Geotechnical Measurements and Explorations

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Lecture No. # 05

Shear Strength of Soil

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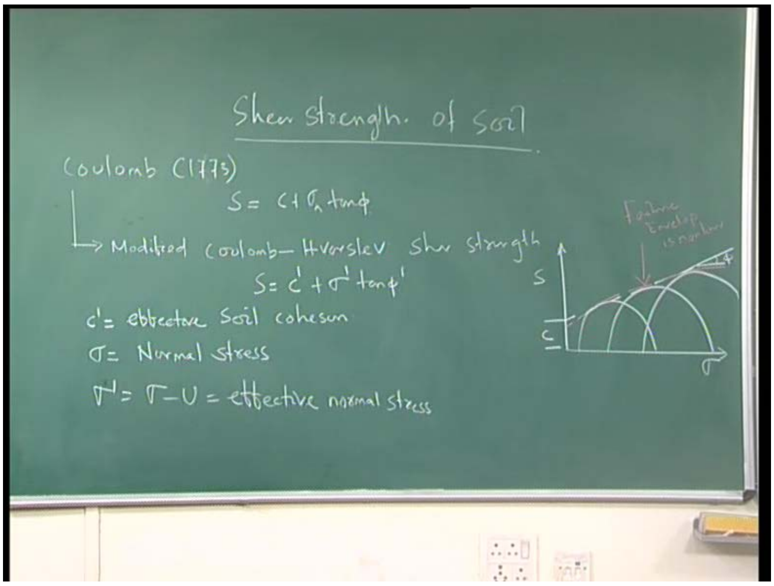

Next chapter is your, shear strength of soil. Coulomb seventeen seventy three, shear strength given c plus sigma n tan phi. So, then it has been modified by coulomb and Hvorslev shear strength, S is equal to c prime sigma prime tan phi prime. c prime is equal to effective soil cohesion, sigma is equal to normal stress, sigma prime is equal to active normal stress. So for cohesive soil, ((no audio 02:12 to 02:33)) so this is c, and this would be phi, this is S, this is sigma. So, generally for cohesive soil, ((no audio 02:54 to 04:21)) discontinuity at the pre-consolidation pressure ((no audio 04:30 to 05:35)).

Let us start with this, a new chapters shear strength of soil. So initially, shear strength of soil was means, given by this coulomb seventeen seventy three, shear strength S is equal to c plus sigma n tan phi. c is equal to soil cohesion, or a sigma n is your stress normal stress. Then later on, it has been modified by coulomb and hvorslev for the shear strength, they have considered, S is equal to c prime and sigma prime. c prime is your effective soil cohesion, and sigma prime is your effective normal stress which is equal to normal stress minus this pore water pressure.

So generally for this, if I draw the more failure of envelop of this mohr-coulomb, generally three mohr-coulomb, three tests required to plot the mohr-coulomb. So, it is a typical diagram, it is I am drawing. So, this is generally the failure envelop, it is a non-linear. So, it has been approximated as a linear one, so from there, the intercept line, that drawing means, draw the three mohr-coulomb, then from there draw a common tangent, where it passes intercept this shear strength axis, that is your c, or unit cohesion, and this angle of this, with this horizontal, that give phi. phi is equal to angle of internal friction.

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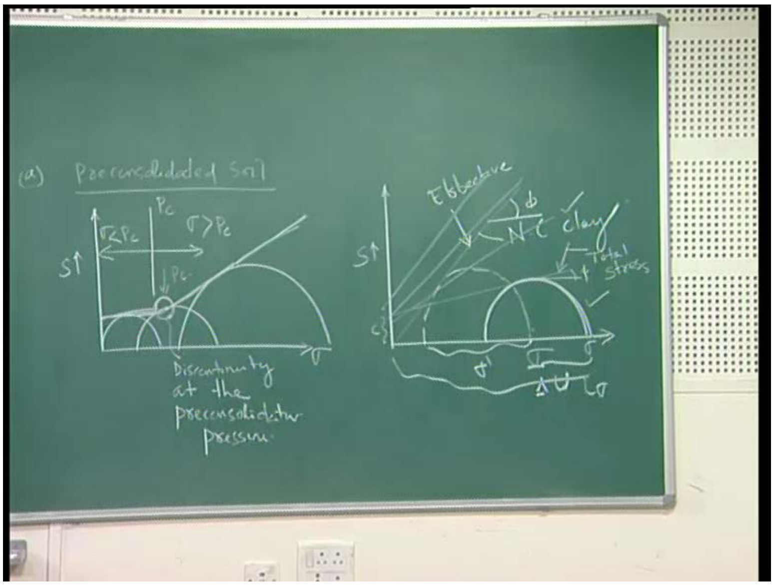

Now, in case of pre-consolidated soil, there is a discontinuity, while plotting this shear strength of the soil from this mohr circle. The discontinuity observed at pre-consolidation pressure, once if sigma is your over bottom pressure is less than your pre-consolidation pressure. So at that time, it will be kind of asymptotic, or may be it is one straight line, at this point there is a breakage, it will go in this direction. So, there is a distinguished discontinuity at the pre-consolidation pressure. I can say, if this is my p c, so this to this will be you are, is indicating, sigma is less than p c, and this to this indicates sigma is greater than p c.

Now, once you draw a mohr circle, if it is a total stress. Now, this effective stress and total stress come into picture, here it is a total stress, S is equal to c plus sigma tan phi, it is a total stress, and this is an effective stress principle, where this modified coulombs theory.

Then, what does it mean, if I draw a mohr circle, and draw the tangent, this is case of a total stress. The moment I say, it is effective stress, what will happen, this sigma, sigma prime will be sigma minus U, normal stress minus this pore water pressure, whatever it is coming. That means, if this is my sigma, so these part will be, this will be my, this will be, this part will be U, pore water pressure or may be delta U change in pore water pressure. So, sigma minus delta U, and this part will be your sigma prime, and this will be your sigma. So, from sigma minus sigma prime, it is your sigma minus delta U, it is your sigma prime, that is your effective normal stress.

Once I plot, total stress and effective stress, if we look at this effective stress, this curve is skewed, it will go slowly slowly slowly like this. It will skew, and at that point, this intercept of this c cohesion parameter, c parameter will goes down. So, if I draw, this is my total stress definitely effective stress will be towards this left, or towards this axis of unit cohesion parameter. So, here one case is your total stress, other typical case, I plot it for your effective stress. Generally this diagram is for normally consolidated clay.

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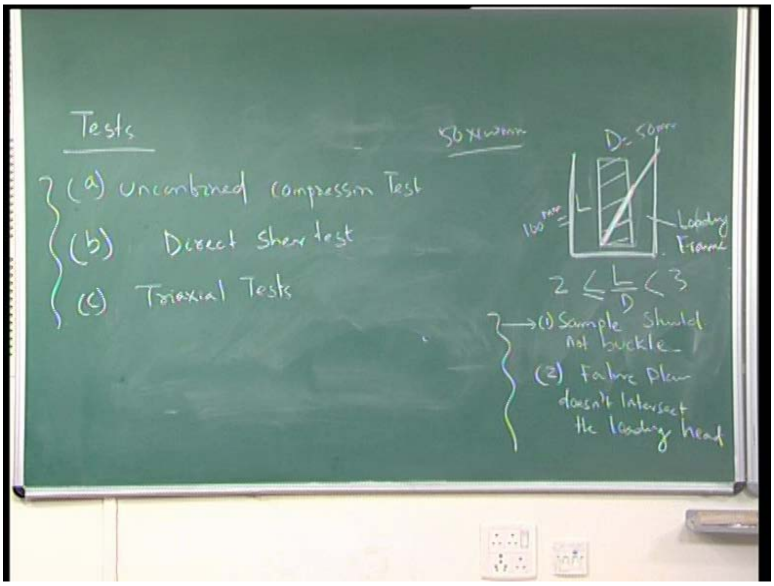

Now come back to, what are the different before you go in detail of shear strengths? What are the different laboratory test required to, find it out, the shear strength parameters? So, the laboratory test are, means test to determine the shear strength parameters. So a, is your unconfined compression test, b is your direct shear test, c is equal to triaxial tests. Now, these are the three test, generally we conduct in the laboratory, to find it out shear strength parameter. So, shear strengths, what are the shear strength parameters? One is your c, other is your phi, or it may be c prime, or it may be a phi prime, in terms of effective. So, these are the three test, generally conducted to find it out, your shear strength parameters.

Generally, what happen, the sample size, soil sample size, generally provided, generally prepared, generally prepared, this ratio is one is to two. One is to two means, the if diameter is thirty eight, so it will be seventy six. So, what is the reason, these sample preparations in the laboratory, it should be L by D, should be greater than three, and greater than two, and less than three. Why what is the reason, that sample has been prepared with one is to two ratio, and main reason is, one reason is, during test, the sample should not buckle ((no audio 13:00 to 13:11)). Then second part of here is, failure plan does not intersect, the loading heads.

The basic reason, this sample size, if this is my L, if this is my D diameter. So, the ratio should be greater than two, and greater than equal to two, and less than three. Generally, the sample size available in the laboratory. So, it will be thirty eight by seventy two, or fifty by hundred, or hundred by two hundred, or two hundred by four hundred, what does it mean, if I say fifty by hundred. That means, diameter is equal to fifty mm, and length is equal to hundred mm. This is the ratio, generally we keep it in the laboratory, preparing the sample. Then, it should, why it has been made up to this, so this sample while loading it should not fail by means of buckle, buckling failure should not occur.

The second reason is, the failure plan, because the sample should fail by shear. This failure plan should be, within the soil sample. The failure plan should not extend, beyond the soil sample, or interact with this loading frame, if this is my loading frame. So, that means, this failure plan should be within these soil sample, and it should not extend or interact with your loading frame. These are the two reasons, why the sample size has been keep it into one is to two ratio.

Now, after the preparation of soil sample is over. These are the three test, one is your unconfined compression test; second is your direct shear test and third is your triaxial test.

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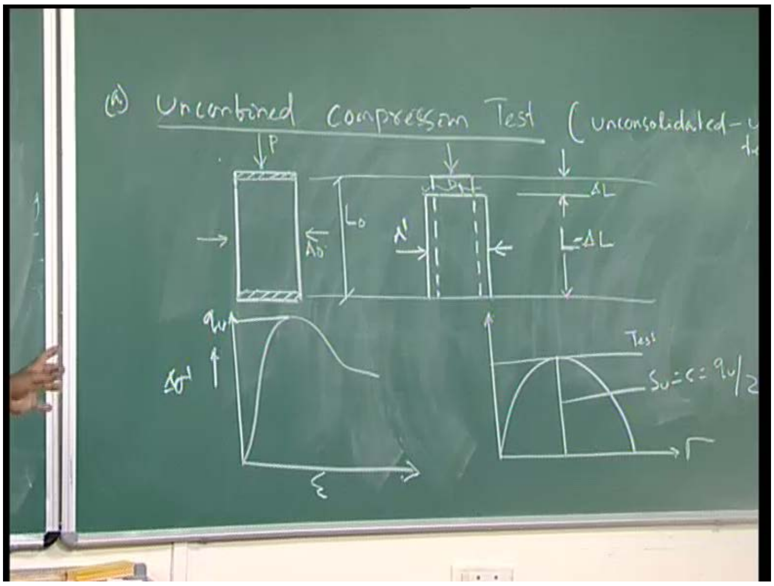

Now, start with case one, unconfined compression test. Now in this case, sometimes it is called unconsolidated-undrained test ((no audio 16:16 to 17:48)). Just drawing this diagram, for more explanation. ((no audio 17:58 to 18:35))

Now see, in unconfined compression test, the sample has nothing only a vertical load, stress has been applied in vertical direction. So, there is no confinement, unconfined means, there is no confinement around the periphery. That means, there is no confinement around the periphery, sample has been applied, a stress in vertical directions.

If I look at this failure envelope means, how the sample will go, it will only compress in vertical direction, that is it. There is no confinement, so what will happen, initially a zero, area whatever is there, so it will be a distorted A, because of this will be distorted, whatever the area of cross-sectional area is will be there, it is my diameter. This new diameter will be the D one. So, change in length will be delta L, so total length after the test is over, it will be delta L, L minus delta L. Sometimes, this is called unconsolidated-undrained test.

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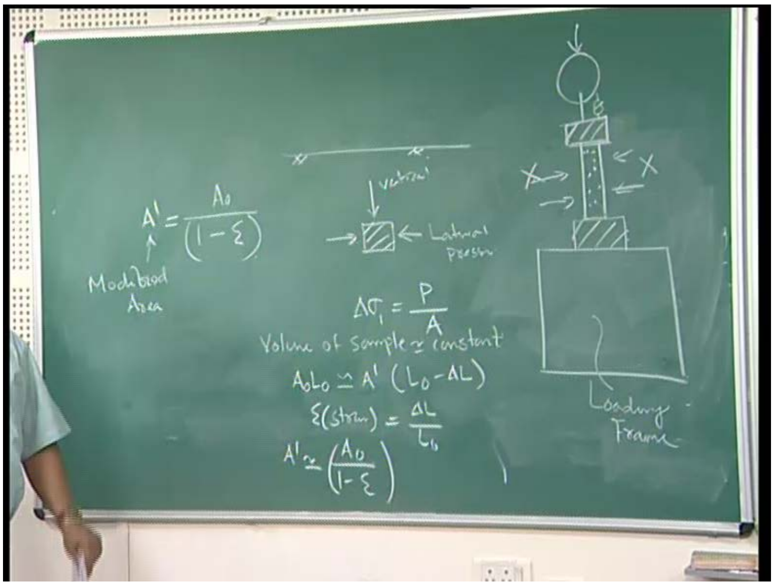

That means, sample has been taken, simply sample has been taken, and with this pedestal means, whatever the loading frame is available. With this loading frame, the soil sample, simply erected in the, or put it in the loading frame. Then, with this loading frame, with the help of (( )) ring, straight means, with the help of (( )) ring constant rate of strain or stress may be stress control, as well as strain control can be done. So, once the soil sample is there, look at there, this is my simple diagram loading frame.

So, then by means of dial gauge, you can measure your, what is your vertical displacement. That means, there is no confinement around the soil sample even the ground surface. Why it is called unconsolidated-undrained? If this is my ground surface, within the ground surface, below the ground surface if I collect the soil sample.

Before collection of the soil sample, it will be acted by vertical as well as lateral pressure. That means, here in this test, the confinement lateral pressure is zero, only this stress has been applied by means of a vertical with the help of (( )) ring. So, the only difference is that, it will be load applied without confinement, that is why, it is called unconfined, and at this stage, no consolidation process is there.

Simply, soil has been taken, and put it in the pedestal, and load has been applied by means of, stress has been applied by constant rate of by means of (( )) ring with constant rate of displacement method, or may be stress control, it is a strain control, may be stress control, may be strain control. So, there is no confinement, no lateral pressure, no consolidation. So that is why, sometimes it is called unconsolidated-undrained. That means, there is no drainage. So in this case, the displacement occurred by means of vertical stress is in the vertical direction. So, it is a very simple test, to get very quickly.

So, delta sigma one is equal to P by A, stress coming to here, will be load applied, divided by cross sectional area. Now, volume of the sample, but at the same time, volume of the sample will be remained constant. So, A zero L zero is equal to A prime L zero minus delta L. With this strain, which is equal to delta L by L zero.

Now, look at this, there is volume of the sample is remains constant. So, stress when once you applied this load P, this stress will be P by A. Now, initially the volume is A zero L zero, A zero area into L zero. Once it is get distorted, so this is my modified area, we get diameter changes, L zero minus delta L. So, it will be L zero minus delta L, this is the length, it is remaining.

So, how much is your strain coming, strain is your change in length by original length. So, change in length, strain is your, this is your delta L, by original length is your L zero. Now, A prime, if I equate it to this, a prime is equal to A zero L zero by L zero minus delta L. So, it will be, in terms of, if I write it, it will be in terms of modified area, which is equal to A zero initial area minus change in strain.

That means, once you are applying, suppose you apply (( )) one kg ,or may be one kilo newton per meter square of the stress, or one kg load, what is the displacement you observed, find it out, how much is your modified area, A prime. Then you apply, another two increase, find is your modified area. That means, it is a continuous, that means change in strain, you will find it out means stress, sorry, change in stress you will find it out P by A, this A will be always as the test progress, it will be a prime.

That means for a particular strain, you will find it out, how much is your delta sigma one, say strain two, xi one, this is your xi one, this is your xi two, then this is your xi three. It will be delta sigma one, delta sigma two, then delta sigma three. With this reading, whatever you are getting with this reading, you plot your delta sigma means stress versus strain. Stress versus strain diagram you plot it. So, once you plot it stress versus strain diagram, this is the diagram you are supposed to get. As there is no confinement, so the stress versus strain initially, it will be elastic. Then, it will goes to plastic, then fails, then it will decrease. So, the peak failure, where it will go peak and decrease, that point, in that case, it is taking as a, we are taking as a failure point. So, this is your q u ultimate strength.

Now, if I draw the mohr circle shear strength versus sigma, what will case in this case. So, mohr circle is a plot of sigma. If this is my sigma one, and this is my sigma three. So, what will happen to sigma three? As there is no lateral direction, there is no pressure. So, that means, sigma three is equal to zero. That means, here sigma three is equal to zero.

So, from where you will get your sigma one, whatever the failure from here, delta sigma by strain means stress by strain, wherever your peak you are getting, that is your sigma one. So, you put it your sigma one. So, if I draw a mohr circle, so it will pass through the origin. Now, from here this point, this is your shear strength c is equal to q u by two, if you draw a tangent, this tangent will be parallel to, or asymptotic or parallel to your sigma axis. Then, shear strength c is equal to q u by two.

So, this is the case, how you are going to get. Particularly, your shear strength means here, shear strength is c is equal to q u by two, and in this case, the mohr circle will pass through your origin o, as sigma three is equal to zero. So, it will pass through the origin o and sigma one, you are getting from stress versus strain diagram from the peak value, you will get your sigma one.

Now, next step you are coming, this is a case first test, this is called unconfined compression test. That means, it is not confined, unconfined compression test. Sometimes, it is called quick test.

How far this test is required, as far as your technical engineering is concerned, how the test is required to us. As this is called a quick test, you can bring, soil sample from the field, undisturbed soil sample, immediately in the compression machine, you put the soil sample, immediately you get an idea particularly, what is your shear strength.

Remember, this unconfined compression test is possible, particularly for cohesive soil. If it is a cohesionless soil, in that case, the soil cannot stand. The soil cannot stand by its own weight. So, this test is applicable for particularly cohesive soils, where the soil sample you can take out, if I leave the soil sample, it can stand by its own weight.

What does it mean? From field, if I take out this soil sample, if put it in a flat surface, so this soil will stand, it will not fail, but if you bring the cohesionless soil. Cohesionless soil means sand. Can you put a sand, so that it can stand? No. In cohesion less soil, sand will fall. So, it is not possible. So, this is particularly for cohesive soils. So, you bring it, immediately within an hour, you finish your test. That means, you will get some behavior, which is related to unconsolidated-undrained. This is called quick test.

Unconsolidated undrained, now you are saying that unconsolidated undrained, where it is applicable in real field, where it is applicable, where is that condition is exist. That means, if somebody says, this is unconsolidated undrained. Unconsolidated-undrained means consolidation is not there, as well as shearing also is not there.

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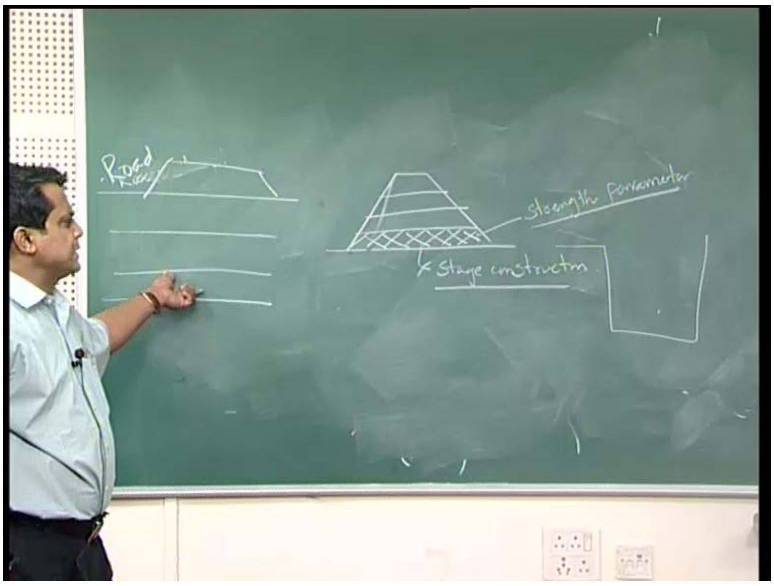

For example, construction of an embankment during construction, what happened. Suppose you have taken a soil sample, taken soils nearby pit, you construct this embankment by stages, if you construct this embankment, what will happen, once you construct this embankment by stages, what will happen? Immediately, what is it is strength. That means, once you take soil sample from pit and compact it layer by layer, within no time, this is not going to be consolidated, this will be remain unconsolidated. Then, within the time, immediate effect drainage is also not possible. So, that case while during this construction, what is the strength parameter, if somebody asked, then in that case, it will correlate to your quick test, or unconfined compression test. Similarly, this is embankment.

Similarly, road construction. So, in case of road construction, subgrade material, immediately put it and compact it, you want to know, once the compaction has been done means, how much what is your strength of that particularly material. It may be sand, it may be clay, it may be silty clay, what is the strength of that particularly soil during the construction, to do that, this quick test is required, and this quick test is nothing, but your unconfined compression test, where you will get immediately S u is equal to c is equal to q u by two.