Lecture-12
Soil-water Interaction

Today I will be discussing about the soil water. In short what water does in the soil mass, what are the different types of waters which are present in the soils. How to differentiate them, what is their role, what is capillarity, what is vadose zone and how to answer the questions which society is asking, in particular why infrastructure gets damaged, why buildings are collapsing, why roads are not functioning the way they should have.

So, all these questions come or they become quite relevant when you see the perspective from the soil water and what water does in the soil system.

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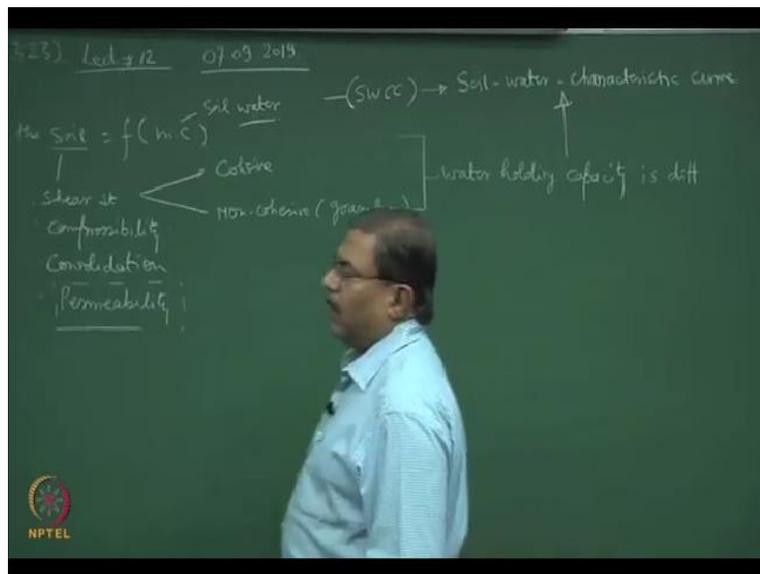
Sometime back I talked about the different types of water which are present in soils. And this is what I have given you some hint that there is something known as environmental water. There is something known as free water, there is something known as hygroscopic moisture, there is something known as soft water, bound water, sometimes we also call it hydrated water.

Now, this is a topic of great interest to the researchers who are working in this subject and particularly those who are more interested in understanding how the environment causes contamination of soils. There is a reason nowadays. This is being studied quite much in details, a lot of emphasis on understanding what moisture does, it so happens that most of the properties of the soil are dependent upon the moisture content.

And this moisture content is nothing but the soil water. Those of you who are interested in advance research in this area should refer to soil water characteristic. Now this is the most latest thing in the geotechnical engineering and for undergraduates it is not a good idea to start discussing this right away in the class.

So, when I say most of the properties are soil, shear strength, beat compressibility, beat consolidation or beat permeability. Now permeability has different roles to play in different subjects. I think I have been emphasizing upon this starting from petroleum to the motion of any fluid in the materials to the water, which is of interest to geotechnical engineers. And from there we say that if soils are cohesive or non cohesive or granular, all their characteristics are bound to change.

Because the water holding capacity is going to be different. And soil water characteristic curve is nothing but a quantification of what is the water holding capacity of the soils.

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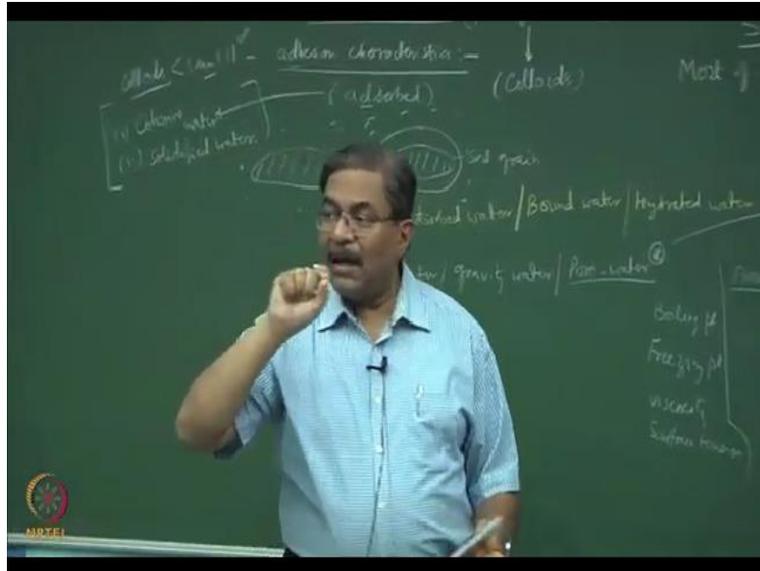
So, if I talk about the soil moisture soil water is a general term and soil moisture is a particular term. Soil moisture is valid mostly for the fine grain materials not for the coarse grain materials. The first category of the soil moisture is the one which is adhesion characteristics. So depending the mechanism of adhesion of moisture on the fine grain materials is adhesion. Sometimes we also call this as adsorbed. Those of you who might get a chance to work in you know research laboratories that analogy used is absorbed or absorbed.

Mostly this is valid for the collides and for a quick understanding collides is the particle size which is less than 1 micron. Normally we talk about the clay fraction of 2 microns which is less than 1. So, happened if I take a grain of a fine grain material, this is the soil grain. The moment this comes in contact with water they will be a adsorbed layer formation alright. This also known as adsorbed water, sometimes people use this as bound water.

Sometimes they also use the word hydrated water. In short, most of the adsorption is because of the surface characteristics of the grains. The surface are hyperactive, if you remember, their surface area is going to be extremely high and hence their affinity is towards anything moisture or contaminant which comes in contact with it to adhere it onto itself. Now in between the 2 particles or the grains of the soil we will have free water.

So all this is free water. Sometimes we also call this as gravity water. Sometimes you also call this as a pore water alright. So the first time I am using the term pore water, most of the characteristics of the soils would directly depend upon the pore water or in other words, the pore water which is the water which present in the pores of the soil mass would be controlling all of them and henceforth our focus would be to understand how the port of pressure characteristics control all the fundamental properties of the soils.

Adsorb water also contains sometimes the cohesive water and solidified water alright. So, the combination of the 2 is adsorb water which is a fundamental characteristics of the colloids when you get a chance to work in this sub clay particle rangers, as I was talking about in petroleum industry normally these type of deposits are quite frequently encountered, where you are dealing with the subtraction of the soil particles which fall in the category of collides less than 1 micron.

Now, if you compare the bound water and the free water reserve is the free water. What you will observe is that the boiling point what is your guess bound water boiling point will be more or less than the free water. It is all bound by the particle and particles having a lot of electromagnetic forces. So, this is going to be higher than the free water alright. So, if I say that these are the characteristics.

So, if I right like this is okay that means the bound water boiling point is higher than the free water. One of the ways to understand the difference between bound and free water would be if I take a sponge, if I soak it in water, if I take it out of the water column and just keep it on the surface alright. So, whatever gets drained out because of the gravity is free water alright is not bound by any particle there is no electromagnetic force acting on this.

So it is just free to follow the gravity. However, the pore water is the one which is still remains in the pores because of the capillary action and this we are going to discuss in detail today, the freezing point also understanding what will happen to the freezing point, freezing point follow the reverse alright. So, the bound water freezing point is going to be less than the bound water sorry bound water the freezing point of the free water.

Because this water is free follows the gravity and hence it would get frozen first as comfortable to bound water, now if we talk about the viscosity these concepts you require in R and D. So, you cannot say that these concepts should not be discussed, these are very, very important concepts. So, viscosity of the bound water is going to be more than the free water. Most of the industrial processes where you form different types of you know products. They all depend upon this type of series.

Then surface tension, so surface tension also of the bound water is better than free water. Those of you might get a chance to work in the field of agricultural sciences, lot of research is going on. And a lot of focus of interest is nowadays agriculture because of you know, food assurance, the population has increased, everybody is talking about productivity of the soil. And by our human intervention, what we have done we have destroyed the productivity of the soil.

So the quality of food security, check it on net how much work is being done internationally. Now, I hope you can realize when I talk about the food security for a country, for a population, these concepts will become very important because if you have most of the time the free water which has have not much of use and unless you design the systems the chances are that this water might be available to the plants freely.

But at the same time if the soil happens to be coarse material, it may turn out. So, you do irrigation and water is the commodity you do not have much water question is can bound water be utilized for growing plants, hydroponics, you go to 5 star hotels, what do you see there in crushed glass, they are producing plants is it not. So, these are the plantations which are soil less, that means they made dose some chemicals, some activators, some raisins, some zeolites which have a very high tendency to retain moisture.

And this moisture slowly diffuses through the roots on is the big subject, is this okay. I am not going to the details of this. So it is the free water which is ultimately going to guide all these properties. So free water and the pore water is going to which is the same thing is going to guide most of the properties of the soils. The second classification is remember this is the first type of water which we talked about adsorbed.

The second one is absorbed water. The difference between the terminology which I am using this is the adhesion or adsorbed and this is absorbed, any idea what this would be. So, you take a rasgulla, take it out of the pan in which you are making it or you have so bit in the syrup. Squeeze it, those who are diabetic, what do they do. They will squeeze it, squeeze out all the syrup and then they eat it.

So the free syrup, which is equivalent to the free water has been displaced, but it is still the rasgulla feel sweet why, because some amount of sugar has got absorbed into the pores alright. So, this water is the same like that.

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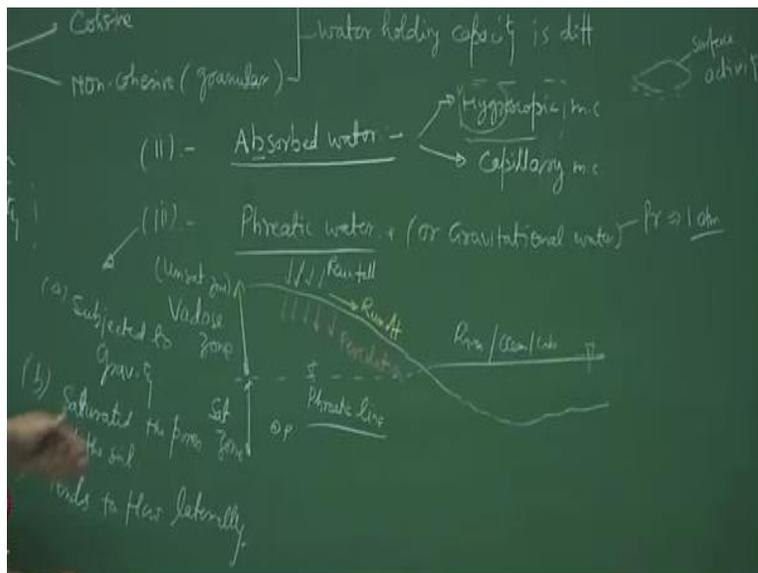
The melting point has something to do with the absorb moisture content, which we with the terminology which we use normally in agriculture engineering. Absorb moisture content can be divided into 2 parts hygroscopic and capillary. Remember some time back when we were talking about the moisture content determination of the soils, I was using these terminologies in a city like Bombay, where the humidity is extremely high.

If I dry oven, if I dry a soil in the oven, particularly fine grain material and if I bring it back to the room temperature, what is going to happen because of the surface activity, a layer of hygroscopic moisture is going to surround the particles. So, hygroscopic moisture content is

equivalent to the moisture which normally spoils your table salt. Correct. So, this is because of the humidity, because of the hygroscopic behaviour of the clay mineral or the material which makes it proactive to absorb moisture, correct.

Another differences adsorption is mostly a surface phenomena. Absorption could include surface as well as intramolecular. And that is why I give you a logic even if you squeeze out the syrup, rasgulla stay sweet they will stay sweet correct. So, absorb moisture will have 2 components adsorbed and sorped, sorption becomes important when you are talking about contaminants in soil which is not the scope of the discussion in this class.

Hygroscopic is the environmental moisture strike out the word hygro, what is the meaning of hygro in your mobile hydro is water is it not. So, what is hygro, when you say anhydrous compound, hydras compound, you understand the difference between hydrous and anhydrous. So, what is hydro lead into moisture, simple moisture on the surface. So, if you consider a small particle and because of the humidity and the environment, this particle uptakes some moisture that becomes hygroscopic, there is a difference adsorb water will have some sort of a energy of binding yeah.

This is something which is not going to have any energy or binding because free water. You take the soil, put it beneath the lamp of 40 watt 20 watt it will simply evaporate. So, this is not a bound water. This is the bound water remember correct, so when you say bound water a lot of energies associated with the binding of molecules are prevalent right. See the third type of the water is phreatic water.

You must have come across this terminology in your irrigation engineering courses, is it not where you are designing dams and when you talk about the storage capacity of the dam and so on, have you come across this sort of phreatic. What is phreatic check on the net p h r e a t i c phreatic which follows gravity atmospheric alright. So, suppose if I give you an example, that there is a hill and then this landscape becomes like this, this is the let us say ocean or a lake or it could be a river alright.

When the rainfall occurs, what will happen, some portion of the rainfall will become runoff. So, this is the rainfall and some portion of the rain would get percolated alright. So, this is the percolation. Now hypothetically, if I draw a plane like this towards the land, this is the land side, this is the water body side. This zone is known as a vadose zone. Remember we talked about this unsaturated zone. However, this line is known as phreatic line.

I hope now you can understand, what is the meaning of phreatic words some of you could look at it yes and exactly so, what I have done intentionally I have dashed this line with the free water surface. So, this is the gravity water, whatever gets run off, whatever gets percolated ultimately this will come and meet the phreatic line, this is a gravitational water, atmospheric conditions prevail over here.

So, the pressure all along the surface are going to be pressure is going to be one atmosphere. Always fine. Now we will see how we are going to utilize this concept. So, about the phreatic water yes please. What is this is only a surface of a thin layer of water which comes only because of the surface activity. Surface activity could be your connections capacity or the surface area. So, you have a lot of parking places which are available on a fine particle because surface is very high, water molecules just come and sit over there.

There is no bonding of any type. The moment you heat it, the moment you put it in a wind everything will get blown off, adsorbed water has energy, adsorb water has energy because this is having the energy of what is known as the binding or the bounding. So that is why we use the word bound water. So, this water is bounded to the soil particle because of some energy. It could be Van der waals forces. Is this fine. No, okay.

Yes. pressure and the phreatic line is going to be always one atmosphere. Natural STP conditions standard temperature pressure condition. So the I am going to talk about phreatic surface. So basically, phreatic surface is the gravitational water, whatever gets percolated ultimately settles down over here because the level of the water has to be maintained fine, number 2 on the phreatic line the pressure conditions are atmospheric. This is how you define it because this is see what is the pressure at this point atmospheric pressure.

So, it has to get balanced with this. So, imagine you have in the offshore environment water and ultimately it has to come and meet the ground, which becomes a groundwater table. So, the groundwater table also has the pressure conditions same as the atmospheric conditions. Is this okay. Now, concentrate on what I am going to write the phreatic water is subjected to gravity, capillary action does not play an important role here.

That means by virtue whatever you check on the net, everything is going to be saturated. So, this is the Vadose zone, this becomes your saturated zone. One of the ways to define the phreatic line is this is the boundary between saturated soil mass and the unsettled soil mass clear and today after some time we are going to discuss what is the state of stress in the Vadose zone and in this saturated zone, then your funda will become very clear.

Here the state of stress is going to be inside and beneath the water table everything is going to be compressor is this part clear. Let us begin this I think then we will catch it. Number 2, the phreatic water will saturate the pores of the soil completely saturated situation, beneath this point, anywhere in this soil mass, the pore water pressure will be more than atmospheric pressure, have you understood this.

So, so well if I consider a point over here at point p, the pore water pressure is going to be atmospheric pressure plus the pressure which is existing because of this much column of the soil and water. Another property of the phreatic line is that it tends to flow literally why, after a few days then we will be talking about the seepage in the soil mass. We will realize that the movement of the ground water is always in the horizontal direction.

Because permeabilities are more as compared to the up and down. And this is a blessing in disguise, nature has created a system like this where the water table will not change in the vertical direction much, but will keep it moves only in the lateral direction. So, one of the properties of phreatic line is that the water moves laterally. Is this is okay. So, I will write a condition here the phreatic water is the gravitational water.

And the pressure at this point is equal to 1 atm 1 atmosphere, as a geotechnical engineers, most of my interest should be in this as for undergraduate or the beginning of the subject or the initiation of the subject is concerned. But later on I think you will realize that in country, our own country there are not many places where you have enough water and the country is having acute crisis of water, that means the Vadose zone becomes more important to study as compared to the saturated zone.

But I am not going to discuss this. So when you talk about the mechanics of the Vadose zone, this fundamental behaviour of the soil becomes very important. But when sorry, no just hold on for a few minutes. As I said, in the Vadose zone, the pressure is going to be because of the capillarity. So I am just going to come on that. So by virtue of the basic differences, anything which is the water table would be either dry.

If it is a general material water cannot stand there because of gravity, water goes out or if it is the fine grain material you remember we have discussed this case earlier also, if this is the fine grain material capillary action would be there will be discussing about this and hence, some portion of the Vadose zone would be either variable saturated or partially saturated or unsaturated clear. So, these are 3 cases which we have created out of this.

So, this dynamics becomes more important to understand for the present day technologists as compared to this yes, then now you are complicating the whole game, but good I am happy that you asked this question. So, now, the sea water intrusion will start you know the density driven flow will take place. So, you have to now sit in my environmental geomechanics course. But it is a good question.

So, why this Deccan Peninsula is having problem of drinking water because salt water diffuser into the freshwater alright and this becomes a diffusive contaminant transport okay. So coming back to your point, anything which is below the phreatic line is going to be positively stressed. Anything above the phreatic line is going to be negatively as well and we will see why it happens, any other question.

Yes please use the mice, how we theoretically compare the freezing point of 2 materials. I mean you can do calorimetry remember, you know 10 +2 calorimetry, which was studied. You were talking about the heat of reaction. And if you really want to find out many can you answer his question he is an expert in freezing of soils and raising of the pore solutions, you can also add to this question.

So, I am particularly asking about the bounded free water how can you measure the freezing point yes, so in very simple thing which you can observe during the experiment is like you remember that whenever phase changes happening freezing, boiling the temperature remains constant. So, for a longer duration of time during freezing, for free water it might be 0, but for bound water it will be like – 2 – 4. You will see temperature plateau in that region.

Thermodynamics of the system yeah, use the word thermodynamics they can follow. They have done a course in thermodynamics. Yeah, and as always much energy how to extract out to make the system freeze is what you are asking. Yeah. And you can use calorimetry also, if you want to be very specific and quantify the phenomena. Actually, these are the on the basis of practical knowledge how you can.

Is there something so that we can get the difference by any theoretical knowledge or I guess can you please repeat your question. Basically, what you are saying it is after the practical experiments is there something to guess the freezing point of not the freezing guess the freezing point but to compare the freezing point of what salt does in water when you freeze it. What sodium chloride does to the freezing point, excellent.

So, I think now, you can connect to compare the freezing point of 2 substances. Am I right, is that your question. And how to do this in another question without doing experiments without okay. Do you know what it means by freezing. That first of all we have gone through life. What happens when freezing is happening to the state of the material, it is energy will increase, energy will decrease. You are taking out the you are extracting the energy out of the system, correct. So, this is the only way you can answer this question.

This is what he was also asking that what is the difference between the bound water and the free water and the hygroscopic water is only the level of energy which is bounding a layer of water molecules onto the particles clear. So, when we said viscosity is high under what circumstances viscosity becomes very high, high pressures, low temperatures, one of the examples clear. So, you can create similar types of situations and then you can justify these answers okay.

Freezing point decreasing because of addition of salts, because of changes of rheology and so on. It is an interesting question what you are asking, but then it is very elaborate concept yeah, anything else, just to complete my response. So, we will look at how easy it is to extract the energy bound any system that will govern. So if there is some mechanism which will oppose the removal of energy is no, no energy of crystallization you should talk about the crystallization.

So, basically freezing is nothing but crystallization. One form of crystallization. Read more about it. yes. You should be having a mice here. Hello. Why is there a difference in surface tension between the bound and the free water okay, I will answer your question 5 minutes alright. So one of the ways to characterize let us go back to the basic capillary model to answer your question and what you have been asking some of you.

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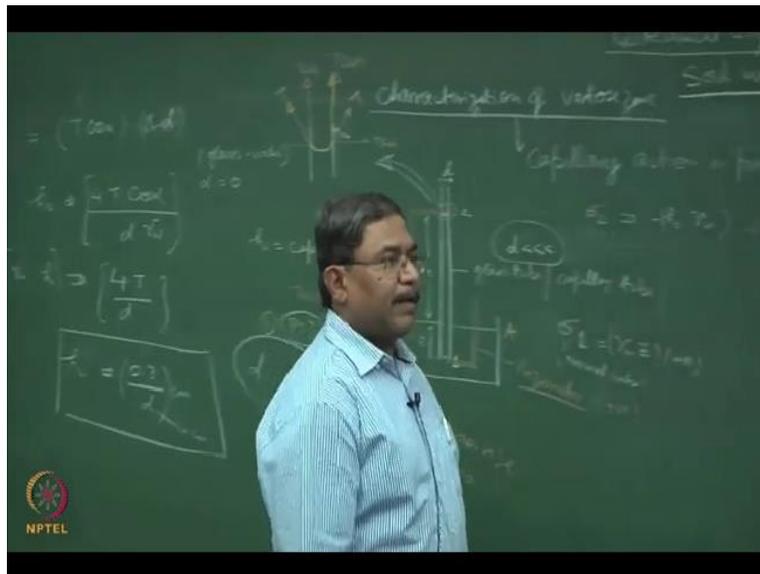
Characterization of Vadose zone. So, by definition first of all this is a zone in which capillarity is predominant alright. Remember the basic concept there is a small glass tube and which is kept in

a water bath, this is a glass tube. Normally we call this a capillary tube that means the diameter is going to be extremely small very, very small diameter alright and this is a glass tube or a capillary tube where do you find capillary tubes in day to day real life situations, not really.

So, very good but then keep this question in mind you should relate with this answer that is what diameter is much more. So, a good example of capillary would be okay pores of the skin, I want to a different level altogether apart from this simple devices which you use in day to day life. Sorry sorry, roots yes. But that again is a capillary action in the soil. I am just asking about a simple device which you use in day to day life.

Capillary action all again falls in the same category thermometer. Thermometer is a beautiful example of a capillary tube alright. So, the moment temperature increases, there is a raise in the temperature sorry at the moment temperature increase there is a raise in the height of the capillary, mercury going into the capillary tube alright. So, this is a glass tube or a capillary tube of a very small diameter. This you have done in your $10 + 2$ physics.

If you leave it like this, this is the water column free surface atmospheric pressure, phreatic surface agree. Suppose A A what are the dynamics of the system. The moment you put this glass tube and a capillary will get form so, the menisci will get form. This is the meniscus draw the free body diagram of the meniscus. This height h c is known as capillary raise alright, free body diagram would be something like this, the glass tube and this is the meniscus.

This is a surface tension. Your question was related to surface tension. This is the contact angle alpha between the water and the glass tube, glasses of quartz and sand particles are also quartz, minerals are mostly quartz. So, this alpha can be obtained by help of most of the devices which are available nowadays, they call them as goniometer and closer devious things lab they have goniometer where you can measure the contact angle for the capillary action alright, most of the R and D is being done in this context.

So, if the diameter of the tube is d. Now, can you draw the pressure distribution, I hope you understood that why this there is a raise in water column in the capillary tube that means there is

a negative pressure which is acting over here is a suction pressure as if the water has been sucked by the glass tube. So, if I consider a point here, let us say point number 1 and point number 2 what is the state of stress at point number 1 and point number 2.

If this is the z at point 1 yeah this is gamma w into z is this okay. This is positive pressure. Anything which is beneath the phreatic line atmospheric line is positive, how to find it out, if I take another small tube which is known as the piezometer, have you ever seen piezometer YouTubes you have seen. So, if you connect a piezometer over here, please understand this concept carefully because this is going to be very useful forever.

So, this tool is known as a piezometer. Nowadays I can put electronic sensor which will measure the pressure. So I can measure the pressure earlier days. This is how the pressures used to be measured, go to any ICU, where doctors measure the pressures of your body clear, body fluids. So piezometer always gives positive pressures. Piezo is a sort of a pressure which is atmospherically induced.

However, if you keep a tensiometer at this point, you know, normally tensiometer are oppositely designed. This is how the tensiometer would be. It is a tube like this. So, if I keep the tensiometer over here, there will be a drop in water column up to this level, which is at h c. So, a tensiometer measures negative pressures. Tension is the word which is used for negative pressures. So capillarity always gives you a negative pressure somebody was asking this question alright.

Piezo pressures are always going to be positive. So state of stress at point number 1 is positive state of stress this is suppose if I say normal stress sigma, I will remove point I will simply say a sigma 1, so sigma is the normal stress. Water cannot take shear stress, I hope you agree. At this point to the state of stress would be there is a drop in water column. So, - h c multiplied by gamma w is this okay. What is h c. Can you compute h c, hydrostatics concepts you can use.

So, what is the force which is acting on the system if I take components, this will become t cos alpha and t sine alpha will vanish I hope you understand because these alpha is on the periphery. So, this is normal contribute yes please. Sorry, sorry p 1 yeah. Normally we defined pressure as

sigma, normal stress alright, because p 1 are normal user the point. So, this is the normal stress at point number 1, and this a normal stress at the point number 2 clear even p 1 we do not use.

The shear stress will be using as a tau, but because you are dealing with water so, shear is going to be 0, yeah this is pressure correct, pressures and stresses the same at that point is it not, the stress is a sort of a pressure okay. So, this is your sigma 2 which is negative and this is a sigma 1 which is positive. So, t sine alpha gets cancelled all around the periphery of the system. So, if I have to draw equilibrium condition can I write like this T cos alpha which is acting on which surface the meniscus and because of that the entire thing is getting lifted up.

So, T cos alpha into pi d, is this correct, this is the periphery is this correct, multiply by T cos alpha and this is what is balancing the weight of the water column in the capillary tube. So, this will be h c into gamma w and what is the volume of the water is this okay. So area into volume this is a volume multiplied by density with the force is this correct. Hope I have not made mistakes. So, the weight of the water which has gone into the capillary tube is described by 4 into height of the column volume multiplied by gamma w.

Equate this and what you are going to get you will be getting h c = 4 T cos alpha pi d gets cancelled out upon d is this okay, d is the force per unit length, surface tension and most of the cases when you are dealing with a glass and water alpha is 0, not a very good assumption. So, nowadays people can find out the alpha value as I said, you can substitute over here and if you are very interested in seeing how all this works, you please contact Dhanaraj.

And see in the laboratory mercury into then porosimeter which works on this concept of thin capillary tubes by which we find out the pore diameters present in the soil mass, concrete or coal sample or steel sample anything alright. So, those who are interested you can show them. So, this gets simplified to 4 T upon d into gamma w, another simplified form of this would be I will come to that later.

Now, very cleverly what I can do, you are asking this question hello h c into gamma w is also defined as u w, but this water is under tensile stresses. So, height of the column multiplied by

gamma w would give me a sort of a pressure term. So this is a pressure, this is okay now, we call this the pore water pressure and the pore water pressure happens to be negative over here. There is one approximation which people have done, they say h c = 0.3 upon d.

And this is in centimeters, where d is also in centimeters. Just let me check. Yeah, it is correct alright. This is a thumb rule equation which has been derived by people. Now concentrate for a minute you will understand a lot of geotechnical engineering without much of efforts. Ready stop writing please. The interpretation is like this, d is the diameter of the pores in the soil mass correct, is smaller the diameter, higher the capillary action agree.

Number one, I can create this d by compacting the soil. So use material if I compact it, what I am doing, I am reducing the d size. So, the more and more you compact the soil, the capillary action increases. Remember in the index properties, when we are talking about different types of gammas there I told if the granular material is standing over the water table, it would be dry. But suppose if it is a compacted fine grain material, the capillaries are going to be extremely active.

That is a capillary zone. So what this indicates is under the hydrostatic equilibrium, a capillary will show you the height of water in it as h c, which is guided by this and it so happens that d is defined as e into D 10, it was interesting equation what is e, what is e very, very good, excellent. So, e is the void ratio and what is D 10 particles finer than 10% of the mass. So, D 10 is a standard material concept or the property which you can get from the particles size distribution curve.

This is one of the applications of PSD particle size distribution characteristics if they are known, immediately you can find out what will be the D value substituted over here, you get the capillary action, most of the disasters which are taking place in the country in terms of infrastructure development are because you are not selecting the material properly, number 1, number 2, you are not compacting the material properly.

And then number 3 you are not designing the whole system properly. The entire thing comes from here, you will do any type of consulting. This is the first rule of the game. Contractors do

not compact. Now, this e into D 10 is also known as effective pore size or effective diameter also both. So, imagine if I take the soil compacted properly e is decreasing D can remain same, D 10 is a fundamental property of the material, e is the matrix clear.

So, heavily complicated systems are going to give you higher h c, what I had to do I had to take care of capillaries raise in most of the practical situations so, that highways do not remain submerged. So in the coastal areas where you are developing road networks, if you are defined this concept most of the time the water table will be sucked up, up to h c value, is this part clear. **(Refer Slide Time: 53:52)**
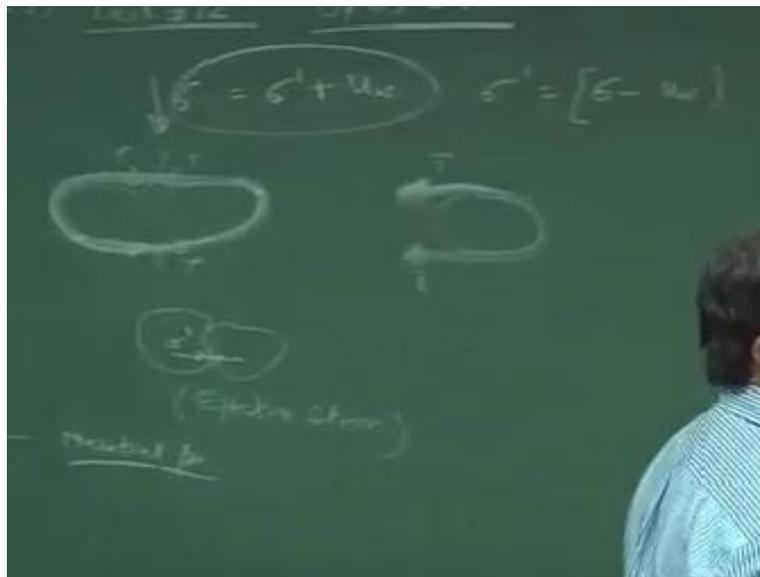
These are 2 particles, I can assume this as D correct. Because ultimately that the pores themselves are being assumed as a tube. So, you are right absolutely right. So, this is d when you compact them what is going to happen this d is going to get decreased clear they come closer, nice. So, truly speaking this capillary tube is an assumption that you have 2 particles of the size and then you are having water inside because of the capillary action and then this happens.

So, if I draw the free body diagram of the particle holders look like if there is a particle and if this is a particle and there is a thin layer of water on this, let us say capillary water, have you come across this somewhere in mechanics you must have solve these problems I am sure in a mechanics well correct. So, if I cut it what is going to happen. This is a grain and there is a layer of water which is nothing but surface tension.

So, what surface tension does, it is sort of a rubber band put a rubber band and do like this, what happened the tendency of the rubber band is to bring this back to the original position because of the tension, exactly same thing is happening. So, same thing is happening over here. So, this is the T this is the t surface tension, the more surface tension gets develop particles have a tendency to come closer to each other alright.

There are lot of ways to interpret this. Now, suppose what is going to happen now because of this. Suppose this is what is going to happen, the particles come absolutely close to each other. At this point of contact, there will be normal stress. This is what is defined as effective stress. So, please do not talk about the pressure term alright. Do not use the term pressure. You always talk in terms of the stresses.

Now, this is the intergranular contact the stress which is acting at the contact of the 2 grains. And what is the root cause of this surface tension clear. So, if I were applying a normal stress sigma on this control volume, this sigma would be equal to sigma prime + u w. This is the theory of effective stress. So, what we say here is the sigma prime value will be equal to sigma – u w, have you understood this.

U w is the pore water pressure. Sigma is the pressure which you applied externally. And what is getting delegated between the particles is sigma prime which is what is known as effective stress. This theory was given by Tuzery. Now, suppose if I asked you to plot the variation of pressure along the length of this tube. So, along the length of the tube if I asked you to draw the pressure distribution clear, how this will look like.

Any idea, this is hydrostatic pressure you have already drawn this in the mechanics course. is this okay, yeah this is z, what about the upper one, upper portion, what is the pressure at this point, we are going to ignore it. So we will put it as neutral pressure 0. This is also known as neutral pressure. Coming back to your question when you apply stress externally, this stress gets transmitted into the pores.

And pores are filled up with water, the distribution of the pressure in the water is all around and equal. So, the net pressure at that point is 0 at the atmospheric conditions. And hence, we call this as neutral pressure. So, pore water pressure is also known as neutral pressure. Unless you increment the sigma value, how the sigma value will get implemented. I started constructing a building and today the height of the building is let us say 3 store.

Tomorrow it become 5, 7, 10, 20, what is happening every day, every day sigma is getting increased, clear. So what is happening because of sigma getting increased the pore water pressure is also getting increased as long as there is no way for water from the pores to escape, typical fine grain soils and then we will discuss quite in detail about consolidation. So now come back to this question.

So, what I was talking about is the pore water pressure also known as neutral pressure, is this okay, have you got this, why this is under static condition, this is the pressure in a equilibrium in the pores unless you create some disturbance. Now, this is what is going to be the pressure diagram here. So what will be this magnitude, this is negative and this is positive, where else you have come across this type of a pressure diagram.

Sorry, very nice, where, beams RCC correct. And what I am talking about here I have created a beam situation in the science itself, initial 2, 3 lecture we were talking about why it is so easy to drive a car on beaches which are wet. And why cannot you drive a car on the beaches which are dry, are you getting the answer, what has happened, what water does, it provides tensile strength to the material clear.

So under tension also you have so much stressor which can be negotiated by external stress. So the pressure which is getting transmitted because of the moving vehicle on the wet sand on the beach is going to be less than gamma w h c beaches and beach sands are notorious for sucking and retaining water in them. Finer the material, come back to this, finer the material, D 10 is going to be extremely low when D 10 is going to be extremely low D is going to be less.

Finer the material capillary action is going to be maximum clear. So what I have to do when I am designing infrastructure on the clay soils, where the grain sizes are very small, what I should be doing, I should be putting a layer of cutting of the seepage which keeps on moving up. That is a concept of design of him, infrastructure in marine place, are you following these concepts they are very simple yeah all throughout the life will remember you can forget them.

And nothing is to mugged up you agree yeah. How the pressure can be linear because it is will be the height of permeability but usually done the graph is linear Very good question and very difficult to answer. So, truly speaking is not linear but for the sake of convenience we are assuming this to be linear, you are right that the pressure would not be linear, you are right but this is an approximation.

So, what you should be doing is you should insert different type of tensiometer all along the column of the soil which is in vadose zone. If you are so eager to come to a lab, we can show you the most electronic mostly sensors which are normally used to measure the negative pressures. But do not get involved in all this things at this stage, but your point is correct. It is not okay. So, have you understood the concept of reinforcement of the soil because of the water present in it.

And that under suction, suction helps you, have you followed everything. Any question which you think would you like to ask. Rest of the things are absolutely simple. There is no complication if you followed this concepts.