Soil Science and Technology
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Lecture – 12
Soil Porosity and Consistency

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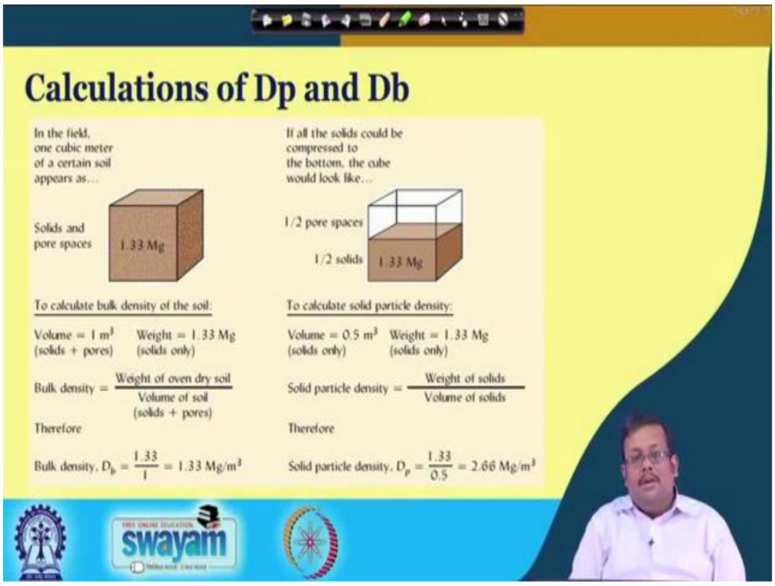

Welcome friends to this new lecture of Soil Science and Technology and today we will be starting from the; from the slide where you left in the last lecture that is calculation of particle density and bulk density. So, in the last lecture we started the bulk density, we defined the bulk density means and also we defined the particle density. Remember particle density is the density of the soil solid particles whereas bulk density is the density of bulk soil.

So, generally soil bulk density is variable; however, soil particle density is more or less constant and we generally take the value of 2.65 gram per cc for soil particle density and , but soil bulk density varies widely from one soil to another soil depending on their percentage of pore space or porosity. So, in the last lecture we talked about how to calculate the particle density.

So, I showed you this example of a block contains solid and pore spaces. So, how we calculated the bulk density and when we compress the solid particles and there is no further pore spaces and then how we calculated the soil particle density. So, we will be starting from there and let us see what are the important implications of these density parameters as for as the soil physicochemical properties are concerned.

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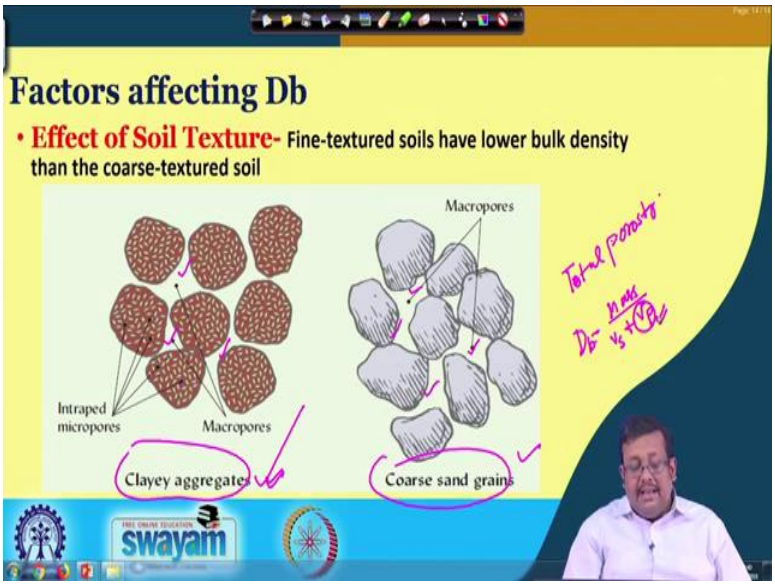

So, there are several factors which effects the bulk density because it is variable. So, let us start with the soil texture; obviously, you know fine texture soils have lower bulk density than coarse texture soils. Because in case of fine texture soil let us consider this is a general we know there is a widespread confusion about these thing. So, let us consider there is a clay soil and there is a sandy soil.

So, if you see the clay soil clay aggregates; obviously, there will be some macro pores and which are larger in size and obviously, there will be some intraped micro pores numerous micro pores. However, in case of coarse sand grains; obviously, there will be only macro pores there will be no intraped micro pores. So, as a result of that the total porosity is always higher in case of clay soil than that of coarse grain soil.

So, as a result of total porosity is quite high in case of fine textured soil; obviously, for a given weight of soil; obviously, the bulk density will be higher in case of coarse texture soil. And the bulk density will be lower in case of light texture soil in case of fine texture soil because we know bulk density or Db equals to mass by volume of solid plus volume of pores. So, in case of clay aggregates this volume of pores is quite higher than that of coarse sand grains.

So, as a result of that in case of fine texture soil; obviously, the bulk density is lower.

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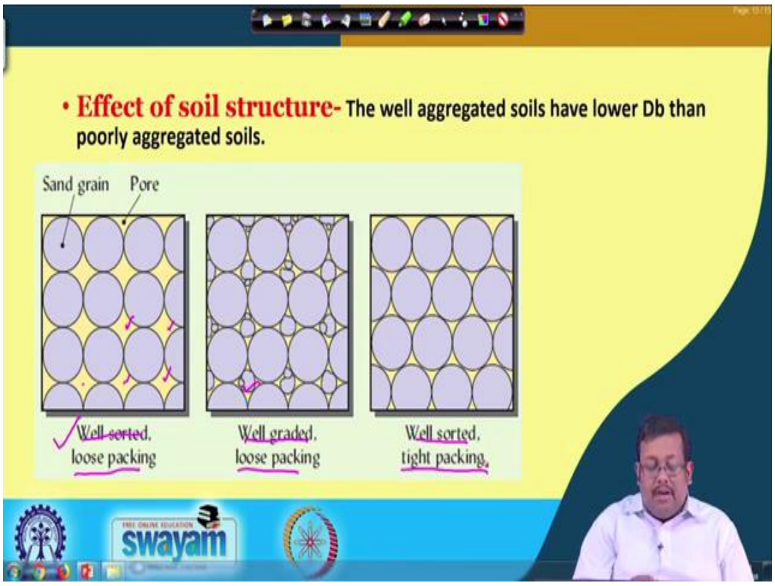

The second important aspect is soil structure; obviously, the well aggregated soil have lower you know bulk density than that of poorly aggregated soil. As you can see here this is a well aggregated soil and you can see the pore spaces are well arranged. However, this is well graded, but there is a loose packing and this is well sorted, but tight packing this is I am sorry this is well sorted, but there is a loose packing.

So, there are well graded and loose packing and this is well sorted and tight packing. So, based on the packing arrangement; obviously, the pore space of the volume of the pore space changes. So; obviously, in case of well aggregate soils have lower bulk density than poorly aggregated soils because it depends on the pore space.

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Third is effect of organic matter it is very important now organic matter helps to form good aggregation as you already know. So, it reduces the bulk density of the soil when there will be good aggregation; obviously, there will be larger porosity and as a result of larger total porosity the bulk density of the soil will be lower. Depth of soil profile is another important issue; pore space reduces with the increasing soil depth. So, bulk density generally increases with increase in depth of the soil.

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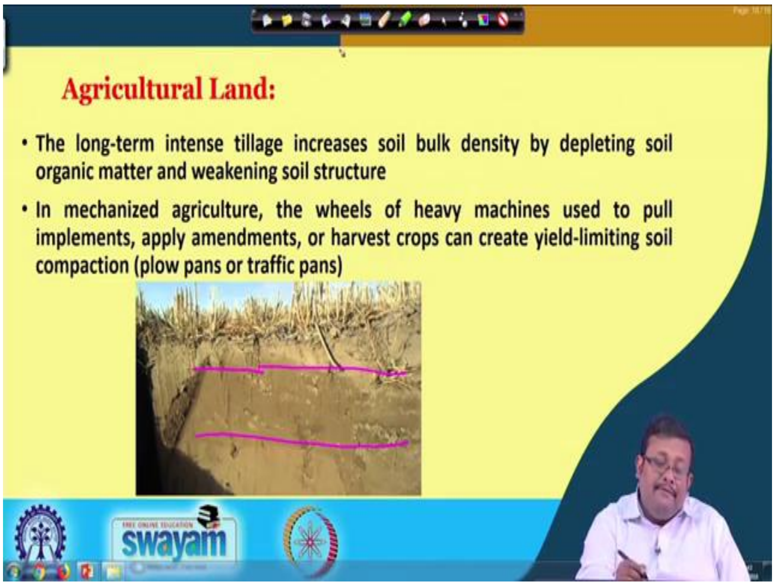

So, in case of agricultural land the long term intense tillage when you are doing the long term tillage usings are heavy implements; obviously, the soil bulk density generally increases and because there are couple of reason.

Because, as a result of continuous tillage the organic matter depletes degrading the soil structure. And also due to the heavy pressure of the implements there will be a compaction effect and as a result of the compaction effect there will be formation of hard layers below the subsoil. So, we call it so, we call it plow pan or you know as you can see here there is a clear plow pan which is a hard and compacted layer which generated due to the heavy machinery pressure; due to the heavy machinery.

And as a result these layer will have higher bulk density and as a result of higher bulk density there will be problem for growth of the crop because plant roots cannot grow further and also the aeration as well as water movement will be impeded. So, these are some problem for increasing the bulk density in agricultural lands.

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Obviously vehicle tires for example, 750 kg load per tires it is will compact soil to above 50 centimeter. And obviously, remember that the more narrow the tire the deeper it sinks and deeper its compaction effect.

As you can see the picture the narrow tire providing is although it is 750 kg load both the tire is giving 750 kg of load, but you know the deeper it sinks and deeper its compaction effect. So, the in case of narrow tire; obviously, it will give more compaction effect. So, summarily we have covered an important chapter of soil that is soil tillage and soil density.

And I hope that you have learnt something new we have discussed about different types of to tillages, what are the benefits of conventional tillage, what are the benefits of conversation tillage and what are the drawbacks of conventional tillage what is primary tillage secondary tillage.

And then we talked about soil crusting, their problems and how to manage soil crusting. Then we talked about soil bulk density and particle density and how to calculate the soil particle density bulk density and what are the factors which effect the soil bulk density because it is variable soil particle density is more or less constant as you know. So, hopefully you have gathered a good knowledge about a soil density and tillage operations. So, if you need more information or more knowledge please go through the book called the nature and properties of soil written by Braddy et al. So, you will have more idea about the soil tillage and other practices.

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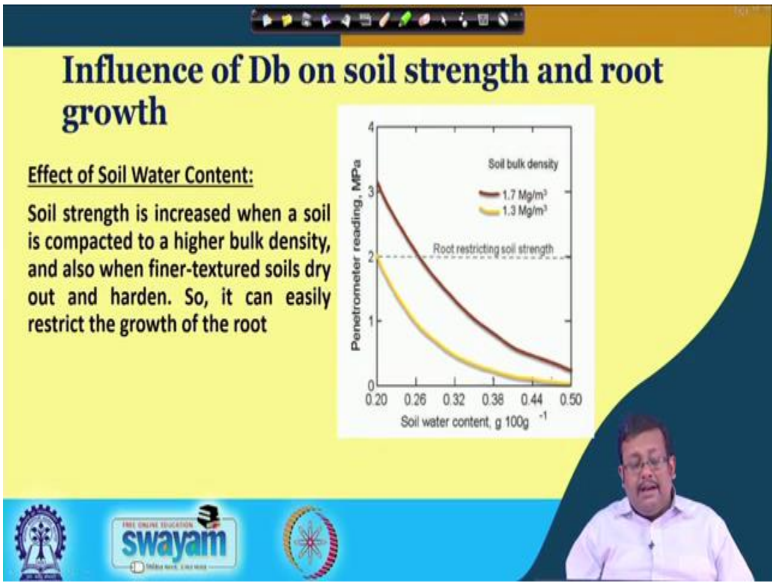

So, that is all from this and also and I also I want to mention that there is also influence of bulk density on soil strength and root growth. As you can see that soil strength is increased when a soil is compacted to a higher bulk density and also when finer texture soils dry out and harden; so, it can easily restrict the growth of the route. As you can see here in this graph as the soil water content is going down from 0.50 per 100 grams to 0.20 gram per 100 grams of soil.

Obviously, the penetrometer reading which basically measures the strength requires for penetrating the soil is continuously increasing. So, obviously, for a given soil bulk density; reducing the moisture content with increase the penetrometer reading or another words it will increase the restriction for a proper root growth and will or another words if we decrease the soil water content it will provide hindrance for root growth or proper root proliferation.

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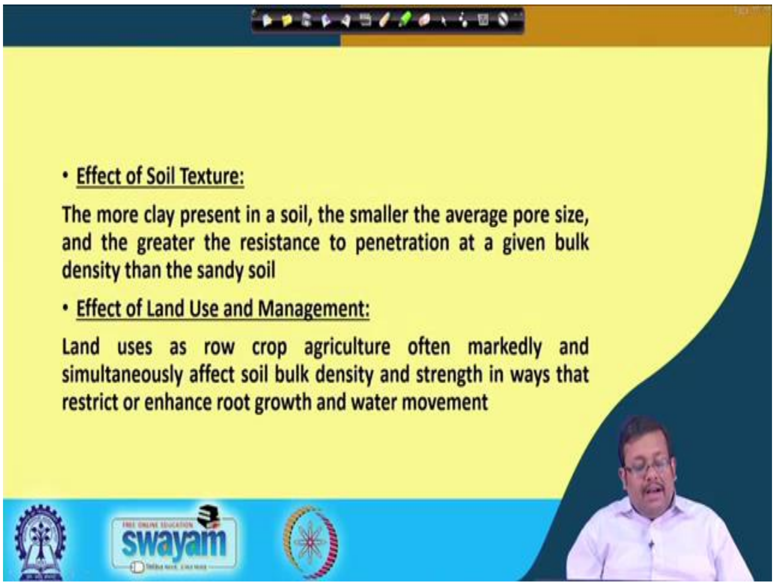

So, also the effect of soil texture is important; the more clay present in a soil the smaller the average pore size and the greater the resistant to penetration at a given bulk density than a sandy soil you know all that. And obviously, effect of land use and management as you can see as you know that crops are grown sometime in rows. So, when we grow the crops in rows there are chances for increasing the soil bulk density so; obviously, we should practice some intercropping. So, these are some management practices for soil bulk density.

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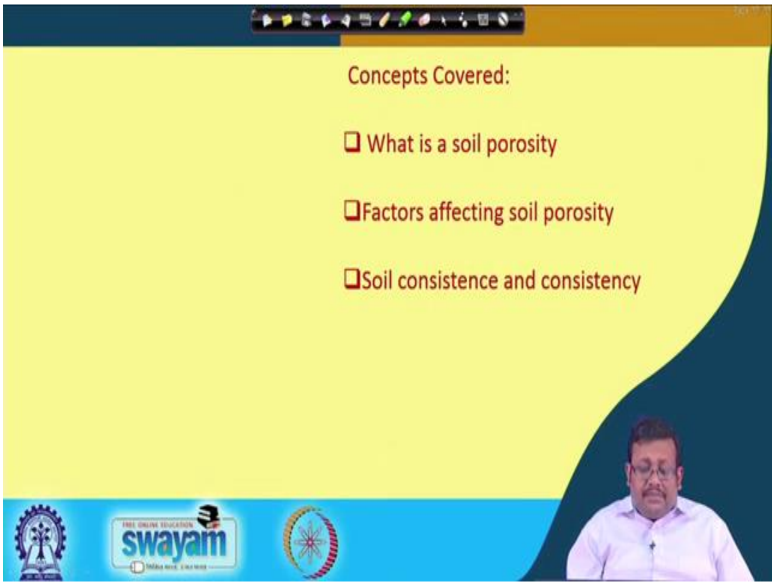

So, let us start a new topic that is soil porosity and consistency; it is also very important these are also very important soil physical parameter. So, let us start and basically in this in this chapter we will cover what is soil porosity and then what are the factors which effect soil porosity and then we will cover soil consistency.

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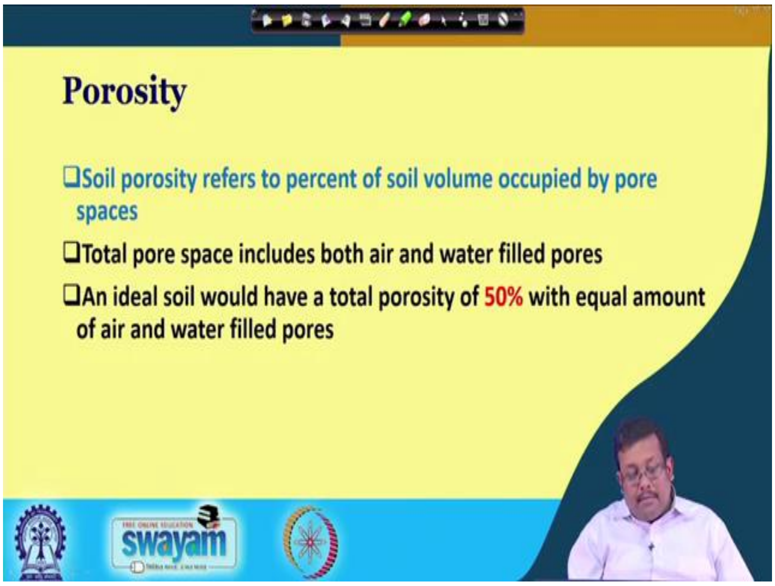

So, what is soil porosity? Well soil porosity refers to the percent of soil volume occupied by pore spaces and remember that total pore space include both air and water field what pores.

So, in the first lecture we have talked about the volume distribution of different factions of soil or different components of a soil. There you have leant that about 50 percent of the soil total volume is occupied by the pore space which is also and this pore space are shared mutually by air and water. And the ideal soil remember that an ideal soil would have a total porosity of 50 percent with equal about the of air and water filled pore spaces. However, depending upon the condition sometime the air filled pores predominant; sometime the water filled pores predominate.

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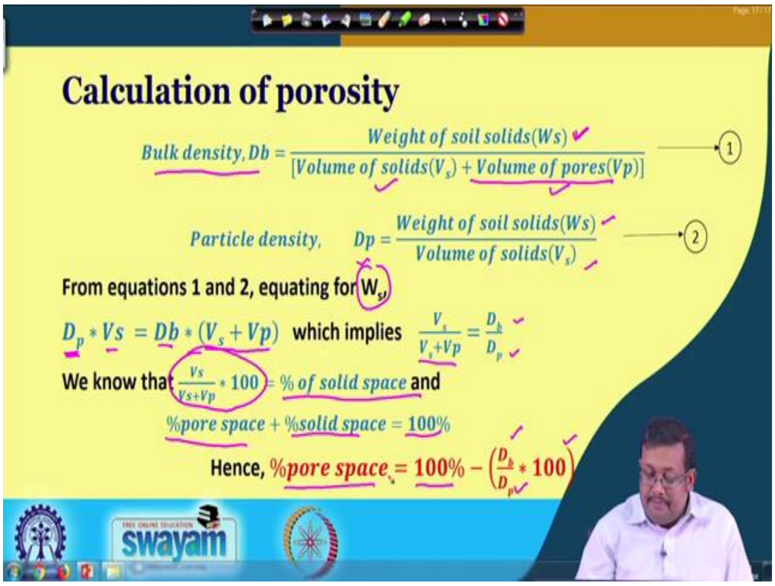

So, how would you calculate the porosity? So, let us see; so we know that from our last lecture that bulk density or Db is basically calculated by these formula which is weight of soil solids over volume of soil solids and volume of pores. And particle density or D p is basically weight of soil solids and volume of soil solids. So, you know all this only the difference in case of particle density and bulk density is in case of bulk density we are also considering the volume of pore spaces.

So, from equation 1 and 2 equating for W s or W is basically the weight of soil solids; to get the soil solid weight of the soil solid which is W s from the bulk density. If you multiply the bulk density with the; I am sorry if you multiply the particle density with the volume of the solids, we will get the weight of the soil solids we know that. And also if you multiply the bulk density with the volume of solid and volume of pore spaces; we will get the W s that is weight of soil solids.

So, basically these are these two are same. So, which basically implies V s by V s plus V p equal to D p over D p. Now we know that that V s over V s plus V p into multiplied by 100 is the percent of solid space. And we know that percent of pore space plus percent of solid space is always 100 percent because solid space and pore space cover total 100 percent of the soil volume.

So, if we replace the solid space by these V s by these expression that is V s by V s plus V p into 100; we will get percentage of pore space that is 100 percent minus D p bulk density over particle density into 100. So, this is the percent pore space formula we generally use to calculate the porosity or percent pore space.

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So, if you see these are two sorry these are two examples. The left one is a brick with higher bulk density and low pore space and the right one is a sponge with low bulks density and high pore space. So, remember that when there is a high pore space; obviously, that will show lower bulk density.

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Now, what are the factors which effect the total pore space? Let us discuss them one by one; first of all the management practice. So; obviously, you know that highly compacted soils have less porosity because when compressing the soil solids; obviously, there will be no further pore space. So, well granulated and organic matter rich soil have higher porosity; remember that organic matter contains huge amount of micro pores. So, when you are adding the organic matter it not only it producing the well aggregated soil, but also it increasingly the total porosity because total porosity is the combination of both macro pores and micro pores.

Intense cultivation reduces the porosity due to reduction in organic matter content; obviously, we know that there is an drawback of conventional tillage and organic matter content increases the porosity we have already discussed that. So, these are some arrangement interventions which effect the percent of total pore space.

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So, as you can see from this picture how compaction is effecting the total porosity. As you can see the left most picture is showing the loosely aggregated soil; however, the next picture is showing highly compacted soil. Now; obviously, in cases of compacted soil you will see there is an impervious layer though which the plant roots cannot grow further. So, these are examples of compaction and it is effects on porosity; obviously, when you are compacting the soil the total porosity will also decrease.

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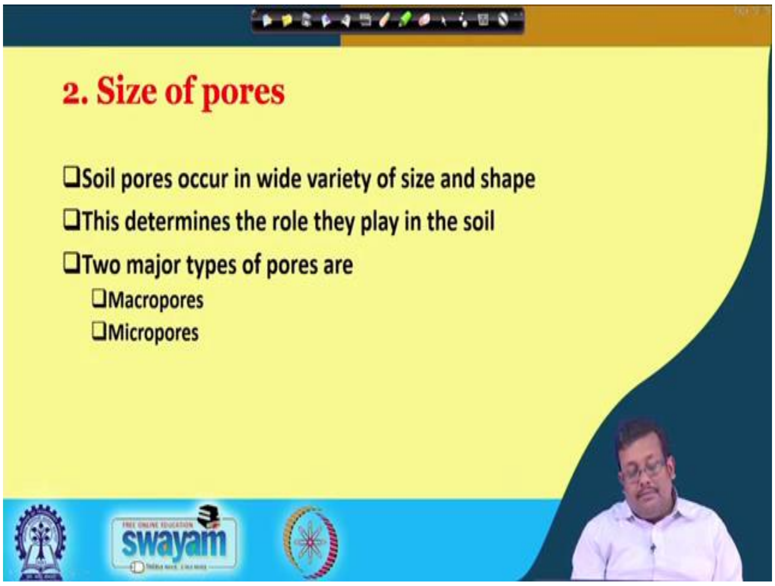

The 2nd important aspect is size of pores; obviously, soil pores occur in wide varieties and size and shape. And these determines the role they play into the soil; obviously, we will discuss them and they are generally basically they are generally divided into broad categories one is macro pores another is micro pores. So, let us see what are the macro pores and micro pores.

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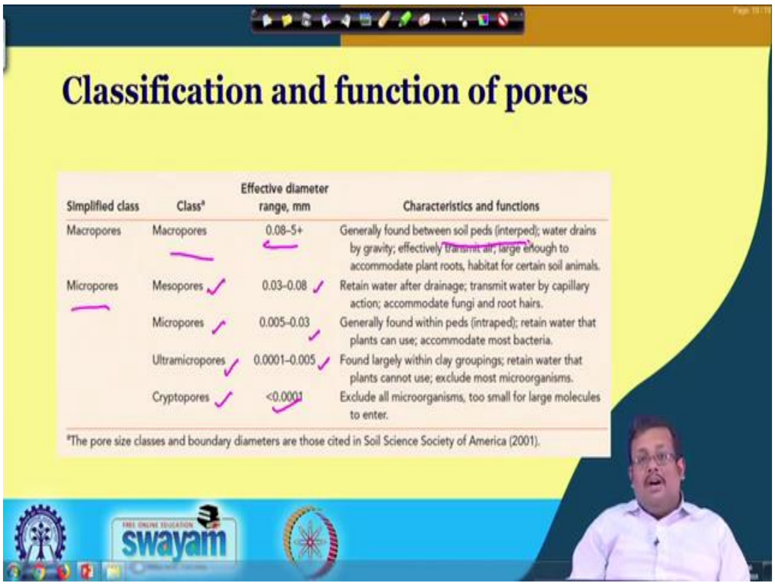

So, if we classify the pores based on their size and their functions; let us see how we can classify them. So, at first you can see macro pores; so, macro pores are having effective diameter of 0.08 to 5 plus millimeter. And micro pores are further divided into 4 classes one is mesopore, micro pores, ultra micro pores and crypto pores. So, mesopores are basically 0.03 to 0.08 millimeter diameter micro pores are 0.005 to 0.03 millimeter diameter.

Ultra micro pores contains 0.001 to 0.005 millimeter diameter and cryptopores are having diameter less than 0.0001 millimeter. Now, in case of macro pores it basically generally found in between the soil peds or interpret regions and basically water drains with this macro pores by gravity and effectively they can transmit air and they also large enough to accommodate plant roots and habitat for certain soil animals.

Now, regarding the mesopores they basically retain water after drainage and transmit water by capillary action accommodate fungi and root hairs. We have already covered this how we have already seen that how this root hairs and fungi helps in aggregation of soil aggregate. So, these fungi and root hairs basically accommodate in the mesopores.

The micropores generally found within the peds entrapped we have seen already in the last couple of slides; it basically retained water that plant can use; however, they also accommodate more bacterium or most bacteria they have in those macro pores. Ultra micro pores found largely within the clay groupings and return water, but that water plant cannot use and they basically exclude most of the microorganisms. And in case of crypto pores they exclude all the micro organisms too small and they are too small for large molecules to enter.

And remember that this classification is given by the Soil Science Society of America in 2001. So, we again we can basically divide the pores based on their diameter into two broad categories macro pores and micropores. And micro pores are further divided into 4 groups that is mesopores, micropores, ultra micropores and cryptopores based on their relative size or diameter of the pore spaces.

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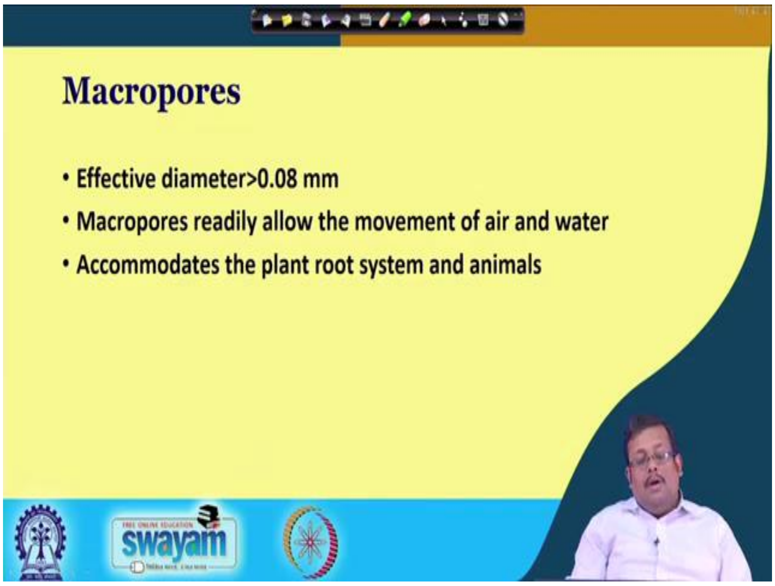

Let us discuss them one by one; effective diameter incase of macro pores are greater than 0.08 millimeter. And macro pores readily allows the movement of air and water and it accommodates the plant root system and animals we have already discussed that.

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So, let us see what are the types of macro pores and there are different we can see in the pictures there are two different types of macro pores. Macro pores in between individual soil grains we can see here; these are macro pores you know which are present individual in between individual soil grains and their these are responsible for movement of air and water in sandy soil.

So, you will see these type of macro pores mostly present in case of sandy soil. And interped pores in well structured soil; obviously, these are some interped pores which are not highly visible, but there are present in well structured soil and they also occur between tightly packed blocky peds and also called prismatic peds.

So, we have already known what are peds and what is prismatic peds. So, as you can see in this in between this prismatic ped; they are tightly they are you know they occurred in between these tightly packed prismatic peds and these are also macro pores.

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And also there is another macro pore called bio pores. So, bio pores is a type of macro pores which are created by roots earth warms and other animals. And you can see they are tubular in shape and they are continuous and in clay soil bio pores or major pores for facilitating plant root growth and both soil structure and texture influence the distribution of micro and macro pores. And as you can see here these are the bio pores these are tubular in shape and continuous and you also here or you can see the bio pores.

And; obviously, these bio pores are the major pores for facilitating root growth in case of clay soils because in clay soils you know availability of macro pores are somewhat limited.

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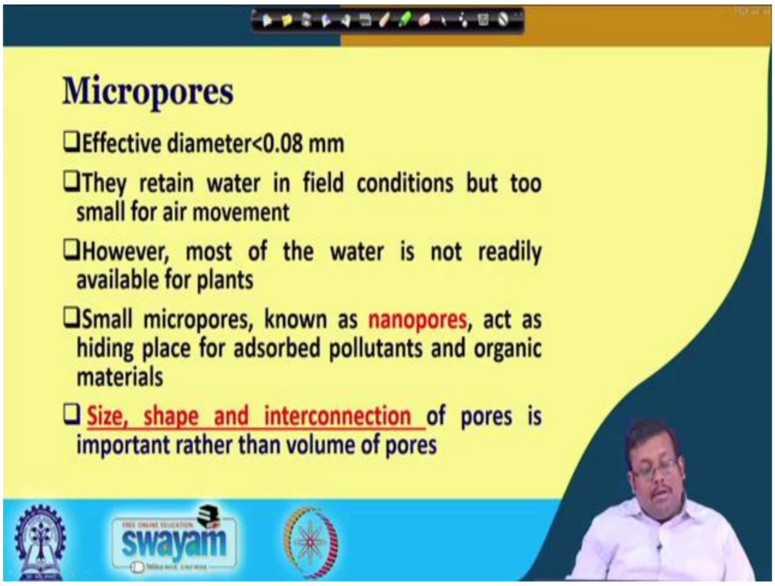

Micro pores effective diameter is less than 0.08 millimeter and they retain water in filled condition, but too small for air movement; however, most of the water is not readily available to the plant. Remember that that is why in case of clay soil all though they can hold more water holding capacity is quit high, but the water supply capacity is not optimum in case of clay soils.

So, these water are not available not readily available for the plants. Small micro pores known as nano pores acts as a hiding place for adsorbed pollutants and organic materials. So, size shape and interconnection of pores are important rather than the volume of the pores.

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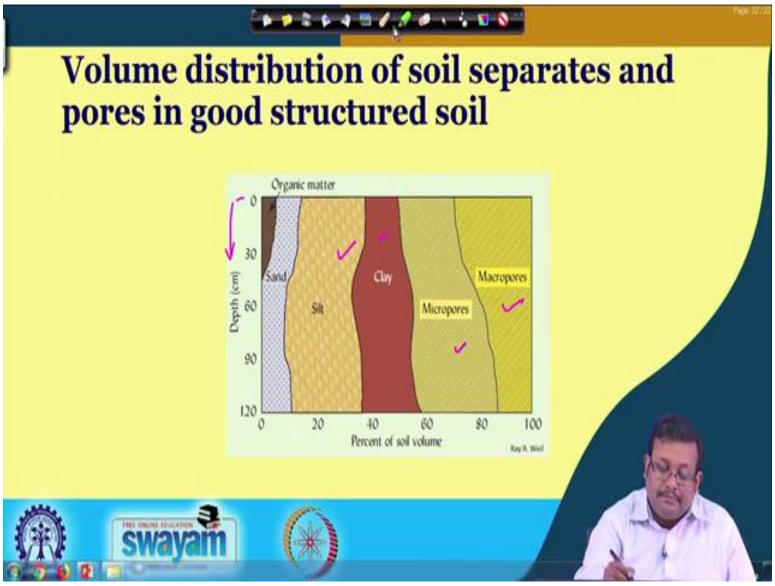

So, if you see the volume distribution of soil aggregates and pores in good structured soil you can see that; obviously, the organic matter percentage will go down as we go from surface soil to subsurface soil; obviously, the organic matter percentage will go down. The sand percentage will remain more or less same; the silt percentage will almost remain more or less same, the clay we will generally increase as you go down.

You can see there is a stark increase of micro pores as we are going down from the surface soil and vice versa for the macro pores; macro pores are going to decrease as we are going down to the soil profile. So, again as you are going down into the soil profile; the micro pores will increase and macro pores will decrease and also the organic matter will decrease.

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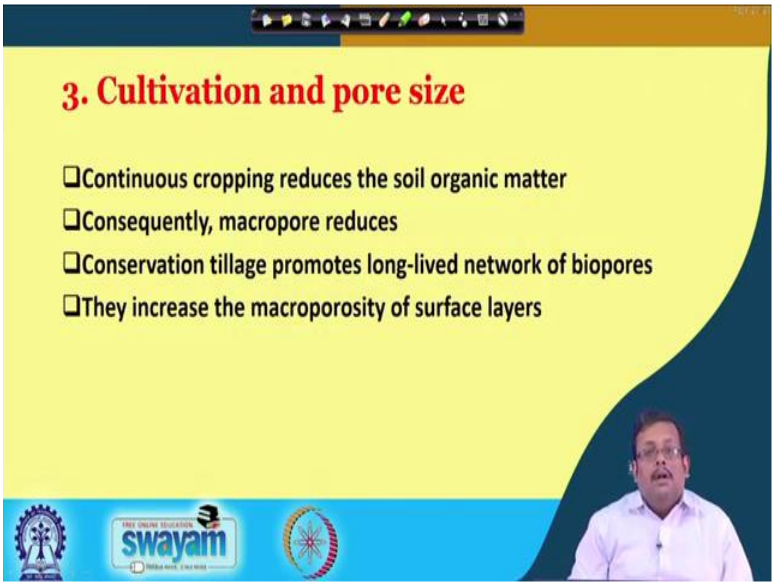

Another important aspect is cultivation and pore size; so, continuous cropping reduces the soil organic matter. So, also as a result of continuous cropping the macro pores reduces. So, we need to practice conservation tillage; this conservation tillage promotes long lived network of biopores and they increases the macro porosity of the surface layer; so, which is important for the growth of the plant.

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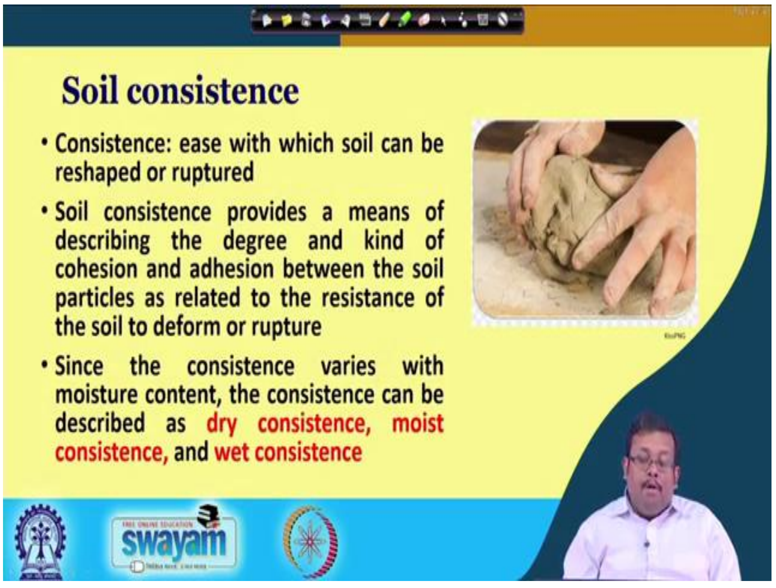

Now, let us see another important aspect physical property of soil that is called soil consistence. Now by soil consistent we mean that the ease with which the soil can be reshaped or rupture. As we can see we are molding the soil we can mold the soil through in different shape. So, soil consistent basically is defined as the ease with which the soil can be reshaped or ruptured.

So, soil consistence provides a mean of describing the degree and kind of cohesion and adhesion between the soil particles as related to the resistance to their soil to deform and rupture. Obviously, by soil consistence it is a manifestation of adhesive and cohesive properties of soil. You know the adhesion occurs between the similar cohesion occurs between the similar molecules whereas, adhesion occurs in different molecules.

So, these adhesion and cohesion manifestation basically occurs through the soil consistence. And since the consistence varies with the moisture content; the consistence can be described as either dry consistence or moist consistence and wet consistence. We will discuss all of them in details later on.

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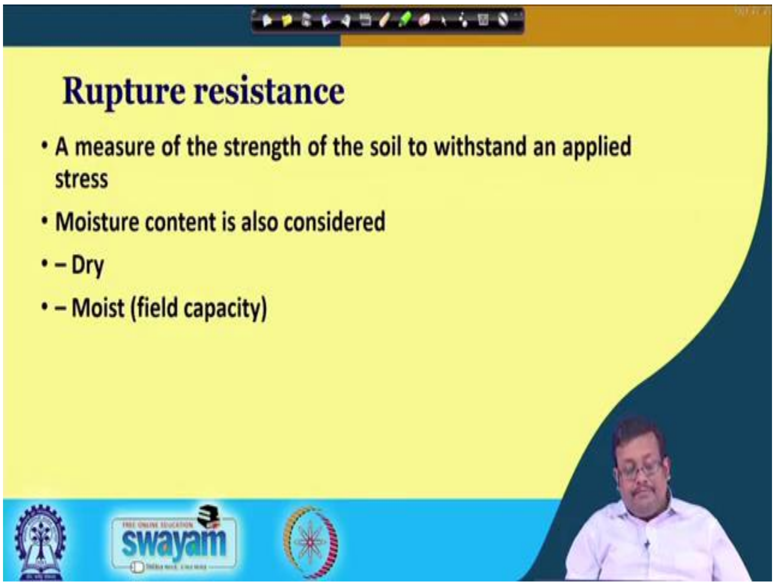

What is rupture resistance? So, rupture resistance basically is the measure of the strength of the soil to withstand an applied stress. And moisture content is also considered as you know that we generally consider moisture content two types of moisture content one is dry another is moist moisture content which is generally a filled capacity. So, rupture resistance is the important aspect for soil consistence.

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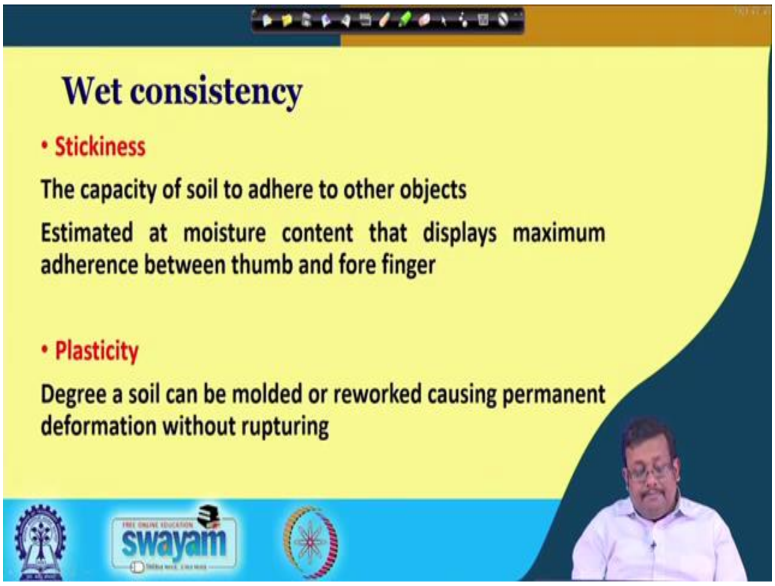

So, let us see wet consistency; we will be focusing more or wet consistency we will not discuss in details dry consistency; if you are interested you can see some literature for dry soil consistency, but let us focus on wet consistency.

So, wet consistency is basically expressed in terms of two parameters; one is stickiness another is plasticity. So, stickiness is basically the capacity of soil to adhere to other objects and it is estimated at moisture content that displays maximum adherence between the thumb and forefinger.

So, if you take the soil and between thumb and forefingers; we can measure the stickiness of the soil which is also express a degree of soil consistency. Another important is soil plasticity which is a degree of soil; degree a soil can be molded or reworked causing permanent deformation without rupturing. So, this is called soil plasticity or plastic nature of soil.

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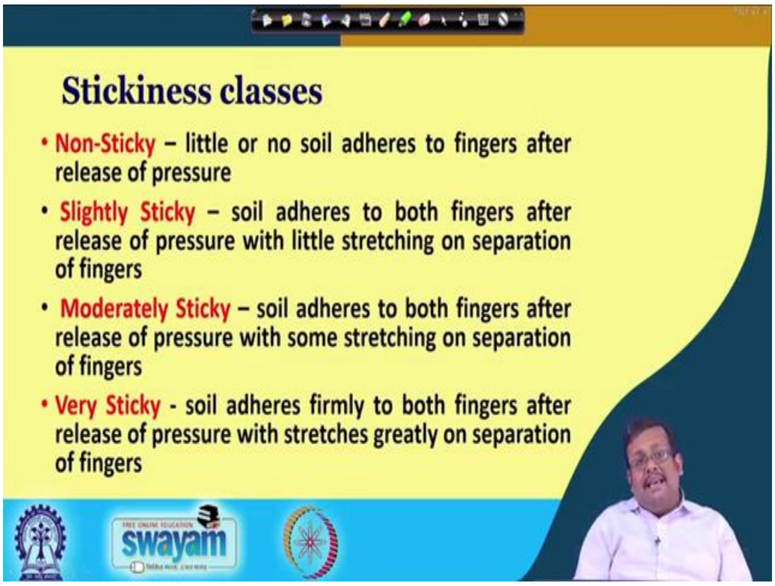

So, there are several sticky classes; stickiness classes you can see 4 difference stickiness classes; one is non sticky then slightly sticky then moderately sticky and very sticky. So, slightly sticky means little or no soil adheres to fingers after release of pressure.

In case of slightly sticking you will see soil adheres to both fingers after release of the pressure with little stretching or separation of the fingers. In case of moderately sticky you will see the soil adheres to both fingers after release of the pressure with some stretching on separation of the fingers. And very sticky a soil adheres formally to both fingers after release of pressure with stretches greatly on separation of the fingers. So, these are different stickiness class based on how they will stick in between thumb and forefingers.

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And; obviously, you can see in this picture the first one is non sticky the second one is slightly sticky and the third one is very sticky. So, let us wrap up here and in the next lecture we will start from soil plasticity and different Atterberg limits and all other important aspects for measuring soil consistency.

Thank you very much.