Soil Science and Technology
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Lecture – 10
Soil Texture and Structure

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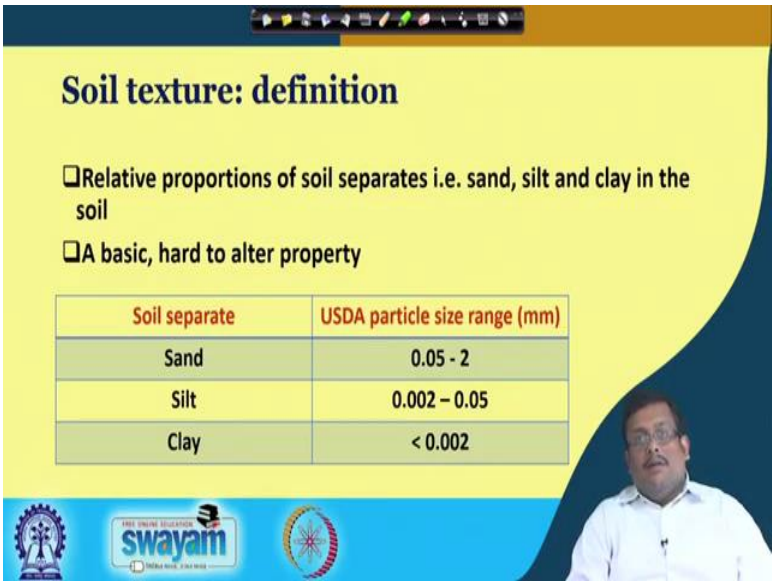

Welcome friends, to this new lecture of Soil Science and Technology and today, we will be discussing about soil texture and its classification. And, what is soil texture we will talk about its definition, what are the different types of you know soil textural classes, what is USDA soil textural triangle, how to use the texture triangle and then we will be also discussing about soil structure which is an very important soil property and what are the different types of soils of structure and what are the factors which affect soil structure and how we can manage soil structure.

So, in this lecture I will try to give you a basic overview of soil texture and structure. Now, obviously, if you want to you know if you want to go for a further refined you know more advanced we know this advanced studies of soil texture and structure you can obviously, consult any standard reference book or any standard books like The Nature and Properties of Soils written by Brady and Weil.

So, let us start with the soil texture. Now, you know that the definition of soil texture says it is a relative proportion of soil separates that is relative proportion of sand silt and clay in the soil. And remember that it is a basic and very hard to alter a property. So, this property is more or less it is constant and you cannot change this property.

Now, in the first lecture of soil I have already told you about there are three major soil separates in a soil which are basically sand silt and clay and as you know according to the USDA particle size range you know sand particles diameter of 0.05 to 2 millimeter, whereas silt contain 0.002 to 0.05 millimeter diameter whereas, in case of clay the diameter of the particle is always less than 0.002 millimeter.

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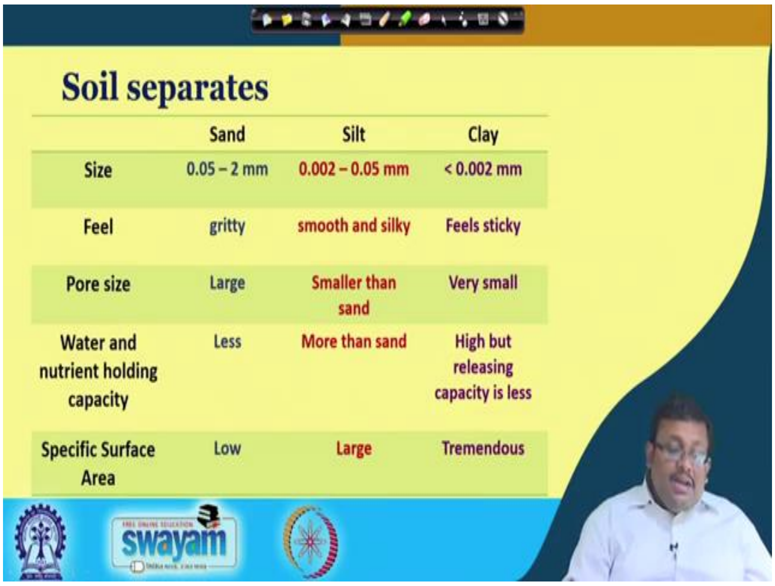

So, based on this classification and you know each of this soil separate has their own significant properties. Now, let us discuss what are that we know what are the intrinsic properties. So, in this table if you can see you know first as for the as per as size is concern we have already discussed it.

The second important point is feel. So, if you feel you know if you rub the soil which is you know if you rub the soil in between your thumb and finger, you will see that you know the sand will the sand will fill a very gritty and silt will feel like you know smooth and silky in nature and clay will be very very sticky in nature.

So, as per as the pore size is concern obviously, the sand particles the sandy soil mainly contains you know higher amount of you know larger pore space, we call the macro pores and you know in case of silty soil or in case of silt we will see that the pore size is smaller than that of sand. However, in case of clay the pore size is very very small. So, in other wards sand mainly contains macro pores where as clay mainly contains micro pores.

So, another important property based on this pore size is water and nutrient holding capacity. So, in case of sand the water and nutrient holding capacity is very very low in case of silt it is more than sand. However, in case of clay it is high, but releasing capacity is low because of huge amount of water holding capacity high amount of water holding capacity of clay the water cannot move freely within a clay soil. However, it can move freely with in a sandy soil, but it is holding capacity is very very less.

Another important property is the specific surface area. So, in case of sand obviously, the specific surface area is very low because of larger particle diameter and in case of silt it is large. However, in case of clay it is very very large or tremendous high specific surface area and we will discuss that you know very soon.

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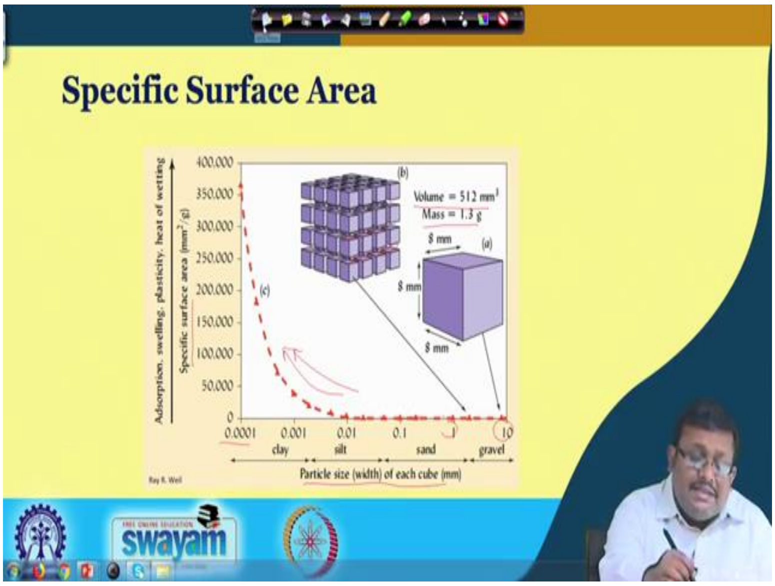

So, this slide shows basically the changes in specific surface area as we go from gravel to sand to silt and clay. Now, you can see from this you know in the x axis we are plotting the particle size or width of each cube if we are considering each soil particle as a cube and if you are going from gravel to sand to silt and clay your seeing that the particle size is reducing from 10 to 1 to 0.0001. So, we are starting from gravel when we are going towards the clay.

So, particle size is continuously going down. So, as a particle size continuously going down you will see that specific surface area which is measured in terms of square millimeter per gram is continuously increasing in this direction. So, obviously, for example, if we consider a volume if a sand particles with 8 millimeter or you know gravelly particle with 8 millimeter; 8 millimeter particle you know particle size then we will have a total volume of 512 cubic millimeter; however, if it is mass of 1.3 gram.

Now, once you break down this big cube into individual very small cube, ultimately you will see the total surface or specific surface area is increased because the internal surface area here will be also available. So, these will add up to the specific surface area and obviously, as you see that as you are going from higher particles to the lower particles I mean lower size particles there is a exponential almost exponential increased in specific surface area and obviously, as the specific surface area increases the adsorption, swelling, plasticity and heat of wetting all these increases.

So, that basically shows that once when we go from sand to silt to clay, obviously, their specific surface area increases and as a result of the increase in specific surface area the adsorption which is a surface phenomena and swelling plasticity and heat of wetting all this properties generally increases.

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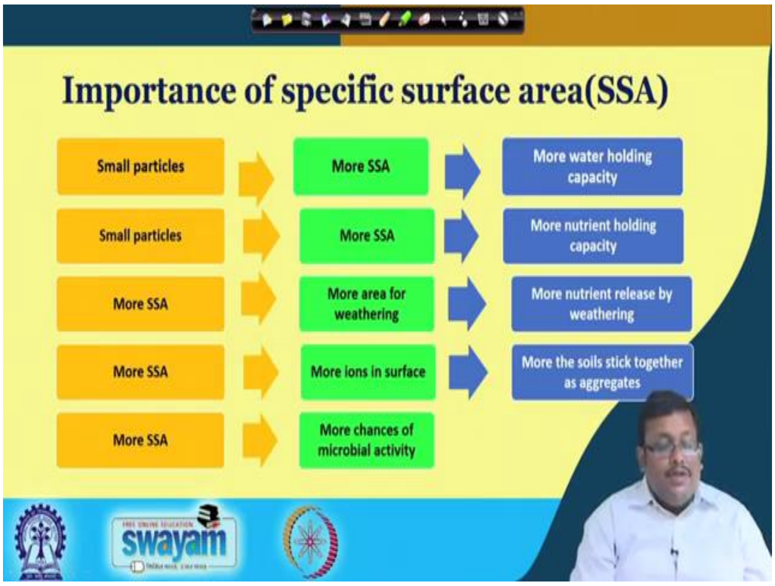

So, importance of specific surface area as you can see from this slide, that when there is a small particle; obviously, there will be more when there will be small particle there will be more specific surface area and when there will be more specific surface area there will be water holding capacity. In case of clay as a we have already discussed that it has got high water holding capacity and it is because of it has got high surface specific surface area because of small particle size.

Also due to the small particle size and due to the higher specific surface area you will see that more nutrient holding capacity as we can see generally in case of clayey soil. Also due to the higher specific surface area you will see that more area for weathering and; obviously, more nutrient released by the weathering.

So, this is another importance of specific surface area. Another importance of specific surface area that when that is a higher specific surface area, obviously, there will be more ions in surface and more the soil will stick together as an aggregate. So, this is the implication of specific surface area and more surface specific surface area will also helps in more chances of microbial activity. So, these slides basically show in a you know in a compressive way that importance of specific surface area and obviously, this changes in specific surface area is very much apparent when you go from you know sand to silt to clay particles.

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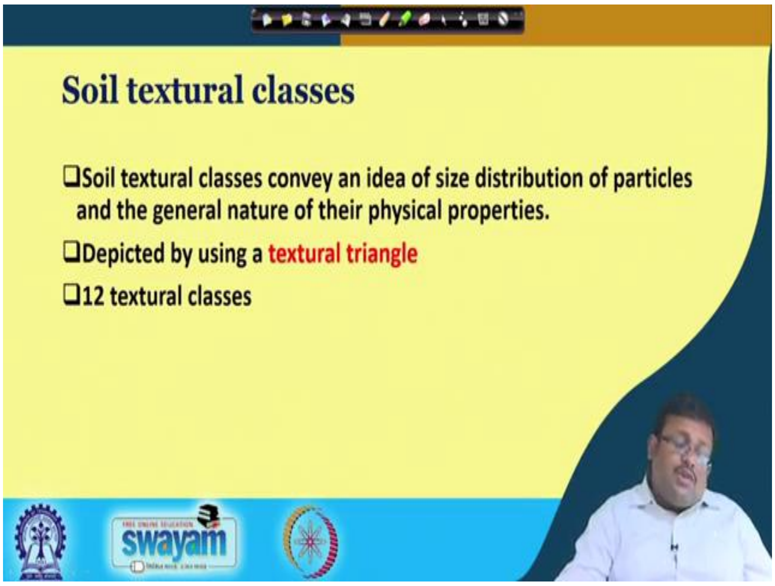

Now, soil textural classes. So, soil textural classes convey an idea of size distribution of particles and the general nature of their physical properties. So, based on the textural variation of the soil we have divided the soil into 12 textural classes and these 12 textural classes the depicted by using a textural triangle. So, let us see what is a textural triangle.

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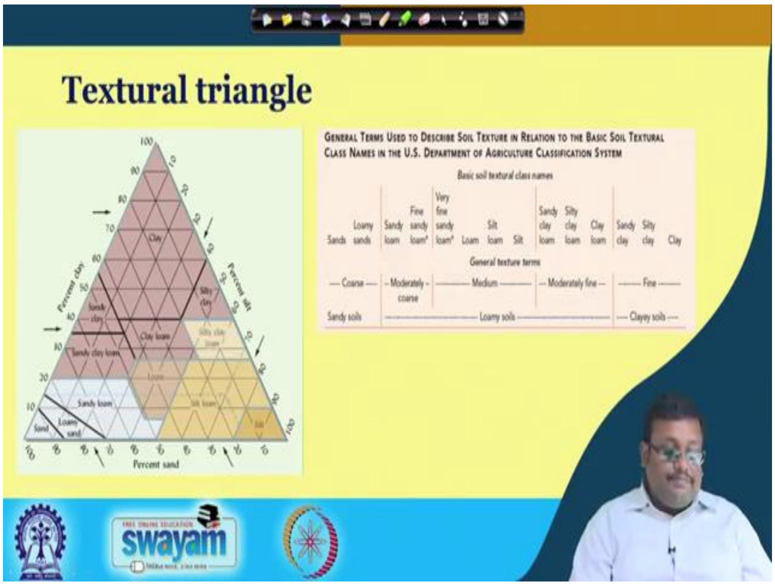

So, textural triangle as you can see this is a textural triangle we call it USDA textural triangle and in this textural triangle you can see there are 12 different textural classes. So, what are these textural classes as we can see? It is starts from clay it is it is starts from you know clay and also silty clay, silty clay loam, silt, silty loam, loam, clay loam, sandy clay, sandy clay loam, sandy loam, loamy sand and sand. And, as you can see in each of the sides of this textural triangle they you know the percent of silt is distributed in this side and percent sand is distributed in this side and percent of clay distributed in this side. So, starting from 0 to 100 percent and remember that all these percentage of sand silt and clay all adds up to 100 percent. So, if we know only two of them you can obviously, you know calculate the third one.

So, based on that also I mean there are general terms which we use for describing the soil texture in relation to the basic soil textural classes, as you can see here you know when the soil belongs to the sands and loamy sands we call them coarse texture soil, when they belong to the sandy loam and fine sandy loam we call them moderately coarse soil, when they belong to very fine sandy loam, loam to silty loam to silt we call them medium texture soils and when they vary from sandy clay loam sandy silty clay loam and clay loam we will call them moderately fine and fine are basically consist of sandy clay silty clay and clay.

So, based on the dominance of clay and sand obviously, we can separate the soils into coarse texture and fine texture soils. So, obviously, sandy soils are generally coarse texture in nature where as the clay soils are generally fine in nature.

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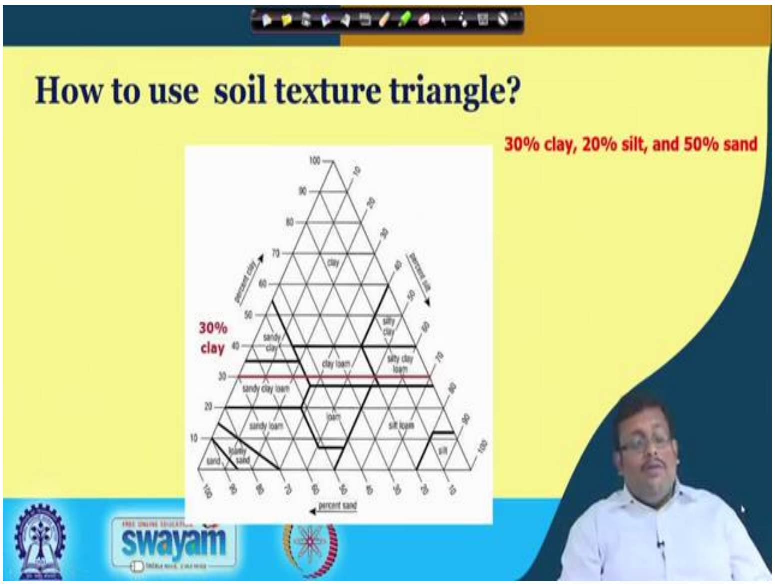

So, let us see how to use the soil textural triangle. So, let us consider an example where there is 30 percent clay, 20 percent silt and 50 percent sand. So, how to use the USDA soil textural triangle to measure or to determine in which textural class our soil belongs.

So, we will start from here. So, let us start with the percent silt. So, here we can get the percent silt know let us starts with the clay. So, there is 30 percent clay. So, we will start from here. So, 0 percent clay, 20 percent clay and 30 percent clay; so, at the 30 percent mark we will draw a parallel line as you can see here these a parallel line which is you know along with the percent sand side. So, this is the first step and in the second step we know there is 20 percent silt.

So, we will draw another parallel line to the clay axis to this is a blue you know green colour line you can see here and you can see both of them intersect at this point and if we go further and we know there are 50 percent of sand then we can draw another line which is parallel to the percent clay. So, you will see that all the three lines will intersect at this point and basically this point belongs to sandy clay loam. So, based on these we can define that our soil the given soil sample belongs to sandy clay loam soil texture. So, that is how we use generally soil textural triangle.

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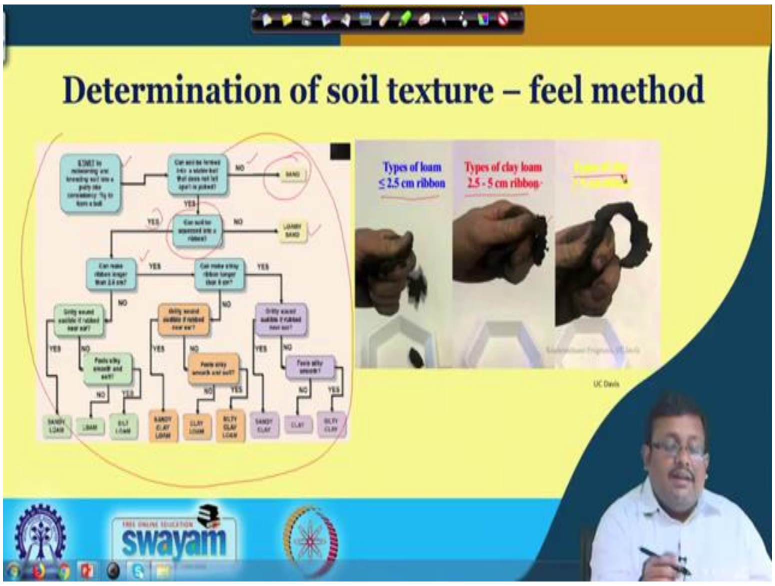

Now, how to use the soil texture how to feel or how to determine the soil texture? Well, there are a couple of ways to feel you know determine the soil texture. One of the you know one of the most a qualitative way is the feel method. So, basically the soil silty is generally go to the feel and take the soil in between the thumb and fingers and they just rub it and they just try to feel it by rubbing in between the fingers. So, and also try to form a try to mold them into different shapes. So, based on that they can say whether the soil belongs to a sandy, belongs to a silty soil or loamy soil or ultimately to a clayey soil or not.

So, there are some well defined criteria for classifying the soils in to different soil texture classes. As you can see here these shows basically, these basically shows the flowchart which generally we use for identifying the soil through feel method. So, these basically gives a very good idea about how to use the feel method for determining the soil texture.

For example, let us start by moistening and kneading the soil into putty like consistency and try to form a ball. So, this is our first step. So, the second steps is can the soil be formed into a stable ball that you know does not fall apart. So, if it is no if the answer is no; obviously, the soil belongs to sand class so, that means, the soil cannot be form into a ball. So, obviously, this is sand. If it is yes, they will go to this step. So, the second question will come can the soil squeezed in to a ribbon? If it is no, obviously, it will be loamy sand because due to the presence of sand the plasticity nature of the soil is very very low if it is then it will go to the further decision making question.

So, based on this flow chart you can literally differentiate different types of soil texture. For example, you can see here they are trying soil sand silt is trying to form a ribbon using a by kneading a soil and obviously, you can see the type of you know the length of the ribbon is always less than 2.5 centimeter. So, obviously, that belongs to loamy type of soil and there is when this ribbon size is 2.5 to 5 centimeter, the types of you know it belong it shows the types of clayey loam and when the size of the ribbon is greater than 5 centimeter it shows the type of clay.

So, based on this size of the ribbon or you know and these decision making criteria you can literally you know classify different soils into different soil textural classes.

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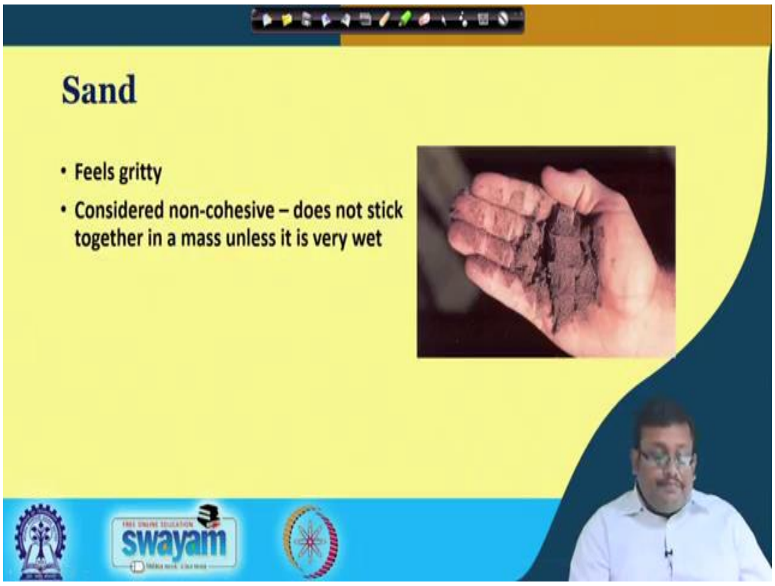

For example, in case of sand it will feel gritty and it will basically considered non cohesive because it does not stick together in a mass unless it is very wet.

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In case of silt, it does not feel gritty, but it is feel somewhat floury and smooth like silly putty in your hand when your rub it.

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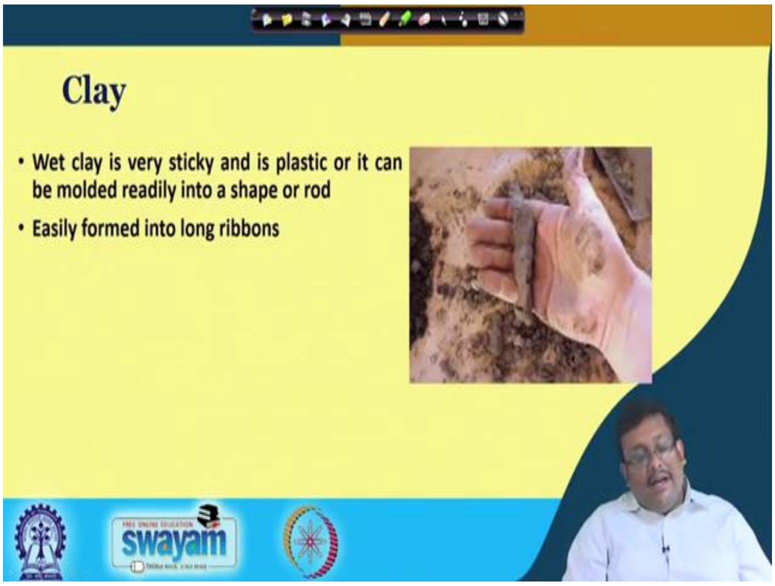

And finally, when in case of clay when it is very it is very sticky when it is wet, and also it is very much plastic or it can be molded into readily into a shape or rod. So, you know clay shows these type of characteristics and also you can use the clay for easily formed ribbons which you cannot do with in case of with sand and silt.

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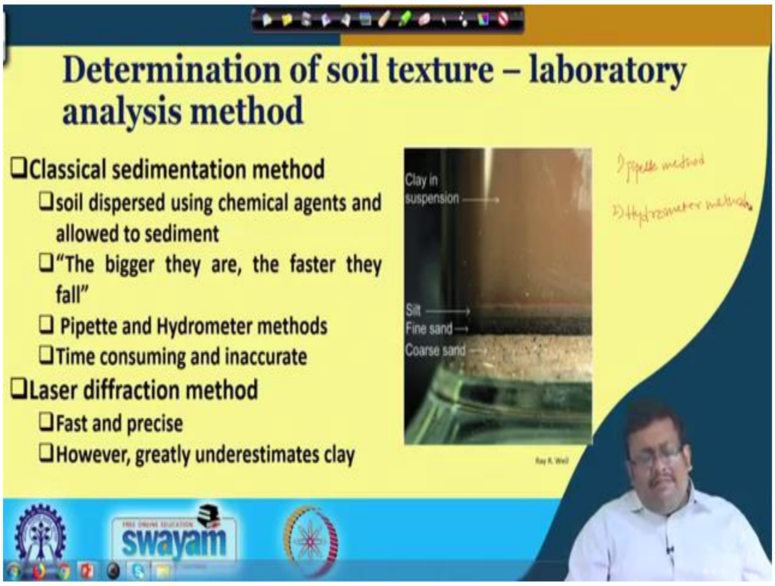

So, how we generally determine soil texture? Well, there are couple of ways we generally determine soil texture in the lab. All these are quantitative in nature and the classical sedimentation method is basically used in the lab and generally we have divided that classical sedimentation method into two major methods: one is called pipette method and the second is hydrometer method.

So, both the both of these are based on the sedimentation principle and based on the Stokes' Law; we will discuss the Stokes' Law in the next slide. Remember that the soil dispersed using chemical agents and allowed to basically to sediment and you know to settle down and obviously, in the particle settle down based on the principle that the bigger they are the faster they fall. And, obviously, you know these two methods are very much time consuming methods and very much laborious methods also.

So, nowadays soil scientist at you know are measuring the laser diffraction measuring the soil particle size or soil texture using laser diffraction method and we call is laser diffraction particle size analyzer. It is very much fast and precise but sometimes it underestimates clay. So, that is one of the drawback of these laser diffraction particle size analyzer

Now, obviously, in this picture as you can see that based on this principle of sedimentation obviously, if we disperse the total soil using some dispersing agent obviously, at first the coarse sand will settle down followed by fine silt and obviously, clay will remain in the solution. So, based on their diameter or based on their size they will settle down and this is the principle which is used for pipette and hydrometer methods.

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And, this is a picture of LDPSA which is more precise and this is the laser diffraction particle size analyzer and it is a very much costly instrument also.

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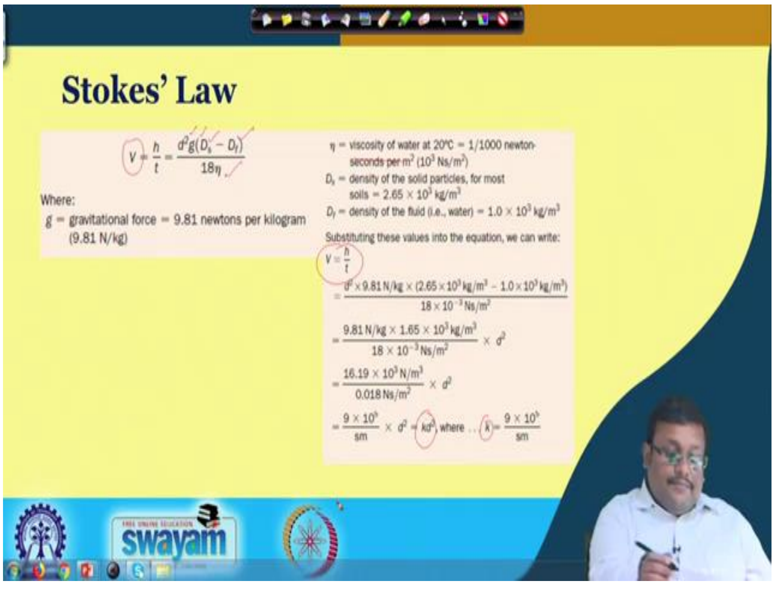

So, let us discuss about the stokes law now Stokes' law basically says the settling velocity of an particle in a liquid and if we denote the settling velocity by V it is basically proportionate to the diameter of the effective diameter of the particle and gravitational force which is denoted by g and the difference between the density of the solid particles and density of the fluid and it is inversely proportional to the viscosity or thickness of the fluid.

So, here D is basically the effective diameter of this particle of the of the particle and g basically shows the gravitational force which is 9.81 Newton per kilogram and eta is basically viscosity of water which is you know measured in terms of 1000 Newton seconds per square meter and D s is the basically density of solid particles for most of the soil which is 2.65 mega gram per per cubic meter and density of fluid is 1 mega gram per cubic meter. And, substituting these values into equation we can write this is V equal to h by t, where h is the distance and t is the time and obviously, when you simplify will get it we will get to this kd square, where k is a constant.

So, in other words this settling velocity of any particle through a liquid is proportional to its diameter, when there will be hydrometer obviously, in case of sandy soil sand particles obviously, they will settle more faster than that of clay particle. So, based on this Stokes law this hydrometer and pipette method were developed and both were used for quantitative estimation of soil texture, we also call it particle size analysis.

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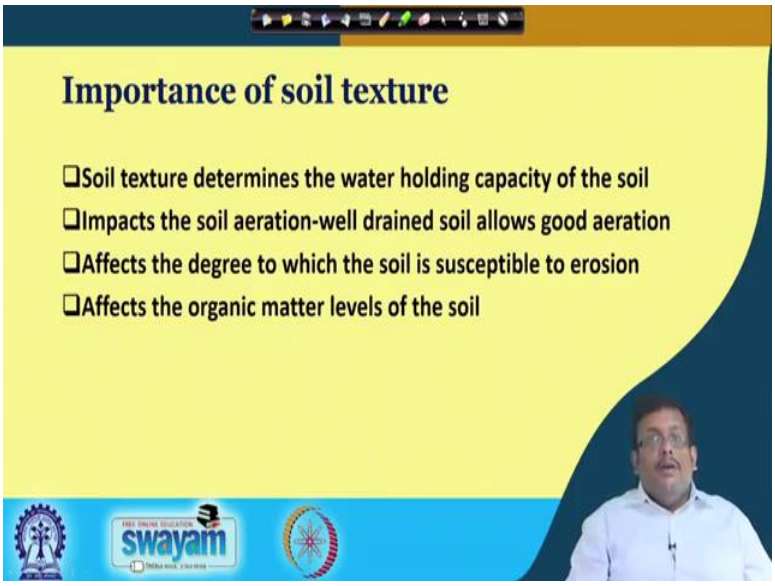

So, what is the importance of soil texture by the way? The soil texture basically determines the water holding capacity of the soil and it impacts the soil erosion.

Remember that, well drained soil allows good aeration and sandy soil will allow good aeration whereas clay soil will not allow good aeration. I mean sometime because the macro pores because the macro pores which are present in the case of sandy soils, they allow good aeration.

And, it also affects the degree to which the soil is susceptible to erosion obviously, sandy soil will be much more susceptible to erosion than clayey soil and it also affects the organic matter levels in the soil. Generally we have seen that there is a you know coexistence between high amount of clay and organic matter in most of the soils. So, that means, the soil texture also determines the organic matter levels in the soil sometimes.

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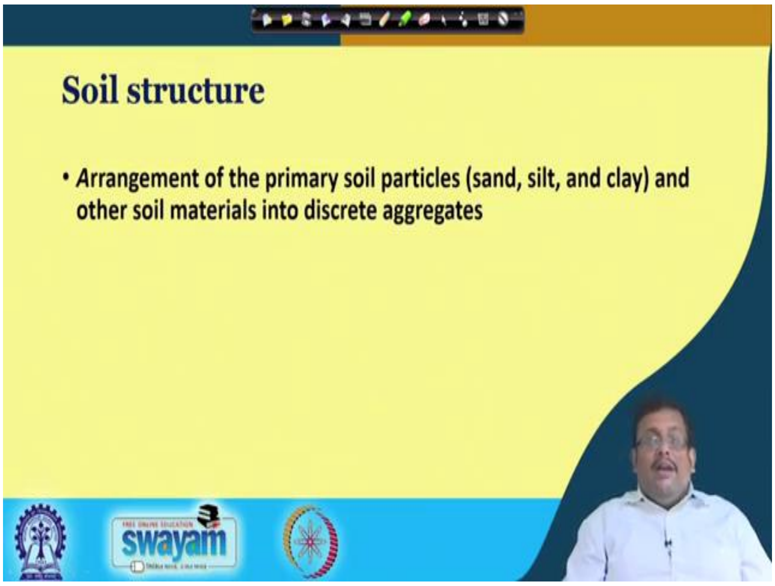

Now, let us start with the soil type structure. So, what is soil structure? Soil structure is another important property which basically is the arrangement of the primary soil particles or sand silt and clay and other soil materials into discrete aggregates.

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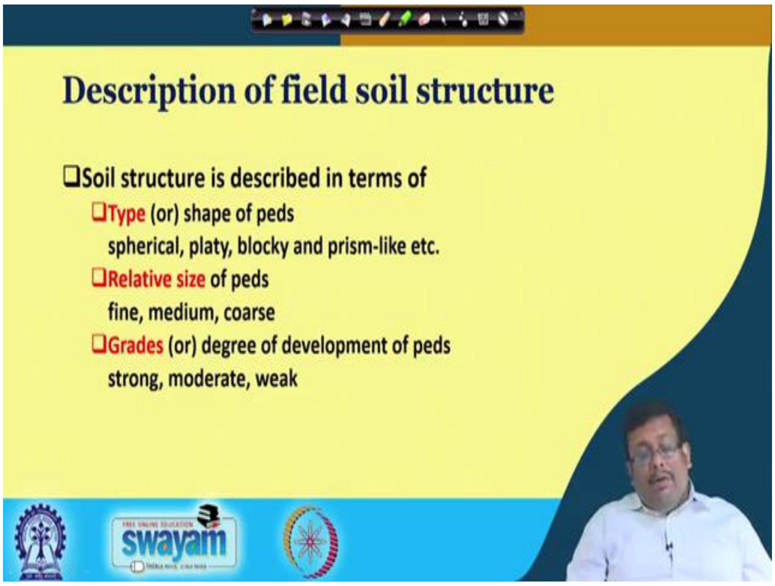

And, soil structure you know can be differentiated you know described in terms of either type either relative size or peds or grades. So, type or shape of the peds type basically shows the shape of the peds; what is ped we will discuss later on and also relative size of the peds we call it class and grades and relative class or relative size or class of peds is basically divided into fine, medium or coarse and grades or degree of development of peds which are basically strong, moderate and weak.

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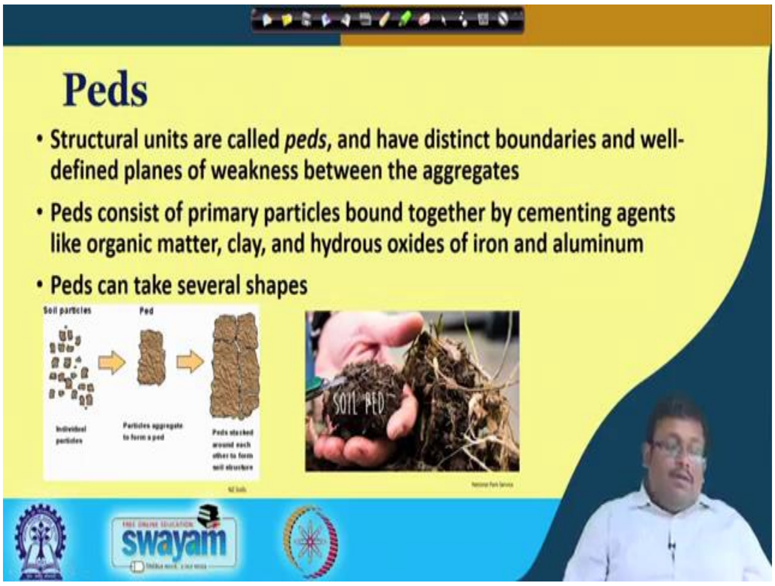

So, let us discuss what are peds? So, peds are the structural units and which have distinct boundaries and well defined planes of weakness between the aggregates and as you can see that peds consists of primary particles remember and they are bound together by different cementing agents like organic matter like clay and hydrous oxides of iron aluminium and also peds can take several shapes.

So, if you see here in this first picture you can see if the individual particles there is sand, silt and clay they stick together and aggregate together to form a ped which is an aggregated which is an aggregate and also peds you know stacked around each other to form a total soil structure. And, this is an actual picture of soil ped.

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Now, what are the different shapes of the peds? So, types of soil structure is basically depends on the shapes of different peds. So, ped shapes are differentiated into granular and crumb and we collectively called them spheroidal structure, and blocky structure, prismatic structure, columnar, platy, single-grained and massive. So, let us see one them one by one.

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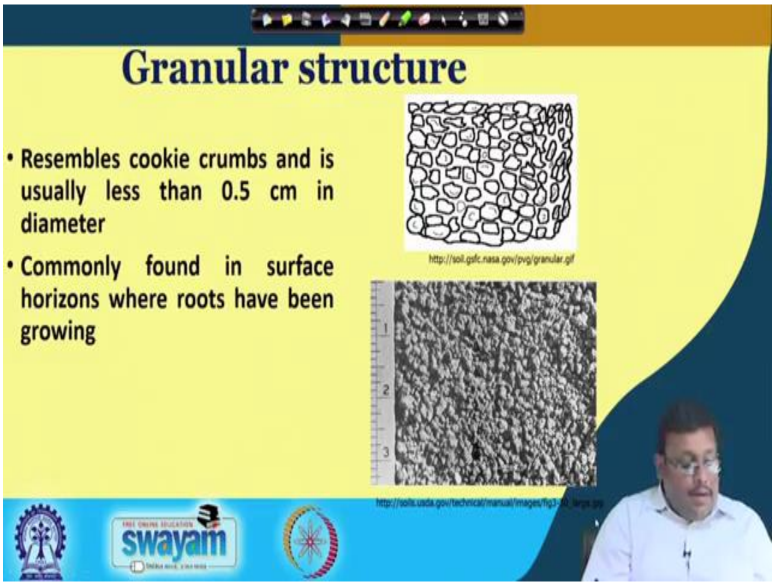

Let us start with the granular structure. Remember that the granular structure resembles with the cookie crumbs and it is usually less than 0.5 centimeter in diameter as you can see in this pictures and these granular structure are commonly found in surface horizons where roots have been growing. So, this type of structure is very much we know they are very much favorable for growth of the plant because they can we know they allow the easy water movement and air and water movement.

There is another structure called crumb structure and crumb structure is a granular structure with more porosity. So, obviously, granular structure has their you know high porosity, but crumb structure is another type of granular structure which as more porous. So, you know both of them or you know both of them are termed as spheroidal structure and both these structures are very much you know helpful for plant growth.

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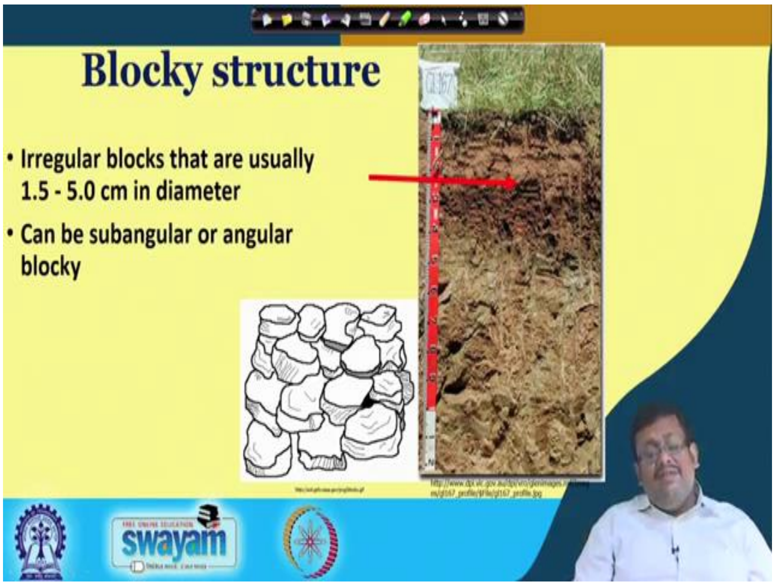

The another structure is called blocky structure and blocky structured basically consist of irregular blocks that are usually 1.5 to 5 centimeter in diameter and it can be differentiated into angular blocky or subangular blocky based on the angle of different sides or different planes.

So, as you can see here in this shows the blocky structure you can easily see here this is a blocky structure and obviously, this blocky structure are differentiated you know you know as I have told you that blocky structure can be also differentiated into angular blocky and subangular blocky.

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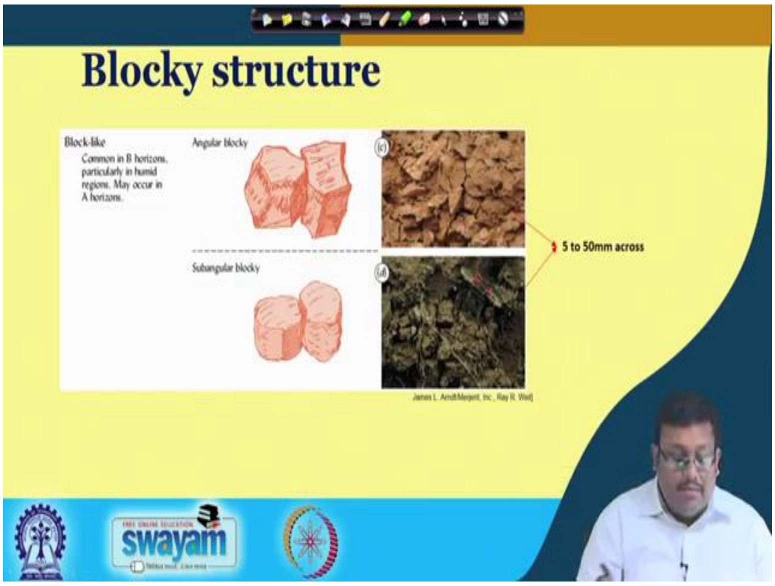

As you can see here the angular blocky are more you know plain. However, in case of subangular blocky the plains are generally curved or not plain I would say.

So, blocky structure are generally of two types.

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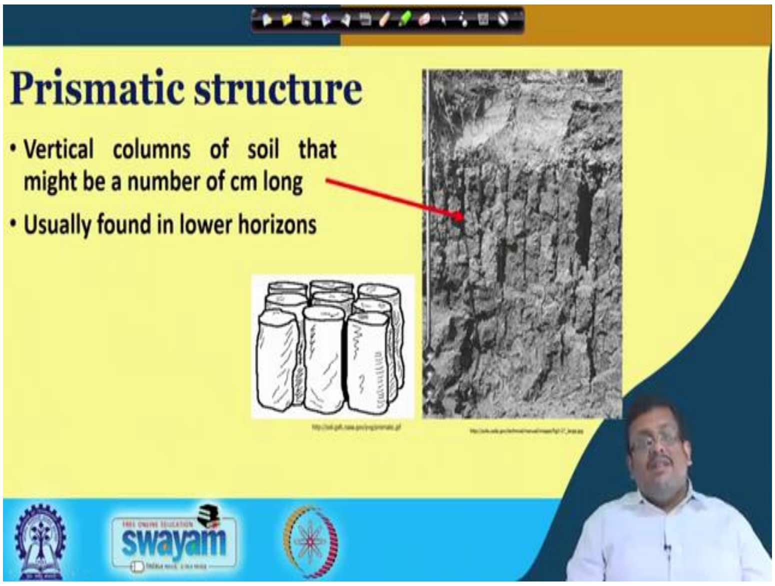

So, let us see what are the other structure. Another unstructured is called prismatic structure as you can see, it is a prismatic like and prism shape and it is these are basically vertical columns of soils that might you know might be a number of centimeter in length.

And, they are generally used you know found in lower horizons of soil as you can see a these are prismatic structures.

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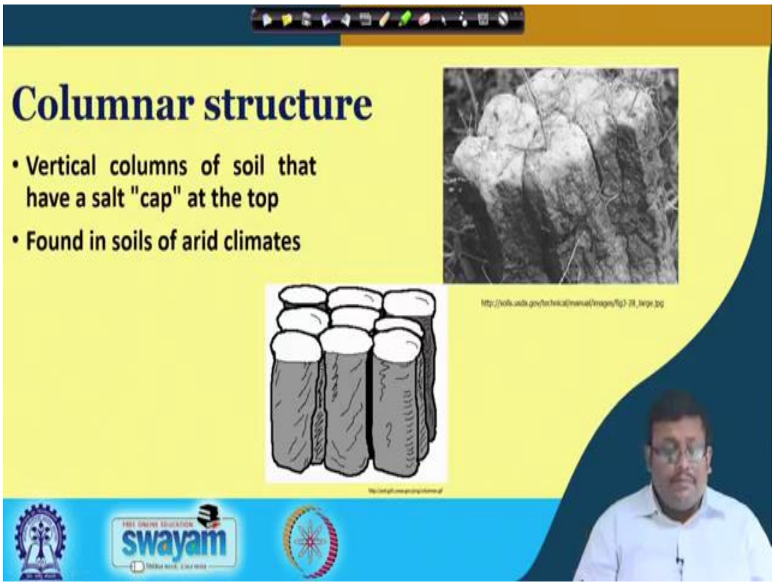

Another structure name is columnar structure and columnar structure are you know the vertical columns of soil that have a salt cap at the top and this columnar structure you can found you know you can see in arid climates.

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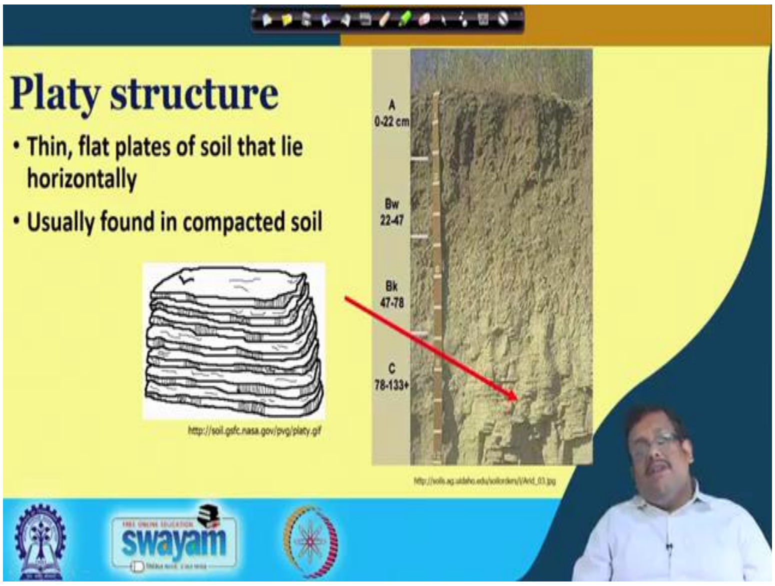

Platy structure: platy structure is basically composed of thin and flat plates of soil that lies basically horizontally as you can see and usually found in compacted soil. Generally due to the heavy machinery operation over the soil surface this type of structure generally occurs and this type of structures are not very much favorable for the growth of the plant because it restricts the water and air movement.

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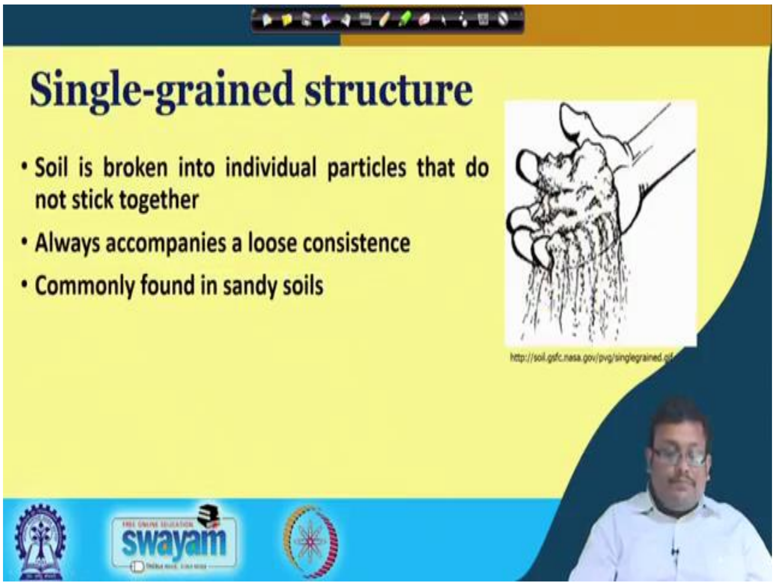

Another type of structure is called single grained structure where the soil is broken into individual particles that do not stick together and obviously, you remember that always accompanies a loose consistency. As you can see in this picture and you can see this type of structure in sandy soil.

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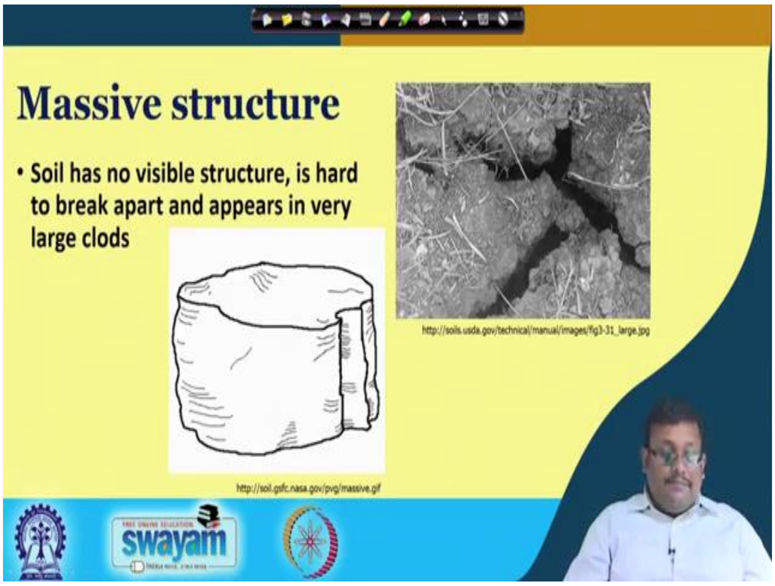

Another structure is called massive structure now massive structure has no visible structure and it is hard to break apart and appears in a very large clods. As you can see the clods are formed and this type of structure you can basically see in a rice field due to the paddling and subsequent drying of the soils. So, this massive structure also does not have any clear plains and we know they are not well defined actually.

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So, we have completed the types of soil structure; now let us see class of soil structure. Obviously, the class of soil structure depends on the size of the peds and they are differentiated into fine, medium and coarse.

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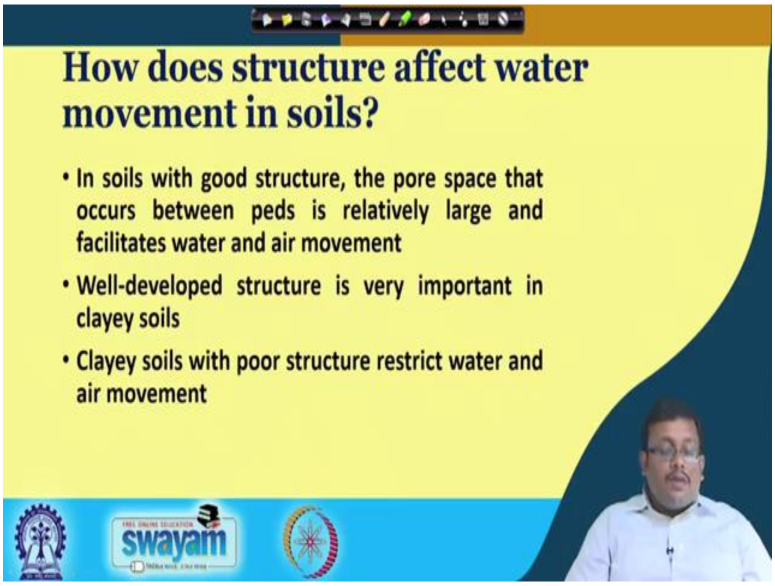

Now, obviously, the question comes that how does structure affects water movement into the soil. Well, in soils with good structure the pore space that occurs between peds are relatively large and facilitates water and air movement. However, well developed structure is very important in clayey soils because clayey soils with poor structure restricts water and air movements.

So, it is always required to improve the structure of clayey soils and we can do that by different methods different management practices; one of them is addition of organic matter.

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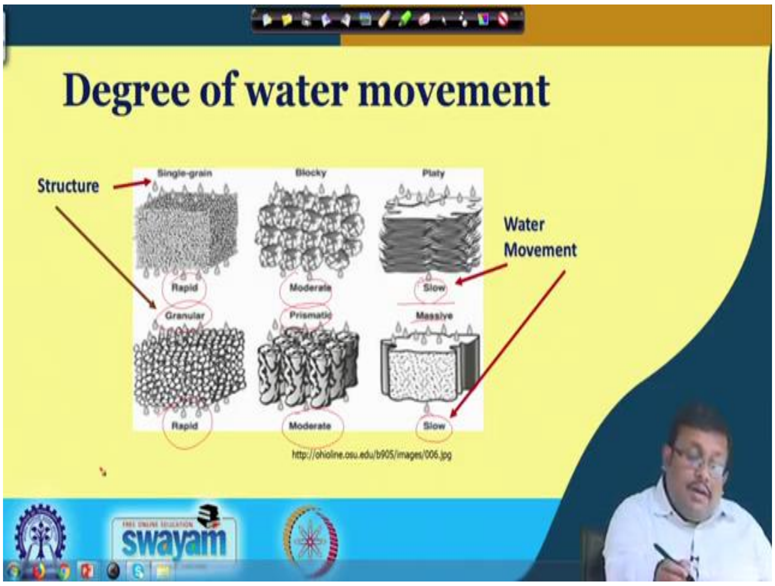

Another important aspect of soil structure is degree of water movement. As you can see here I have shown here six different types of structures starting from single-grain, blocky, platy, granular, prismatic and massive. And, as you can see you know this single you know the water movements how it varies from one structure to another structure.

Obviously in case of platy structure; obviously, in case of platy structure due to the platy and compact nature water movement will be very much slow. And, in case of blocky structure it will be moderate and in case of single grain it will be rapid in nature and also in case of massive soil structure, it will be very much slow generally we found it in rice soils prismatic structure I mean it will be moderate flow you will see moderate flow and granular structure which is very much helpful for plan growth you will see rapid movement of water.

So, as you can see based on the soil structural classes also you can you know the water movement varies significantly.

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So, can we alter the soil structure? Is it possible? Well, unlike the soil texture structure can be altered by tillage. As I have already told you texture cannot be altered, however, structure can be altered by tillage. And, tilling soils that are too wet or compacting soils with heavy equipment can break down the natural structural units and we will discuss that effects when we will be discussing about tillages. And, remember that soil texture can be obviously, soil texture can be obviously, change by implementing different types of management practices and one of them is incorporating huge amount of organic matter. So, altering of soil structure is possible.

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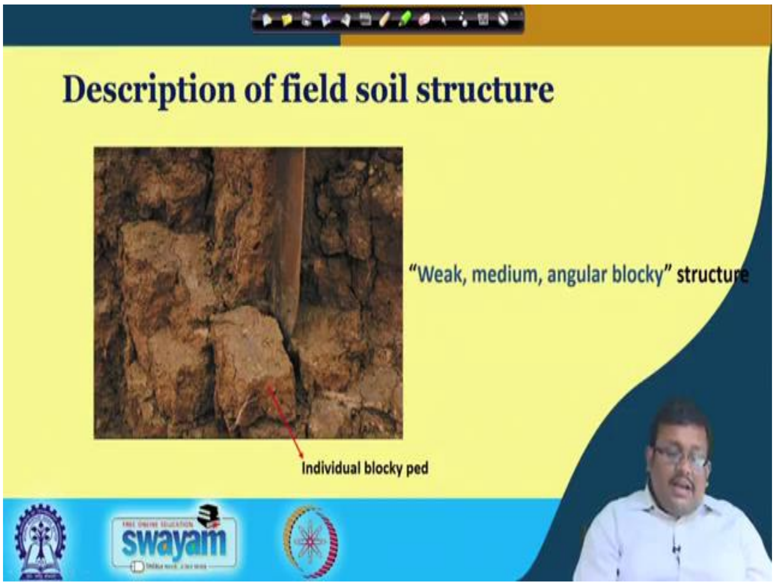

Now, let us see some description of field soil field soil structure as you can see here these are individual blocky ped and this is an example of weak medium angular blocky. So, it shows a combination of both type class and grades of soil structure while defining a soil structure.

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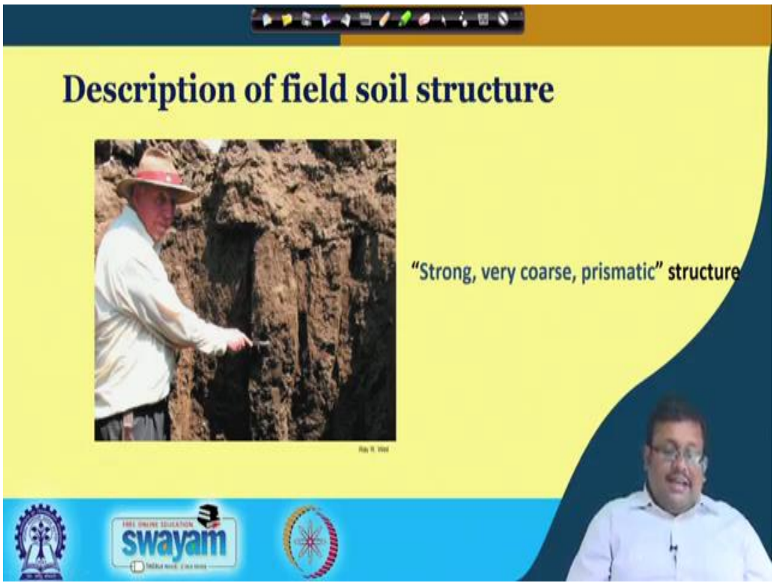

Then it is a strong very coarse and prismatic structure.

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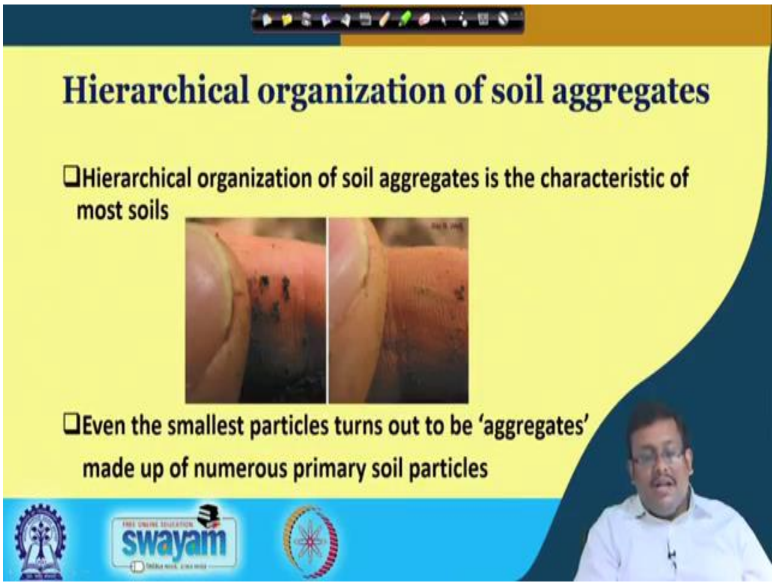

Remember that hierarchical organization of soil aggregates is very important and it is the characteristics of most of the soils because even the smallest particle turns out to be aggregate made up of numerous primary soil particles.

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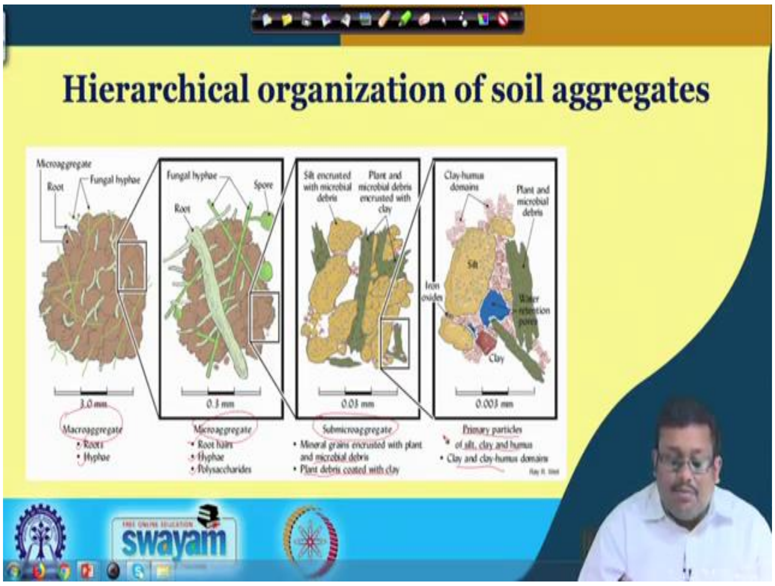

As you can see from here the smallest particle turns out to be the aggregate made up of numerous particle primary soil particles and these slide shows how primary soil particles aggregate together to form a soil structure.

So, we start generally with primary particles like sand silt and clay humus. So, these primary particles formed the sub micro aggregate by plane by adding by the cementing action of plant debris coated with clay and also different microbial aggregates. Sothe soil is encrusted with microbial debris and plant and microbial debris. In the third step it will for micro aggregate and in the micro aggregate you will see both root hairs, hyphae and polysaccharides which are acting as cementing agents and finally, you will see macro aggregates. The micro aggregates will form the macro aggregates by interconnection of roots and hyphae.

So, you can see from primary particles to macro aggregate different types of binding agents are responsible and you know that shows how these primary soil particles show hierarchical organization to form a macro aggregate.

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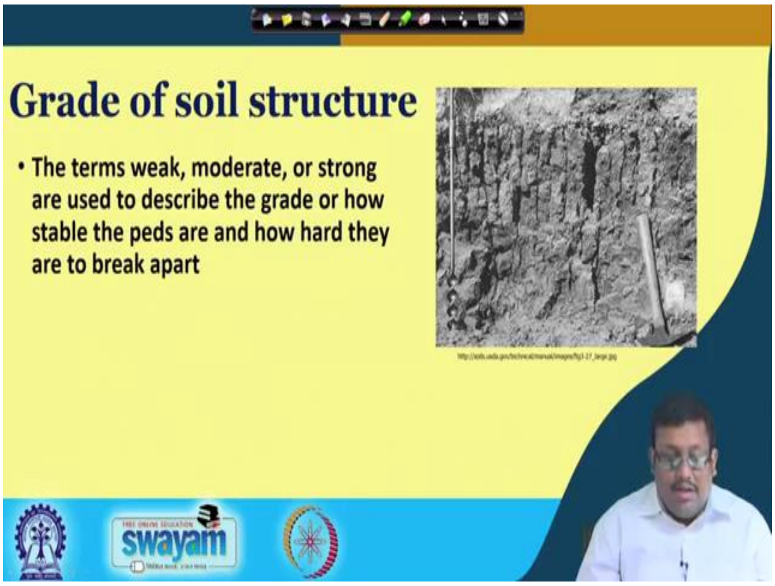

Grades of soil structure; obviously, the terms weak, moderate and strong are used to describe the grades or how stable the peds are and how hard they are able to be break apart. So, based on this we can differentiate the, we can term what is the grade of soil structure.

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So, it is my final slide. So, summarily we can say that texture is basically the size of brick used if you are making a house. The texture is basically the size of brick used and structure is basically the arrangement of bricks or the house represents a soil structure, then hallways, doorways and windows in the house represent associated pores and channels. So, soil texture and structure thus very very important soil physical properties.

Thank you.