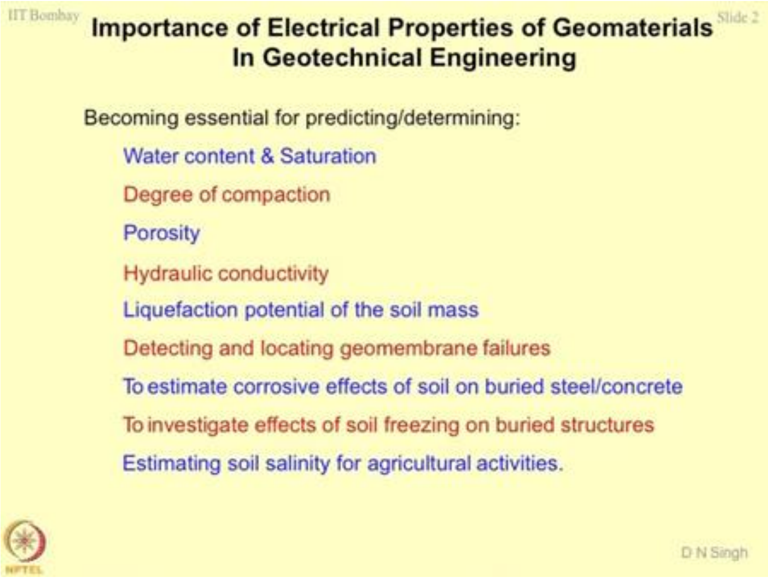
Environmental Geotechnics
Prof. D. N. Singh
Department of Civil Engineering
Indian Institution of Technology, Bombay

Lecture – 43
Electrical characterization- 1

(Refer Slide Time: 00:15)



So, let us talk about the importance of electrical properties of geomaterials in geotechnical engineering. These types of studies are becoming very essential and important for predicting and determining the following. The first is accurate determination of water content or the saturation of the geomaterial or the porous media. This is where actually most of the researchers contemporary research going on, where people are trying to come up with several methodologies. And they are trying to see which methodology happens to be the best among the all.

Degree of compaction, in most of the real-life situations, where the compaction control is a very important issue, particularly designing amendments or the foundation fills and so on, precise determination of degree of compaction is very important in the in-situ conditions. So, till now in classical geomechanics we have talked about degree of compaction based on the proctor density is not we defined relative densities or relative compaction efforts in the fields, but they are not very helpful. So, what people are trying to do is they are trying to ascertain a degree of compaction under in-situ conditions.

Some of you must have heard the importance or the application of nuclear density probe or nuclear probes for finding out the moisture content and dry density under in-situ conditions is a good example of the efforts which have or the initiatives which have been taken by the researchers to define the degree of compaction to the most precise level.

Porosity of the material because as you have noticed, porosity guides almost all the properties of the geomaterials and the porous media and its precise determination is very difficult all right. You have talked about several methods for finding out porosity including mercury porosimeter, helium gas pycnometer, simple water absorption will also give you porosity, but you have seen where you would be if you follow simple water absorption technique and does not give you the most reliable results.

So, determination of porosity of geomaterials is becoming extremely important. And particularly for the situations where the diffusive contaminant transport takes place is it not. So, which you remember the diffusion coefficient is directly proportional to porosity terms. So, if you know the porosity, you can get the diffusion coefficients or vice versa. If you know the diffusion coefficient, you can get the porosity.

Hydraulic conductivity, so hydraulic conductivity is also a very important parameter which people want to determine precisely and particularly for unsaturated soils, is it not? So, this is where the electrical properties of geomaterials become very handy. If you know them you can determine indirectly hydraulic conductivity of the porous media or the geomaterials.

Liquefaction potential of the soil mass is another important application in geotechnical engineering of electrical properties. If you know the electric properties, you can easily determine the liquefaction potential of the materials or the geomaterial in porous media. I will discuss this in detail later on.

Detecting and locating geomembrane failures, this is the only technique which can be applied to determine what is the extent of leakage or the failure of geomembranes and where they exist all right. So, you can find out the location of the cracks or the failure of the geotextiles or the geomembranes if you know their electrical properties.

And to estimate corrosive effects of soil on buried steel and concrete. So, corrosivity you much have notice when you are talking about the corrosion potential of soil, electrical resistivity was a very important parameter there. So, if you know the electrical resistivity of the soil mass, you can also estimate the corrosion effect of the soil for the structure which are buried in it particularly either steel or concrete structures.

Similarly, to investigate the effects of soil freezing on buried structures. So, I can I am sure that you will agree with me that there is a full gamut of activities you know where people want to understand a mechanism or to identify some problems associated with geotechnical structures. And this is there electrical properties become very useful or handy. Estimating soil salinity for agricultural activities, this is another important parameter where electrical properties of geomaterials are becoming extremely important.

Now, you could always debate that electrical property or the thermal property which one is more suitable for a given circumstances, what is your gut feeling. If you obtain the electrical properties or the thermal properties, which one are going to be more appropriate and useful?

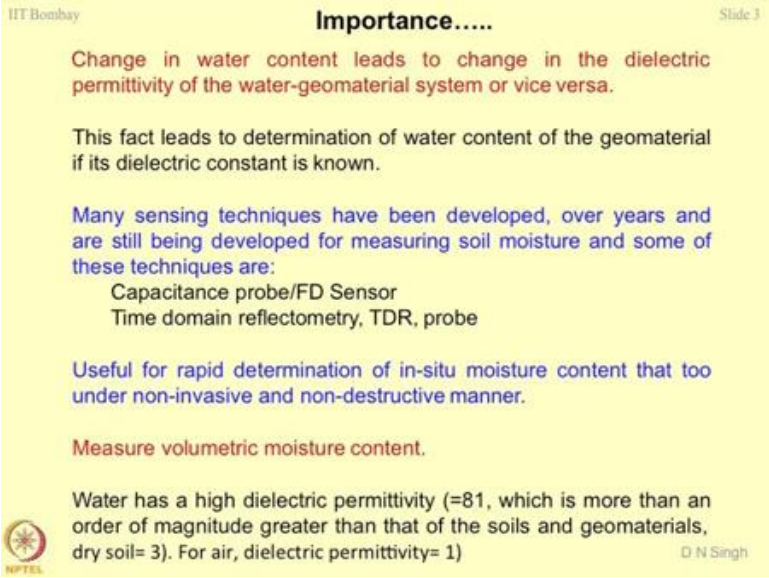
Student: (Refer Time: 06:00)

Why? Actually, there cannot be a direct answer. You have to be careful in selecting the properties which may be helpful in a given situation, like the biggest problem is comes to the mind when you are of using thermal properties is the thermal flux. If thermal flux goes beyond a certain limit, your thermal properties get affected quite a lot. Similarly, when electrical flux goes beyond a certain point, it is also going to affect or the influence the properties quite you know substantially.

So, it is a matter of convenience and the matter of confidence which should help you in deciding whether you would like to go for thermal properties or electrical properties. In short, characterize a material based on both thermal electrical properties and then check that reserve is these two where do you stand ok, and how-to employee certain parameters to characterize the geomaterials in a better way.

So, this is a complete spectrum of the problems which people are trying to study in the present-day world particularly civil engineers and geotechnical engineers. And I am sure that you cannot under mean these problems, they are problems of quite you know significant value in nature.

(Refer Slide Time: 07:21)



Now, what is the basic concept? The basic concept is change in water content leads to change in the dielectric permittivity of water geomaterial system or vice versa. So, this is the basic issue. If you can measure the change in dielectric permittivity of the porous material or a geomaterial, you can always find out what is the change in the water content; or if you know the change in the water content, you can find out what is the change in the dielectric permittivity. I will define dielectric permittivity slightly later and we are talking about the electrical properties part.

So, this fact leads to determination of water content of the geomaterial if its dielectric constant is known. So, this is the famous tops equation which relates dielectric constant of a geomaterial with its volumetric moisture content. What it says is that if you know the dielectric constant of a material, you can determine volumetric water content; or if you know the volumetric water content, you should be able to get a dielectric constant.

Now, based on this concept many sensing techniques particularly in geophysics have been evolved over the years, and they are still being developed for measuring soil moisture. And some of these techniques are capacitance probe which you are seen in the laboratory which is known as sometime FD sensor also. FD corresponds to frequency domain. So, based on this, we also called it as FDR - frequency domain reflectometry. And the other technique is time domain reflectometry that is the TDR probes.

So, these are the two categories of the sensors or the probes which are being used for determining soil moisture content. And when we say soil moisture content, most of the time these soil moisture contents are the volumetric moisture contents of the material. So, it so happened that all these sensors or these concepts are very useful for rapid determination of in-situ moisture content, and that too under non-invasive and non-destructive manner. This is a very important thing. Present day research is more into non-destructive, non-invasive techniques that means, you should not destruct the matrix of the soil mass all right.

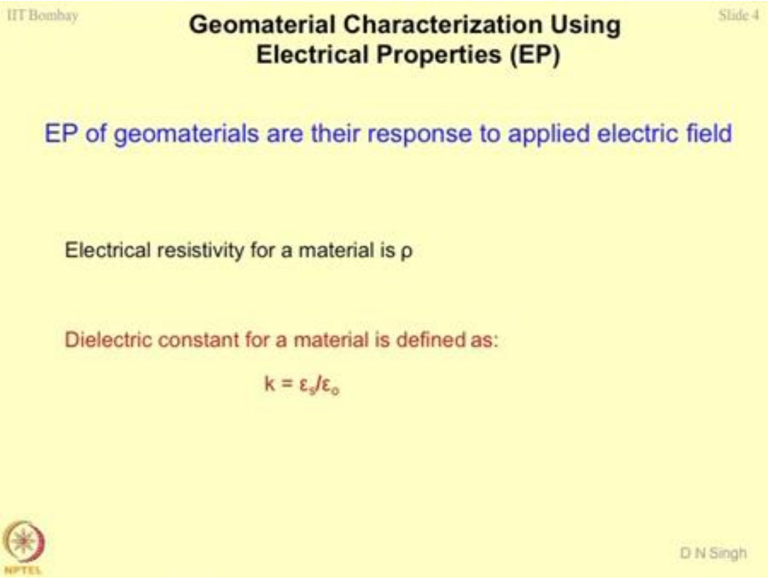
So, under these circumstances the best situation is, you should have a probe or a sensor and which goes up to the place of interest in the soil mass or in the geomaterial and then it measures the properties which are required to be known. And of course, as I said that when we talk about the moisture content, it is the volumetric moisture content and not the gravimetric moisture content. Lot of studies are been conducted by people to show the applicability of these sensing devices by correlating volumetric moisture content to gravimetric moisture content. And what they have noticed this that yes there is relationship between volumetric relationship volumetric moisture content and gravimetric moisture content.

I have told you in the previous lecture if you know the theta value theta is the volumetric moisture content, this will be equal to porosity multiplied by saturation or porosity multiplied by γ_d all right. So, these are the two relationships which can be used for determining. Oh, I am sorry it should not. it is gravimetric moisture content multiplied by γ_d all right.

So, second equation is theta equal to w into γ_d. And first relationship is theta equal to porosity multiplied by saturation. Now, here you should you should remember that water is a material which has a very high dielectric permittivity, which is approximately 81 which is more than any order of magnitude greater than that of the soils and the geomaterials. And for dry soils, the dielectric permittivity is 3. And for air, the dielectric permittivity is 1. So, sometimes minerals contribute a little bit in the form of k value - the dielectric value, and the total dielectric permittivity is above 3.

So, basic idea is if you are measuring a material, and if you know it is dielectric permittivity, you can put it on a scale of 1 to 81. And then you can determine whether the geomaterial or the porous system or the soil mass happens to be saturated or not. So, if the values are closed to 81 it is understood that the material is fully saturated. If it is close to 3 is understood that you are working in the driest possible state of the material. So, this becomes a sort of a nominal relationship, where k values of the dielectric permittivity changes from 3 to 81.

(Refer Slide Time: 12:37)

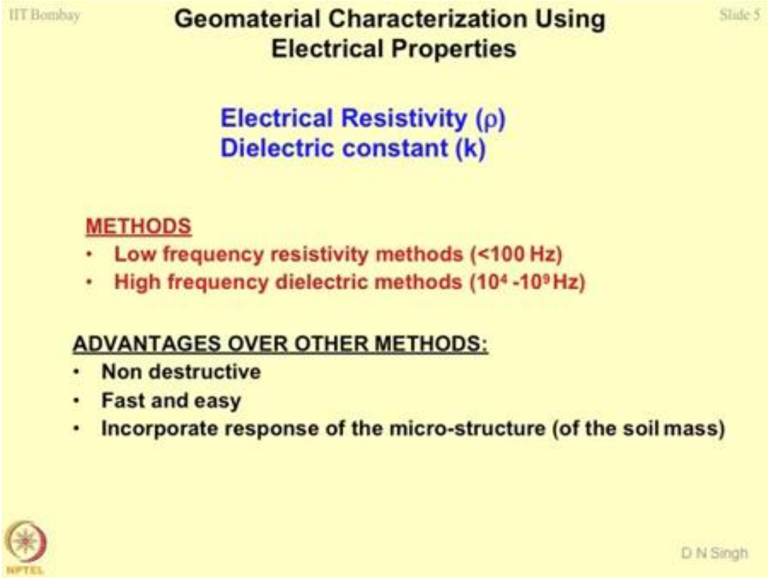


.

Now, let us talk about geomaterial characterization using electrical properties. So, electrical properties of geomaterials are basically their response to applied electric field. Now, when we say what is the significance of this, the significance is we try to talk about two parameters that is the electrical resistivity for a material which is defined as rho. And dielectric constant for a material which is defined as k. If you go back to your 10+ 2 physics, you must be remembering that $1/(4\pi\varepsilon_0)$ is the term which we use now in capacitance, is it not. So, $1/(4\pi\varepsilon_0)$ is nothing but the $\varepsilon_s/\varepsilon_0$.

So, epsilon naught happens to be the permittivity of the free space and epsilon s happens to be the permittivity of the material. So, k is nothing but it is the relative permittivity of the material with respect to permittivity of free space. Now, based on this the concept of FDR comes into the picture that is frequency domain refractometry, where if you know the capacitance of the material, you can always work out it its k value, because epsilon naught is known, epsilon s can be obtained depending upon how much charge is stored in a capacitor.

(Refer Slide Time: 14:01)



So, when we say that these are the two parameters which will dictate electrical properties of the soils. The question is how to determine them is it not, electrical resistivity and dielectric constant. Well, this is a never-ending story because as the knowledge and the state of the art is increasing people are adopting new and new techniques and lot of new concepts are coming into the picture. What I will try to do here is I will try to give you some basics of the methodologies which are adopted to obtain electrical resistivity and dielectric constant of the material.

So, this is where I talk about the methods. Prima facie, there are two methods one is known as low frequency method another one is known as a high frequency method. Now, when we talk about the frequency, what is this frequency of this is the frequency of AC alternating current all right. So, based on the pulse of the current which we are using if it is a DC current or if it is a low frequency current, then the methodologies are based on low frequency resistivity methods. However, if the frequency of the ac goes beyond you know 10^4, 10^9 Hertz, 10^9 hertz is nothing but 1 gigahertz and 10^4 hertz is 10 kilo hertz range. So, when you are working in this range, this is known as high frequency dielectric methods.

What is the difference between the two methods? Here I am using the word resistivity and here I am using the word dielectric. So, when you are working in low frequency ranges is only the resistance which comes into the picture, and hence the generalized name of the method is low frequency resistivity measurement methods. However, when you work in higher frequency range, the resistance is become in significant why? Because at high frequency the resistance is will be quite low, is it not. The passage of current from one point to another point will be very much high, so that means, the resistance of the system gets subdued and the capacitance parts becomes more important. Is this part clear?

So, based on this concept that means in the low frequency ranges capacitance does not contribute, and in high frequency ranges resistance does not contribute. So, this is the main issue when we talk about the methodology clear. So, based on this either the measurements are done at low frequencies or DC currents or at high frequencies with gigahertz range or the kilo hertz range of the frequency of AC. And the basic idea is to obtain dielectric constant of the material in this case second case, and the first case only resistivity.

Now, how high frequency dielectric methods are also termed as dielectric dispersion. Have you heard of dispersion term somewhere else in geomechanics?

Student: contaminant transport (Refer Time: 17:25)

Correct, contaminant transport. And in classical geo mechanics, load dispersion is it not. So, you apply a certain load and what happens? It gets dispersed into the soil mass either 45 degree with the vertical or 45 plus π/2 and so on the different methodologies. So, you talk about low dispersion there. Now, when we say high frequency dielectric methods, what you are interested in is we are interested in finding out how dielectric response of the material changes with frequency clear.

Now, what is the understanding about the dielectric constant of the material? If dielectric constant is more, material is good conductor of current or less conductor, it is reverse. So, these concepts actually you should assimilate. When frequencies are more, the capacitance does not come to the picture, clear. What happens? That dielectric properties gets enhanced ok. It over takes resistivity part of the material, why? High frequency of the current makes a material more conducting clear.

Now dielectric constant if it is more, a material is a good capacitor not a good conductor; in your parallel plate capacitors, why did you put a piece of you know quartz in between?

What is quartz acting as? Quartz is nothing, but a dielectric material. So, what it does, it is stores charge in it clear. So, more and more dielectric response of the material, it tells you that the storage capacity is more, is this part clear.

So, what I am trying to tell you here is the methodologies happen developed based on several concepts. The first concept is in which frequency range you are working and what is that you want to study about the material. Second is I am very much particular about studying a certain response of the material and that is why I am adopting high frequencies. And what is that response? That is a response which is known as dielectric response of the material. So, it so happened that the resistivity is not talk much use except for profiling in your geophysical studies, mostly what do you do? You do resistivity profiling clear.

But if you want to detect the metal properties in terms of its porosity, in terms of its saturation, state of compaction moisture content in it, what you have to do? You have to study its dielectric response. In other words, I would like to study dielectric dispersion of the material for an entire frequency range which is a high zone of frequency is starting from kilo hertz to gigahertz is this ok? Is the difference clear to all of you? Have you followed the basic difference between the methodology number one methodology number two?

In other words, you are augmenting one response of the material and diminishing the other response in one method; and in second method, your diminishing one response of the material and augmenting another response of the material. And what are these responses? One is resistivity, another one is capacitance. Is this ok?

So, based on this technique all the probes work and your resistivity profiling does. When you are doing resistivity profiling, what is the basic idea? The moment there is the change in the stratification of the soil the resistance offered changes and that is a zone where the resistivity's are going to be different. So, this you could achieve very easily by using low frequency current. But when you are trying to understand the electrical response of the material, then it becomes very important to understand, how dielectric constant is changing for a given frequency range.

Now, what is the advantage of these methods over the other methods? As I said in the previous slide that these types of studies are non-destructive in nature. What you need to do is in a control volume, you have to just put a across the control volume two electrodes. These electrodes could be point electrodes, they could be even plate electrodes or the needle earlier electrodes or whatever. So, geometry of the electrodes is also important. And what do you get is very fast and easy way of determining the material property. Why fast? The moment you get the electrical response of the material that is directly you know equivalent to some moisture content of porosity or whatever.

So, you get the parameters very easily and rapidly. And this is the beauty of these studies, you are not disturbing the soil mass. So, whatever response you are getting that response will include the microstructure of the geomaterial particularly soil mass. Whenever Suchit presents a seminar, you should attend because he has done extensive work in microstructure analysis of geomaterials particularly soils using high frequency spectroscopy. Why do you use the word spectroscopy? Because you are trying to see the spectrum of the material response in a frequency domain, clear. Yes please.

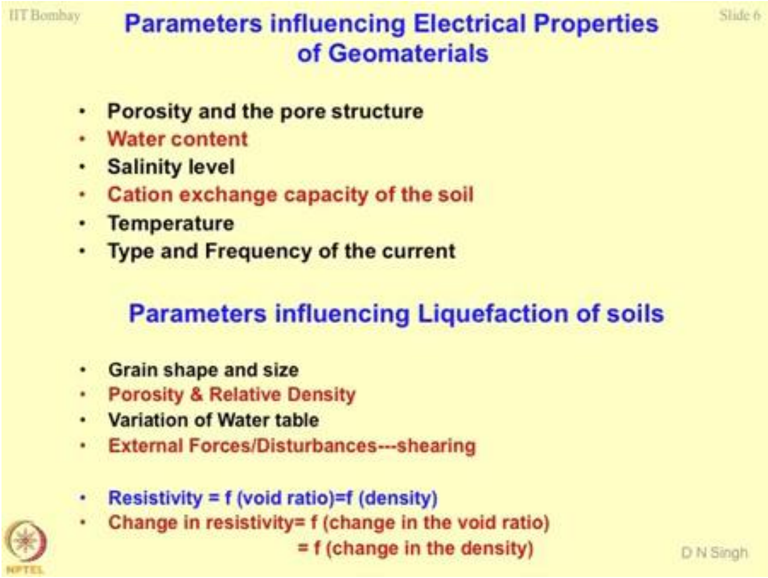
Students: These two methods low frequency resistivity method and high frequency dielectric methods which basically their laboratory methods are field methods because in the field we are interested we are interested in to measure the resistivity of a media.

They could be both you can do these studies in the laboratory on disrupt samples and disrupt samples also. And of course, you can use these studies or you can imply these methodologies in field also and density conditions. So.

Student: Ok.

So, good way to see the micro structural changes would be if you work on a undisturbed sample and you describe this matrix and remold the samples and see what is the difference in the microstructure. So, this is how you can identify the micro structural changes which have undergone in the sample because of its manhandling or whatever.

(Refer Slide Time: 24:11)



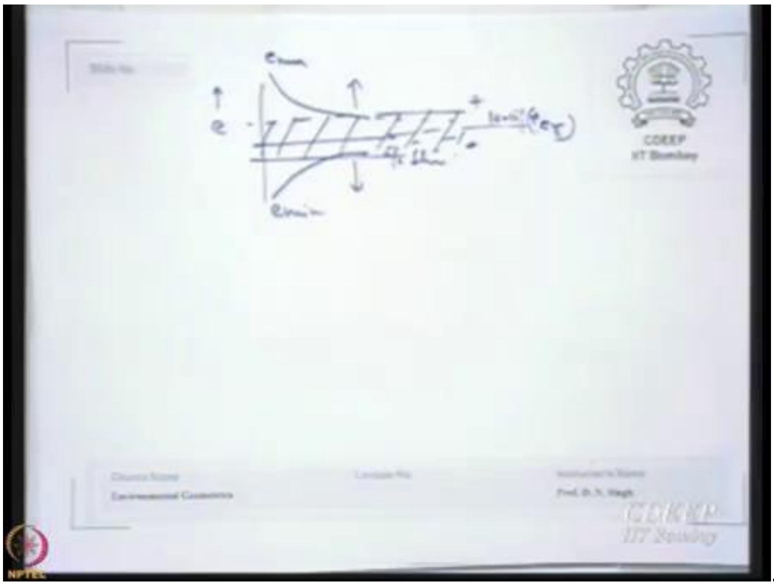
Let us talk about the parameters which influence electrical properties of geomaterials. Of course, the porosity and the pore structure we will definitely influence, water content, salinity level, cation exchange capacity of the soil all right. If you remember we had correlated cation exchange capacity of the soil to its dry conductivity divided by the conductivity at hydroscopic moisture. So, hydroscopic moisture content for grained soil is very important. So, you can talk about the ratio of sigma value divided by sigma at you know hydroscopic moisture content and that should be a function of cation exchange capacity. Temperature of the ambience, type and frequency of the current; this we have discussed already.

And of course, what I have listed out here is the type of the soil, is it not. So, type of the soil will also contribute a lot, fine grain material, coarse grain material. We will be talking about this in a different lecture completely, may be next lecture or next to next lecture. Now, this something interesting that why people are talking about liquefaction detection or liquefaction potential determination of soils by using electrical properties. I hope, you will agree that liquefaction of soil depends upon its shape and size of the grains, is it not.

Porosity and relative density, what else? The variation of the water table and the external forces or the disturbances particularly shearing. So, there is lot of similarity because all these parameters are susceptible to change in the electrical property of the material. If you can know these materials properties easily, you can find out its liquefaction potential, particularly for the sandy soils.

What is the basic concept behind this? Resistivity is a function of void ratio, and which in turn is a function of density. So, all of you are aware that if density crosses a certain limit or the void ratio crosses the critical void ratio, what will happen? A liquefaction will take place. So, in a reverse way, if I know the density where the critical void ratio is, and if that happens to be the base resistivity of the material, any change in the void ratio you know with respect to the critical void ratio is going to tell you whether the soil is going to liquefy or not. What is?

(Refer Slide Time: 27:37)



Student: What is critical void ratio?

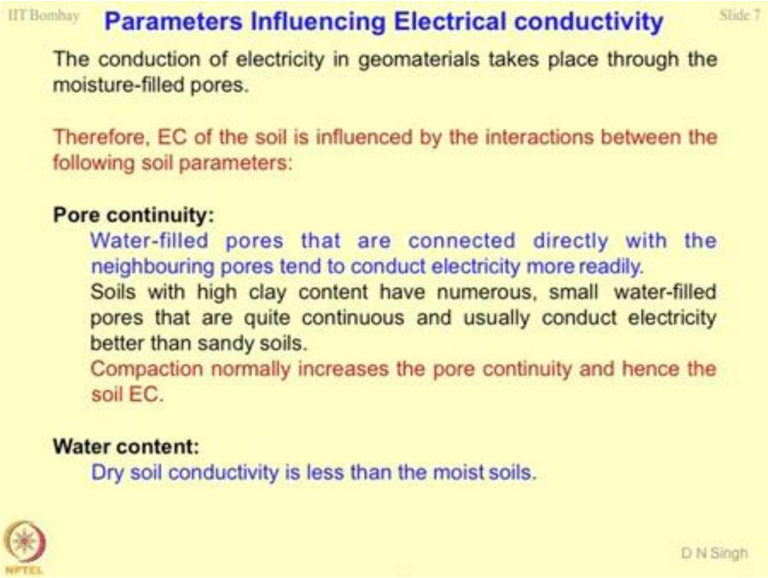
Oh, critical void ratio. If you plot void ratio with respect to percentage strain, what is going to happen? If the material is very loose because of shearing, it will attain a certain minimum value of e. And if your metal is very dense, you are starting from a low value of void ratio, if you shear it, what will happen dilatancy. So, somewhere if you extend them, they tend to go very close to a value which is known as e critical. So, this is the critical void ratio that means this is the most natural form of the material whether you start from the loosest state or the densest state.

So, shearing will always create a stable of material which is much more stable or constant volume. Of course, this you will be studying in your next course. So, idea is the variation with respect to e_{cr} to e_{max}; and e_{cr} to e_{min} ok. If you can map the variation between e_{cr} and e_{max}, and e_{cr} and e_{min}, this is the potential of the material to change its void ratio. In other words, there is the potential of the material to change its density; in other word this is the potential of the material to change its electrical properties.

So, if you can measure the change electrical properties, you can directly correlate them with the change in void ratio and that is what you require fine whether a material is going to liquefy or not is it ok. See that the liquefaction should be taken place anything which is in this range or in this range, because this is the more stable state of the material in plus minus let us say 10, 15 %. So, if you are crossing the limits of 10, 15 % of e_{cri} value in terms of void ratio, you are going to exhibit or the material is going to exhibit the liquefaction property, because this is the most stable state of the material is band.

So, beyond this band in terms or e max or e min both sides we are going to have liquefaction, is it ok. So, it is a simple fundamental based on which you can define the liquefaction potential of the material. And of course, the another, so if you know the change in resistivity, you can find out the change in the void ratio or vice versa; if you know the change in the void ratio, you can find out the change in resistivity which is nothing but change in the density. So, this concept people are trying to use to define the liquefaction potential. This is one of the direct methods by which you can find out how susceptible the material would be for liquefaction.

(Refer Slide Time: 30:43)



Now, let us talk in details about the parameters which influence electrical conductivity of the geomaterials. Again, the basic concept here is that the conduction of electricity in geomaterials is mainly through the pores or the pore fluid. In another lecture, I will come I will discuss in details how conduction of current takes place through the geomaterials, but to start with this is the good idea to understand that the conduction of electricity in geomaterials is immensely through pores all right. Pores may be filled with water, they may be completely filled with air and then the soil would be saturated or unsaturated or a partially saturated soil, where you have both the phases air and water.

The question is why conductivity is not through the grain to grain, because grains are not good conductor of current clear. So, basic the majority of the conduction is through pore fluid. Therefore, electrical conductivity of the soil is influenced by the interactions between the following soil parameters, what are these parameters? The pore continuity. What is meant by pore continuity? Water filled pores that are connected directly with the neighboring pores, then to conduct electricity more rapidly.

How do you obtain pore continuity, how do you check the pore continuity? You have to conduct MIP - mercury indigent pore symmetry, to see whether the pores are interconnected or not and that is where actually you required pore size distribution, pore connectively distribution in the materials and that is the reason why you study MIP. Soils with high clay content have numerous, a small water-filled pores that are quite continuous and usually conduct electricity batter than sandy soils. What is the meaning of this? The electrical resistivity of clays would be less or more than sands?

Student: more

It will be less, sorry conductivity; conductivity will be more that is right. So, the resistivity will be less, conductivity will be more. What is the other reason? Most of the clay particles are charged all right. So, that is the best possible differentiation you can make between the materials, whether the soils are more resisting or less resisting depending upon their conductivity or resistivity. Compaction normally increases the pore continuality and hence the soil electrical conductivity. So, well compacted soils will always show you less resistivity more conduction.

Now, this is where the concept of H to H contact or the grain to grain contact comes into the picture. So, for the same situation of the pore-fluid and the same type of soil in what way densities going to contribute to the conductivity, higher the density the conductivity will be more. The second parameter is water content, is basically because of the ion conductivity. So, more the solution or more the water pore water; better will be conductivity.

Student: (Refer Time: 34:22)

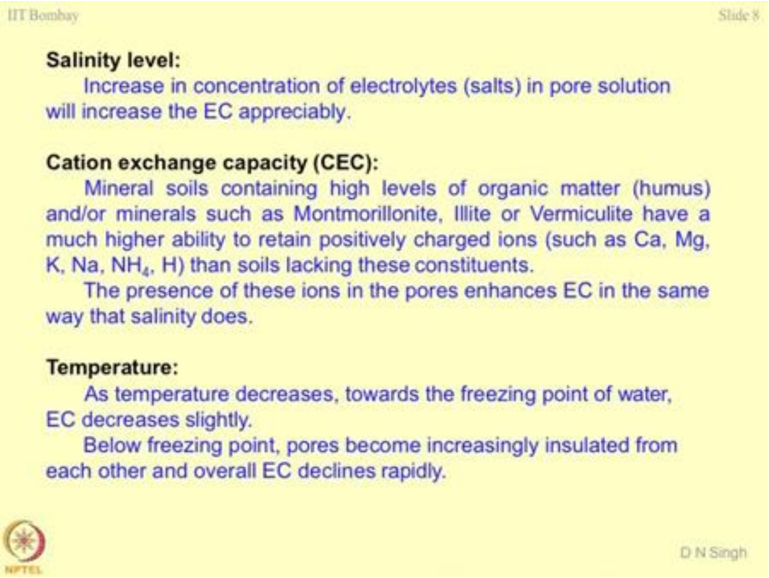
Sorry.

Student: More compression means the water dissipates more. So, hydraulic conductivity, electrical conductivity will be less.

Yeah, you have asked the good question. Even if there is no water and even if the only hygroscopic moisture is present in the soil that is good enough for ionic conduction clear. Now, because of compaction what is going to happen? To the any conduction the conductivity due to grain to grain content is going to get added up all right. So, you think of a situation where the particles are a spread apart adds only the fluid through which the current is passing. So, conductivity is some value.

There is another situation where that field is present whatever may be the amount or the fraction, but there is a grain to grain contact also. So, there is another mechanism which is getting added to the previous mechanism and hence the conductivity increases, so that means, a well compacted soil will show a better conduction of electricity as compared to a loose compacted soil with the same pore fluid. I will discuss in details the models which are normally used for defining the flow of current in porous media in the subsequent lectures. So, coming back to water content, dry soil conductivity is less than the moist soil so, which one in more dielectric constant; moist soil correct.

(Refer Slide Time: 35:59)



Salinity level, increase in concentration of electrolytes that is the salts in pore solution will increase the electrical conductivity appreciably, so that is why if you do a net search Google search, you will find that there are most of the time people have come up with EC sensors electrical conductivity sensors. So, many sensors are there which talk about only electrical conductivity of the soil, but they are blind of the cations or the anions which are present in the soil mass. You got this point?

These sensors will measure only the conductivity. So, because of the presence of a cation or anion, the conductivity is definitely going to increase, but qualitatively and quantitatively, they cannot tell you which species of cation or anion is present in the soil mass or the geomaterial. So, basic idea is that salinity always increases conductivity. In other words, the concentration of electrodes will always increase conductivity of the solution or the soil mass or the geomaterial or the porous media.

Cation exchange capacity, well this is very well understood, and we have discussed several times. Mineral soils containing high level of organic matter and or minerals such as montmorillonite, Illite vermiculite have a much higher ability to retain positively charged ions such as calcium, magnesium, potassium, sodium, ammonium and hydrogen, then the soils lacking these constituents.

So, if this is the case, the presence of these ions in the pores would enhance the electrical conductivity in the same way that salinity does, because these ions will be acting like you know concentration of electrolytes in the pore solution. So, if cation exchange capacity is more, conductivity is going to be more correct; cation exchange capacity of clays is much more so actual conductivity of clays will be more is this correct. It is quite coherent, but what about the thermal resistivity of the clays it is high.

So, what is the meaning of this? How electrical resistivity and thermal resistivity are related to each other, they are inversely proportional to each other. Temperature, as temperature decreases towards the freezing point of water electrical conductivity decreases. And below freezing point, pores become increasingly insulated from each other and overall electrical conductivity declines rapidly. So, this concept can be utilized for monitoring the gas hydrates or the frozen soils. Is it not? Ice is a good conductor of electricity or not?

Student: (Refer Time: 38:56)

Sorry, as compared to water.

Student: High.

Why? Excellent, it is a bad conductor, but why? Ion conductivities always more in liquid phase as compared to solid phase clear. So, the moment water phases, the ion conductivity is going to be less and hence ice is an insulator as compared to water. If you add some electrolytes in water, it becomes much more conductive. Is this part clear? So, just by measuring the electrical properties, you can differentiate between the state of the water which is present in the pores.

Extent this philosophy a bit. If ice is present in water or in the pores, what will happen to dielectric constant? It will be less or more? It will be less clear. So, it becomes insulator that means, the storage capacity becomes more. So, you can very easily differentiate between the soils which have free water, bound water and the frozen water.

Student: (Refer Time: 40:06)

Why?

Student: (Refer Time: 40:08)

Sorry.

Student: (Refer Time: 40:10)

Storage capacity of what?

Student: (Refer Time: 40:12)

I am simply talking about resistivity. So, water in free form will always show you higher value of dielectric constant as compared to the water which is not in the free form. So, the idea here is that if I am trying to differentiate between the frozen soils and the soils with free water and the bound water, I can put again it on a scale of dielectric constant and I can say that this type of soil happens to be dry soil, this type of soil happens to be frozen soil, this type of soil has more free water, this type of soil has more bound water and so on. Is this part clear?

So, this becomes a very interesting tool to differentiate between different states of the pore solutions and their physical forms. So, a pore solution in gaseous form is going to be different than a pore solution in the liquid form based on its dielectric property. So, that is the reason why to use the GPR for finding out the gas reserves. What is the reason? What is GPR? Ground Penetrating Radar. What it does? It sends the signals and these signals will measure the dielectric constant of the soil mass.

So, if the hydrocarbons are present, the finger print will be a different value as compared to a signal where the water is present, as compared to the signal which is for dry soils. So, depending upon the dielectric contrast, you can easily pinpoint that which location is going to have more petroleum more pores, more water, dry lands, added lands and so on and that is what actually people are using in satellite imaginary I suppose, is this correct this concept. So, that is why this has a very being scope in present day science and technology, people are trying to study more and more into details the parameters and how do they get influenced because of different phenomena is this ok. So, in short, these parameters will help you in differentiating the type of soils, the type of pore solutions which are present, and their state of physical state gaseous liquid solid and so on. So, this becomes a big scope of work.