Soil Science and Technology
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Lecture – 11
Soil Tillage and Soil Density

Welcome friends to this new lecture of Soil Science and Technology and today, will be starting a new topic that is Soil Tillage and Soil Density and then, we will go ahead with other topics. So, in this today's topic, we will start with first Soil Tillage; then, we will discuss about different types of Tillages and you know; what is conventional tillage; what is conservation tillage; what are the benefits of conservation tillage and you know soil crusting and so on and so forth.

So, let us start today's topic that is Soil Tillage and Soil Density. So, let us start with first soil tillage.

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So, what you actually you know what we actually mean by tillage? The term tillage is basically you know is the preparation of soil for planting and the cultivation of soil after the planting. So, you can see in this picture that this tractor is tiling the soil and you know there are different types of tillages which we will learn in a couple of minutes. And so, tillage is basically the preparation of soil from planting and it is basically helps in providing a favorable soil physical condition for growth and germination of the plant.

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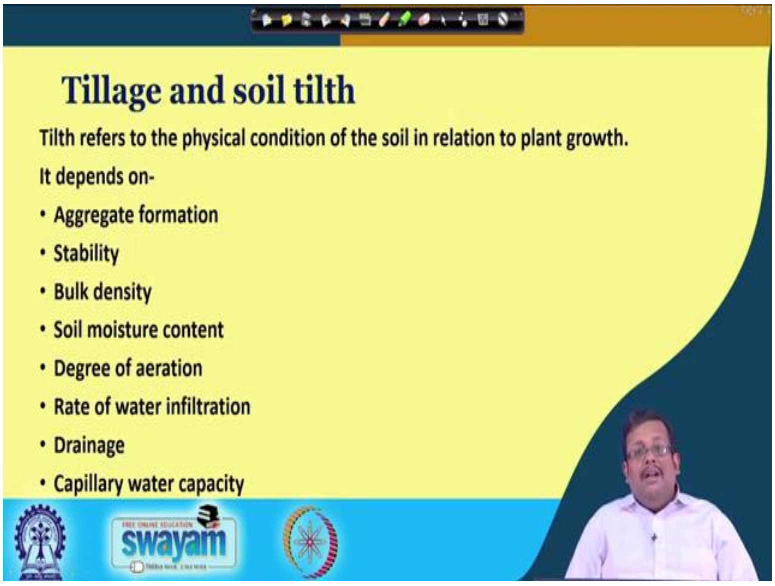

So, let us see what is soil tilth? Tilth is basically the physical condition which occurs after the tillage. So, in other words tilth refers to the physical condition of the soil in relation to the plant growth. Now it basically a good tilth of a soil basically depends on aggregate formation and then, its stability, then bulk density, then soil moisture content and degree of aeration, rate of water infiltration drainage and capillary water capacity and all these things. So, tillage is a term which shows basically the preparation of soil to provide a favorable physical condition for plant growth and germination, germination and plant growth. Whereas, tilth is the physical condition which achieve due to tillage.

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So, let us see what is the first kind of tillage. Now, first kind of tillage is basically conventional tillage which is generally see which we generally see in Indian fields and basically in conventional tillage farmers use machines like plow or disc to turn over and losing the soil after harvest and this can leave the soil exposed to rain and wind and which can sometime lead to erosion of the topsoil that is needed to grow at crop you know needed for the growth of the crop.

Now, generally in case of conventional tillage, we generally use different types of implements, the different types of equipments for making the soil more loose and or in other words, to increase or to decrease the bulk density of the soil. So, that you know the, their favorable physical condition for the growth of the crop is maintained; there is more aeration and more air movement and water movement. So, these are the reason generally farmers go for conventional tillage. However, the conventional tillage has a limitation that it exposes the soil which is subjected to different types of wind and water erosion.

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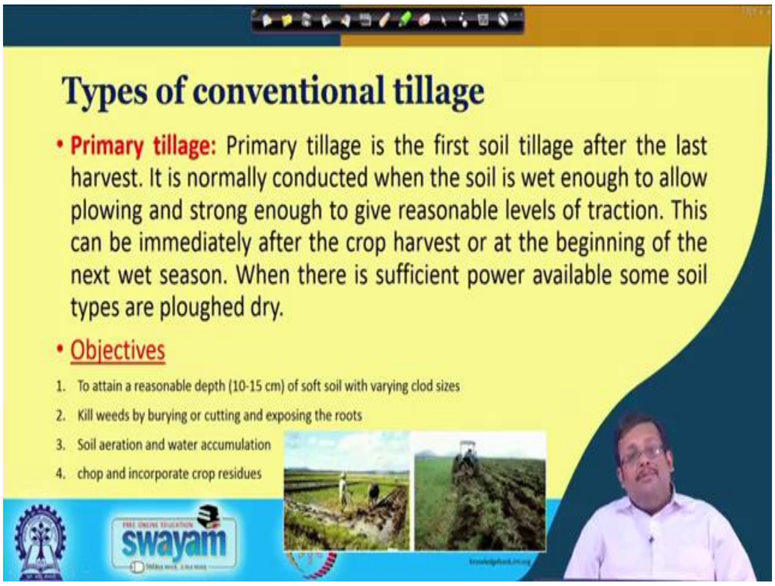

So, what are the different types of conventional tillage? Now the first type of conventional tillage is called Primary tillage and Primary tillage is a first soil tillage after the last harvest and it is normally conducted when the soil is weight enough to allow plowing and strong enough to give reasonable level of traction.

Remember that this type of primary this primary tillage is basically done after the last harvest and it is normally conducted when the soil is you know wet enough to allow plowing and the strong enough to give reasonable level of traction and this can be immediately this can of the you know this primary tillage can occur immediately after the crop harvest or at the beginning of the next crop season.

And when there is insufficient power available, some soil types are ploughed in dry condition also. As you can see here I have given 2 pictures we have to you know the farmers are tilling the soil and this is a this is an example of primary tillage. Remember that primary tillage always done after the harvest of the previous crop or just beginning of that, but the beginning of the next wet season.

So, what are the objectives of primary tillage? This is a primary tillage objectives are there are 4 major objective. First of all to attain a reasonable depth that is 10 to 15 centimeter, we call it furrow slice of soft soil with varying clod sizes.

Now, you know reasonable depth you know to attain a reasonable, you know for the germination of a crop and for their proper growth, we need to maintain a good soil favorable condition or good soil physical condition up to 0 to 15 centimeter depth because that is you know that is the depth up to which most of the plants roots for most of the field crops grow. So, the first objective is to attain a reasonable depth of soft soil with varying clod size.

The second and one of the major objective of primary tillage is to kill the weeds by burying or cutting and exposing the roots. Third one is the Soil aeration and water accumulation and finally, to chop and incorporate crop residue. So, these are couple of the, these are couple of objectives of Primary tillage.

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And you know there is another type of tillage called Secondary tillage. Remember that secondary tillage is any working completed after primary tillage and you know there are couple of objectives for doing the secondary tillage. There are 5 objectives for doing the secondary tillage. One is the as you can see here one is reduction of clod size. Then, Weed control; then, Incorporation of the fertilizer; then, Puddling and Leveling of soil surface. Now, we know that in the primary tillage, we reduce you know we breakdown the clods and further in the secondary tillage, we try to reduce the clod size.

The secondary tillage also helps in weed control. Secondary tillage helps in incorporation of fertilizer. We will discuss that later when will discuss the fertilizers. Puddling is an important secondary tillage operation for rice crop and also leveling the soil surface because when we are reducing the clod size it is becoming more smooth. So, you can in this picture that this is example. This is an example of secondary tillage.

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Now, regarding puddling, you know you must have seen this paddling quite a lot time in the rice field. Because you know we generally do the puddling operation in the rice field in the standing water, in the presence of standing water and we are further breaking down the clods due to secondary tillage and one of that major reason of doing the puddling is to make an impervious soil layer and due to the impervious soil layer, the water movement or water infiltration into the soil is nullified.

So, as a result the water accumulated the top of the soil which is required for the growth of the rise crop. So, this is called puddling and this is an example of secondary tillage operation.

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So; you have seen that there are you know there are different types of primary tillage and you know the there is some limitations of primary tillage because because of primary tillage soil become more subjected to erosion and so, in recent decades agricultural land management system has been developed that minimizes the need for soil tillage and leaves the soil surface largely covered by plant residues and thereby, maintaining several aspects. So, we call these new technique of soil tillage is as Conservation tillage.

Now, as a result of conservation tillage, you generally we maintain soil biological habitat and we stabilize a soil structure. We maintain for soil biological habitat, then we stabilized a soil structure. Then, you know we can conserve the soil organic matter and finally, physically protecting the soil from drying sun scouring wind and beating rain.

Now, as you know this conventional tillage requires minimum soil disturbance; obviously, the soil microorganisms and microorganisms can thrive better in the soil and stabilizing the soil structure, because we are leaving there plant residues not removing the plant residues, these decomposed and produces huge amount of organic matter and as you know from was soil structure lecture that these organic matter is helpful for producing the better soil structure and conserving soil organic matter, obviously we are not exposing the soils. And since we are not exposing the soil the it is not coming into direct contact with the sunlight and as a result, there will be reduced decomposition of organic matter and ultimately there will be conservation of organic matter.

And finally, physically protecting the soil from drying sun, scouring wind, and beating rain obviously, these are couple of you know limitations of primary tillage which can be addressed through conventional tillage. Now, according to the US department of agriculture or USDA, they defined conservation tillage as that tillage practice that leaves the at least 30 percent of the soil surface covered by residues. So, that is an important aspect. So, unless you know unless you leave the plant residues into the field after the harvest, you cannot tell you cannot you cannot term it as a conventionality as a conservation tillage.

So, it is an important aspects of conservation tillage. We have to maintain at least 30 percent of the soil surface covered by residues. So, that you can conserve both organic matter, you can produce the stabilized soil structure and you can produce the better habitat for soil biological organisms.

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So, now conservation tillage is basically a technique for planting seed that minimizes the disruption of the soil and therefore, helps prevent soil erosion. We have already discuss that in the last slide and remember that farmers use special equipments to plant series leaving most of the residues like stocks of the previous crop intact and planting in this way, allows the crop residue to break down which adds further organic matter like composting while protecting the soil from erosion. We have already covered that in the last slide.

So, basically well we are leaving the residues into the field, they decompose and further adds organic matter into the soil and also protect the soil structure and you know protect the soil from being eroded. So, these are some advantages of soil conservation tillage.

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Another important tillage operation for conservation tillage is called No till and basically in case of No till, one crop is planted in the residue of another with virtually No tillage. So, this is called No till condition as you can see in this picture, they are just planting the seeds in the residue of another. So, it is virtually no tillage is being done; it is called No till condition.

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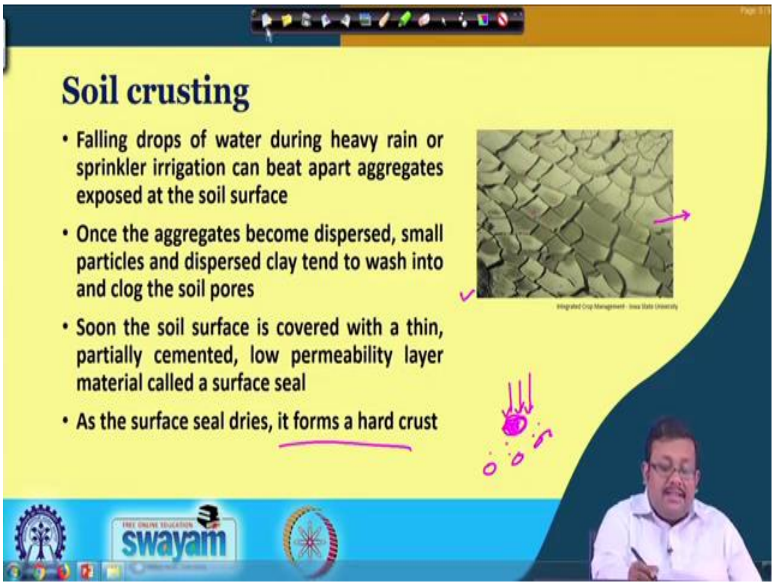

Another important unfavorable condition for soil is called Soil crusting. Now Soil crusting generally occurs due to falling you know due to the beating action of falling rain drops. Now you know that falling drops of water during heavy rain or sprinkler irrigation can break apart aggregates expose into the soil surface. So, if you think this is the soil particle due to the beating action of falling rainfall; these aggregates will further breaks down and it will produce the individual particles and these involves the aggregate became disperse. The small particles and dispersed clay tends to wash into and clog the pore space.

Once it clogs the soil pores, the soil surface is covered with a thin and partially cemented low permeable layer material called a Surface seal. Now, with the surface seal dries, it forms a hard crust. So, that is called soil crusting. You can see the soil you know the figure the picture of soil crusting I have presented here and you must have seen it a couple of times. So, this is an example of soil crusting and these soil crusts are basically occurred from clogging the pores, soil pores by very small particles like clay particles and thereby restricting the movement or the restricting the restricting the infiltration of the water into the soil.

So, this is an example. This is called the Soil crusting. So, what are the problems of Soil crusting?

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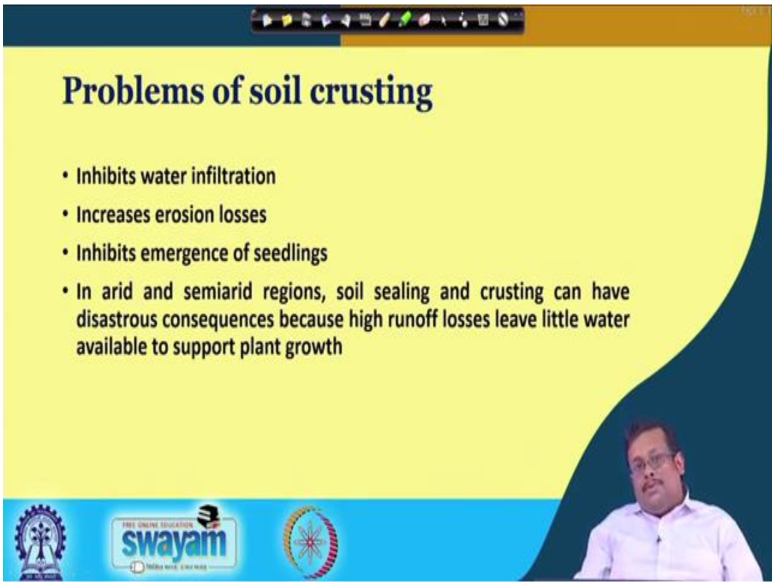

Why should we bother if there is a soil crusting? Obviously, because you know in if these there is a soil crusting it will inhibits soil water infiltration, it will increase the erosion losses and it will inhibits the emergence of the seedlings because the due to the soil crust and the hard surface the seedling cannot germinate and in special in arid and semi arid regions, soil sealing and crusting can have disastrous consequences because high run off losses leave little water available to support the plant growth. So, there are some you know problems which occur due to the soil crusting.

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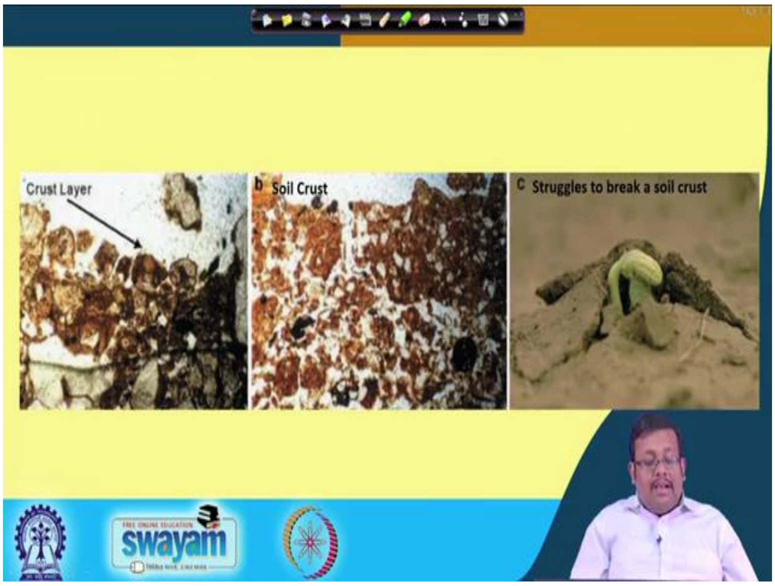

Now, you can see there are three pictures of soil crusting as you obviously, you can see that crust layer and finally, you can see in the last picture the seedling is struggling to break up a soil crust.

So, this is a problem for seed germination. So obviously, we should be very careful to avoid any type of soil crusting or if it occurs, we must break the soil crust using different types of management practices.

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So, what are the different managements you can you know management of soil crusting. So, for example, first keeping some vegetative or mulch cover on the land to reduce the impact of rain to rain drops. So, if you keep some vegetative or mulch; mulch is a protective layer which you know over the soil surface. So, if you can produce the protective layer over the soil surface obviously, it will reduce the impact on the beating raindrops.

And when a crust just formed, it may necessary to rescue a new a newly planted crop by breaking up the crust with light tillage and for light tillage, you can use a rotary hoe. You can see in this picture as you know this is an example this is an rotary hope and these rotary hoe you know breaks the soil crust and preferably when the soil is moist still moist. And obviously, it all the soil crusting can also be minimized using different types of soil conditioners.

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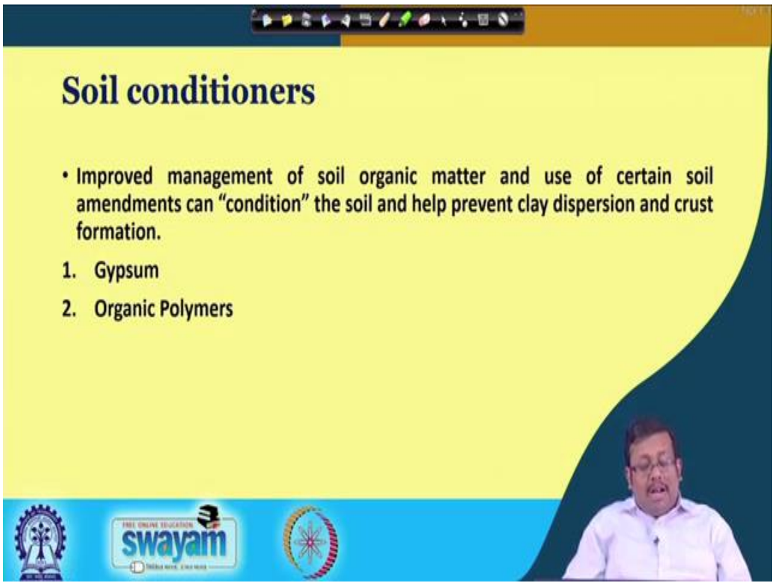

So, what is Soil conditioner? Soil conditioners are basically some chemical agents, which we generally add to the soil to improve its physical condition.

So, improved management of soil organic matter and use of certain soil amendments can condition the soil and help prevent clay dispersion and crust formation. Two important soil conditioners are Gypsum and Organic Polymers.

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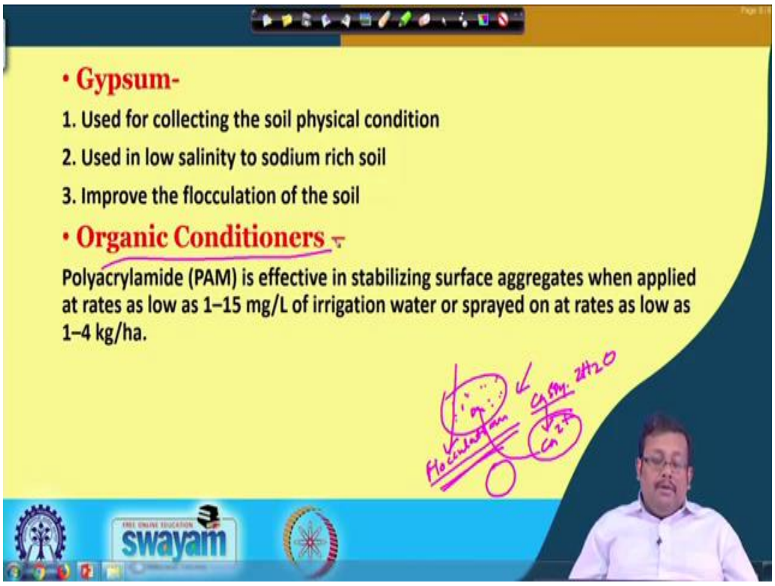

So, why Gypsum? Gypsum is basically used for correcting the soil physical condition, and used in low salinity to sodium rich soil and finally, it improves the flocculation of the soil. What do you mean by flocculation? So, if there are individual soil particles or individual clay particles by adding the gypsum, we are basically adding calcium sulphate 2 H 2 O.

And this calcium sulphate will generate calcium cations. These calcium cation will help in aggregation of these individual soil particles together to form an aggregate and ultimately, it will settle down. So, this is called Flocculation condition. This is called Flocculation and flocculation occurs due to aggregate formation and this calcium which comes from gypsum basically helps in the flocculation condition. And remember that when there is a flocculation obviously, the structures has stabilized and the porosity favorable pores will be, you know favorable condition will be maintained porosity will be maintained for proper movement of air and water for the growth of the crop.

So, these are important aspects another type of organic conditioners are Polyacrylamide or PAM which is basically effective in stabilized surface aggregates when applied as rates as low as 1 to 15 milligram per liter of irrigation water or spread at rates as low as 1 to 4 kg per hectare. So, when we apply these organic conditions; these also helps in producing better stabilized soil structure. And as a result of stabilized soil structure obviously, the porosity will be maintained and as a result better air movement and water movement will be ensured. So, these are you know some soil conditioners. So, let us see.

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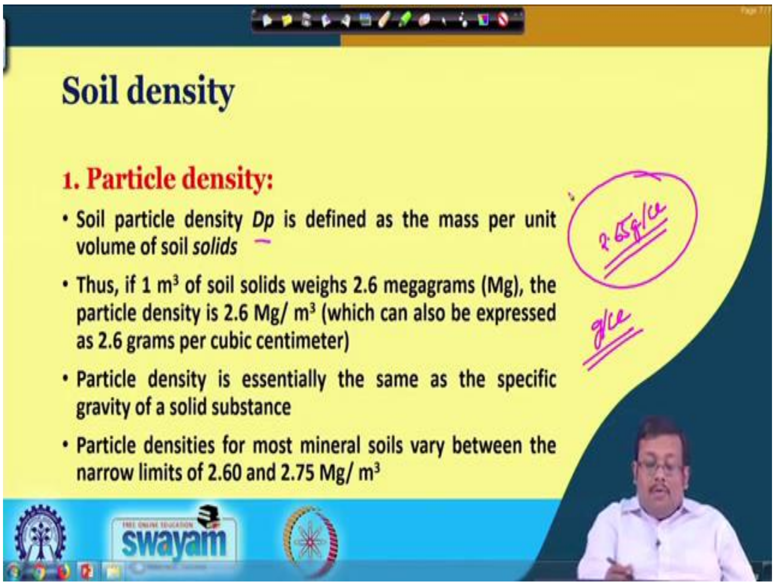

So, we have covered the soil tillage part; different types of tillages and then we you know conventional tillage, conservation tillage, primary tillage, secondary tillage; their objectives, their problems and we also cover the soil crusting. So, let us start another important aspect that is Soil density. Now, there are 2 types of density we generally talk when we are talking about soil. The first one is called Particle density and the second one is called the Bulk density.

So, let us start with the Particle density. So, particle density or generally we termed it as Dp is defined as the mass per unit volume of soil solid. So, if a 1 cubic meter of soil solid weight 2.6 mega grams or one you know 2.6 tones, the particle density is 2.6 mega gram per cubic meter which can also be express at 2.6 gram per cubic centimeter. Generally, we express this soil density in grams per cc. So, 2.6 mega grams or 2.6 tones per cubic meter is equivalent to 2.6 grams per cc. So, particle density remember that it is essentially the same as the specific gravity of a solid substances and particle density is for most mineral soil vary between the narrow limits of 2.60 to 2.75 mega gram per cubic meter.

Generally, for the sake of simplicity we generally consider an average value of 2.65 grams per cc as the soil particle density.

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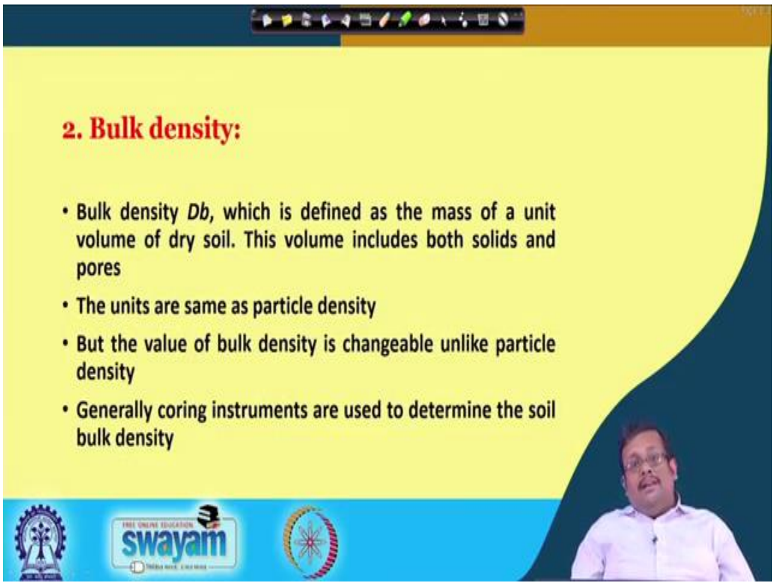

So, another important density is Bulk density and we generally term soil bulk density as Db which is defined as the mass of a unit volume of a dry soil and these volumes includes both solids and pores. As you know that soil contains both solids and pores, so when you are talking about bulk density, we are measuring we are considering the volume of both solids and pores. So, this is the difference between the bulk density and particle density.

In case of particle density we are only considering the volume of solid particles; however, in case of bulk density we are considering the bulk volume that is the volume of solid plus volume of pores. So, the units are same as particle density. Generally we term generally we expressed in terms of grams per cc, but the value of bulk density is changeable like particle density and the generally coring instrument are used to determine the soil bulk density.

So, let us see how we generally measure soil bulk density? Now another important thing I just mentioned that value of bulk density can be changed. However, particle density is more or less constant. So, we will see some examples later on.

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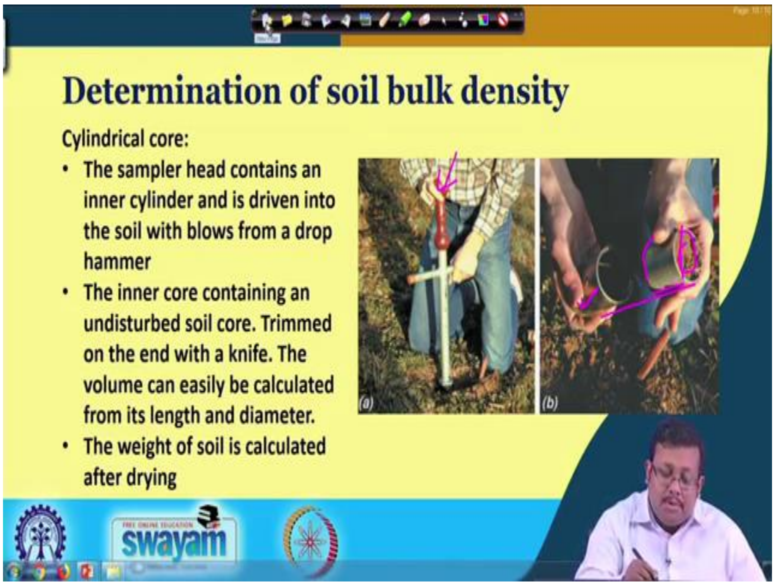

So, how we determine soil bulk density? Generally, we use some cylindrical core for determining the soil bulk density and as you can see this is the cylindrical core I have shown here it some pictures, this is the cylindrical core and which has got a fixed volume. So, the sampler head contains an inner cylinder. This is the inner cylinder and which is basically driven into the soil by blows from the top of the hammer. So, we generally gives blows from the top with a help of a hammer and the inner core contains an undistributed soil core.

So, the inner core contains an undistributed soil core and generally, we trimmed on the edge of the knife. So, after we take out the soil, we generally cream the edge of the soil and the volume can easily, can be calculated from the length of the diameter. So, we know its length; we know its diameter. So, from that we can easily calculate its volume and obviously, the weight of the soil can be calculated after drying it at 105 degree centigrade for 24 hours. So, this is how we calculate the soil bulk density.

So, calculation formula of soil bulk density, I have discuss in the next slide. So, let us see.

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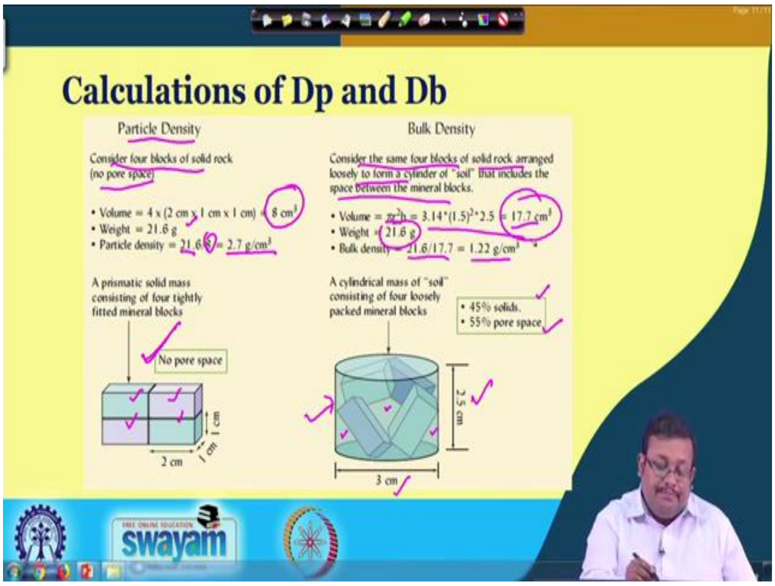

So, let us first consider a particle density. So, if you consider 4 blocks of solid rocks, where there is no pore space; obviously, the total volume will be 4 multiplied by 2 centimeter into 1 centimeter 1 centimeter. So, the total volume should be 8 cubic centimeters. However, the cumulative weight for all the 4 blocks is 21.6 gram. So, particle density is basically the total weight by the volume of solid.

So, it gives us 2.7 grams per cubic centimeter. So, this is particle density. Now obviously, it is a prismatic solid mass consist of 4 tightly fitted mineral blocks where there is no pore space; it is a important. Now, in case of bulk density, consider the same

4 blocks of solid rock arranged loosely to form a cylinder of soil. So, you can see this is a cylinder of soil and in the cylinder of a soil, all these 4 blocks are arrange together so that it includes the space between the mineral blocks also. So, you can see, these are the space between the mineral blocks.

So, the total volume of the cylindrical soil is basically pi r square h. So, you can calculate is the ultimately 17.7 cubic centimeter and weight is same, obviously, 21.6 gram because pore space does not contain any weight. Obviously, bulk density is 1.22 gram per cc. So, you can see this cylindrical pore there will be 45 percent solid and 55 percent of pore space and as you know this 2.5 centimeter there length and 3 centimeter diameter as we can see from the last slide, the we know that cylindrical core length and diameter.

So, we can easily calculate this. So, once we calculate this, we just have to calculate the weight of the soil and from there we can calculate the bulk density. Obviously, you know in this case, it is a dry bulk density because we are drying the soil. We are taking the weight of a dry soil.

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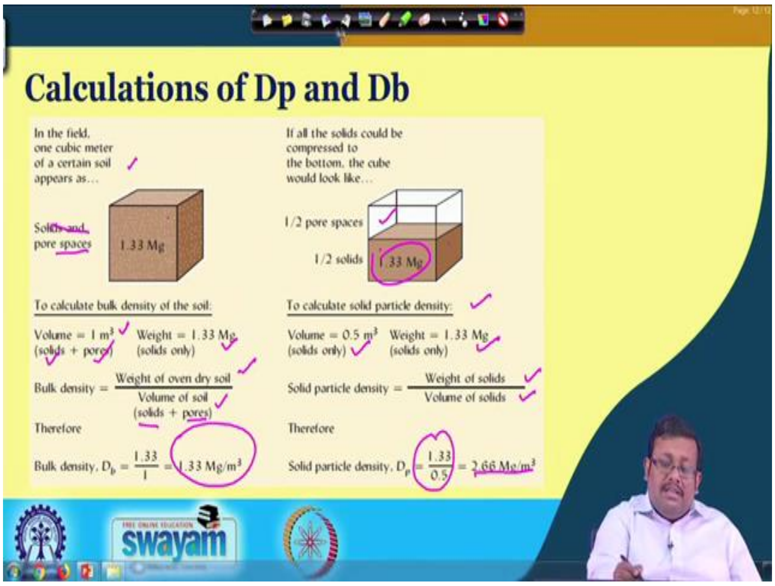

So, here also you can see in the field 1 cubic meter of a certain soil appear as 1.33 mega grams or tones solids and pore space.

So, in the field 1 cubic meter of certain soil appeared as 1.33 mega grams. So, to calculate the bulk density of the soil, you see volume is basically 1 cubic meter which contains both solid and pores because this contains some pores also. Weight is 1.33 mega grams bulk density weight of oven dry soil and volume of soil that is contain solid plus pores. So, therefore, bulk density we are getting 1.33 by 1 that is 1.33 mega grams per cubic meter. So, if all the solids could be compressed to the bottom the cube would look like this.

So, you can see we are compressing the soil, we are you know half of the pore space and half of the solids. So, solid will still contain still weigh 1.33 mega grams and to calculate the soil particle density we are getting volume; right now 0.5 cubic meter way is the same 1 point weight is the same 1.33 mega grams. So, soil particle density is weight of solids and volume of the solids. So, we are getting 2.66 mega grams per meter cube or 2.66 grams per cc.

So, I hope that now it is clear how we calculate soil particle density and soil bulk density and these are very much important. These are very much important soil physical parameters or physical properties which has different connotation with soil physicochemical conditions and favorable soil physiochemical condition. So, let us wrap up here and in the next lecture, we will start from the next slide.

Thank you very much.