can proceed to the solution of this problem.

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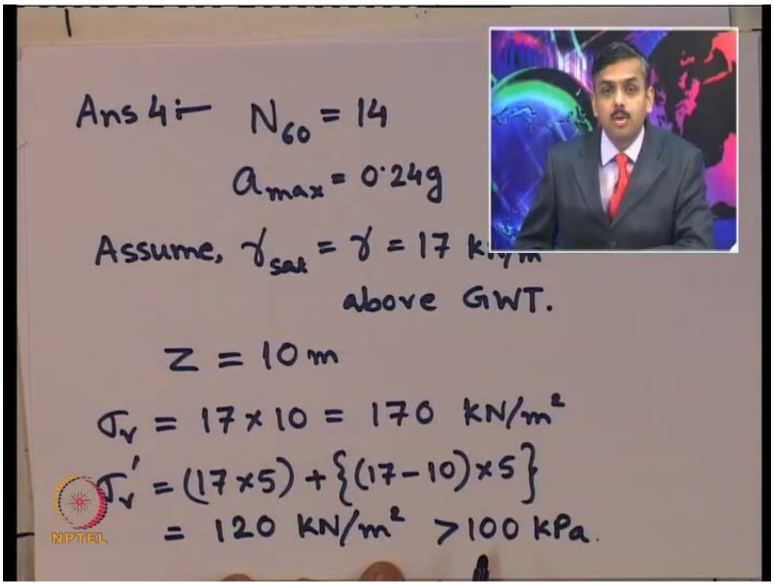

Let us first write down the given parameters for this problem number 4. We are writing n 60 is given as 14, a max is given as 0.24 g. Now let us assume or consider that gamma saturated equals to gamma equals to 17 kilo Newton per meter cube above ground water table also that is, when the data is not provided we can assume reasonable value of gamma. If somebody wants to consider some lower value of gamma above ground water table or if the value is provided to us we can use that exact value. In other word we can use either gamma of 17 maximum above ground water table or little lower than that value, as per actual if it is given to us. And the depth at which we need to compute this factor of safety against liquefaction is 10 meter. Now, what is the total stress in the soil element at that 10 meter depth sigma v is nothing but 17 times 10 which is 170 kilo Newton per meter square. And what is the effective stress sigma v dash at 10 meter depth? 17 into 5 which is up to the location of ground water table because in the question paper it is mentioned ground water table is at 5 meter depth below the ground surface plus.

We need to take the submerged weight 17 minus 10 into 5. You can note here I have considered unit weight of water as 10 kilo newton per meter cube, if somebody wants to consider as 9.81 kilo newton per meter cube that is also correct one can consider that as well but, for the simplicity we can consider 10 also, which computes to be 120 kilo newton per meter square as the effective vertical stress at the depth of 10 meter which is more than 100 k p a or 100 kilo newton per meter square. This value of 100 is necessary because later on we will see based on this value we need to decide whether we should go for some particular correction in liquefaction computation or not.

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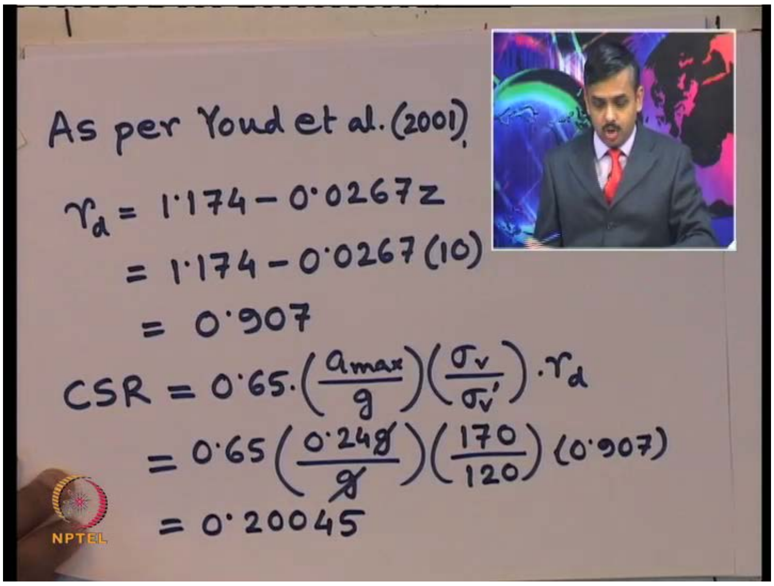

So, let us proceed to the calculation of various terms. So, as per the paper of youd et al 2001 which we have described in detail and discussed for liquefaction computation, the r d that parameter r d due to the flexibility of the soil which needs to be considered is expressed for 10 meter depth we can use this expression. So, the value of r d at 10 meter depth will be 0.907. And what is the expression for CSR, cyclic stress ratio as given in this paper? We know CSR is 0.65 times a max by g, g is acceleration due to gravity sigma v by sigma v dash times r d. So, all these parameters we know.

So we can calculate CSR very easily. 0.65 it is given to us a max is 0.24 g, this is also g so, this gets cancelled sigma v is 170, sigma v dash is 120 and r d is 0.907 as we have computed here, which gives us the value of CSR comes out to be 0.20045 that is the value of cyclic stress ratio. Now, let us see how we can compute the cyclic resistance ratio that is CRR for computation of factor of safety against liquefaction.

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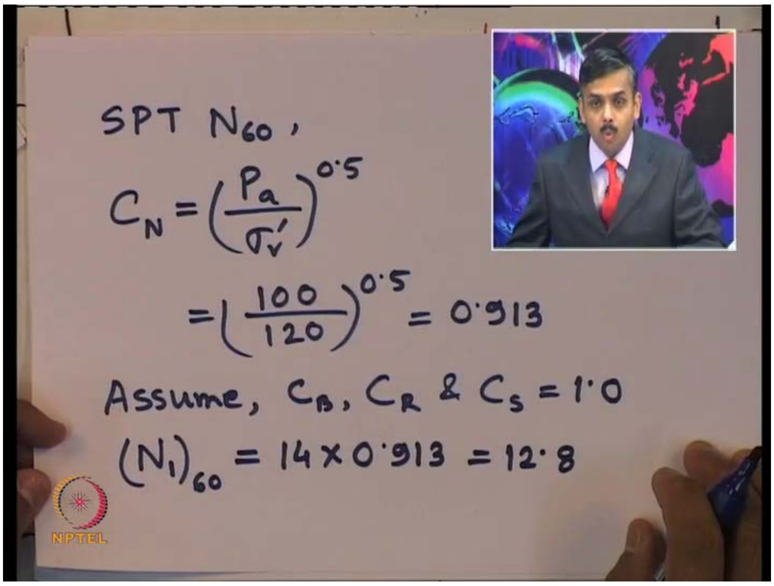

Before that the SPT N 60 value needs to be corrected further. So, what are the corrections required the over burden correction C N is required because only energy correction is done here, the over burden correction is not carried out. So, C N if we take the expression given in the youd et al paper is this, which is the correction factor for over burden pressure for the SPT N value needs to be carried out is 0.5 which is 0.913.

Now, other correction factors let us assume or let us consider that, C B, C R and C S all are equals to 1 that is no correction is required because no other information is provided in this question number 4 about the bow hold diameter used for this SPT, the rod length and the sampler tube liner material. So, in absence of these data we can take no correction factor but, if these data are available. Suppose a particular bow hold diameter is provided we need to check what should be the bow hole correction factor if a particular rod length for SPT is provided we need to check what is the C R value and if the sampler lining condition is given to us we need to check what is the value of this correction factor. So, we can write down N 1 60 which is corrected SPT value including energy as well as over burden and all these correction factors becomes 14 times 0.913 which is 12.8. Now, this is the correction of SPT N value statically. Now, we need to do further correction which requires the percent fines correction as proposed in the paper by youd et al 2001 for clean sand condition because we need to convert this N value corrected N value to equivalent clean sand condition.

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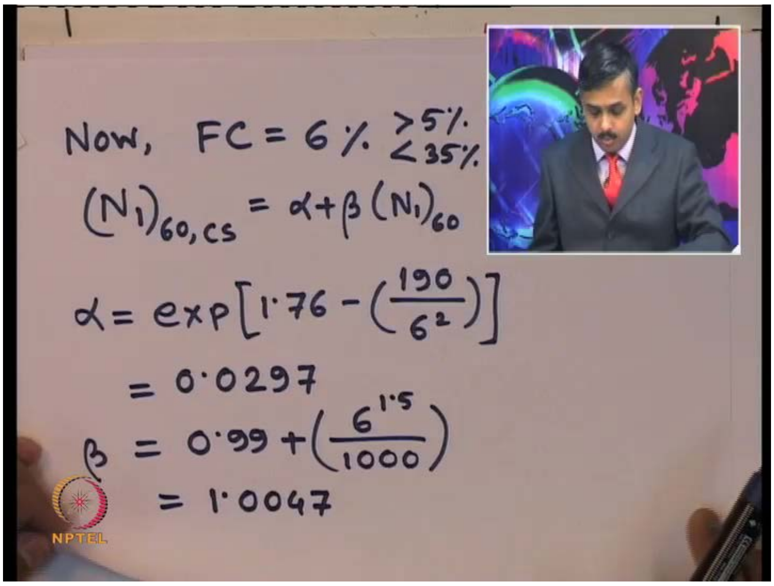

So, let us see what should be that correction. So, fines content is given to us as 6 percent in the problem whereas, the correction or corrected value of N 1 60 clean sand is expressed as alpha plus beta times N 1 60. So, in this case alpha is the parameter which can be calculated using this expression because we know in this case percent fine is more than 5 percent and less than 35 percent, that is the range as we remember in youd et al paper is given. So, for that range between 5 to 35 percent of fines this is the expression of alpha needs to be used 1.76 minus 190 by FC square so, 6 square, which gives us 0.0297 and the expression of beta for this range that is percent fine within 5 to 35 percent is given by this one. Now, this on calculating this values we get 0047. If I compute this 2 values and put it here, with the known value of N 1 60 which we have calculated we will get what is corrected value of N 1 60 with respect to clean sand condition. So, let us see how much is the value of that N 1 60, C S.

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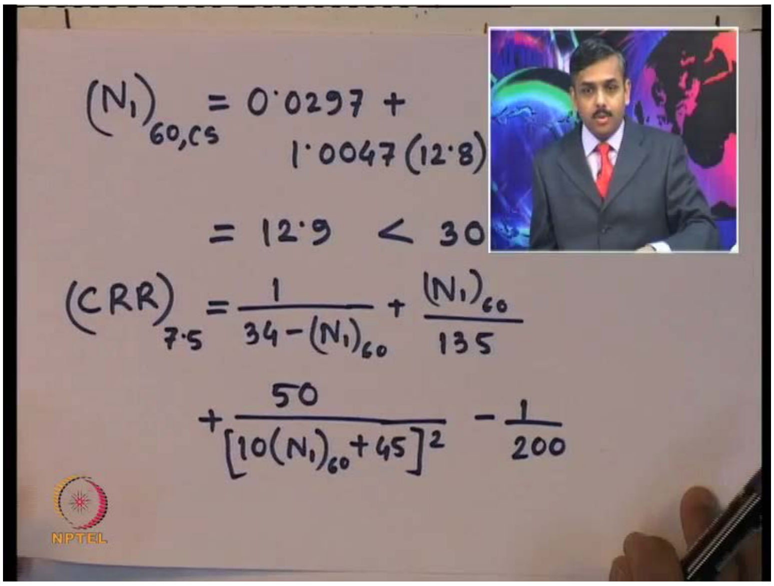

So, N 1 60 clean sand comes out to be 0.0297 plus 1.0047 times 12.8 this is N 1 60 we had calculated already, which gives us 12.9. This clean sand value is less than 30. Hence, check against liquefaction hazard needs to be done. That is the conclusion one can made here itself as a design propose that any side which is having N 1 60 clean sand value less than 30 needs to be checked against liquefaction potential. So, now if we use the equation for CRR that is cyclic resistance ratio at 7.5 moment magnitude of earth quake as given by youd et al in the paper. It is given as this N 1 60 by 135 plus 50 by 10 times N 1 60 plus 45 whole square minus 1 by 200 that is the expression for CRR. Here, we need to use in this N 1 60 the value of N 1 60 C S because that is the clean sand condition value.

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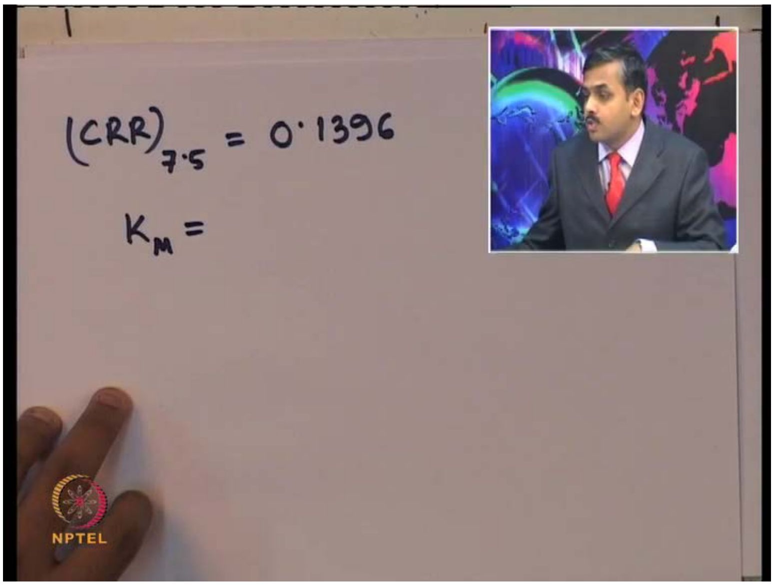

So, if we put that value of N 1 60 over here what we will get let us see. So, the CRR 7.5 comes out to be 0.1396. With this value now if we check other correction factors like K M, K M is magnitude correction factor for this CRR because in our given problem what was mentioned.

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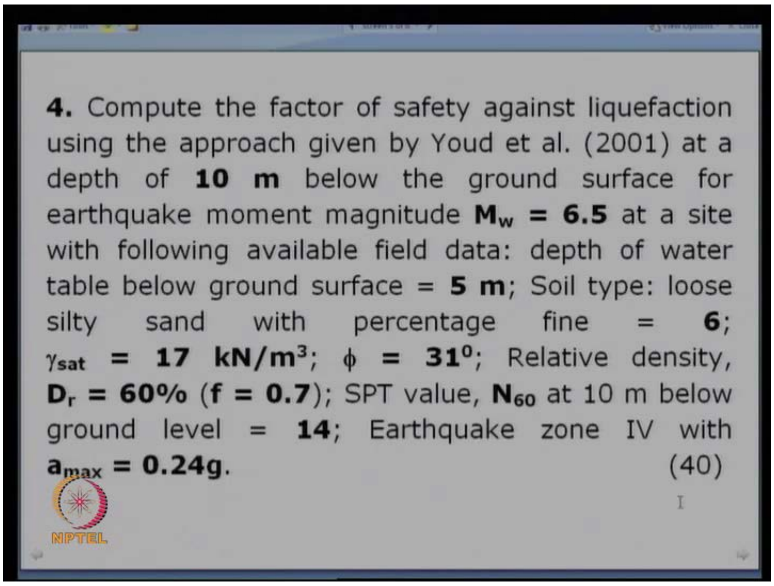

We need to compute if we look at this slide here, we need to compute for earth quake moment magnitude M w of 6.5.

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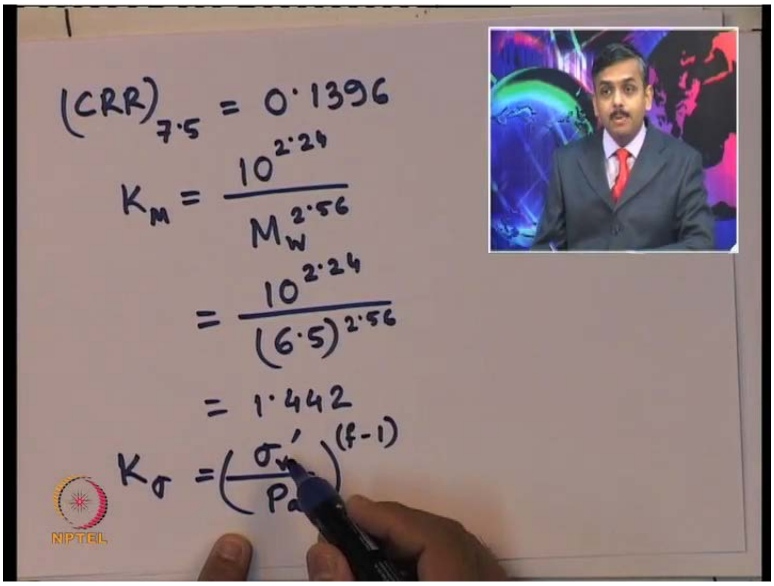

So, a magnitude correction factor K m is necessary because it is for 7.5 we need to find out for 6.5. The expression for k m is 10 to the power 2.24 by m w to the power 2.56. So, that gives us 6.5 to the power 2.56. We choose 1.442 that is the correction factor for magnitude. Now, another correction factor we need to find out here that is, k sigma which is given as sigma v dash by P a to the power f minus 1.

This is over burden correction factor to the CRR needs to be applied, as we have discussed in the theory. Sigma v dash if it is more than 100 k p a then only we need to incorporate this, in this present case it is 120 k p a so, we need to apply that and f factor is given in our question as 0.707.

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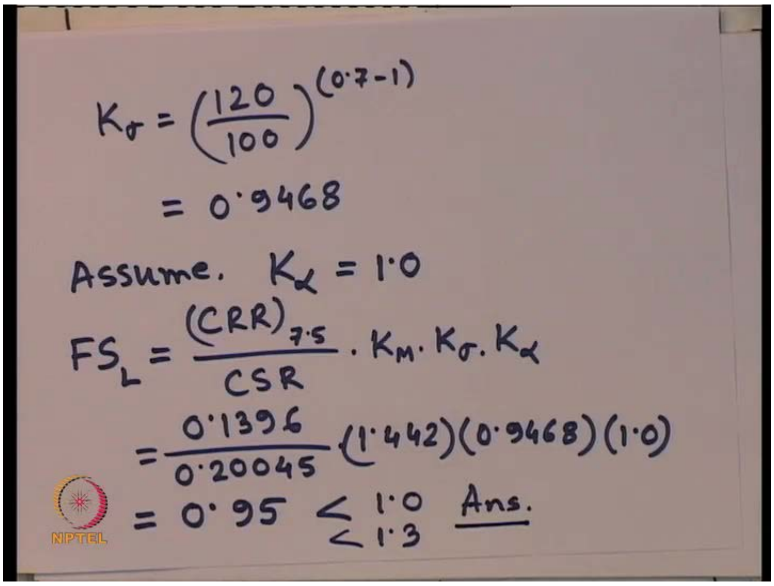

So, if we compute it what we will get the k sigma is 120 by 100 to the power 0.7 minus 1 which gives us the value of 0.9468. Now, considering or assuming k alpha that is due to the slope the correction factor is 1 because no information about the sloping ground condition is provided in the problem in that case we can take as 1. So, factor of safety against a liquefaction is expressed as CRR 7.5 by CRS times this correction factor K m, K sigma and k alpha.

So, if we put all our known values what we will get 0.1396 by 0.20045 times 1.442 times 0.9468 times 1, which gives us the value of 0.95. So, for the given problem at 10 meter depth if an earth quake of magnitude moment magnitude of 6.5 is expected at 10 meter depth with the given soil condition factor of safety against liquefaction will be 0.95 which is less than of course, 1 also, less than 1.3 which we generally use for design of any structure in that particular soil any foundation anything we want to construct in a particular soil, the factor of safety against liquefaction must be equal to or above 1.3 which is not the case here. So, what should be our comment this is the answer of the problem but, if we want to comment on this answer. The comment should be any foundation will not be suitable if we want to put it in the same soil condition at 10 meter depth in terms of liquefaction is concerned with moment magnitude of 6.5 at that site. So, that will be the conclusion. So, with this we have come to the end of the solutions of this quiz and this quiz of 100 marks can easily be solved as we have seen in the slide.

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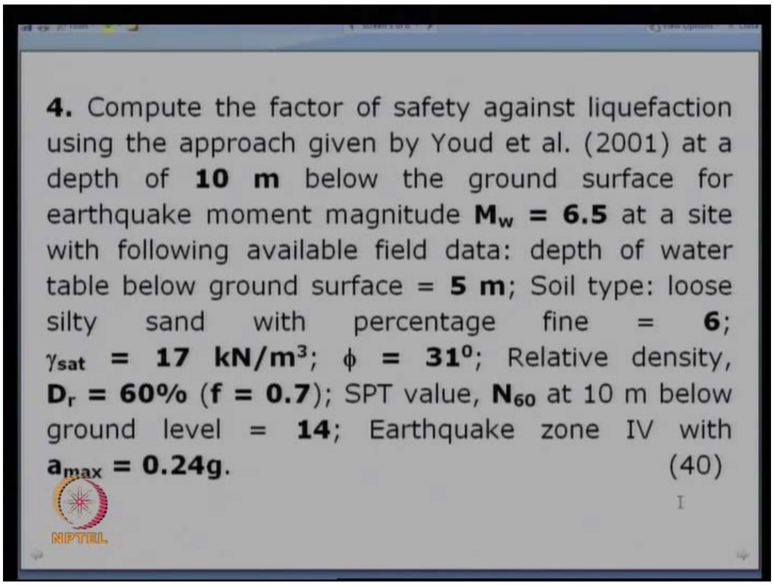

This problem carries 40 marks so, it completes or ends the solution of quiz. After completion of all the 7 modules which I have taken for this course on soil dynamics, the technical part of this course on soil dynamics has come to an end but, this course on soil dynamics will really not to be ending if I do not acknowledge few people who has held me in several ways to come out with this soil dynamics course which I have given the lecture in this video course.

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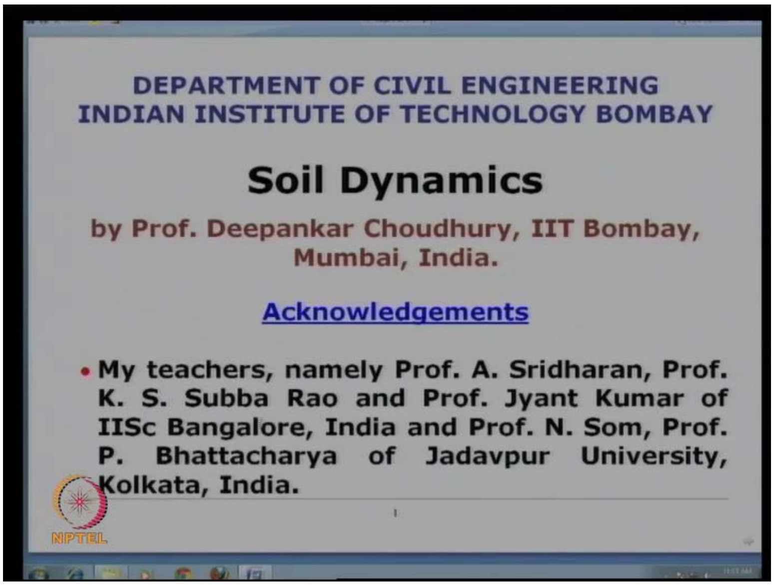

So, the acknowledgments which I want to put on record for this soil dynamics course first goes to my teachers from whom I have learnt during my student days this topic of soil dynamics and machine foundations namely my teacher professor A. Sridharan then, my teacher professor K. S. Subba Rao and professor Jayant kumar of Indian Institute of Science, Bangalore India which is commonly called as IISC Bangalore. They taught me the subject in several ways during my masters and Ph.D program for the application and the theoretical aspects of the soil dynamics and machine foundation aspects.

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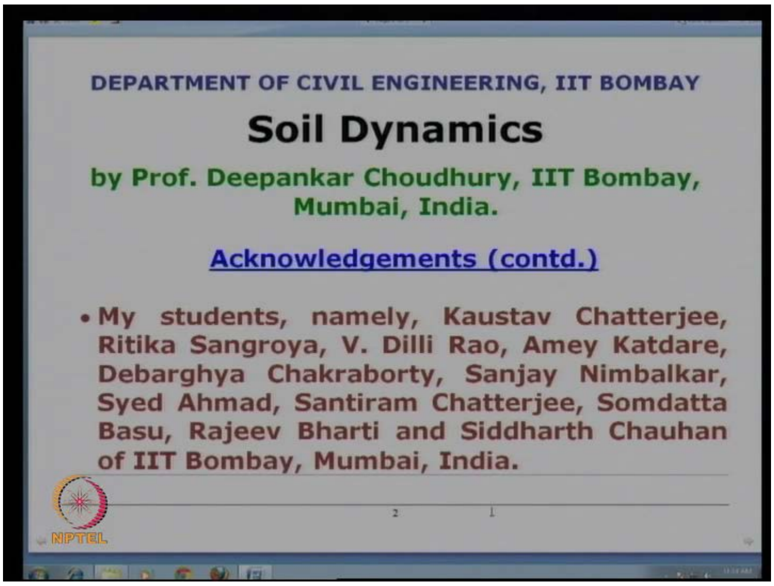

Also, I would like to put on record the name of Professor Nithin Som and Professor Phalguni Bhattacharya of Jadavpur University, Kolkatta India, where I did my bachelors degree and during the bachelors in the fourth year in one of the special course on design of foundations elective course there was a small portion on machine foundation from which I got my first step of learning in this problem of soil dynamics. So, first acknowledgement goes to all my teachers whom I have mentioned over here and the next important acknowledgment without whom I could not probably had given this video lecture on soil dynamics are all my students. As we all know for us that is we are the teachers the students is the main backbone for our any activity whether it is research or teaching.

And in IIT we mostly learned through teaching process as well not only from research but, also through teaching, by teaching this exceptionally brilliant students of IIT and for this course also I must acknowledge the contributions or the suggestions or the questions came out from the student community which I am teaching in this institute of IIT Bombay from several years last about 10 years. So, I should put in record the name of the students like Kaustav Chatterjee, Ritika Sangroya, V Dilli Rao, Amey Katdare and Debarghya Chakraborty. These students had helped me to prepare the slides, which I have presented during this video lecture and also to check the several parts of the video and its output etcetera at different point of time.

Also, I want to put on record my former students like Doctor Sanjay Nimbalkar, Doctor Syed Mohammed Ahmad, Mister Santiram Chatterjee, Miss Somdatta Basu, Mister Rajeev Bharti, Mister Siddharth Chauhan of IIT Bombay Mumbai, India, who worked with me under various capacities like either as my former PhD student or my former master student or my former B.Tech project student and who came out with subsequent number of or some new input in this world of soil dynamics, which gave an another new approach of various analysis, which I have discussed throughout this course at some of the portions like, design of retaining wall considering, mass spring dashpot model then, behavior of railway sub grade soil by considering mass spring dashpot model also, for the slope stability aspect etcetera. So, I must acknowledge the contributions made by these students during the process of teaching and research on this topic of soil dynamic and machine foundations.

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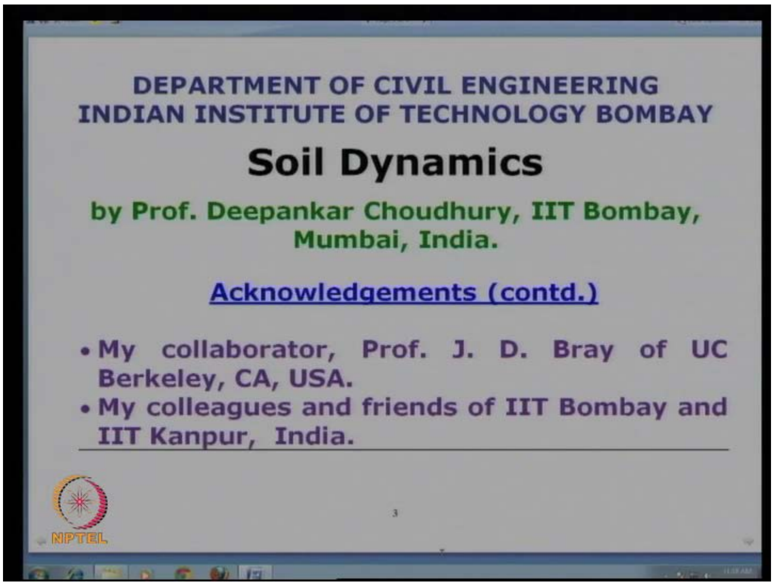

My next acknowledgement will go towards my collaborator you can see here, where I have visited as boys trust fellow at university of California Berkley in USA. So, there my research collaborator was professor Junathan d Bray whose, lecture on geotechnical earth quake engineering and soil dynamics also helped me to get the input on this subject some of which I have tried to provide in this video lecture also. Last but not the least, I want to put on record the help provided by Seedeep of IIT, Bombay, NPTEL program of MHRD government of India and all my colleagues and friends of my institute, present institute IIT, Bombay and my former institute IIT Kanpur who had held me in various capacities while providing this video lecture on soil dynamics through their expert comments or criticism or how to improve the quality of the presentation and lecture topics etcetera. So, if any one of you are interested to contact me here, I provide the further contact details.

This is my name Deepankar Choudhury. I am a professor in the department of civil engineering IIT, Bombay, Powai, Mumbai 40076 India. This is my postal address, my telephone number is plus 912225767335 this is my office number and plus 91225768335 is my residence number. You can also reach me via email my email Id's are d c at the rate civil dot i i t b dot a c dot i n or d Choudhury at i i t b dot a c dot in. Also, you can reach to my website which is available at this u r l where, you will get the details about my teaching, research and various other administrative, academic and professional activities in this field of soil dynamics and machine foundations. So, with this we have come to the complete end of this video course of soil dynamics for NPTEL.

Thank you.