Geology and Soil Mechanics
Prof. P. Ghosh
Department of Civil Engineering
Indian Institute of Technology Kanpur
Lecture - 48
Problem on Shear Strength of Soil - a

Welcome back to the course Geology and Soil Mechanics. So, in the last few lectures we covered the shear strength of soil and we have seen the different kinds of laboratory experiments as well as field test and there are several say issues related to shear strength of soil. Now today we will be taking a few problems few numerical problems on shear strength of soil and which will give you some insight how to tackle the problem related to shear strength.

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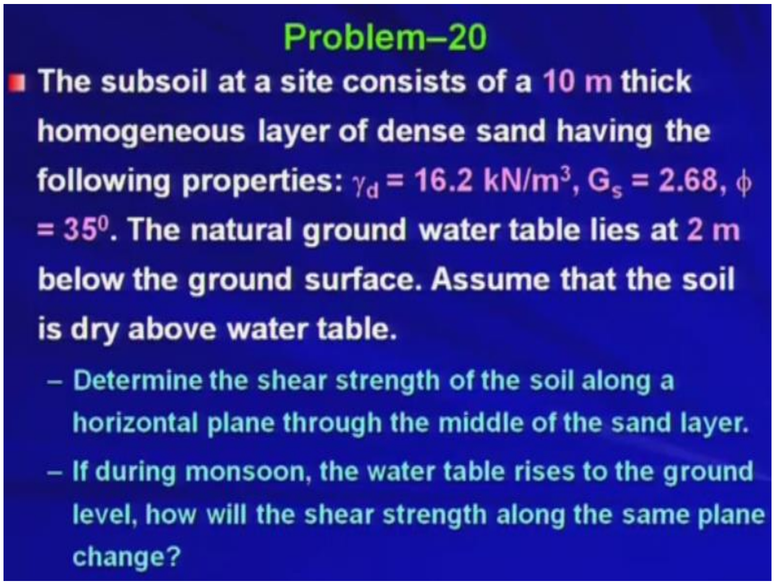

Now the first problem in this chapter that is in shear strength is here. So, the subsoil at a site consists of a 10 m thick homogeneous layer of dense sand having the following properties gamma d 16.2 kN/m cube, specific gravity G s equal 2.68, and phi equal to 35 degree okay. So, phi is nothing but the angle of internal friction and C is 0 here so because this is a dense sand kind of thing so we can consider C is 0 right.

The natural ground water table lies at 2 m below the ground surface. Assume that the soil is dry above water table okay. So, there is no such capillary rise and all those things we are considering. So, above the water table soil is completely dry. Determine the shear strength of the soil along a horizontal plane through the middle of the sand layer and the second part if during monsoon the water table rises to the ground level how will the shear strength along the same plane change?

So, these 2 things we need to determine okay. So, first thing is the determine the shear strength of the soil along a horizontal plane through the middle of the sand layer okay. So, you have the sand deposit, at the middle of the sand layer so if you consider any horizontal plane so how the shear strength will be mobilized here. So, I mean what will be the shear strength which will be mobilized at that particular horizontal plane okay. So, let us let us solve that problem.

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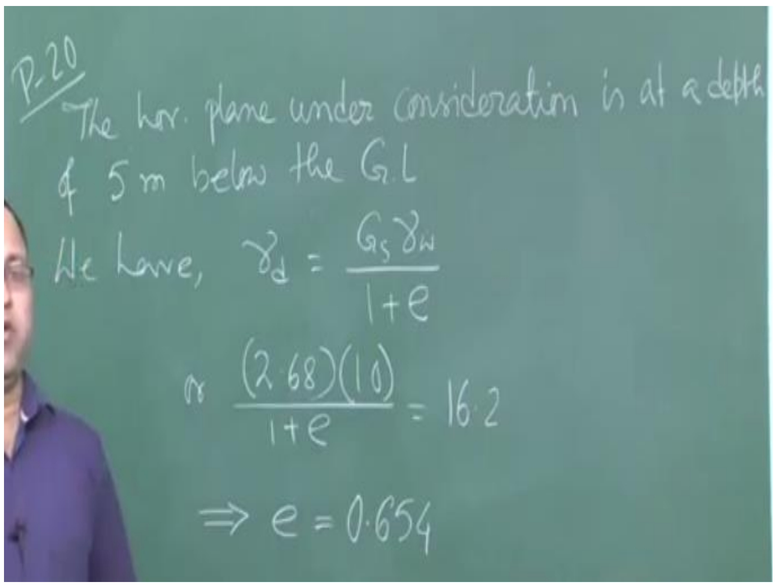

Problem 20. So, the horizontal plane under consideration is at a depth of 5 m below the ground level right. So, the horizontal plane on which you are going to find out or determine the shear strength basically that plane is lying at 5 m below the ground level okay. Now we know from our earlier discussion that gamma d is equal to G s gamma w divided by 1 + e where e is the void ratio right. Or we can write 2.68 that is the specific gravity this is your gamma w by 1 + e is equal to 16.2 kN/m cube that is given in the problem okay gamma d is given. So, from this I can get the value e is equal to 0.654 that is the void ratio is 0.654.

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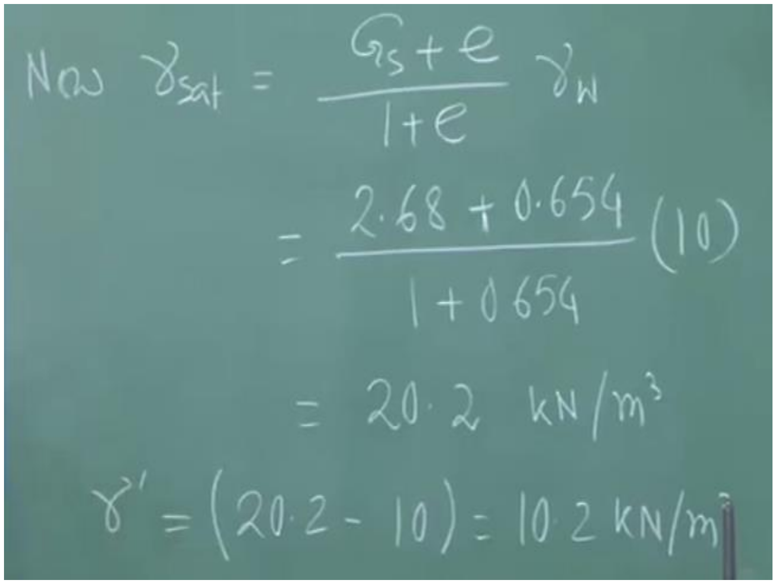

So, once we know the void ratio of the soil then we can find out gamma saturated because these are the things we need. So, gamma saturated is given by so these things are known to you from your earlier discussion into gamma w. So, if you put all the values you will be getting gamma saturated is equal to 20.2 kN/m cube. Therefore, gamma submerged so gamma prime that is your gamma submerged is nothing but 20.2 - gamma w is nothing but 10.2 kN/m cube. So, we have got all the necessary parameters like your gamma saturated, gamma prime that is gamma submerged, and gamma d of course it is given in the problem.

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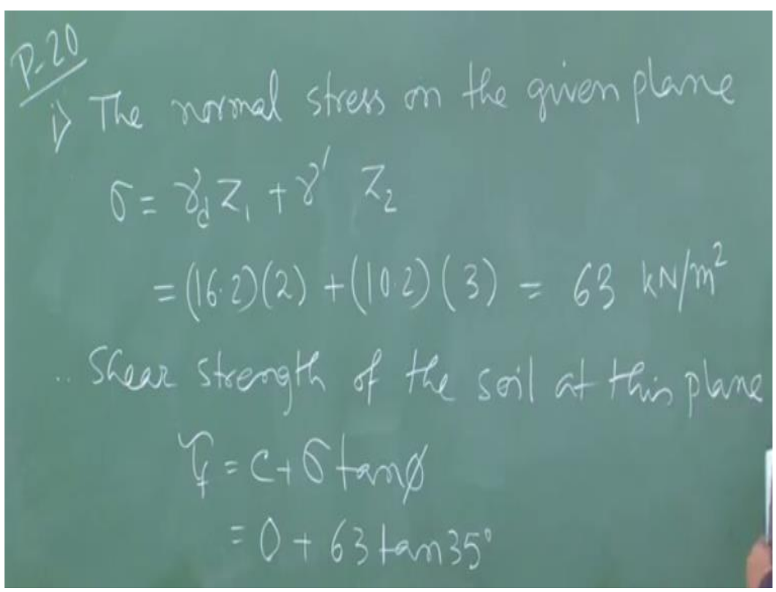

Now we are coming back to the first part of the problem. We need to find out the shear strength on the horizontal plane which is lying at 5 m below the ground level. Now if I want to find out the shear strength that means tau f whatever you have seen in the discussion right. Tau f is nothing but c plus sigma tan phi. Now what is c? c is the cohesion that is 0 for this particular type of soil that is dense sand and what is phi? phi is the angle of internal friction that is given in the problem that is given as 35 degree.

Now what is the unknown parameter here that is sigma. So, basically if you want to find out the shear strength on any plane basically you need to know the magnitude of the normal stress acting on that particular plane that is sigma. So, in this problem so if you want to find out the shear strength along the horizontal plane basically you should know the normal stress acting on that particular plane.

So, what is the normal stress on that particular plane? That is nothing but the overburdened pressure coming on that particular level. So, the normal stress on the given plane is nothing but sigma is equal to gamma d into z 1 plus gamma submerged into z 2 where z 1 is the depth which is lying above the water table and z 2 is the depth which is lying below the water table. So, above the water table what is the unit weight. That is gamma d and below the water table you have the unit weight as gamma submerged.

So, gamma submerged I am writing as gamma prime of course so I should not write should not mix up with the notation. So, gamma prime z 2 right. So, if you put the values here you will be getting 16.2. Now what is the depth above the water table that is 2 m plus what is the magnitude of gamma prime that already you have got 10.2 and what is z 2 the depth below the water table is 3 m.

Now because you are considering total 5 m depth at which you are considering the horizontal plane right. So, 2 m + 3 m total 5 m. So, this gives me 63 kN/m square. Therefore, shear strength of the soil at this plane tau f is equal to c + sigma tan phi so which is nothing but 0. c is 0, sigma already we have calculated that is 63, tan 35 degree.

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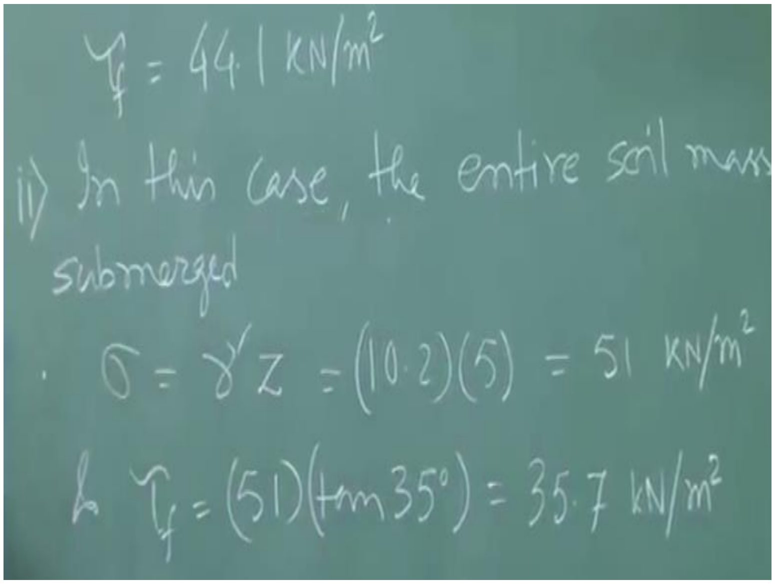

So, which gives me tau f equal to 44.1 kN/m square. So, this is the shear strength at that horizontal plane which is lying 5 m below the ground level okay. I hope that you have understood how to calculate the shear strength on a particular plane below the ground level. Now in the second part in this case the entire soil mass is submerged. So, if you see the second part of the problem if during monsoon the water table rises to the ground level how will the shear strength along the same plane change.

That means the water table rises to the ground level. So, the whole soil deposit is submerged now. So, in this case the entire soil mass is submerged. Therefore sigma, now I need to calculate only so phi is not going to change because that is the property, angle of internal friction of the soil. So, that is not going to change. Only variation you will be observing in the normal stress distribution right. So, normal stress will be nothing but gamma submerged into z.

So, gamma submerged is 10.2 into 5 that is the whole depth up to the horizontal plane and that is coming as 51 kN/m square and tau f is equal to 51 tan 35 degree which is equal to 35.7 kN/m square. Now if you see this problem so this problem I have taken for understanding the special thing that when you had the water table at some depth below the ground level you got the shear strength on a particular plane that is horizontal plane as 44.1 kN/m square.

Now when the water table rises okay up to the ground level so then you have got the shear strength on the same plane as 35.7. That means reduction is happening due to the rise of the water table to the ground level right. So, what I mean to say that if you want to design some structure some geotechnical structure on a particular say soil deposit at some depth say so you need to calculate or need to consider the variation of the water table otherwise you will be getting some misleading result.

So, I mean if you design the geotechnical structure based on the soil strength or the shear strength now you need to consider the variation of the water table or the worst condition which is coming into the picture. That means in this situation the worst condition is when the water table is reaching or rising up to the ground level. So, that is giving you the worst shear strength. So, this is the shear strength which soil will give. Now if you design something okay based on this shear strength design some geotechnical structure, foundation, or retaining wall or whatever so some something you are designing based on this shear strength okay.

Now when the water table will rise during monsoon up to the ground level then basically the soil is there to provide you this much of shear strength right. So, but you have designed on this. So, you are gone basically. So, or if you on the other way if you design the structure based on this critical or the worst condition then basically whether the water table is coming down or whatever variation you will be getting so that will not create any problem in the design okay. I hope that you have understood. That is why I have taken this problem to say this thing specifically.

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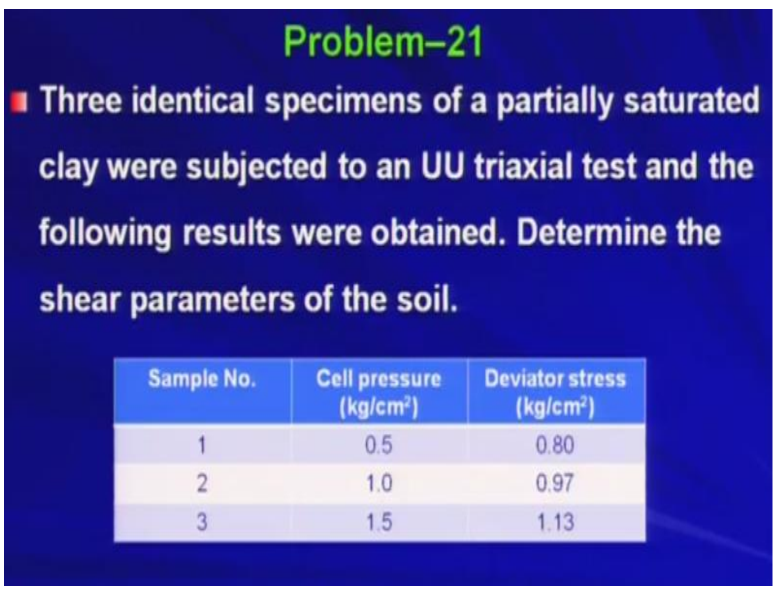

Sample No.	Cell pressure (kg/cm^2)	Deviator stress (kg/cm^2)
1	0.5	0.80
2	1.0	0.97
3	1.5	1.13

Now we will take the second problem. The next problem says that 3 identical specimens of a partially saturated clay were subjected to an UU triaxial strength and the following results were obtained. Determine the shear parameters of the soil. Now basically this problem we are considering to talk about the to determine the shear parameters means shear strength parameters means that c and phi that is cohesion and angle of internal friction.

So, these 2 things are known as shear parameters or the shear strength parameters in soil mechanics. Now this is the test we have performed some UU test and based on that we have got this results. So, what are the results? So, 3 samples we considered sample 1, sample 2, and sample 3 and cell pressure we varied for sample 1 it is 0.5 kg/cm square.

For sample 2 it is 1 kg/cm square and for sample 3 it is 1.5 kg/cm square and the deviator stress you have applied till the failure. That is for sample 1 is 0.8 kg/cm square for sample 2 it is found as 0.97 kg/cm square and for sample 3 it is 1.13 kg/cm square. So, these are the things you have observed from the test. Now you need to find out the shear strength parameters okay.

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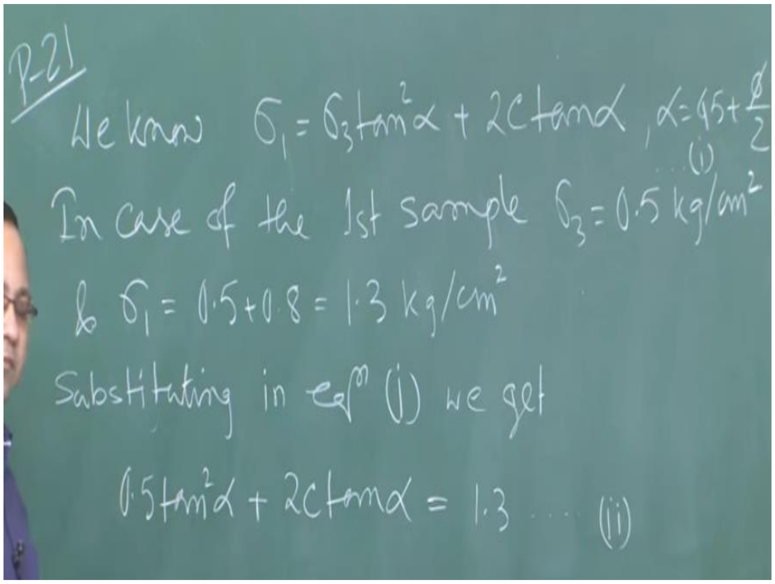

Now we know from our earlier discussion that sigma 1 is equal to sigma 3 tan square alpha + 2 c tan alpha right where alpha is 45 + phi by 2. I hope that you recall this. This expression we derived from the Mohr circle Mohr-Coulomb failure criterion when we considered at that time we have got this expression. So, sigma 1 is equal to sigma 3 tan square alpha + 2 c tan alpha. So, that is valid for Mohr-Coulomb failure criteria okay.

So, now in case of the first sample sigma 3 is equal to 0.5 kg/cm square and sigma 1 is equal to what sigma 1 will be, how much? So, sigma 3 plus deviatoric stress right. Sigma 3 is 0.5 and deviatoric stress is 0.8 so you will be getting 0.5 + 0.8 which is coming as 1.3 kg/cm square. So, this is your sigma 1. So, substituting in, so say this equation I am calling as equation 1, so substituting this in equation 1 we get 0.5 tan square alpha + 2 c tan alpha is equal to 1.3 okay.

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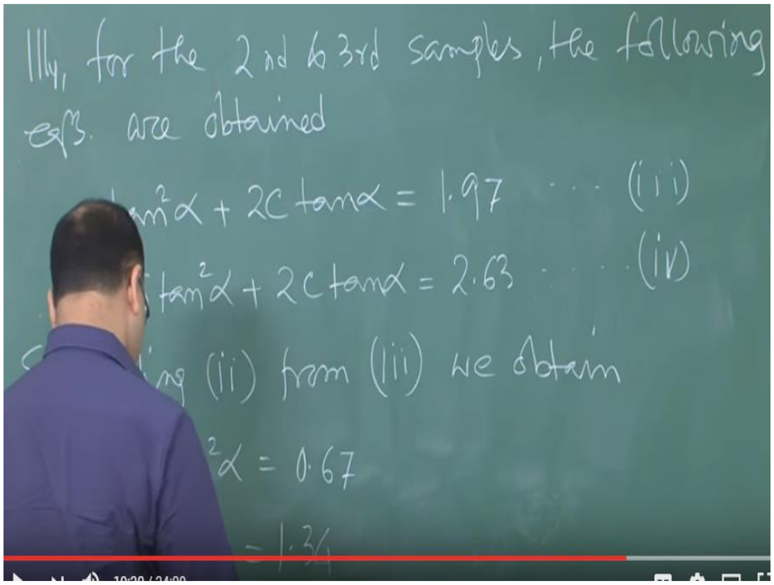

Now similarly for the second and third samples the following equations are obtained that is for second sample this equation will be 2 c tan alpha is equal to 1.97 say equation 3 and for sample 3 you have got this is equal to 2.63 okay. Now subtracting 2 from 3 we obtain 0.5 tan square alpha is equal to 0.67 okay.

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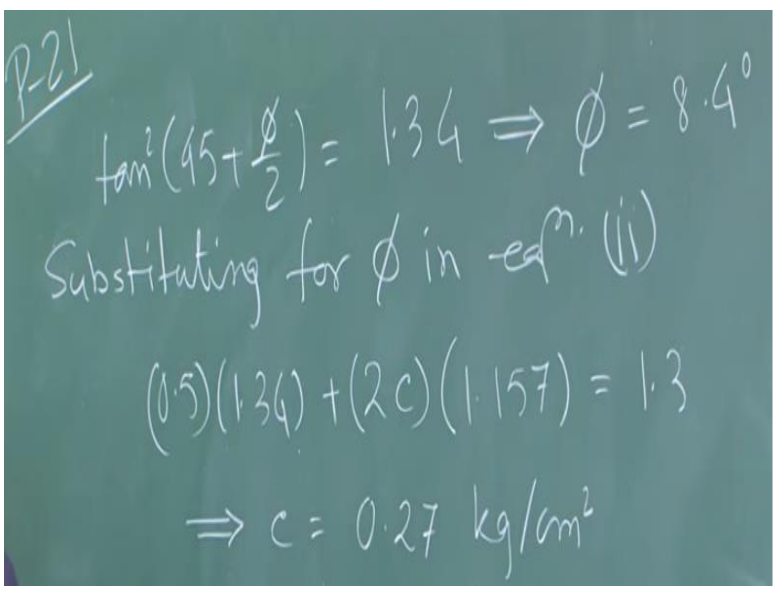

So, therefore tan square alpha is equal to 1.34 which I can write tan square 45 + phi by 2 is equal to 1.34 and from which I get phi is equal to 8.4-degree okay. Now substituting for phi in equation 2 okay we get 0.5 into 1.34 + twice c multiplied by tan alpha so tan square is 1.34 so tan alpha will be 1.157 is equal to 1.3. So, from this I get c is equal to 0.27 kg/cm square okay. So, we have got the shear strength parameters.

So, basically if you see this problem we have used equation 2 and equation 3 for all the times but you have to check this thing with equation 4 that whether these parameters are satisfying equation 4 or not equation 4 is given there. So, in this equation you have put the values of c and phi and then you have to see that whether equation 4 is getting satisfied or not right. So, that will we will check.

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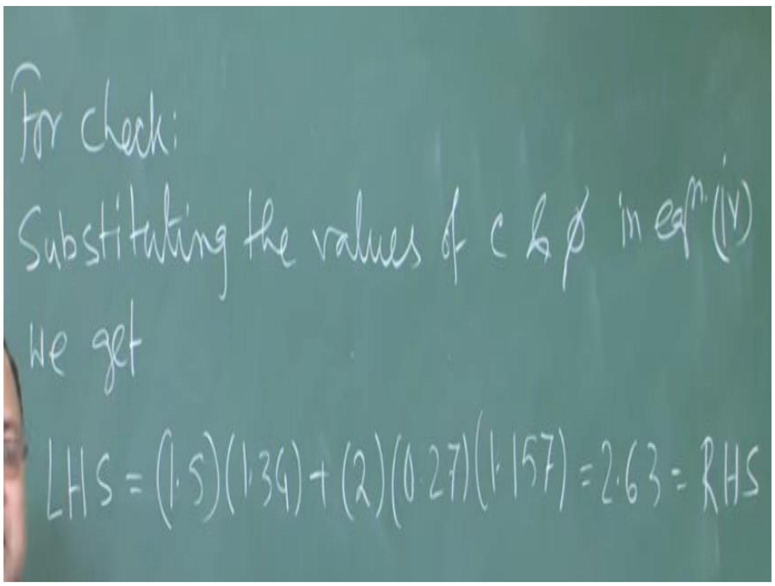

So, for check, for check, substituting the values of c and phi in equation 4 we get LHS left hand side is equal to 1.5 into 1.34 + 2 c tan alpha 1.157 is equal to 2.63 is equal right hand side of equation 4. So, it is getting satisfied. So, that means the shear strength parameters for this problem is c equal to 0.27 kg/cm square and phi is equal to 8.4-degree okay. So, you have got the shear strength parameters for this problem okay.

I hope that you have understood that how we have used the equation, basic equation, of this Mohr-Coulomb failure criteria and based on that we have got the shear strength parameters and this observation is basically you are getting from the laboratory experiment. So, if you perform any kind of you I mean any on any sample or any say particular soil deposits of identical 3 samples say you are considering and then with the variation of cell pressure okay you are doing the UU test and from this test you can find out the shear strength parameter c and phi right okay.

Thank you very much. So, I will take the next problem in the next class. So, I hope that you have understood these 2 problems whatever we have solved just now okay. So, which will give you some insight how we can use the laboratory experiment to find out the shear strength of the soil and also, we can we have seen that with the variation of the water table how the shear strength varies on a particular plane. So, in the next class we will take I mean few more problems. Thank you very much.