Irrigation and Drainage
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Lecture - 03
Soil Properties - II

So this is lecture number 2 sorry lecture number 3. So, in this again we are going to see some of the soil properties. So, as I mentioned the mostly the soil structure, bulk density and particle density and then other properties like void ratio porosity say the other things ok. So, this is the soil structure; so, soil structure so, this is basically the arrangement of soil particles in a soil.

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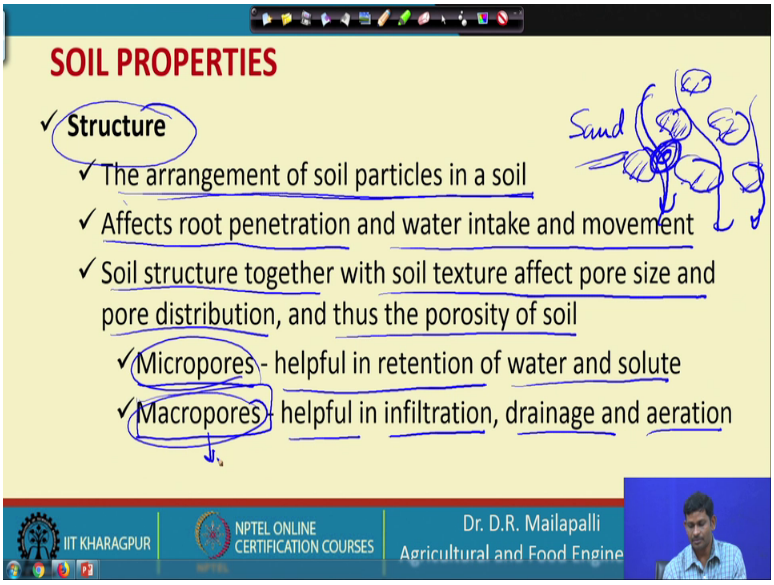

So, in the previously what we saw was the soil constitutes sand, silt, clay right, but the same time if you see; so, the individual soil particles are going to arrange in a definite shape alright. So, that is why the arrangement of solid particles are very important when you are talking about you know the; these water flow right. And then the effects of basically this are going to affect root penetration and water intake movement ok. So, that is what the arrangement the soil particle arrangement is very important right.

So, the soil structure together with the soil texture affects soil pore size and pore distribution and thus the porosity of the soil. So, the for example, you have like sand ok; so sand has definitely compared with other you know textures; so right so, sand has; so bigger particles right compared to other ok.

So then if you have a soil structure; suppose these particles are arranged in some fashion. So, definitely; so these individuals soil texture and also the arrangement of these individual particles. So, definitely influence the pore sizes the pore sizes and also the pore distribution and definitely that is going to ultimately influence the water movement ok.

So, for example, in case of clay versus sand; so, clay the porosity is going to be is you know smaller and sand and that that the pore space going to be you know larger. So, definitely the water freely moves into the pores compared to the clay soils. So, let us say here macropores sorry micropores. So, this is this helpful the retention of water and solute whereas, micropores which are bigger than micropores definitely helpful in infiltration and drainage and aeration ok.

So, the macropores what we are talking mostly due to you know dead roots or loaded holes or maybe any cracks all cracks. So, all mostly depends on you know bigger pores it causes bigger pores ok.

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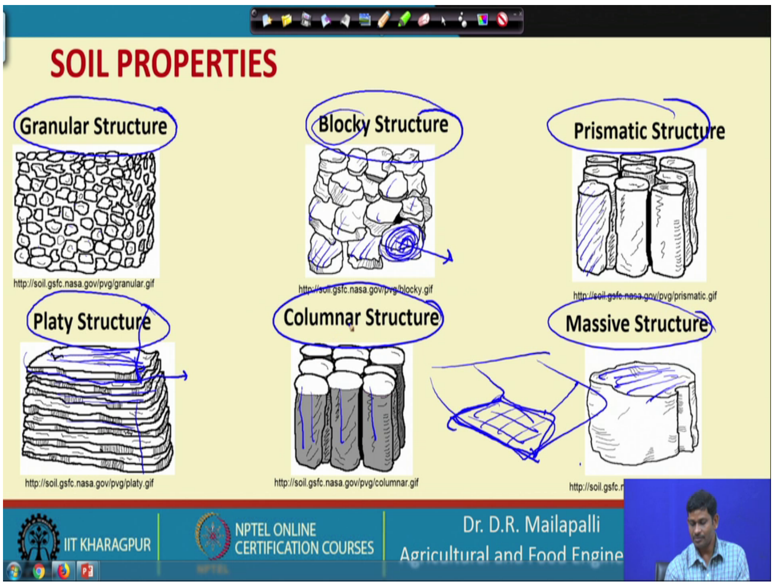

So, then next is; so, as I said this soil structure so, arrangement of soil particles. So, the soil particles could be arranged in a granular structure right.

So, if you see these all are like you know well definite shape; they are closely arranged one by one; so like attach to one to other. So, this is kind of you know if you see some kind of biscuits ok. So, like a porous biscuits it looks like this crunchy biscuit ok, whereas here another arrangement of in the soil particles could be in a blocking. So, like all like a blocks block shapes small blocks ok. So, like one by one the blocks are arranged one by one ok. So, this the one block contains you know number of soil particles, it is not one soil particle ok. So, that is why these soil particles are arranged in this blocky manner.

Similarly, see soil particles like arranged in a prismatic manner; so it is like a prism right and soil particles are arranged in platy structure. So, these are the plates right the plates; so here the problem is if you see the water movement. So, horizontal movement could be possible, but vertical movement will be difficult in this case from here to here because of the plate ok.

So, here this is column structures right; so, the particles arranged like a columns like a columns here massive structure. So, if you see you know this is a ground; so, sometimes you know the massive structures are like you know big cracks you know a big cracks is kind of a pallet. So, this; so all soil particles are arranged in a big, in a chunks big chunks. So, here what we observed in this is; so, soil particles can be arranged together and to form a different shape like a granular, blocky, prismatic, platy structure, columnar structure, massive structure.

So, how these structures are going to influence the water movement? So, that is our main intension here; let see. So, in this picture it is clearly showing.

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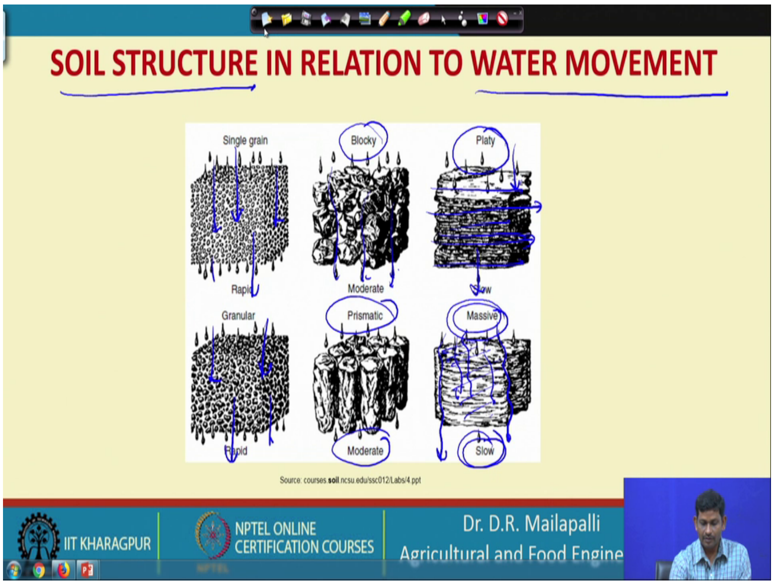

So, in case of granular structure; in case of granular structure or single grain granular structure, so the water flow is really rapid right; this is very rapid even granular structure also it is rapid. Whereas, blocky structure if you see the water flow is moderate ok; water flow is moderate because of the blocks.

And then platy structure it is very slow because you got the plates in this direction right; the plates are arranged in a stacked one by one. So, vertical movement will be slower here and prismatic also the moderate and massive which has in a big chunks. So, the water is only pass through you know the cracks basically. So, the otherwise it is very slow; once it is moving through the massive structure, the water movement will be slower. So, the definitely this picture shows the how the soil structure is going to influence the water movement ok.

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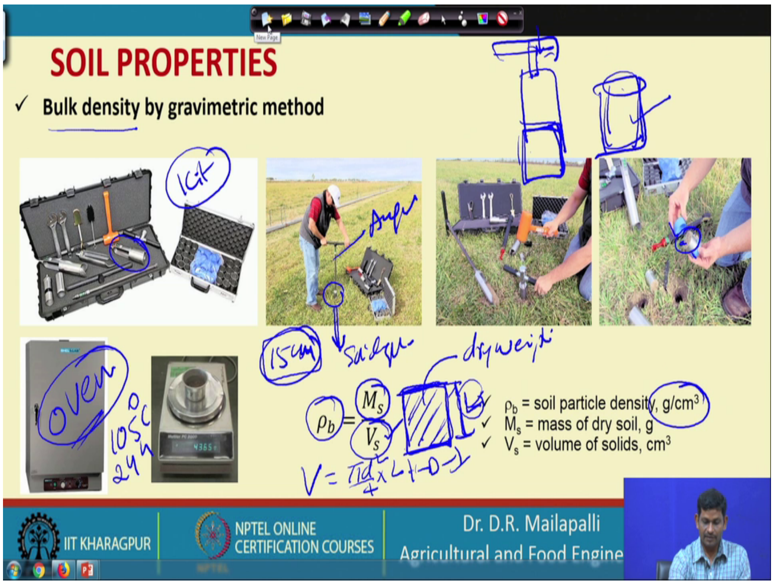

So, the next is how to estimate some of the properties like; so here I am going to show what is the bulk density ok? So, here if you see this is a bulk density and finding out how to find out the bulk density of a soil. So, what is the bulk density? What is the density? So, density is mass per unit volume. So, you have a volume of a particular you know material right and or you have a material which is filled in a glass ok. If you know the weight of the material which is you know putting in the glass or and divided by a glass volume; that will give the density of the particular material. So, since it is the bulk; so this is bulk density you can say.

So, similarly; so soil has this physical property called bulk density. So, if you put soil in any you know the glass knowing the soil mass weight divided by glass volume will give the bulk density; so here but in the field how to estimate this? So, this is called bulk density measurement kit; so, this is the kit generally we will use to take of the samples.

So, as you see here the different pictures the first you have to the dig out hole using an augur ok. So the once with augur; reaching a particular what you call the soil depth. So, suppose you want to take measurement at 15 centimetre soil depth. So, that you want to find out the bulk density at 15 centimetre depth.

So, using soil auger you take out the you know soil up to 15 centimetre then put the insert this is called if you see the different cores ok; this is the soil cores these are the soil cores. Then so, soil core will have; so this kind of thing, so here you will be meddling a top. So, this will have a core of cylindrical core like once you take out; so, you are going to have this kind of cylinder with soil ok.

So, at 15 centimetre depth; so using the soil core take out the soil core; so like this and protect it or put the caps on both sides right and take out here and find out what is the dry weight of the soil; dry weight of the soil which is which is inside the cylinder or core inside the core ok,

So now knowing the dry weight; knowing the dry weight how to find out the dry weight? So, here this is called hot air oven this is called oven; so, put the material which is brought from the field to a oven at 105 degree Celsius for 24 hours, then you will get a dry weight of I mean the moisture will be completely dried and you get the dry sample and find out the dry weight. So, that is that that is the M S; M s is the dry weight and since you know the soil core; so the soil core will have the length and it has a diameter right.

So, knowing the length and diameter you can find out volume. So, the volume V is equal to pi d square by 4 into L pi d square by 4 into L. So, this is area and length, so that will give that will give the total volume ok. So, then you will get the bulk density; the units or gram per centimetre cube ok. So, this way you can find out the bulk density in the field sorry.

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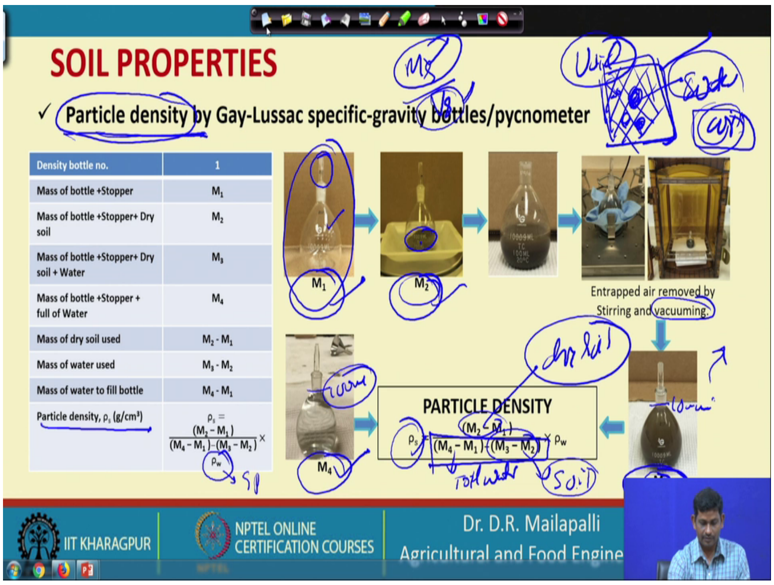

And now the next thing is finding out the particle density ok; so, particle density in the sense. So, the bulk density that as such will contains the pores right as I mentioned initially. So, the soil will have the solid particles like solids as well as some gaps or some voids; so, that will be like filled with you know water and air ok.

So, whatever you measure the bulk density; so, that includes water air sorry the gaps where what you call that voids right or the pores, it contains the pores then that is the bulk density. So, particle density; so exactly the mass of soil divided by the volume of solids ok. So, here what we do? We only consider the volume of solids ok; it is not the total volume not the total volume.

So, how to measure this particle density in a laboratory ok? So, here; so this is the measuring cylinder right. So, may not measuring cylinder this is the measuring jar you can say. So, find out empty weight; so that is M 1, so that contains the you know a bottle as well as the stopper ok.

So, then add this soil and find out the weight M 2; now add water and also add water into that and take out you know the air gaps, whatever it may be some air. Because soil contains you know porous space that may be the air might be hiding. So, you have to take out that by using you know by vacuuming; so, take out that one and then after making up to 1000 ml right thousand ml; so, find M 3. So, you got M 1 with empty M 2 with some soil inside and M 3 with soil plus water and that M 4 is completely water up to 1000 ml ok. So, another calculations if you see; the particle density which is equal to M 2 minus M 1 that is soil, so this is the soil dry soil right. And M 4 minus M 1 M 4 minus M 1; so, this one and this one this will give what? This is this will give total; total water total water occupied by 100 ml ok.

And M 3 minus M 1; M 3 minus M 1, so this will give this will give what? So, this will give sorry M 3 minus M 2; M 3 M 3 minus M 2. So, this will give the amount of water which is occupied by the soil ok, amount of water which is occupied by soil. So, the rho s which is equal to that this is the dry soil; so, that is M s and so, this difference, whatever difference you are seeing that will give the volume of water equivalent the dry soil.

So, here we have taken out the voids out ok; taken out voids out that is why the there is no chance of you know air gaps in the measurement, otherwise that would be equal to your bulk density. So, here the particle density ultimately you get M 2 minus M 1; M 4 minus M 1 minus M 3 minus M 2; this one is the specific gravity of water or density of water this is the density of water right, so this way you can estimate the particle density. So, generally the particle density varies from 2.6 to 2.7 gram per centimetre cube ok.

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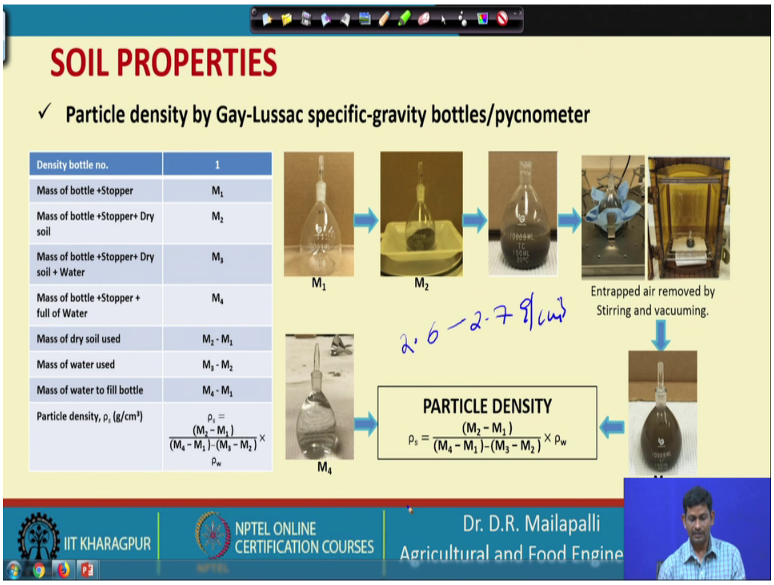

So, next is your basic soil water relationships.

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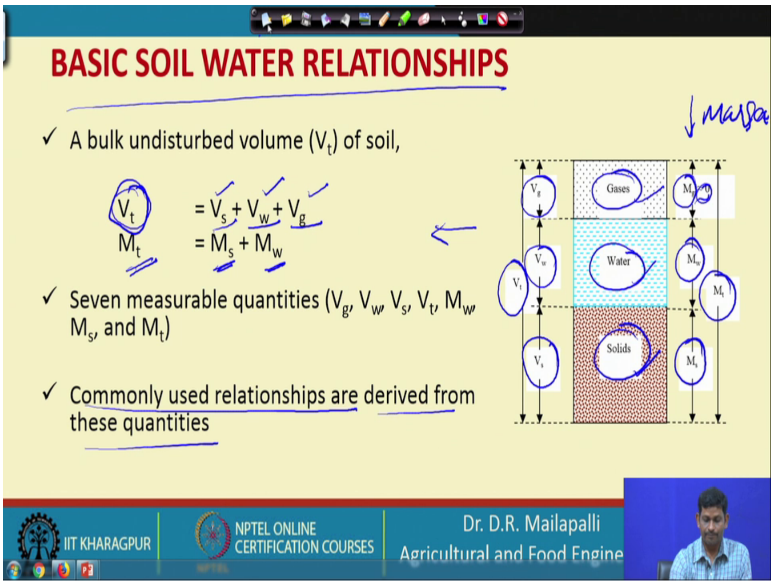

So, once you have this volume right if you see here this is the picture. So, as I said the soil will have the solids and water and gases and if you find this is the total volume V t.

So, that includes the gases volume, water volume and solid volume and individual volumes are V s is the volume of solids V w is the volume of water, V g is the volume of gas. And similarly the other side; so this side these are the masses.

So, here M s is the mass of solids, M w is the mass of water, M g is the mass of gas, zlv considered as 0 and the total mass is M t. So, with these information, we are going to define some you know some relationships. So, the bulk density; so, from this picture if you see the bulk density will be will be equal to; so, M t not M t.

So, we are going to do that, but basically let us see. So, V t is equal to V s plus V w and V g; so volume of solids, volume of water, volume of gas. So then total mass is equal to mass of solids and mass of water ok; so there are 7 measurable quantities you can all includes 7 measurable quantities. So, commonly use relationships are derived from these qualities, we are going to see what kind of relationships are ok.

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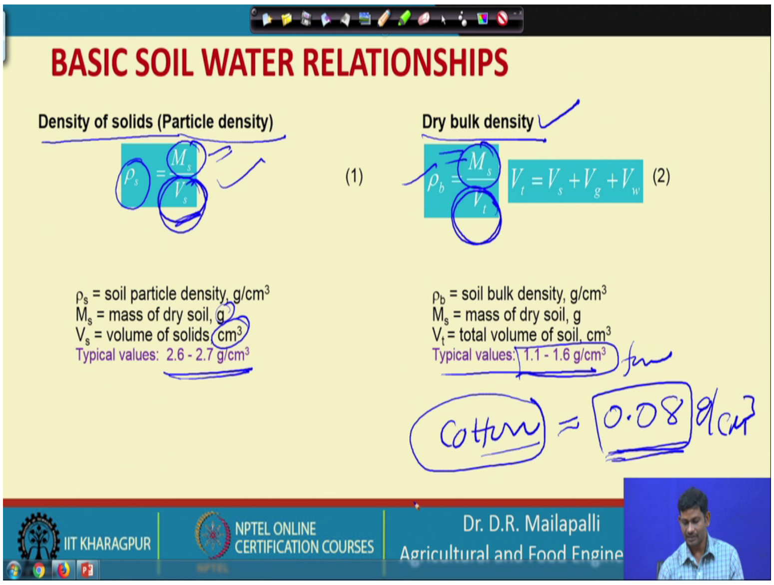

So, go to the next slide if you see; so the first thing is as I have mentioned. So, this is the dry bulk density or the sorry, this is the particle density and this is the dry bulk density ok. The particle density which is mass of solids divided by volume of solids ok; so mass of solids and the grams volume of solids that is centimetre cube and the value 2.62, 2.7 gram per centimetre cube; whereas, the dry bulk density; so mass of solids divided by total volume total volume. So, the main difference is from here and here; so the mass is same.

So, mass of solids mass of solids same the only difference is here we consider volume of solids here the total volume in case of dry bulk density ok. And typically the values are 1.1 to 1.6 gram per centimetre cube power for soil for soils. Whereas, if you see the cotton right; so, the cotton generally I mean it will be like 0.08 gram per centimetre cube.

See how because the cotton is very light and compare to the soil right so, but this is the bulk ok, this is the bulk and see the density 0.08; it is very light compared to here; if you put both in water. So, the cotton is I mean generally is going to float various soil is going to drop right or sink you can say ok.

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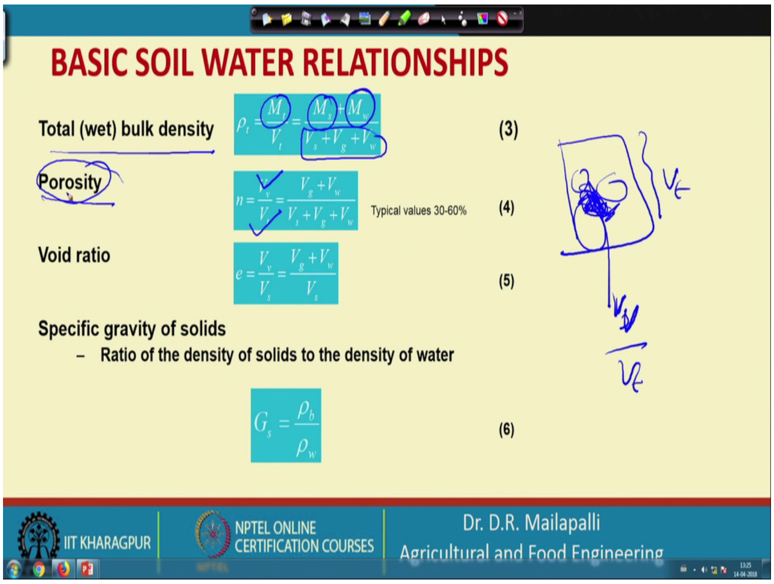

So, so the next slide we are going to see the relationships basically ok. So, here the total bulk density or the total wet bulk density; so, dry bulk density wet bulk density, what is the difference? The difference is if you take dry weight of soil that is dry bulk density, if you take wet weight I mean solids plus water. So, that will be you know wet bulk density.

So, if you see here bed bulk density; so this is mass of solid including water ok, if you see the mass of solids plus mass of water. So, this one and the total is just like your dry bulk density case and the porosity, porosity will be the volume of voids divided by total volume of total volume ok.

So, what in case of porosity your targeting? Suppose, so this we are looking into this voids this voids. So, volume of voids; so volume of these voids volume of voids sorry volume of voids and divided by the total volume will give the porosity ok, will give the porosity.

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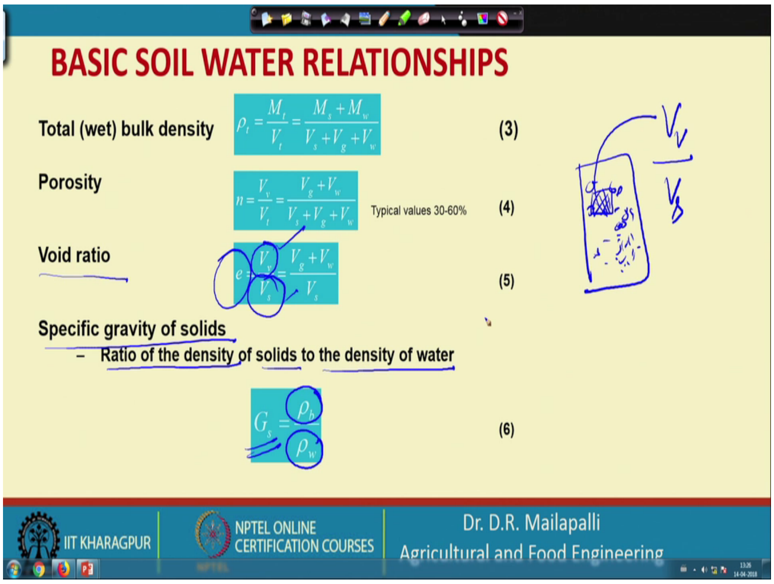

Then you have void ratio; so, void ratio is, so how the ratio of volume of voids and volume of solid volume solids; how proportionate? So, solids how proportionately the volume voids and solids or you know in a relationships ok.

So, here V o suppose you have you know the soil which has soil particles right and this is the void, it does not contain any solid particles. So, I mean this is V; so, these volumes of void divided by and combine all soil particles right; all soil particles that makes volume of solids ok. So, this will give this will give the void ratio e then the specific gravity of solids. So, this is specific gravity so; that means, ratio of density of solids to the density of water ok. So, this is the density of solids divided by density of water; so, that will give the specific gravity of solids ok.

And then we are going to see the next slide a few more relationships.

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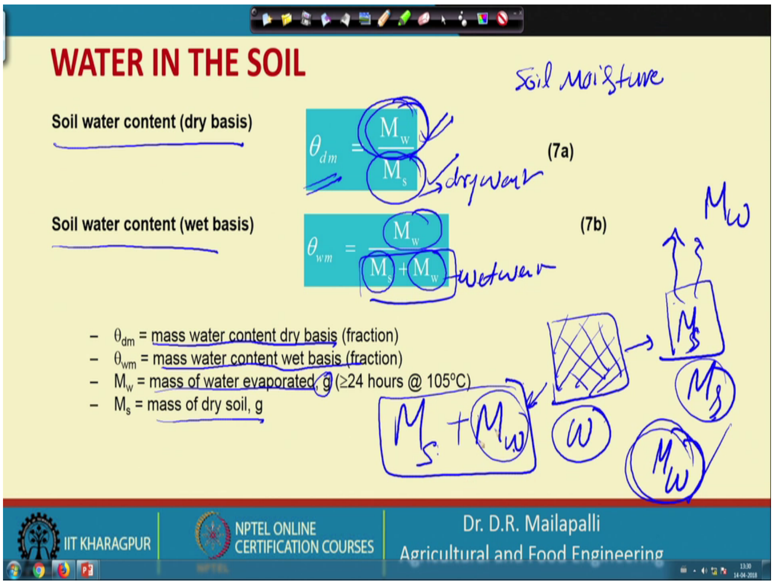

So, here this is a water in the soil how much water is present in the soil we call the soil moisture. So, that is called soil moisture soil moisture is the percentage of moisture which is present in a soil; amount of moisture present in the soil.

So, soil water can be estimated here using a moisture probes or geometric; basically a geometric method. So, here the soil water content in dry basis is equal to mass of water divided by mass of solids and similarly soil water content wet basis; so, mass of water divided by mass of solids and mass of water. So, here this is only say dry weight and this is wet weight ok, this is a dry weight and this is a wet weight of sample.

So, and then; so, this is where we find out dm is mass water content dry basis, theta wm which is mass water content wet basis and M w that is mass of water evaporated. So, mass of water evaporates that is gram mass of dry soil M s is mass of dry soil. Suppose you have taken a sample soil sample wet soil sample from the field ok. So, find out that weight ok. So, that weight will give you what? This is a mass of this is the total mass M w and M w and M s ok. So, this will get total mass if you take soil sample directly from the field; so, this contains mass of solids and mass of water ok.

The moment if you put it in you know; dry it using oven. So, the water is going to evaporate; so, that is M w and the amount which is left is M s that is solids mass of solids. So, it is only simply the you know the ratios the ratios if you want to get you know dry weight; I mean soil moisture content in dry basis. So, knowing the M W; so, M w how do you know the M W; in this case when you do weight.

So, that that you get only M S; so M s plus M w minus M s will give the M w ok. So, that M w here divided by M s ok; so, that will give the water content in dry basis and then the M w divided by the total right total in sense this one. So, that will give the soil water content in wet basis ok.

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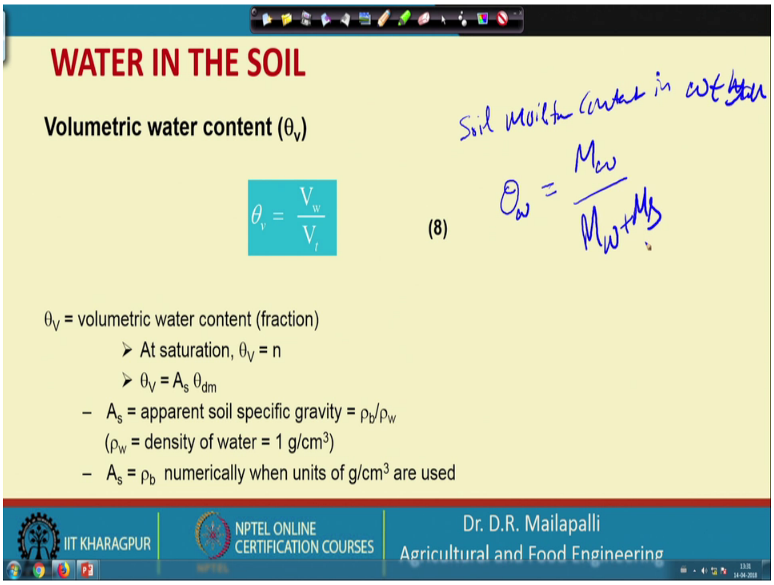

And so, then that is wet basis whatever we got the soil moist sorry the soil moisture. So, that that in; so, the soil moisture in wet basis we got. So, that is a dry basis we call now how to find out soil moisture in volumetric basis ok. So, one is soil moisture content in you know weight basis in weight basis. So, that is that is that is what we got; so, like theta weight basis wet basis. So, that is equal to know M; M w divided by sorry M w plus M s ok. So, this is soil moisture content in wet basis.

So, how to convert this into a dry volumetric basis? So, that is volume of volume of water and total volume. So, that this is a volumetric basis.

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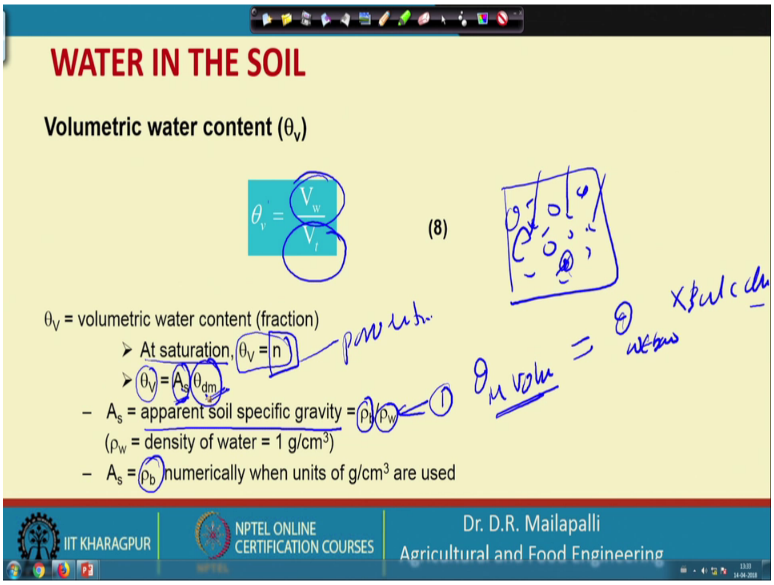

So, at saturation what happened? Saturation so; that means, you have soil will have the pores right. Since saturation what happened this all pores are filled with water whatever the pores in between soil particles will be filled with water. So, then that is the saturation and that will be equal to your n; so, n is your porosity n is a porosity ok.

So, then in order to find out in order to find out the volumetric basis using the you know wet basis. So, wet basis needs to be multiplied with the bulk density ok. So, what you can say? So, theta in volumetric basis is equal to theta in wet basis multiplied by the bulk density ok. So, bulk density; so that will give the theta in volumetric basis.

So, here also; so, theta V which is as right into theta d m; dm is dry basis soil moisture content multiplied with multiplied with apparent soil specific gravity. So, soil specific gravity is equal the bulk density of the soil divided by the density of water ok. So, since density of water is equal to 1; you will have the apparent specific gravity which is equal to the bulk density of soil. So, the simply what we did; the volumetric basis which is equal to bulk density of soil multiplied by drive dry moisture content or moisture content in dry basis ok.

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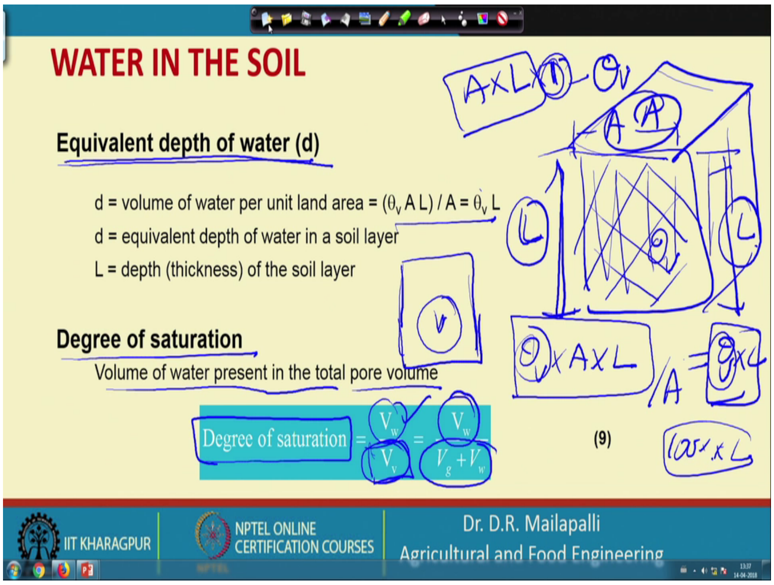

So, and next is; so once we know the soil moisture which is present in the soil. So, how to find out the equivalent depth of water ok? So, what is the depth of water present in the soil profile? What is the depth of water which is present in the soil profile? So, if you know the soil moisture which is theta; V volumetric basis and the soil depth is L.

And this is the area in the sense you have you know 3 dimensional; suppose so, this is area; so, then finding out the volume here right. So, theta V because this is the volume basis theta V into area multiplied by L. So, this will give the total volume of water in the soil right; so, divided by area if you can divide by area then you will get theta V into L. So, which is which is the water available in this soil can be depth of soil L depth of soil ok; so, that is theta V into L.

So, what happen if suppose theta V is 100 percent theta V is 100 percent into L; so, that that will give; so because 100 percent means what? There is no soil present in the no soil present in this is kind of a cube right; a cube there is no soil then what is the amount of water? So, that will be your volume of water occupied by the cube ok. So, that is simply the area multiplied by length; L since your theta V is 1 ok.

So, since this is soil is occupied at only the fraction of solids that the fraction of voids that represents the porosity ok. So, that is the reason we do not put a 1; instead of that we put the theta V ok. So, that is the fraction of space available for the water to occupy right. So, this is and the this is this is the way we can estimate the equivalent depth of water ok;

and the degree of saturation here; which is equal to volume of water present in the total pore volume; so degree of saturation.

Suppose your soil ok; so you are the total volume is V volume of soil is V and some portion which is V is wet; some portion is wet some volume is wet. So, the volume of water which is available divided by the total volume right total volume that will give this not total volume of voids basically volume of voids. So, that will give the degree of saturation.

So, volume of water divided by volume of voids; so, that will give the volume of; I mean degree of saturation. So, a I mean how much amount of the voids or filled with water? So, that will give the degree of saturation.

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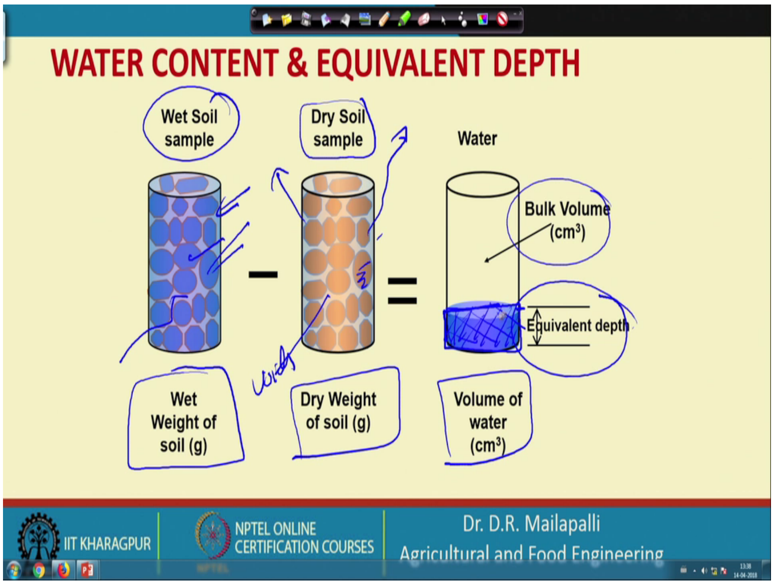

And then; so, next is this is the pictorial way of representing the available water. So, initially if you see; so the wet soil sample; so, this has the soil particles right this has soil particles and also the voids which are occupied by water this that is called the wet weight of soil. And then when you dry it with a dry the sample; so water is evaporated right. So, you can clearly see the solids and voids; so these are all voids these are voids; so, this is the dry weight of soil.

Then if you can see the whole thing distributed. So, this is the total bulk volume right and I mean if you can put the water here, whatever the water which is evaporated here.

So, only and if you put that back into the if you put that back into the you know cylinder that will occupy this much depth ok. So, this is called equivalent depth and this is the bulk volume ok.

So, this way you can clearly say the amount of water which is present inside right; present in the cylinder will be equivalent to, equivalent to this much of water right this much of water. I mean if you take out solids and solids out; so, the water occupied by the cylinder is this much ok.

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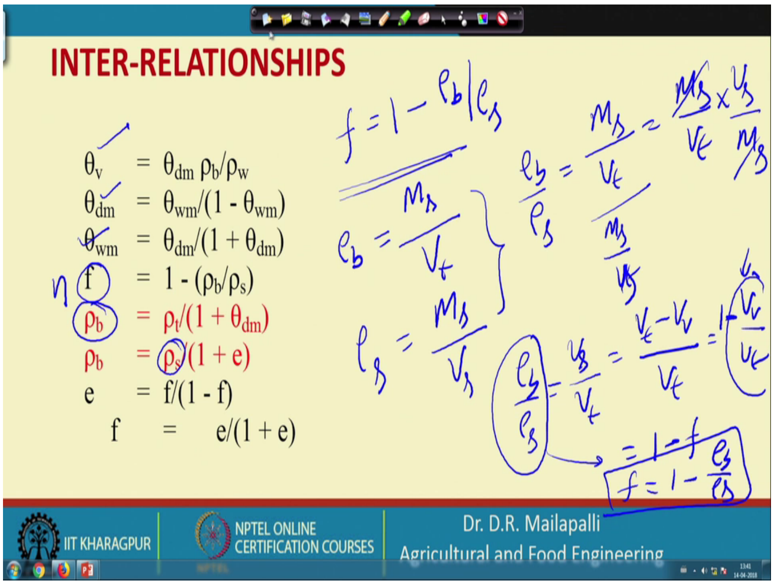

So, here we have some relationships; so, we already know we what is theta V right; what is theta dm which is the soil moisture in dry weight; dry basis soil moisture in wet basis wet basis ok. So, and so, the here f is the porosity we can also say its n here and then rho b is the bulk density and rho s is the particle density; so, these are inter I mean they are interrelationships.

For example here if you see f which is equal to 1 minus rho b divided by rho s. So, how do we get this relationships, how do you get this relationships? So, if; let us put. So, rho b rho b is what? Rho b is the bulk density isn't it; so the bulk density is mass for example, M s right divided by the total volume total volume and whereas, rho s which is equal to M s divided by V s right; volume of solids.

So, if you can divide these. So, rho b divided by rho s which is equal to M s divided by V t and divided by M s divided by V t. So, which is equal to M s by V t in to sorry here V s this V s and V s by M s. So, M s gets cancels out; so you get rho b by rho s which is equal to V s by V t ok. So, then you can say V s can be written as V t minus V v because all total volume minus volume of voids that will give the volume of solids divided by V t and this will give V t; V t 1 divided by V v by V t 1 minus.

So, V v by V t which is we call it is a porosity volume of voids divided by total volume. So, the porosity here if you see f ok; so what we did? Rho b by rho s which is equal to 1 minus f or f is equal to 1 minus rho b by rho s.

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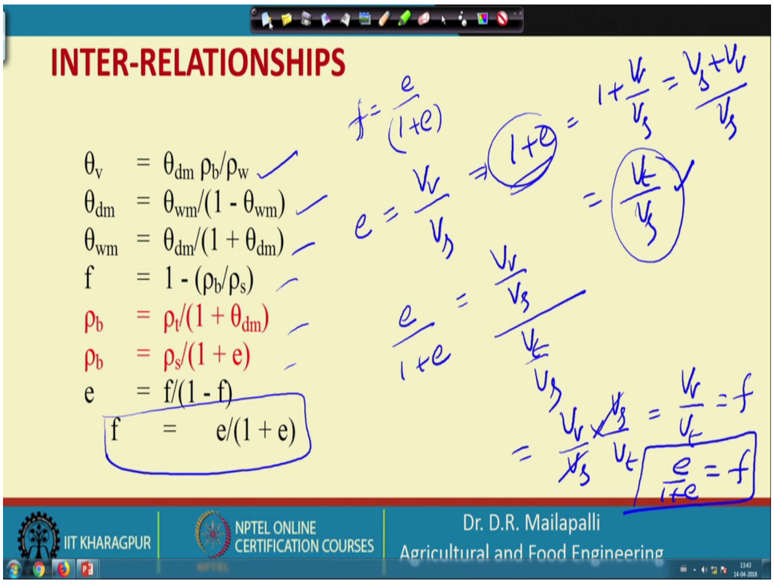

So, this way you can I mean all have the relationships here you can also find this relationship. So, this is f which is equal to e by 1 plus e; so, where e is the void ratio, f is the; f is the porosity ok.

So, void ratio e which is equal to volume of voids divided by volume of solids right; this is void ratio. So, let us put 1 plus e; so which is equal to 1 plus V v divided by V s by V v divided by V s. And V v; V s plus Vv equal to V t divide by V s right. So, 1 plus e which is equal to V t by V s; so, now, the next thing is e by 1 plus e right, let us put e by 1 plus e. So, which is equal to e we have V v by V s divided by. So, 1 plus e we have V t by V s. So, here if you see this is V v by V s multiplied by V s by V t. So, which is equal to vv by V t right this is gets cancelled; so, V v by V t will be equal to porosity ok So, the finally e by 1 plus e which is equal to f.

Similarly you can also you know derive or you can also prove other relationships right. So, remember his relationships is very important for your problem solving. So, this way I mean with this I conclude this lecture.

Thank you so much.