Geotechnical Measurements & Explorations

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Lecture No. # 01

Consolidation and Consolidation Settlement

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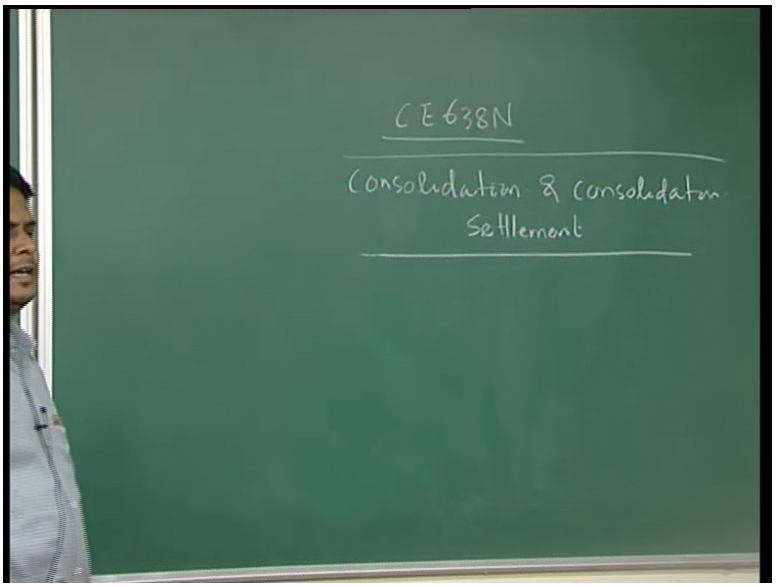

It is a second lecture c e 638 n. Let us start with this basic fundamental concept of consolidation and consolidation settlement. What do you mean by this consolidation?

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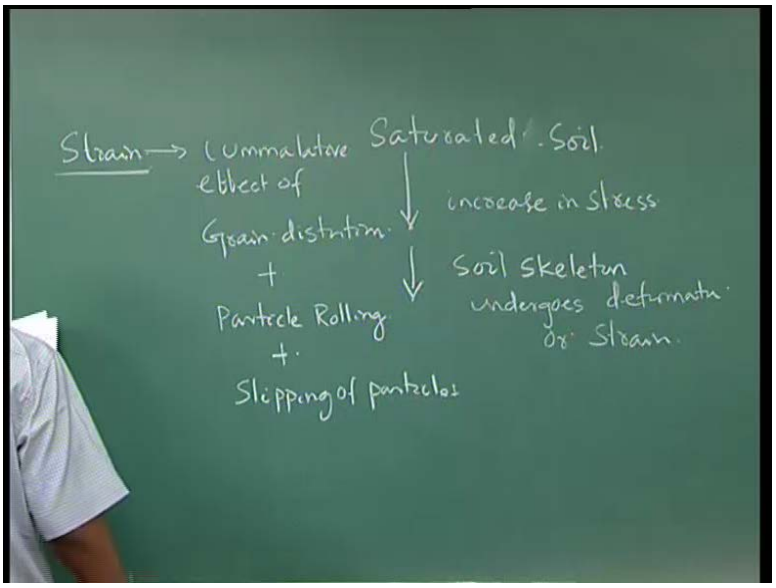

Now let us say saturated soil; it is acted by increase in stress. So then, then soil skeleton undergoes deformation or it is called strain. Now, come back to strain. It is cumulative effect of one is grain distortion then, plus particle rolling then plus, slipping slipping of particles.

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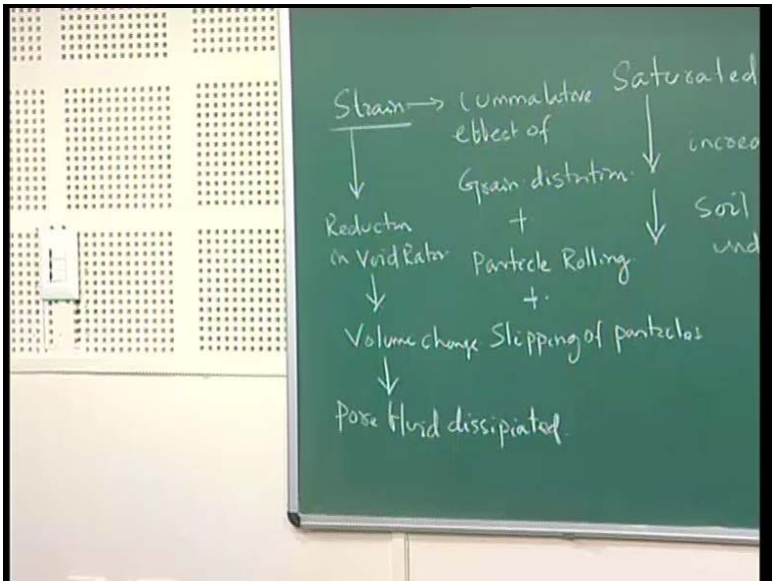

So then from here because of this, there will be reduction in void ratio or we call volume change or pore fluid dissipiated. Now with this let us start with this consolidation and consolidation settlement.

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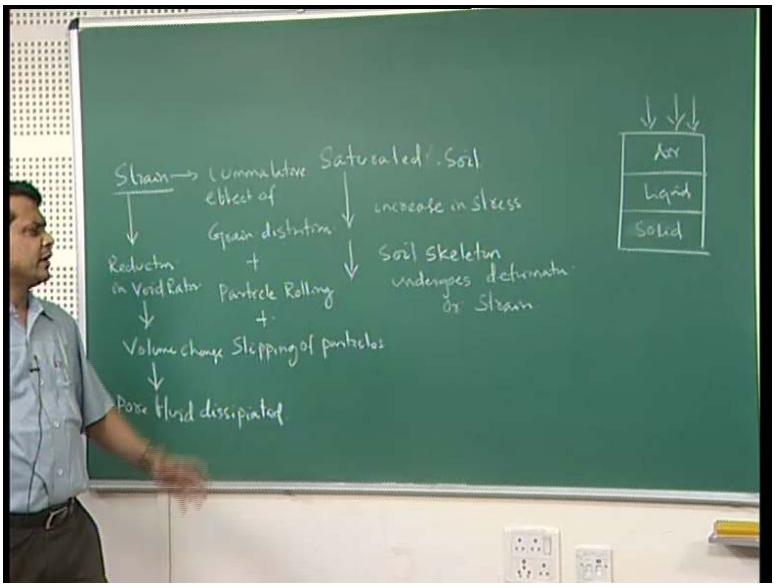

The concept of consolidation; now a soil, soil consist of if I take it three phase system; it is solid, it is liquid, it is air. With these three phase system now if we say this saturated soil if I apply increase in stress by means of application of external loaded or may be other means, then what will happen? The soil skeleton changes or deform or may be the soil skeleton deformation occurs. How the soil skeletation skeleton deformation occurs? If you come back here the soil skeleton deformation is called nothing but, strain. In geotechnical engineering if I come back to strain the physics behind it is cumulative effect of grain distortion.

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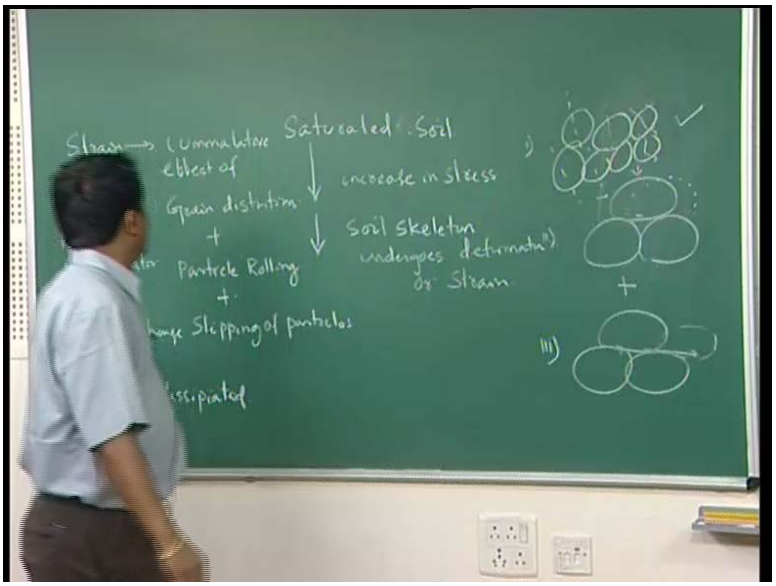

Now grain distortion means the particles arranged or oriented in different size, different shape. Grain distortion means this grain size, grain will particle will disintegrated that means what will happen? The particle breakage will occur because of particle breakage will occur there is a distortion of this particles. That is number one, now number two; number two particle rolling what happen by externally apply stress particle, particles are like this. Once you apply this load once you apply this load the particle starts rolling above this other particles. This because of this rolling of these particles again deformation will occur.

Third part is your slipping of particles or solid particles. It may happen without rolling without rolling the particle may slip the particle may slip. So, once particle slips then again the soil undergoes deformation. So, strain if I if I make it summarize strain in geotechnical engineering, it is cumulative effect of grain distortion number one. Second part is your particle rolling. That means particles roll above each other or may be single particles rolls above the other particles. Then third is your third is your slipping of particles. It may be one phenomena or it may be two phenomenon or it may be cumulative of one two three. So, in that case you put it in a different strain intersection it is a cumulative of grain distortion, particle rolling, slipping of particles. Now what will happen? What is this physics behind it? What will happen because of this?

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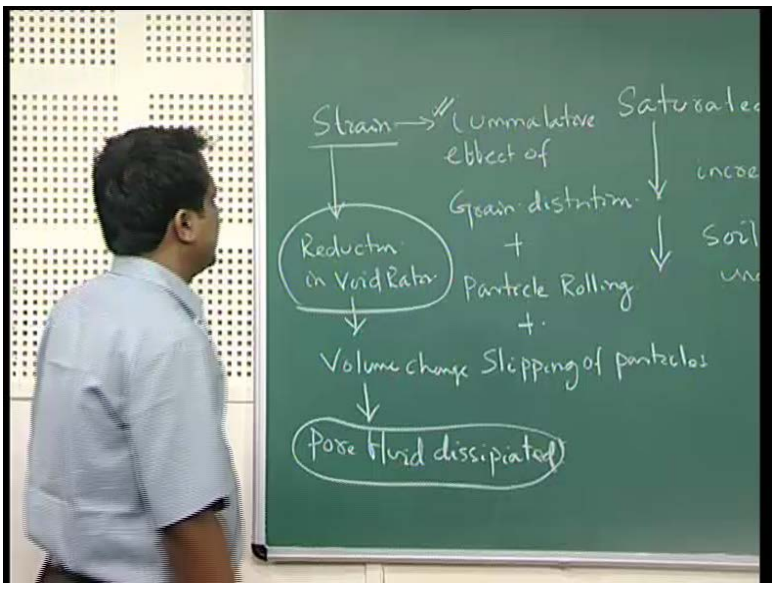

There is a reduction in void ratio void ratio void ratio. Because there is a reduction in void ratio then what will happen volume change will occur. Once volume change occur means this pore fluids, this fluids inside the soil will dissipated that is called strain related to your consolidation. This is the complete definitions and behind it is once again because of your grain distortion, particle rolling and slipping of particles.

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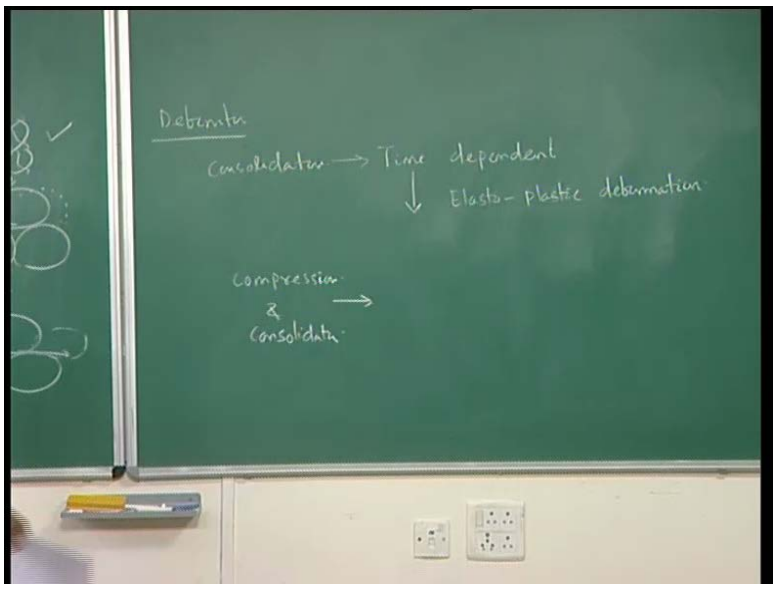

If I define or definition consolidation it is time dependent, also it is elasto plastic deformation. Then before I define this consolidation, ask your self this questions what is the difference between compression and consolidations?

In compression is a simple volume change without any time. That is called compression. In consolidation if we say it is consolidation this is a time dependent phenomena time dependent phenomena because this all this cumulative effect grain distortion, particle rolling, slipping it takes time over the period of time then the reduction in void ratio will occur, then volume change. So consolidation means the phenomenon is time dependent and its behaviour is elastoplastic deformation.

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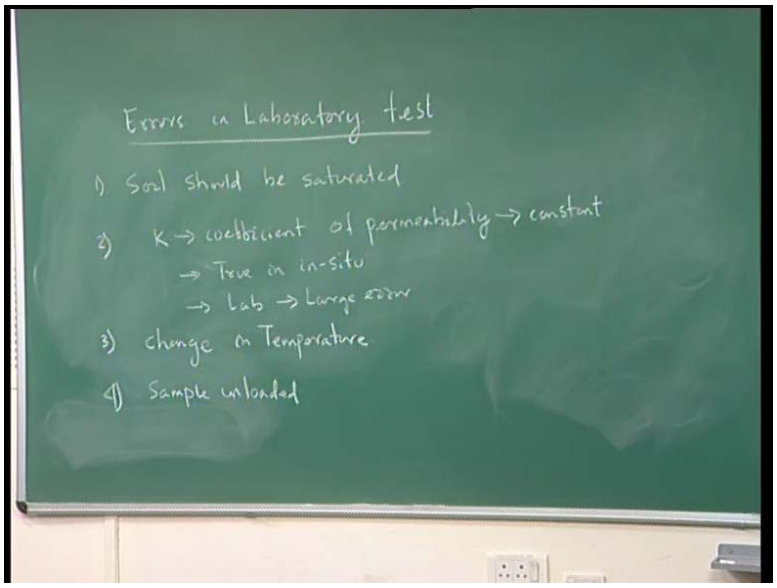

Now come back to what are the errors generally we counter encounter during laboratory tests. Before I go for in details; let me write this points then I can explain. Let me start with this what kind of error or possible errors that may happen or may occur during our laboratory test? It may not truly reflect your field test means in field conditions or in see to conditions. Let me start with this back. Let me start that these are the four points; one is soil should be saturated, second is your coefficient of permeability, third is your change in temperature, fourth is your sample unloaded.

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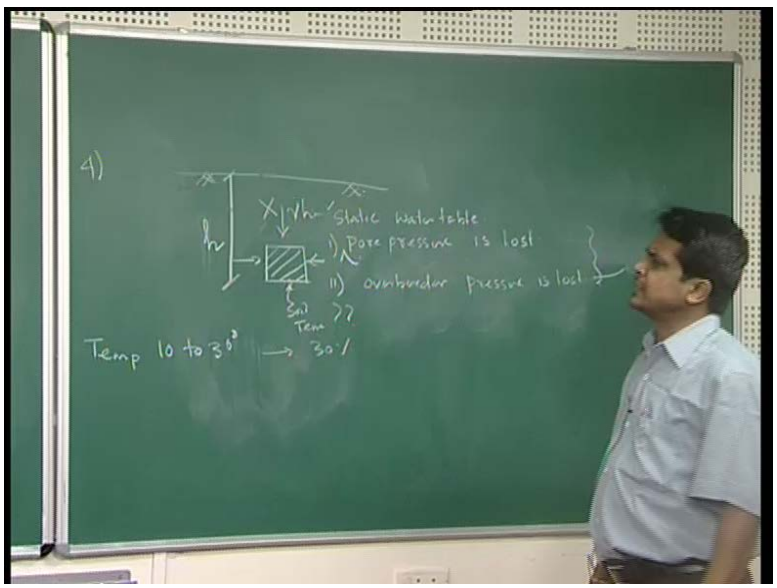

Let me start with this back, then from bottom to top let me go. First part is your say let us say fourth sample unloaded. Suppose in the case of, we collect undisturb sample in field say at a distance h or at a distance z. So, where this sample has been, undisturb sample has been collected? Before collection of undisturb sample now you ask this questions, what will happen the moment you collect this sample below the ground? So, it will last pore pressure is lost, then second is your over burden static water static water table, pore pressure is lost. Then over burden pressure is lost. The moment soil particles collected or may be soil samples collected at distance h from the ground surface, before collection of the soil sample if you look at here this pressure acted in this three dimensions; one is vertical other is your lateral. The moment you collect the sample undisturbed sample immediately it lost this over burden.

So we are starting with this point number four; sample unloaded. That means before unloading suppose I collect a soil sample at a distance h from the ground surface what will happen with the soil sample? This will be acted upon by over burden pressure this gamma z as well as confining pressure. The moment the soil sample has been taken out from the ground surface what will happen? This over burden pressure gamma h it lost to bring to the laboratory. Then is there any then the next question is is there any static water table pore pressure? Yes there is a static water table pore pressure immediately it will be lost. Both this cases will be lost this [error] the moment you bring it to lab from field to lab it will take time. That gives an error that gives an error.

So this is I can say this is my first error if I number it one two three four; it is it is most important part of this error encounter in the laboratory test you can put it. Now, come back to third point third and second these are same. If I say coefficient of permeability you can assume that coefficient of permeability in the in see to condition it is constant either x or y. The moment you take it out in the lab, the permeability, coefficient of permeability it lost this coefficient of permeability. Another major part is temperature a distance h in the ground what is this temperature soil temperature? Say forty degree or say thirty degree. The moment you take out the soil from this ground surface and bring it to lab, these immediately the temperature variation is there. If the temperature variation if the temperature variation from ten to thirty degree means arbitrarily say ten to thirty degree the result will be changing from this consolidation thirty percent say.

That means in the lab this change in temperature has to be applied means it has to be applied considering in see to condition what is the temperature. Now coefficient of permeability it is not true coefficient of permeability is constant (( )) conditions in see to means in the field condition which is not true in case of lab. That means in laboratory large error may be encounter. Then first one is most important that is your soil should be saturated. If soil is not saturated what will happen? This where this consolidation means expulsion of water from the void space over the time means it is a time dependent phenomena. If there is no water how this (( )) change will occur? Volume change may occur because of your secondary consolidation that means without water.

So, the soil if it is saturated you can find it out consolidation also partially saturated. There is no problem you can do it but, the prime phenomena is soil should be saturated. Once it is saturated if it is not, if it is fully saturated you bring it back to lab. In the lab soil has to be fully saturated before the consolidation test has to be performed. So, these are the common errors. It occurs means there are the possible errors. It may occur in the laboratory test. Before doing this consolidation test or may be odometer test in the laboratory these errors should be taken into consideration, means this factor should be taken into consideration so that this error can be nullified as far as possible.

Now with this laboratory test what are the things you are going to get? What is your output? Means why you are doing this consolidation test in the laboratory? So, first we will start with these consolidation characteristics.

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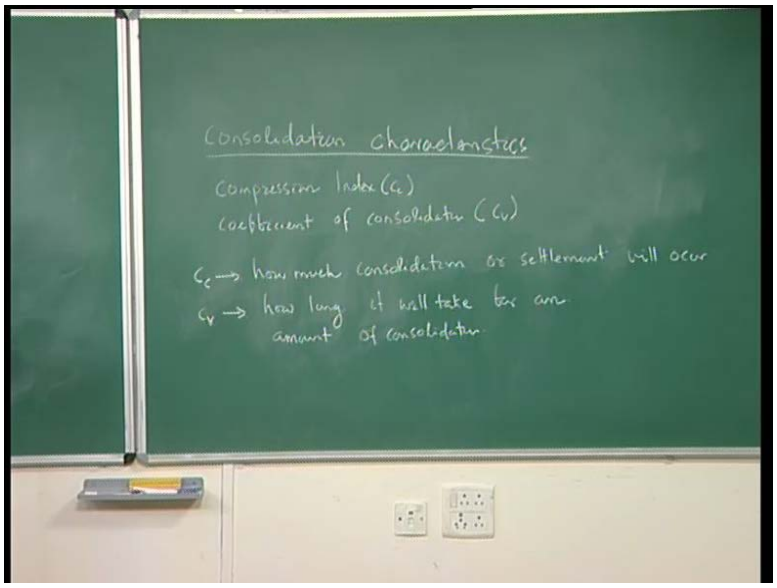

Compression index, coefficient of consolidation, now the basic means consolidation characteristics if I say; one is compression index other is your coefficient of consolidation. These two parameters required particularly in consolidation may be in soil mechanics or may be in foundation engineering, design parameter you can say. Now, what is it mean? By means of cc cc means means compression index cc means how much consolidation or settlement will occur means how much consolidation or settlement will occur?

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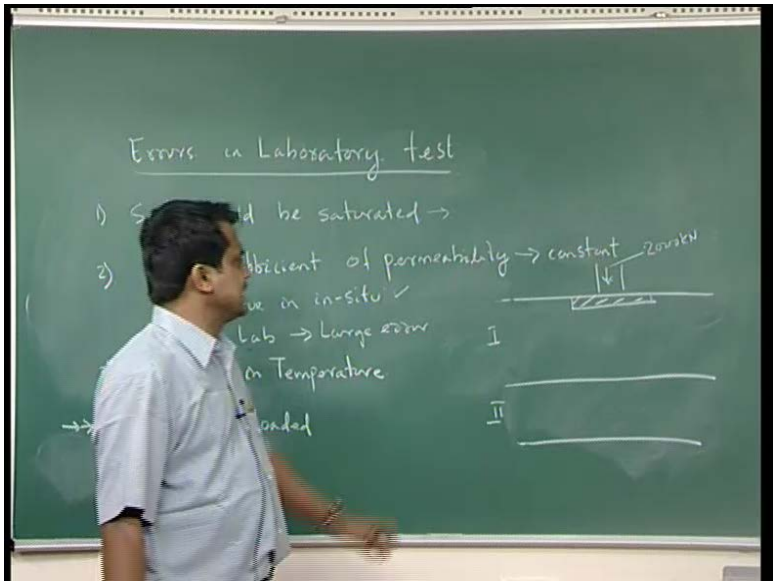

That means if there is ground surface there is a soil layer of soils are there may be footings footing is there, apply a load. Then cc means how much consolidation and how much settlement suppose if I say this is my layer one this is the layer two.

Now for this layer one, with application of load say 2000 kilo Newton this footing (( )) this load is coming on this footing (( )). So, that means with this load how much settlement it will occur? Say may be within ten years (( )) twenty year's time or may be say as it is a time dependent, you can fix like a residential building we construct for say fifty years plan we ask it for fifty years. So, may be twenty years thirty year forty year fifty year with a time dependent you fix this time. How much consolidation or how much settlement will occur for this cc compression index?

Now come to next part is your coefficient of consolidation cv. The moment I say cv it is how much and it is how long? Total how much settlement will occur first part cc? cv is if this settlement will occur how long? If there is a settlement or there is a consolidation is there then how long? one year two year three year six month or may be ten year twenty years so, these are these two phenomenon's are primary means characteristics or may be basic characteristics of this consolidation which has been used particularly in design of foundations the cc and cv we will discuss over this. Now, first we will go to this laboratory part (( )) this consolidation characteristics or may be consolidations this parameter cc and cv. Then we will start this one by one. Now, there are two consolidometer to test apparatus are available.

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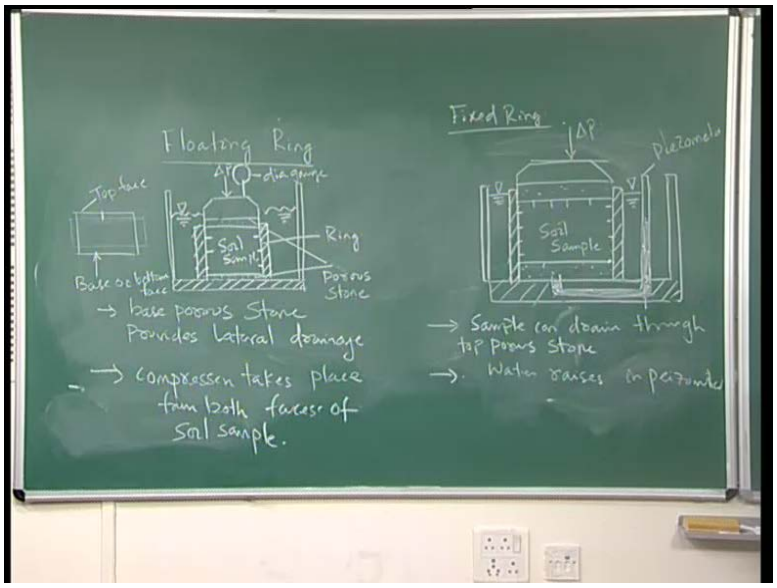

One is floating ring, other is your fixed ring. Now, if you come this to floating ring and fixed ring in this case of floating ring it is if we look at here this is a floating ring diagram, a soil sample is fix soil sample (( )) sample is there at the top there is a porous stone at the bottom there is a porous stone. You can say this is top this is bottom or you can say this is top this is bottom depending upon that how you will decide it. So porous stone has been coated and search as has been applied. Here it is dial gauze it measure this deformation.

Now in this case what will happen? Base porous stone particularly if this is my base, base porous stone provides lateral drainage. That means if I apply load here the load has been applied this porous stone is there, this is the porous stone this load has been transfered from here to this porous stone to soil sample. Then your this drainage of water has occurred here at this base porous stone means lateral drainage occur at the base porous stone the compression will be occur by means of applying search as from the top porous stone. It will be occurred so, here drainage will be occur then compression in this case compression will be takes place both at the top as well as bottom. That is why it is called floating ring that means compression takes place from both phases of soil sample. This phase also compresses, this phase also compresses if I say that this is my soil sample so this compression will occur both phases. This phase if this is called top phase and this is called base or bottom phase bottom phase.

So this compression occurs both the phases top and bottom of the soil sample. In case of fixed ring what will happen? This ring is fix at the base so it has been this is my base ring is fix so piezometer has been attached piezometer has been attached. Once load is applied here because base is fix so the drainage can occur only at the top porous stone. Load applied so this is fixed this is connected with this piezometer. So, once it is applied because this is a piezometer water is there. So once it will apply this flow starts from this top of this porous stones.

So this is the basic difference. If we look at this floating ring and fix ring this is as per the American society of testing materials. This floating ring based porous stone provides lateral drainage in case of fixed ring drainage or drain through top porous stone. That means in this case lateral drainage occur in case of base, in this case drainage occurs in case of top porous stone. Then compression takes place in this case both the phases fixed ring compression takes place in case of only one phase. So this is the basic difference between floating ring and fixed ring type of things. So what will happen? The moment you apply what is the load increment you have to apply? How this test has been performed in the laboratory? That means suppose you say.

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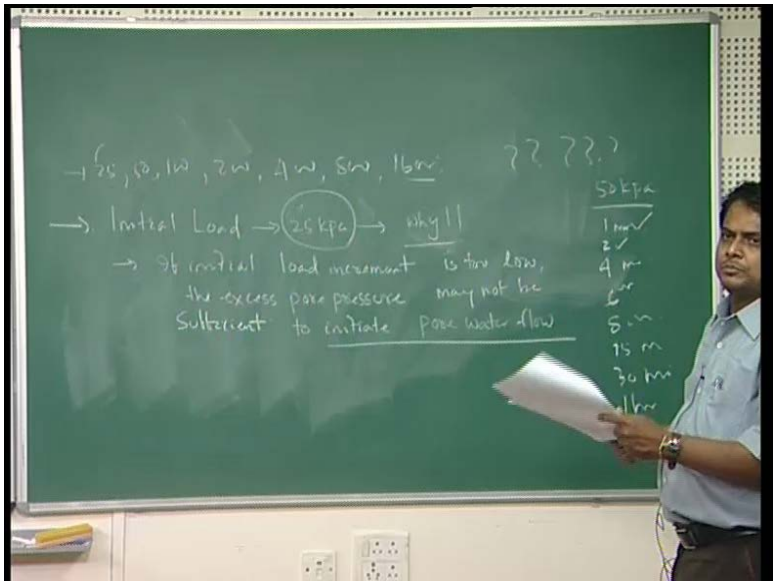

You apply a load 25 k p a initially. For example, increase in load this is my delta p what is a next step? how much load increment you are going to you are going to apply? In case of geotechnical engineering if you look at here if it is 25 k p a then, next step of load

application will be fifty next will be your hundred it is just double. 25 50 100 200 400 800 1600 like this.

So why now the question comes here in particularly this course or may be in geotechnical engineering why this load has been applied in the soil sample always double? Initial it is 25, next is your 50, next is your 100, next is your 200 you think this is for you. May be read some books and tell me all geotechnical engineering whether it is a direct set test, whether it is consolidation test anywhere else the load application initial load whatever you are taking, load application is always double that means 25 5000 200 400 800 and 1600 because with this double, this load application you are going supposed to get best result and but, what is the reason? Why I cannot apply 25 40 or may be seventy or may be hundred ten? Why it is 25 50 100 200 400 800 always it is double?

Next question is generally initial load generally initial load of twenty -five k p a has been applied in case of consolidation test. Then why what is necessary to apply initial load of twenty five k p a? So, the reason being, if initial load increment is too low then, the excess pore pressure may not be sufficient to initiate pore water flow.

The reason being just I have written for your better understanding you can write it, the reason being why this initial load is 25 k p a? Why not ten, why not five why not fifteen why not thirty? In general it is standardize means if this initial load increment is too low say instead of 25 if we apply ten if it is too low; then the excess pore pressure may not be sufficient. Means whatever excess pore water pressure generated it may not be sufficient to initiate pore water flow. What will happen? The moment you apply this load, so initial load let us say ten or fifteen you apply so it is tries to compress the soil. Once try to compress the soil pore water pressure inside the soil sample try to come out through void space.

So it may be possible that initially this load is not sufficient that this pore water will come out. To help that as per this a STM standard it says initial load of twenty-five k p a is recommended. So that it will initiate, it will start initiate or start your pore water pressure flow or may be pore water flow. So, these are the two things you just while doing the test these are the two things guidelines initial load increment initially what is the load you are suppose to apply? 25 k p a minimum then afterwards you start with 500 200 400 800 and 1600. Then with this application of suppose you apply a load of fifty,

suppose you apply a load of fifty k p a similarly, as the as you are increasing your load in double you can take the measurement of dial reading displacement or the volume change of the soil, dial reading in one minute, double it two minute four minute six minute eight minute fifteen minute then thirty minute then one hour, two hour, four hour, then eight hour, sixteen hour then go to twenty-four hour. The way you apply this load just double. Similarly, the reading you have to take it for your consolidation is just double. After the double intervals; one minute means the next interval time is two minute. You apply this load with this application of load with this two minute you can record.

So for today's class it will be, I am keeping it here so maybe you can think why this has been doubled in both time as well as in load, you can answer me. I will start this next part in the next class. Thank you.