Geotechnical Measurements and Explorations

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Lecture No. # 08

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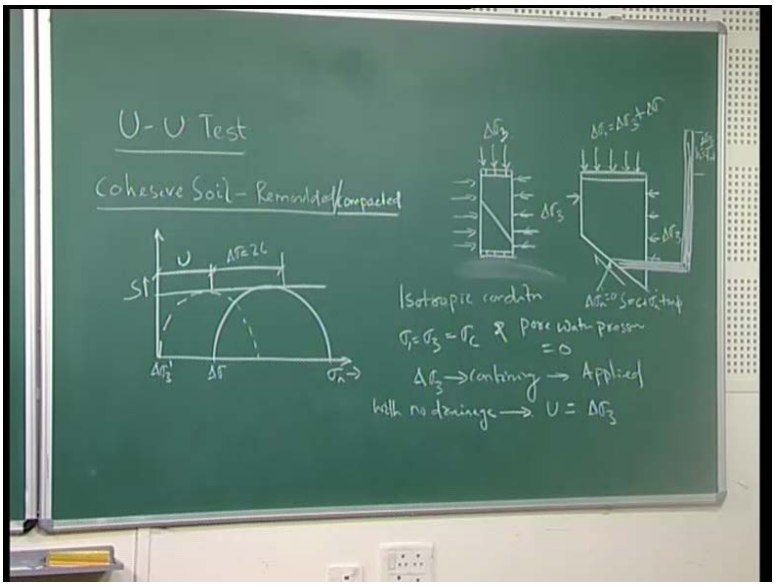

Now, we will start this triaxial test on cohesive soils U-U, C-U and C-D test. So we will explain it step by step; U-U test for cohesive soil - remoulded or may be compacted. Now, take a soil sample…

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In isotropic condition isotropic condition, sigma1 is equal to sigma 3, which is equal to sigma C, and pore water pressure is equal to 0, delta sigma 3 is you confining, it is just you have applied, you can say applied pressure; that means with no drainage, this means U is equal to delta sigma 3 confining pressure.

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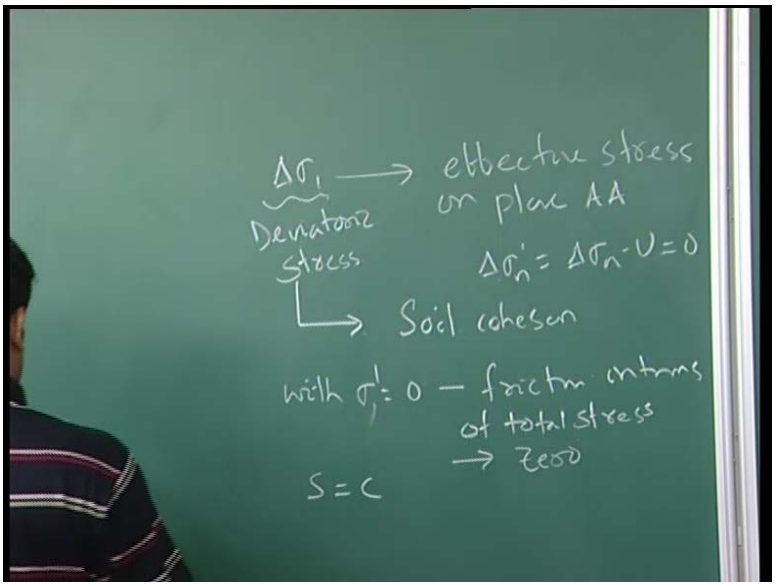

That means delta sigma 1, this is your deviatoric stress deviatoric stress, which will be effective stress on plane AA; and delta sigma n prime is equal to delta sigma n minus U, which is equal to 0, this will be carried by soil cohesion. So with sigma prime, effective stress sigma prime is equal to 0; that means friction in terms of total stress in terms of total stress, it is 0 that means S is equal to C.

Now if you look at this is my U-U test, earlier we have finished for cohesion less soil; in triaxial test U-U test, unconsolidated, undrained, means drainage path is closed. If you look at there, this is my soil sample, typical soil sample. Initially, what will happen? Confining pressure has been applied; all round confining pressure has been applied. So this will be your confining pressure let us say delta sigma 3. In isotropic condition, what is isotropic condition? That means sigma 1 is equal to sigma 3, which is equal to sigma C; in isotropic conditions, pore water pressure is equal to 0. So delta 3 is your confining pressure it is applied; how this shear strength means, triaxial test has been conducted?

Initially the soil sample has been put it in the triaxial mould, inside that triaxial the pressure delta sigma 3 all round confining pressure is applied; once the all round confining pressure has been applied, then with this pressure you can say that the consolidation may be applied with your isotropic conditions or consolidation has been done without also isotropic conditions. So, I have taken the failure envelope of the soil sample in these directions; so here once after the consolidation means, there is no

consolidation you have to apply for shearing means delta sigma1 is your deviatoric stress that is your delta sigma 3 plus delta sigma.

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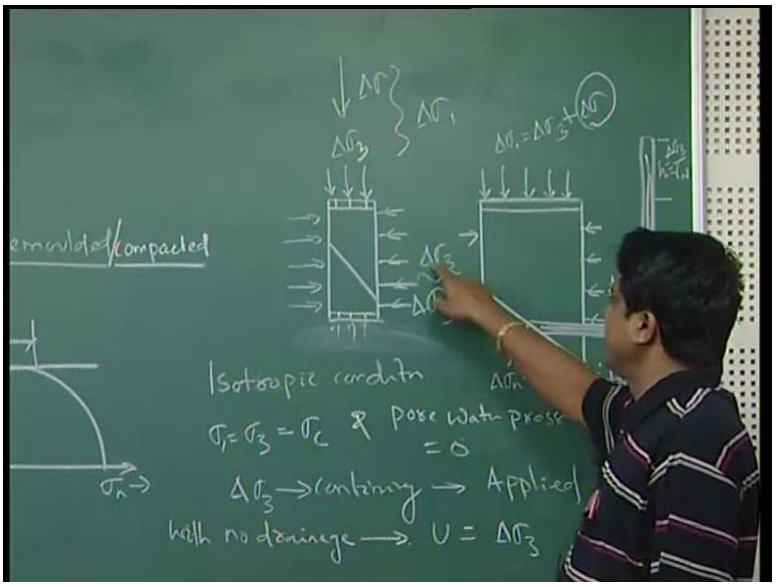

This is my stress applied in vertical, if I say this is total my sigma 3 or delta sigma 3, this plus delta sigma will be my delta sigma1 delta sigma 1. Now, what will happen? That means delta 3 is your confining pressure, delta 3 is your confining pressure applied; as it is unconsolidated-undrained that means there is no drainage, what will happen? U is equal to delta sigma 3; whatever the pore water pressure, it will be because of your applied confining pressure. The moment you apply your deviatoric stress delta sigma1; that is your effective stress on plane AA, effective stress on plane AA; what will happen?

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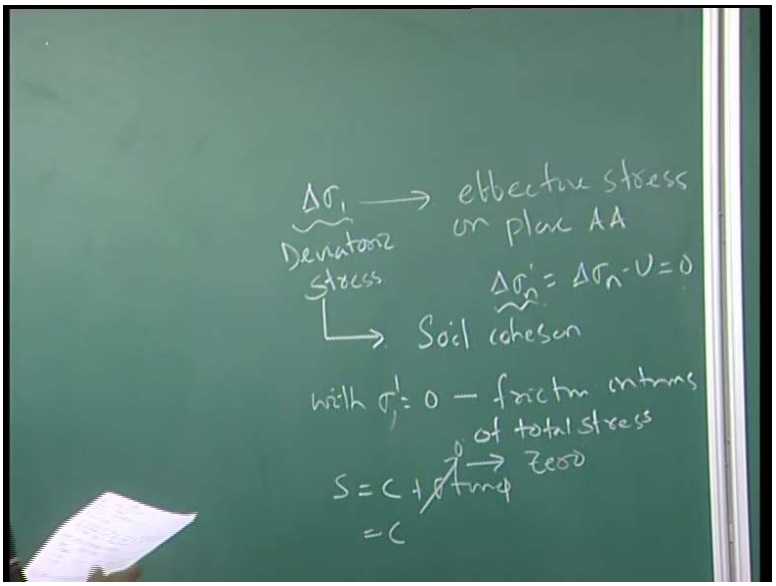

Delta sigma prime, effective stress is equal to delta sigma n minus U, which is equal to 0. So what will happen? With with this term, what will happen? Friction in terms of total stress, friction in terms of total stress is equal to 0; that means S is equal to C plus sigma tan phi. So this will be 0, then S is equal to your C; that means your shear strength will come in terms of C. Now the diameter of Mohr circle is unchanged by pore pressure, but origin of circle is shifted to left by pore pressure U. If you look at here it is unchanged, but this origin has been shifted from here to u here to here in terms of U, in terms of U, U is your pore water pressure.

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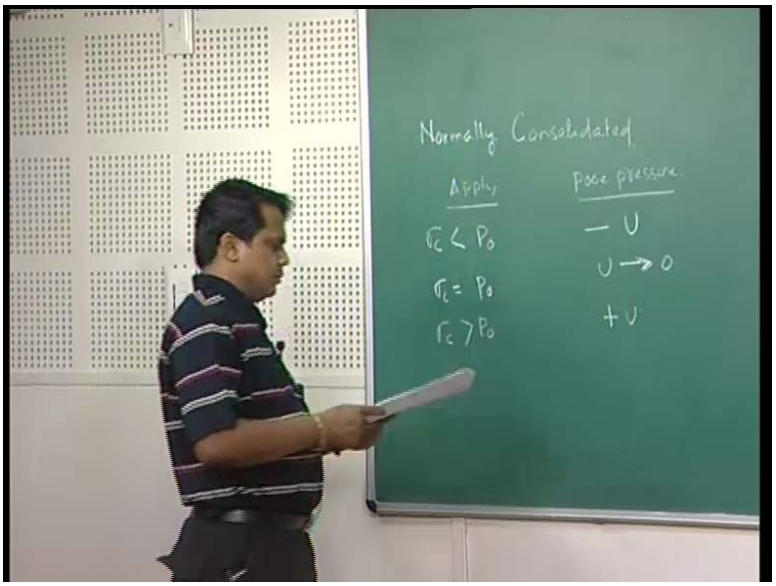

Now, for normally consolidated for normally consolidated, apply and pore pressure, what will happen? If sigma C less than P 0 that means it will be negative pore water pressure; sigma C is equal to P 0, U tends to 0; if sigma C consolidation pressure is greater than over burden pressure P 0, then your positive pore water pressure is developed; negative pore water pressure will develop when sigma C is less than p 0 that means, when the consolidation pressure is less than P 0, what will happen? It will try to it will try to take the water inside, so negative pore water pressure will be negative pore water pressure will be generated; when sigma C is greater than P 0 positive pore water pressure that means pore water pressure built up inside the soil, so it will show that the positive pore water pressure will be developed; when sigma C is equal to P 0 that means pore water pressure tends to 0.

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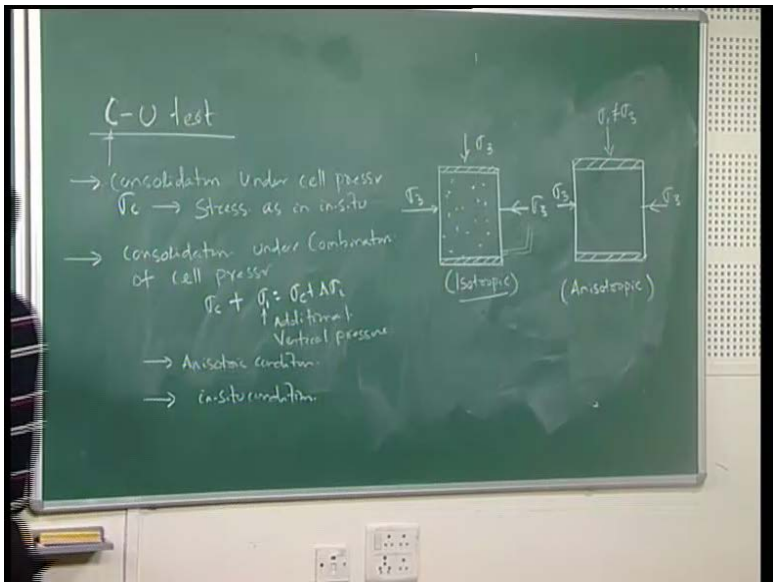

Now next part is your consolidated-undrained test C-U, that is your C-U test; C-U test means consolidated-undrained test; that means consolidation consolidated-undrained test means, consolidation will be there, during shearing this drainage valve will be closed; that means after consolidation, shearing will be done means, in undrained conditions particularly, in undrained conditions. Now, if I draw the diagram in two conditions; one is your isotropic conditions, other is your anisotropic condition.

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In isotropic conditions that means, consolidation under cell pressure sigma C, under cell pressure sigma C, it is not it is not stressed it is not stressed as in in-situ. Now second is your consolidation under combination of cell pressure consolidation under combination of cell pressure; that means sigma C sigma C that means that is your cell pressure plus additional vertical pressure, additional vertical pressure sigma1 is equal to sigma C plus delta sigma1, this is your additional vertical pressure. It is says, this is your anisotropic condition, and this is truly in-situ condition.

Look at this two conditions, C-U test, C-U test is your consolidated-undrained consolidated-undrained that means this soil sample has been a first allowed to consolidation; then after consolidation is over, then the shearing will be done in undrained conditions, shearing will be done in undrained conditions. I have made two conditions; one is your isotropic, another is your anisotropic. In general, what will happen in laboratory? The consolidation has been done by means of all round confining pressure or cell pressure sigma 3. That means what happen? Initially the soil sample, you apply… First the soil sample is there, go for saturation; once it saturation has been achieved with your b parameter checked; then you go for your consolidation.

The consolidation has been done with only whatever the cell pressure apply, whatever the cell pressure is applied with by means of cell pressure application the consolidation has been done; once you open your drainage valve or by measuring what is the change in change in water level that also standard way you can find it out your consolidation under the cell pressure. These conditions, particularly consolidation under cell pressure, because the cell pressure around these three, sigma1 and sigma 3, because this is cylindrical shape, sigma1 and sigma 3 are same. That condition is called isotropic.

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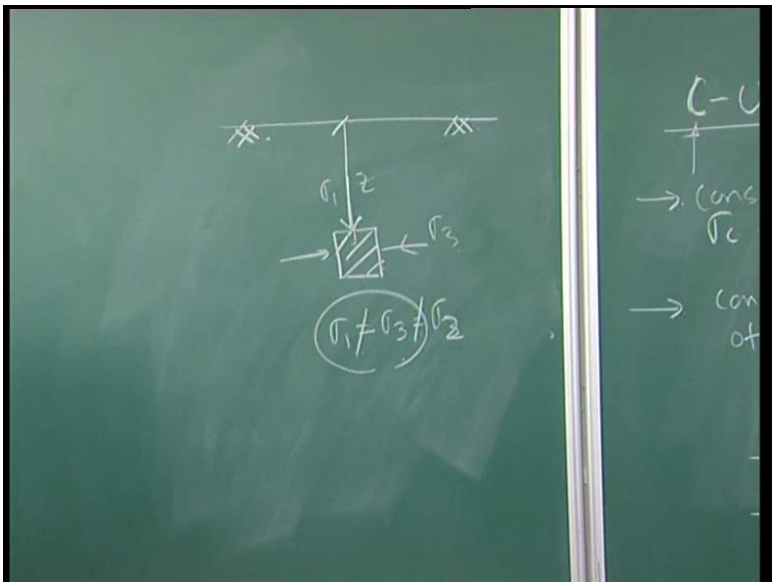

But what will happen? It is not truly reflecting, it is not truly reflecting the soil sample, suppose this is my field conditions, suppose soil sample is collected at a distance or at a height of Z from the ground surface. Once the soil sample is there, what will happen? This has both vertical as well as lateral pressure; this is your sigma1, sigma 3. It is not it is not always that sigma1 will be always sigma 3 or which is equal to also sigma 2; in that condition, stresses in all round if it is same, in that condition it is called isotropic, but which is not true in case of in field conditions.

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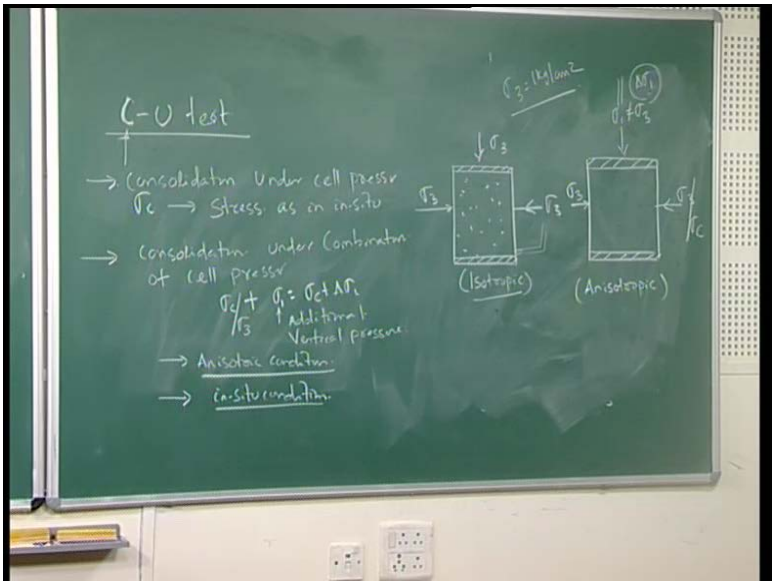

That means to simulate the field conditions, in laboratory, what will happen? Consolidation under combination cell pressure; under combination cell pressure means, first you apply your confining pressure or may be cell pressure, let us say that is sigma 3; let us say sigma 3 is equal to sigma 3 is equal to 1 kilogram per centimeter square. Apply the confining pressure all around, I will show you a video may be after this test completely the shear strength part is there about this equipment also may be some photographs or video. So, let us say confining pressure sigma 3 - 1 kilogram per centimeter square has been applied.

Then once this kilogram per centimeter square has been applied, you apply additional vertical pressure additional vertical pressure vertical pressure that is your sigma1, which is equal to means, additional vertical pressure if you say delta sigma 1, additional vertical pressure say delta sigma 1 you apply. That means what will happen? Sigma 1; all-around confining pressure is your sigma 3; what will happen sigma 1, earlier in isotropic sigma 1 is equal to sigma 3. In that case, because of additional vertical pressure has been applied, so sigma 1 is equal to sigma 3 or sigma C plus delta sigma 1 that is your additional vertical stress applied. So in this case, sigma C or it you can say that sigma 3 plus sigma 1 that is your sigma C plus delta sigma 1 that represents that represents your anisotropic conditions anisotropic conditions, and that will truly represent in-situ conditions, that will truly represent your in-situ conditions whatever is there.

That means in general, once again I am repeating in general, in consolidation consolidated-undrained test, there are two types; one is your isotropic conditions, another is your anisotropic conditions. Generally in laboratory, isotropic conditions has been applied for your consolidation; in that case, all round confining pressure sigma 3 maintained constant; with this, all round confining pressure, the consolidation has been achieved. But in case of anisotropic cases means, additional pressure after all round confining pressure sigma 3, additional pressure sigma 1 that is that is equal to that is equal to sigma C plus delta sigma 1 additional pressure will be applied. So that means sigma 1 will become sigma 1 will be become sigma 3 plus delta sigma 1. So, this will this will this will be your anisotropic condition that means traces in x and y directions are different, so that will truly represent in-situ conditions.

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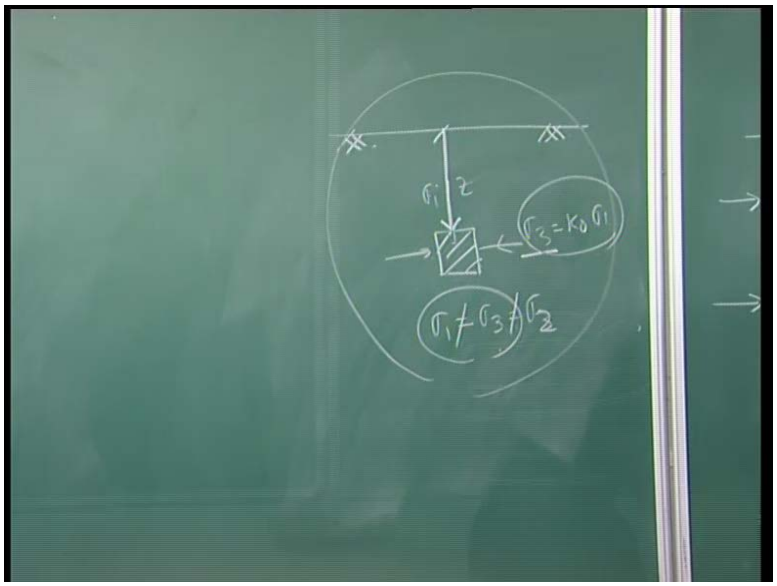

That means if I take a soil sample below this ground surface, sigma 1 is not necessarily that equal to sigma 3, because what will happen? Sigma 3 is equal to always kind of K 0 sigma 1. So definitely sigma 1 will be different than your sigma 3. So to achieve that condition, anisotropic conditions should be applied in the laboratory for your consolidation. That means before starting your undrained condition shearing for consolidation anisotropic condition to be applied in the laboratory.

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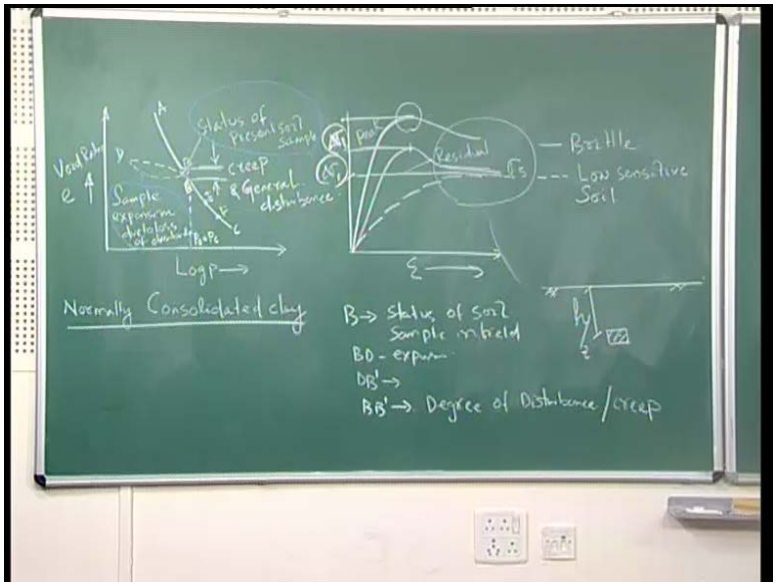

Now, let us draw draw the basic diagram of void ratio and log P.

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There are two graphs I am drawing; one is your e versus log P, other is your delta sigma 1 versus… Stress versus strain, you can say stress versus strain.

(No audio from 24:13 to 25:20)

Let us start explaining this first condition void ratio e versus log P, under normal it is a… For this this graph, I draw it for particularly normally consolidated clay. Under normal field condition, soil consolidate under path A B and C; A B and C A B soil soil consolidate under path A B C. So, means under normal conditions, soil consolidate under path A B C. So present status of this sample, if I take a soil sample in the field, as I said in the field condition, as it is normally consolidated clay that means this consolidation process is in underway. So, at an height h or z, so once I take this soil sample means, soil sample point B that means present status the sample of the soil, once you say that at a distance h the soil sample is there, so the status of the soil sample represent the point B.

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It represents point B. So corresponding to an overburden pressure P 0, corresponding to1over burden pressure, this is from B status you can say that corresponding to one overburden pressure overburden pressure P 0 P 0. When sample is removed that means the moment, the sample is removed from the ground surface, as it is a normally consolidated soil as I say, the present state of the sample is say at point B, so corresponding to your overburden pressure P 0; it may be here, it may be here. So the moment sample has taken out from the field, it lost is overburden; it lost it lost is overburden.

Once it lost the overburden, what will happen? Without overburden pressure, sample will try to expand; sample will try to expand that means this expansion is your B D. Once you take out, this is at the field condition, then once you take out the soil sample from the field, what will happen? The sample will lose its overburden pressure, so it will try to expand that is your B D B D; that means pressure is lost, and hydrostatic pressure condition are changed, so line B D is that conditions, which represent sample expansion due to loss of confining. This is your you can say sample expansion sample expansion due to loss of overburden, sample expansion due to loss of due to loss of overburden.

Then D B, what will happen? D B, D B is your after sample placed in triaxial, after sample placed in triaxial, what will happen? At this condition this is your field conditions, so B D is your sample has been taken from field that means it lost a sample expansion will occur due to loss of overburden. From D D to D to B prime that means A B, if I write it, B is your status of soil sample status of soil sample in field, then B D I have written, this is your expansion due to loss of overburden; then D B prime D B prime will come. The moment you put it inside your triaxial, put it inside your triaxial, because of confining pressure because of confining pressure, it will again recompression will start D to B prime; this is your D to B prime.

So, what will happen? From bringing the sample from field to making in the laboratory in the triaxial test, this will be it will go from, to regain it is original position, it will go from B to B prime, it will go from B to B prime. If I have taken here B to B prime, what will happen? So, B B prime is nothing but is your degree of disturbance, degree of disturbance or it may be because of your creep.

Now look at this once again I am saying, once again this explanation is there; A B C for normally consolidated soil, A B C for normally consolidated soil, this is your normal A B C is your normal consolidation graph. That means, normally consolidation normally consolidated clay means, the consolidation is going on, let us say B, B is your point, where the sample it represents status of present soil sample, then what will happen? The moment you take the soil sample from the field to laboratory, it will lose mean, it will it will lose the overburden. Then sample try to expand; the sample expansion because of loss of overburden that is your B; that is B is here B D. Then the moment you put the soil sample inside the triaxial inside the triaxial, what will happen because of a confining pressure sigma C, it will be it will become again it will recompress from D to B prime; this amount this particularly B to B prime is your general disturbance of sample from field to laboratory, and it represents your creep.

Now, if you look at here, now these are increased in stress means stress versus strain, one I have drawn for brittle, other is your per low sensitive soil that is for particularly residual part; means after peak, this residual part will merge with your low sensitive soils or you will get a residual means, strength remains after your peak. Now if I draw, this graph represents about your sample disturbance. Now, come back to within terms of residual means, C-U test in terms of residual and peak.

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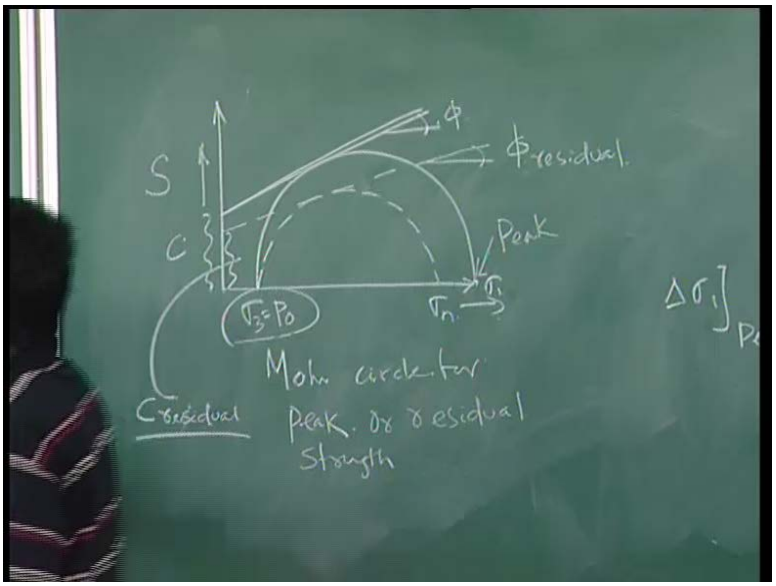

If I draw it…

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Now Mohr circle for residual and peak; if you look at this diagram means, this for this particularly what will happen in stress versus strength in consolidation test, C-U test. So it will go it will go reach achieve a peak, and that peak we have consider as a failure, peak failure. So sigma 3 is equal to is nothing but is your P 0, it will start here, then here it is coming, this is your confining pressure applied; here it is coming your peak that means that is your sigma1, where it is coming, this point. And this gives Mohr circle in terms of peak failure, Mohr circle in terms of peak failure, this represent C, this this represent phi sorry this represents phi, and this represents C.

Now if I if I want to draw for residual strength, the same confining pressure it is there, but if you look at here residual strength, the strength here it will be somewhere else the peak, peak will be somewhere else say delta sigma1, and here it will be somewhere else say delta sigma1; if you compare both compare both, that means delta sigma1 for peak is greater than delta sigma1 residual. So, what will happen, the moment you draw in terms of residual, what will happen? Delta sigma1 peak, for residual it will shift, it will shift slightly away from your peak, but sigma 3 is constant. So, what will happen? This peak if it is lie, the shear parameter it will be become slightly flatter side, the graph here the curve here you will look at here, it will come slightly flatter side, what will happen? This

is for your C residual, and this is your phi residual. Because of P, this this C value will be high, phi value will be high; and because of this, it will be phi residual and C residual.

So while designing, what parameter you need from consolidated-undrained test - C-U test means, if you want for peak, then you can use the C and phi for peak and design; if you want, for particularly phi residual and C residual, so you can take this value of residual value, where you can utilize for your design. So, this is all about means brief discussion particularly, consolidated-undrained test, how this behavior, how it represents with this field conditions; then what will happen? If it is a residual you want or peak, this has been explained. Next step is your consolidated-drained test.