Pavement Materials
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Lecture 04
Consistency Limits and Classification of Soils Part-1

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Hello everyone, today we are going to talk about the consistency limits and classification of soils. If you remember in the last lecture, we have completed our discussion on the particle size distribution of the soils including coarse grained soil as well as fine grained soil.

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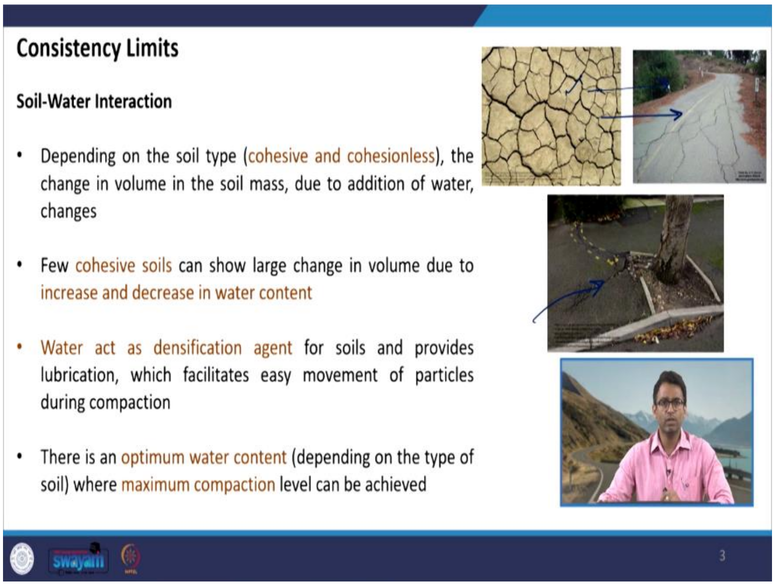

To understand the consistency limits, we have to understand first the relationship or the interaction between soil and water. Depending on the type of soil now, by now we understand that the soil can be either cohesionless or gravel in nature and we have also cohesive soils like clays which have interparticle forces between them. So, depending on various types of soil, the change in the soil volume due to addition of water will change.

Now, some types of soil when they come in contact with water, they will display large changes in volume while there are types of soil whose volume does not get affected by changing the moisture content. Now, when we talk about the change in volume, this is typically true for cohesive soils and they can show large change in the volume due to increase or either decrease in the water content.

So, the pictures which you see are the resultant of what happens when the moisture content in such cohesive soil changes and which leads to further change in the volume. This first picture which you see shows a shrunk soil which means, the volume has the moisture has gone out due to various reasons because of which the soil has shown shrinkage and these are the typical cracks on a very stiff soil or very stiff cohesive soil, which we expect once the volume of the soil decreases.

Now, what happens what is the problem with such occurrence. The problem is you try to imagine that the soil is typically used when we talk about the pavement construction it is typically used as a foundation layer. If such type of volume changes occurs beneath the pavement layers, the stability of the structure will get affected such type of occurrence of cracks can lead to the occurrence of cracks on the surface also which you see how the propagation has taken place and how the pavement system is failed because of the presence of such type of soil as the foundation layer.

Alternatively, if the volume of the soil will increase, which we also call a swelling of soil, in that case, there will be increase in volume and this increase in volume beneath the pavement layers will also lead to instability of the entire pavement structure and such changes of volume will occur in the surface in the form of heaving.

And you can see how the pavement has failed because of the presence of excessive cohesive soil which are very sensitive to the change in moisture content in the foundation layer. In general water in soil it acts as a defensive densification agent it acts as a lubrication agent, which improves the movement or which facilitates the movement of particles about each other when we are trying to compact the soil.

So, on one hand water basically acts as a stabilizer you can say which helps to properly densify the soil mass, but in some typical soils which we have discussed now, excessive change in moisture content will finally lead to the change in volume which can greatly affect the stability of the structure. Now, when we talk about compaction when we talk about densification as I mentioned, water will act as a lubricating agent there and it will help to achieve higher density in the soil mass.

So, depending on the type of soil, there will be one particular moisture content for a given competitive effort where we will get the highest density and this water content is called as the optimum water content. So, for any given soil mass, there will be one particular optimum water content or there will be one particular water content which we call as the optimum water content for a given competitive effort where the soil will achieve its maximum density.

So, we will discuss about the compaction characteristics and the strength characteristics of the soil in the further lectures. Having discussed about the interaction of the soil with water in different forms. So, just to have a recap we have discussed that in some soils changes in moisture content can lead to a large change in volume which is not desirable. However, on the other hand generally soil act as a densification agent and it facilitates compaction of the soil mass and increases its density.

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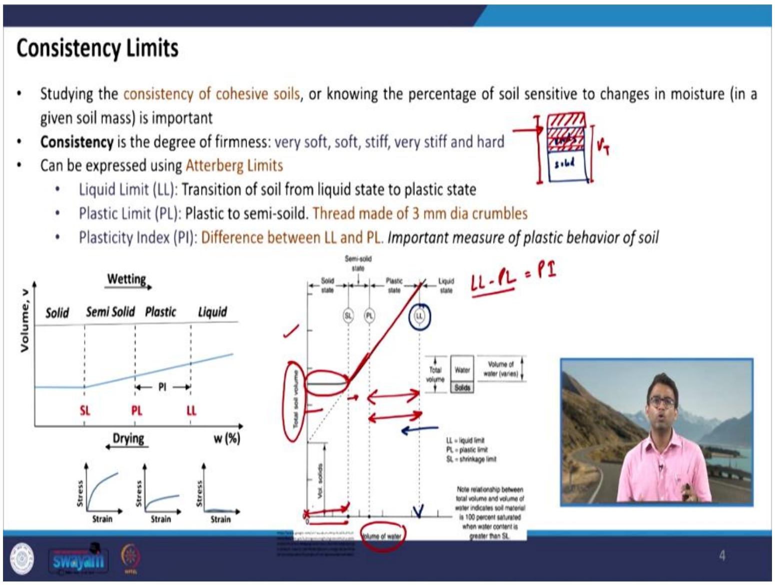

Now, studying the consistency of cohesive soil or knowing the percentage of soil that is sensitive to the change in moisture is very important because as we discussed that moisture in some soil can be very critical or the changes in moisture content in some soils can be very critical. And we have also discussed previously that one given soil mass does not necessarily consist of similar type of soil, you can have a soil which is a mixture of course, as well as fine grain soil, in the fine grained soil we can have several other categories for example, we can have silt, we can have clay, even in clay, there are certain minerals that can be very harmful when we talk about engineering structures.

So, in order to study the consistency of soil, let us first define what do we mean by consistency. So, consistency in general is the degree of firmness. So, this is just a simple form of definition we are placing for consistency. And in layman's terms how we define how can we quantify the degree of firmness, we will say that the soil is very soft, we say that the soil is soft, not very soft, we can say that the soil is very stiff, we can say the soil is very stiff and sometimes we can say the soil is hard in nature or very stiff and hard in nature.

So, these are the very generic terms which can be used to define the degree of firmness in the soil. But when we have to use the consistency properties, we have to define or we have to explain the consistency in a more quantitative manner rather than qualitative manner. So, the quantitative definition of consistency can be understood by defining Atterberg limits. So, Atterberg he was a

Swedish scientist who in around 1911 studied various types of soil studied the interaction of cohesive soil with water and based on his studies, he defined some approximate water content corresponding to which the properties of the soil will change from one phase to another.

And these phases which we will be discussing are again arbitrarily defined, it is always approximate in nature. So, the work of the experiments proposed by Atterberg for explaining the consistency of soil was later modified by A Casagrande around 1932 and his experiments are those which we still use today to understand or to quantify the consistency of soil. So, let us first look at the Atterberg limits, before talking about the Atterberg limits, let me just inform you that these limits corresponds to moisture content.

So, these limits are actually limits of moisture content, it is that particular moisture content at which the soil will have a phase change from one phase to another and let us try to understand these phase changes. So, the first Atterberg limit which we are going to discuss is the liquid limit. So, what is the liquid limit? It is that particular moisture content at which the soil will transform from a liquid state to a plastic state.

So, try to imagine that you have a mass of soil you have mixed it with excess quantity of water. So, what will happen if you mix soil with excess quantity of water, it will be very fluid in nature it will look like a fluid which means it will not have any shear strength in it. When you deform it, it will not resist the deformation. Now, if you allow the water to evaporate or to water to go out from the soil mass slowly what you will see that the soil will start becoming hard.

So, this soil is changing or it is transforming from a liquid state to a more of solid state, but this is not a direct transformation from the liquid state first the soil will go to state which can be defined as a plastic state. So, what is that plastic state? It is that state at which the soil will start having some shear strength, it will start to rise resist deformation which we apply to it. So, liquid limit is that particular transition point or that particular moisture content at which the soil shifts from its liquid state to plastic state.

So, this is shown in both the fingers here, which you see that this is the liquid limit again an arbitrary point where we say that the soil is going from a liquid state to a plastic state. And the soil will stay for plastic state in the plastic state for some time and again further when we try to reduce the moisture content in that soil mass it will have another shift. Now, it will shift from plastic state to a state which we call as the semi solid state. So, in the semi solid state again the sheer strength of the soil mass will increase it will have more resistance to deformation.

So, that particular moisture content at which the soil transits from the plastic state to the semi solid state is called as the plastic limit of the soil. So, add at this particular moisture content if I take the soil mass in my hand, if I try to roll it, I will be able to roll the soil or I will be able to play with the soil and make a thread of approximately 3 mm before it crumbles. So, again we will discuss about how the plastic limit is determined or evaluated using some empirical laboratory experiments.

We have another limit which we typically do not use much when we talk about pavement engineering, but since we are discussing about Atterberg limits, let me also define that particular limit. So, what is that limit that limit is the shrinkage limit which is the moisture content beyond which the reduction in water content will not lead to reduction in the volume of the soil mass.

So, what does it mean and it is again that particular transition state from where the soil will start shifting from semi solid state to the solid state, but how are we defining this change from semi solid state to solid state it is that moisture content beyond which the volume of the soil will not change even if we are reducing the moisture content. Let me explain you this, let us say if you try to see the entire volume of the soil.

So, soil will have let us say in the dry state we are looking at the soil. So, in the dry state the soil will have mass of solids and there will be some air voids within the particles. So, if you see the volume of the soil it will have the solid part and it will have voids in it. Now, let us say we start to add water in this volume. So, what will happen if you start adding water let us say we added some water, so the water has filled this void.

So, we are adding water but you see the volume of the water is not changing, the volume of the soil is not changing here this volume of soil remains the same, the water is actually going inside the pores and filling the voids. So, if we add more water again there will be no change in the total volume but we are adding an additional material which is occupying space within the voids and the space will be occupied up to this point.

Now, beyond which means the soil here is in a complete saturated state. Now, beyond this point, if we start adding any additional water, it will increase the volume of the soil. So, the shrinkage limit is that particular limit at which the soil is completely saturated and beyond which the addition of water will lead to increase in the volume of soil. So, this can be understood using this particular figure you see.

So, here you see we are increasing this is the graph between total soil volume versus volume of water. So, you see when we are going from the left hand side to the right hand side up to this point, though we are increasing the water content, the volume of the soil is not changing. And beyond this point, which means this is the point where the soil is completely saturated and beyond this point when we increase the water the volume of the soil will increase.

And then we have certain zones where we are describing the soil behaving like a semi solid material or a plastic material or a liquid type of material. Now, why are we interested in understanding this behaviour or this consistency? Because as we discussed, there are soils which are very sensitive to change in moisture content and we want to avoid those soils to be used in the construction.

So, these soils which are more sensitive to the change in moisture content are basically plastic soils which means that they will remain for a very long time in the plastic state. So, which is that plastic state? This is the plastic state. If you see this graph and we have discussed about the limits, so, a measure of the plastic state will be the difference between liquid limit and plastic limit and this difference is called as the plasticity index.

So, larger is the value which means larger is this range at which the soil is behaving in the plastic state and we have to avoid those kinds of soils. And therefore, plasticity index is the measure. Now, the question is experimentally how do you determine the liquid limit and plastic limit. So, let us talk about that experiment.

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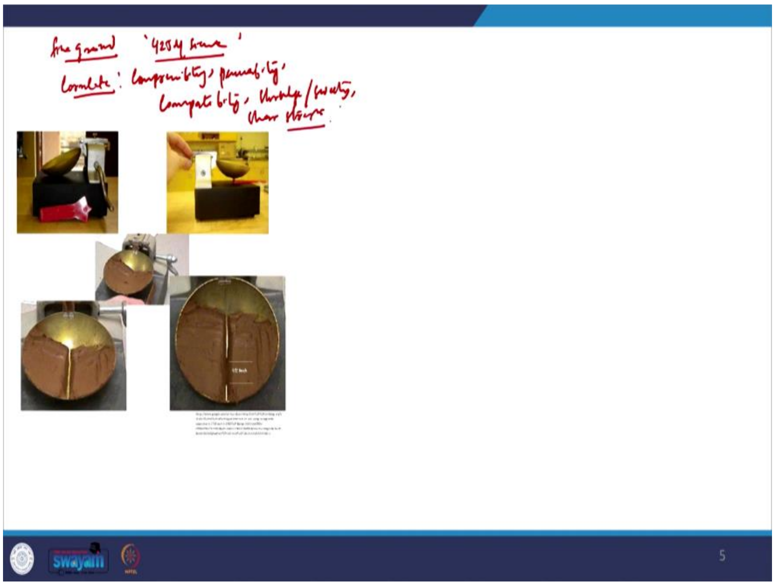

Well before talking about the experiment, let me tell you that the Atterberg limits and the plasticity index they are used in several engineering classification systems in order to characterize basically the fine fraction of soil, even in the final fraction this is again generic you have to remember for further in classes also that whenever we are testing fine grained soil in the laboratory for defining the consistency limits or understanding the characteristic of the cohesive material, we always take soil sample that is passing 425 micron sieve.

So, I may miss mentioning it every time in the lecture, but this is just for your information that usually materials or soil samples passing for 425 micron sieve is used for the classification or for testing the fine grained soil for which we are interested to see the plasticity characteristics or we are trying to see the behaviour of the cohesive material. So, as I was mentioning that Atterberg limit and plasticity index they are used in several engineering classification system to characterize the fine fraction of soil, these tests are also used for all, these indexes are also used for accepting these materials for construction.

In addition, these indexes which we will be discussing, they are also used to explain or correlate with other soil properties such as its compressibility, such as its permeability, such as its compatibility and also its swelling and shrinkage behaviour, and also the shear strength. So, that is why it becomes more important to study about these properties because they be a direct correlation with other important characteristics of the soil.

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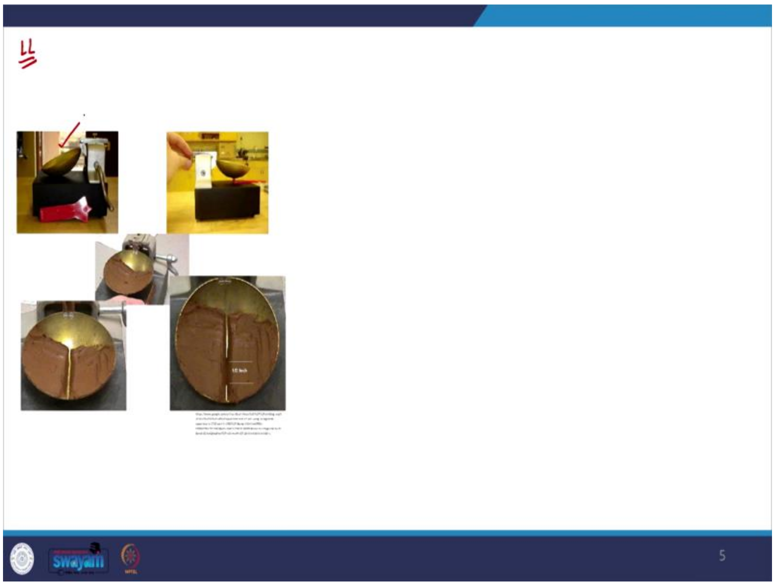

So, now, let us discuss about the tests that are used to explain the consistency limits or the Atterberg limits. So, the first test is the liquid limit test. So, the liquid limit test is done using the Casagrande apparatus which you see here, I have the Casagrande apparatus with me now, so, you can see it in my hand. So, it consists of a hard base, this is the hard base, this is the brass cup this is a simple equipment which is operated by hand.

So, this is a hand operated equipment. So, this is a brass cup where we will keep the soil mass in a certain manner I will tell you that and then this is the handle. So, in this experiment basically this brass cup which is filled with soil is lifted up and down and this lift is approximately 1 centimetre. And how are we lifting this? We are actually turning this handle to lift, so, you can see that when you turn the handle the brass cup lifts itself and then it falls on the hard base.

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So, I will explain you this experiment. So, as I mentioned Casagrande liquid limit apparatus, it is a hand operated device and it contains a brass cup which can be raised and it is allowed to fall on the hard rubber base. And how are we doing that? We are doing that by turning the handle as I showed. And the rise of the cup is 1 centimetre. So, in this test what we do we take 100 gram of soil again 100 gram of soil passing for 425 micron sieve it is mixed thoroughly with distilled water to form a paste and it is placed in the cup up to a depth of 10 mm.

So, in the cup we basically we are filling this and this depth is approximately 10 mm this depth is and you can see here. So, the depths from here to the bottom part of the brass cup will be approximately 10 mm. Then what we do we have a cutting tool. So, there are two types of cutting tool one is the Casagrande cutting tool and the other is the ASTM cutting tool. Typically, we use Casagrande cutting tool to carry out this experiment.

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Again in my hand now, you can see both the tools. So, this is the Casagrande cutting tool, you can see this and this is the ASTM cutting tool. So, in this particular class I will be explaining the test using the Casagrande cutting tool, but you can use any of the cutting tools.

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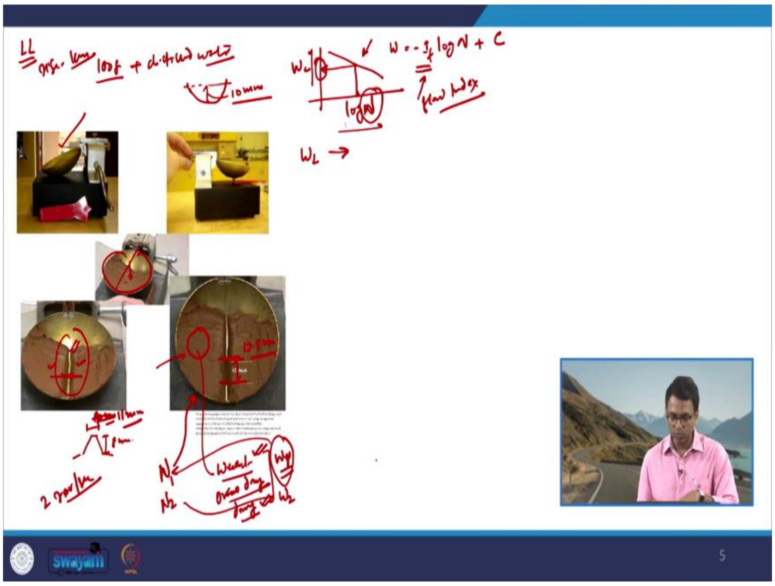

So, this Casagrande cutting tool has a depth of 8 mm. So, if like this is the tool, so, this depth is 8 mm and the width is 11 mm. So, this is the standard dimension. Then what we do we take the Casagrande cutting tool and we make a groove by cutting normally through the sample which you can see in this picture that if you see the Casagrande tool in my hand, so, I will just take it normally and I will cut through the brass cup I will cut through the I mean soil sample which is placed in the brass cup.

And it will make a groove which will look something like this, then what we do we will start turning the handle of the Casagrande apparatus the handle is usually turned at a rate of two revolutions per second. And we will stop when we see that this because what will happen when we turn the handle that the soil sample from both the sides, they will try to close each or they will try to come close to each other because of this force which is being applied, they will try to move.

So, we will stop turning the handle when we see that the soil sample has closed by approximately 12.5 mm, the closure is 12.5 mm we will stop them. And we will note down that how many blows are required to achieve this particular criteria. Then what we will do we will take the soil sample from this paste we will take the weight of the soil sample we will oven dry it then we will take the dry weight.

So, using the weight before drying and weight after drying I can calculate the moisture content in the soil and I will know that at this particular moisture content N number of blows or N1 number of blows we are required to close the groove by 12.5 mm. Then what I will do in the same soil paste I will increase the water content I will repeat the experiment and then at a different number of blows it will close 12.5 mm and then I will see what is the moisture content let us say W2 this was W1.

So, I will do this experiment at least four times which means I will have four moisture contents corresponding to that I will have four number of blows for 12.5 mm closure and then what I will do I will plot the relationship between the water content and log N. So, in a semi log graph and I will basically, this is a typical type of graph which you will get which means with increasing number of blows the corresponding moisture content will decrease.

Log N is the number of blows or N is the number of blows for the closure of the sample by 12.5. So, this is a straight line I can just write down the equation that W is equal to minus I_f log N which this is the slope plus C, I_f is called as the flow index in soil mechanics. But what we are interested in is in finding out the liquid limit.

So, liquid limit is moisture content corresponding to 25 number of blows. So, we will find out that what is that moisture content corresponding to 25 number of blows and this moisture content is defined as the liquid limit of the sample. So, I hope you understand that how the experiment is actually done.

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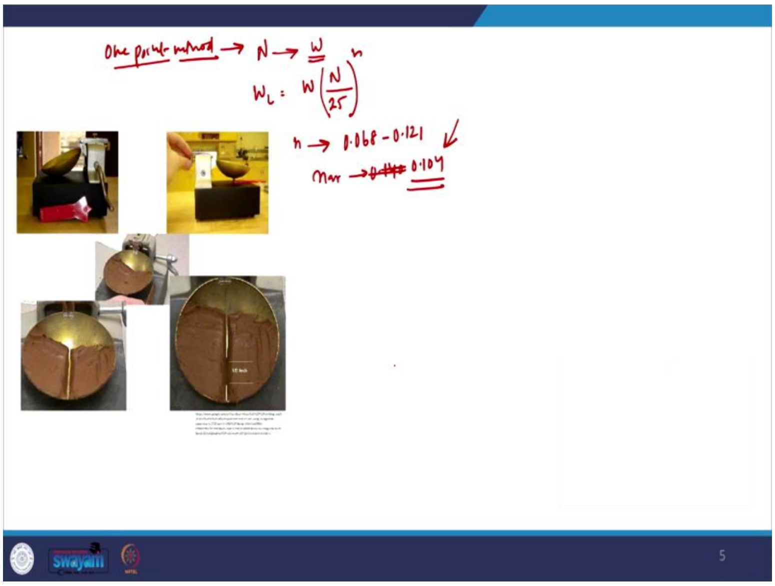

There are other methods again that are available to evaluate the liquid limit of the soil for example, we have one point method. This method is a quick method if we are not ready to spend much time in the conventional liquid limit test. So, here what we need to do we need to do the experiment only one time. So, you just find out that what is the value of N to close 12.5 mm and you just measure the moisture content at that particular for that particular sample.

And then you can use this simple equation W (liquid limit) = moisture content × N number of flows required to close to 12.5 mm divided by 25^n. So, the value of n for typical cohesive soil it ranges from 0.068 to 0.121 and you can take an average value of 0.104 to do the calculations, but again you have to be very cautious because this is an approximate method.

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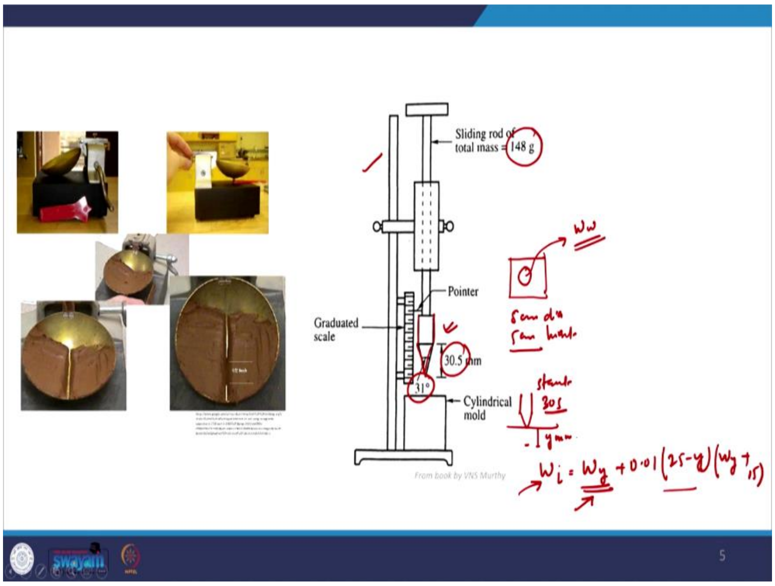

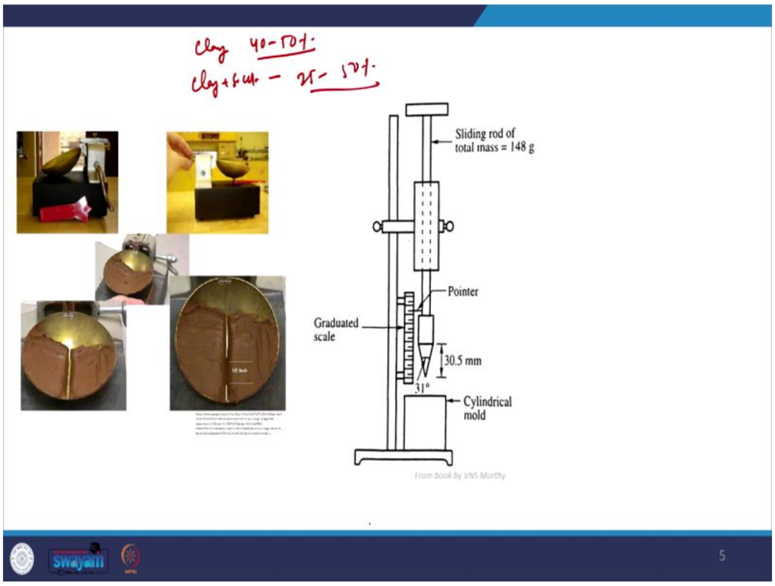

Another method which is again a popular method for determination of liquid limit is the use of a cone penetrometer which you can see here. So, what we do here again this is a simple experiment we have a cup, this cup has a specific dimension of, the dia is 5 centimetre and the height is again 5 centimetre. So, we will take the soil mass will mix it with water to make a paste and we will press it in this particular mould.

Then we will put it just beneath the penetrometer equipment. So this penetrometer contains a needle, this needle has a specific dimension for example, you see that the height of the cone is 30.5 mm and the cone angle is 31 degree. And the total mass of this penetration is 148 grams. So, we allow this mass to penetrate the sample. So, we will keep the cone here. And we will start the test. And we will allow the cone to penetrate for 30 seconds. And we will see that how much, to how much depth the corn has penetrated.

And then what we will do in that source from that soil sample, we will take out a part and we will determine the moisture content in that soil. And what we will do, we will use a simple equation where liquid limit is equal to the moisture content corresponding to y mm penetration, if this is Wy (mm) + 0.01 × (25 -y) × (Wy + 15). So, this is an empirical equation again, which can be used to calculate the liquid limit.

Again, we have to be cautious because this is an approximate process. So, usually the liquid limit of soil vary in a wide range for example, the typical values for clay will be around 40 to 50 percent liquid limit whereas, if you have clay with some quantity of silt in it, the value can be somewhere between 25 to 50 percent. So, this is just an approximate range.

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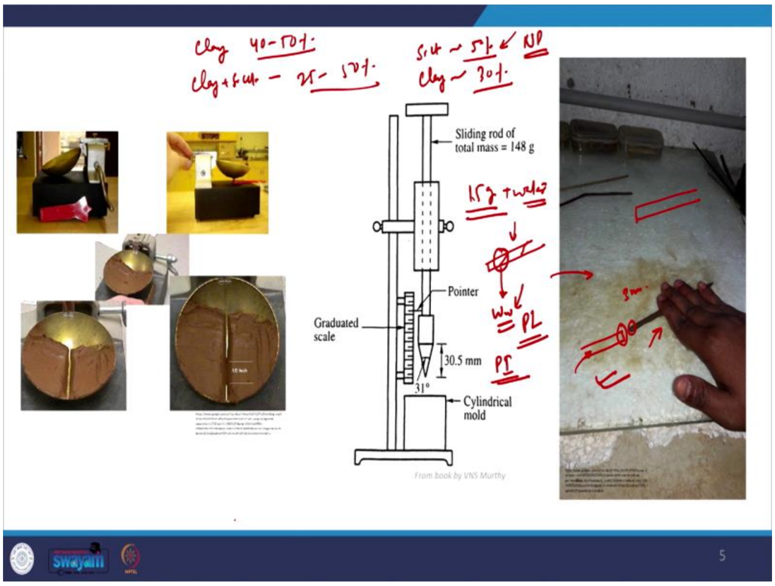

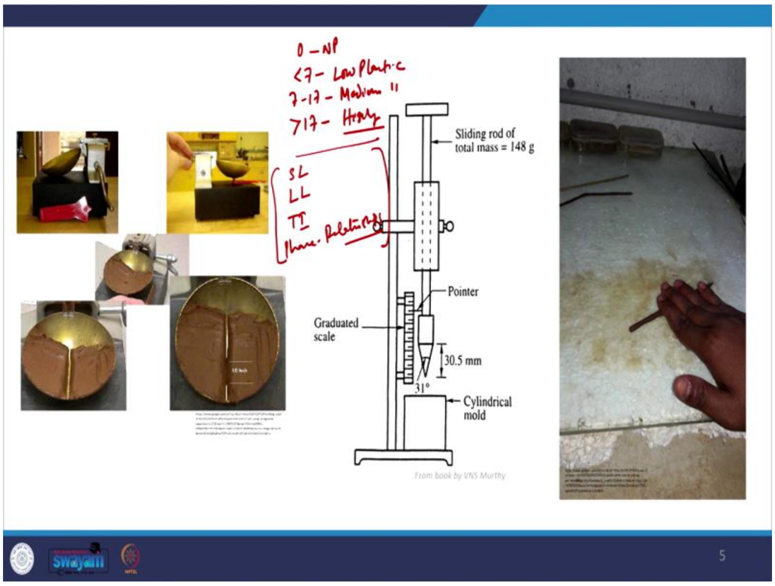

Let us now discuss about the plastic limit test again this is a very simple test, which you can do in the laboratory. So, what we do here we take 15 grams of sample passing 425 microns, we add it with water to mould the soil sample we will add that much water. Then what we do we will using the forefingers and a glass plate here, we will start rolling the sample, we will first make a small ball and we will start rolling the sample.

So, we will roll the sample such that we are able to make a thread of diameter 3 mm. So, we have another glass rod here which we use to ensure that we have rolled the soil sample to a dia of 3 mm so we will keep on checking it with the standard glass rod of dia 3 mm. So, if you are able to roll it to 3 mm without occurrence of any crack in the sample, what we will do we will squeeze out the water a little.

And again we will do the same experiment, we will squeeze of the water remould the specimen and again we will try to roll it in the using our four fingers and the glass plate between our four fingers and the glass plate. And we will keep doing that until we observe that once we have rolled it to 3 mm or I will write here, we have rolled it to 3 mm the soil sample start to show crumbling.

Again, this is a visual experiment so it is more of qualitative in nature but we will stop when we see crumbling occurring. So, in that particular soil mass where this crumbling has occurred, we will take a part and we will determine the moisture content. And this moisture content is defined as the plastic limit.

And using the value of plastic limit and the liquid limit which we have discussed previously, we can calculate the plasticity index. We are talking about plastic limit again it varies in a wide range for different types of soils for example, if it is a silt with some amount of clay, then approximately it will be around 5 percent. If we have clays the plastic limit can be very high around 30 percent. If it is completely silt or has more of cohesionless material, then you will not be able to mold that particular type of soil into thread.

So, it will be denoted as non plastic whose plastic limit will be equal to 0. So, based on the plastic limit approximately we can say that if the value is 0 it is a non plastic material, if the value is less than 7 it is a low plastic material, if the value is between 7 to 17 it is a medium or an average plastic material and if it is greater than 17 it is a highly plastic material. So, this is the way we can classify the plasticity of the soil based on the plasticity index also.

Before we move forward, I just want to also mention that we have discussed about shrinkage limit there are other indexes in soil mechanics which we use like liquidity index, we use toughness index, we use other phase relationships. So, though these all indexes and values are important from the perspective of soil mechanics, but we do not typically use them to classify or to understand the soil to be used in pavement for pavement application and so, we are not discussing this in this particular lecture.

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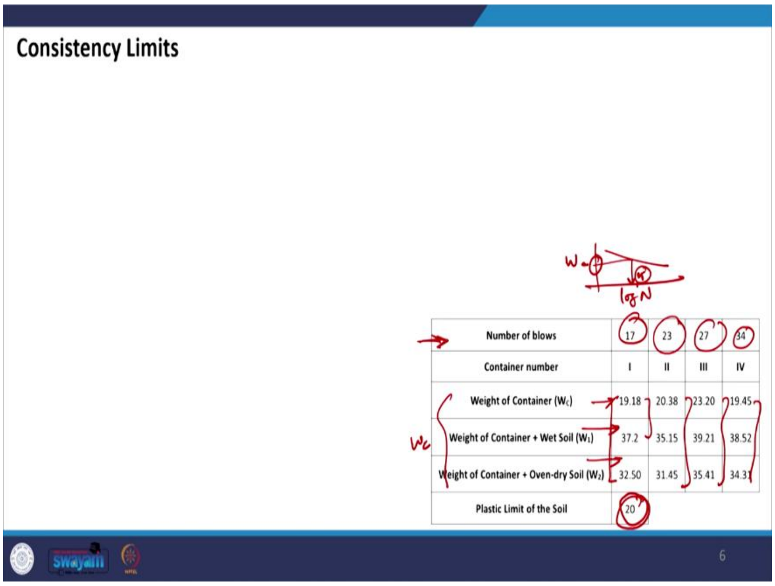

Number of blows	17	23	27	34
Container number	I	II	III	IV
Weight of Container (W_C)	19.18	20.38	23.20	19.45
Weight of Container + Wet Soil (W_1)	37.2	35.15	39.21	38.52
Weight of Container + Oven-dry Soil (W_2)	32.50	31.45	35.41	34.31
Plastic Limit of the Soil	20			

Moving further, this table just will give you it will help you to do some calculation on your own to see if you are able to use the data to calculate the liquid limit. So, here what is given that the soil has been tested, the plastic limit of the soil is 20, then the soil the weight of the container has been given where you are keeping the soil after each trial in the liquid limit test, weight of the container plus wet soil is given which means the difference in these two will give us the weight of the wet soil and then we have the weight of the container plus oven dried soil which means the difference in these two will give you the weight of the oven dried soil.

So, using the weight of the oven dried soil, using the weight of the wet soil you can determine the water content. So, you have water content here using these three values you have number of blows here. Similarly, you determine other water contents using these three values that are given, which means you will have four water content four number of blows just plotted in a semi log graph with water content in the y axis and logarithmic of number of glows in the x axis just try to use the straight line equation and you try to find that what is that water content corresponding to 25 number of blows.

And that water content will be the liquid limit using the plastic limit you have the plastic limit you can calculate the plasticity index of the soil. And finally, how are we using the value of plasticity index this will discuss when we talk about the classification system.

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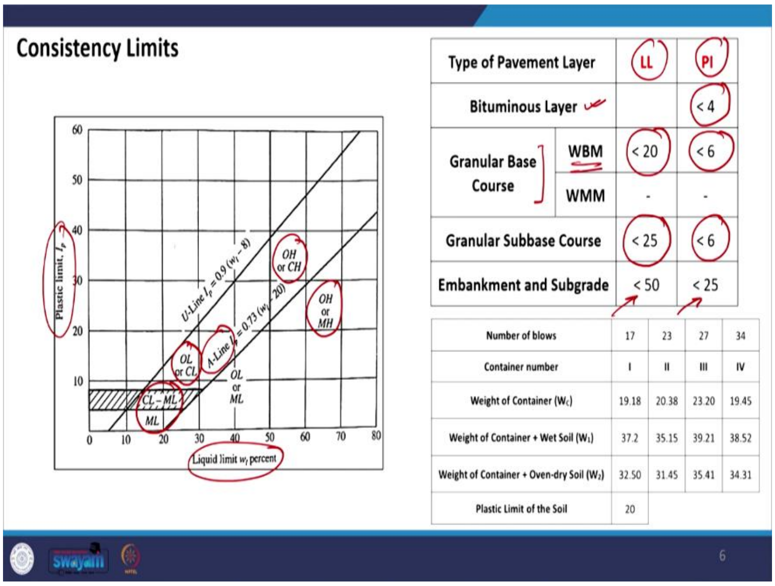

For example, this graph is typically used in the classification system. So, this is the graph from the unified soil classification system where we have A-Line. So, what A Casagrande did he studied different types of soil. And he plotted a relationship between plastic limit and liquid limit and depending on where the values lie, he divided this chart into different parts and where and which can be used to classify the soil.

You do not have to worry about these terminologies now, because we are going to anyway discuss about these terminologies, when we start discussing about the classification of soil. So, using the value of liquid limit and plasticity index, we can understand whether this soil can be used for different applications in pavement construction.

For example, as per the ministry of road transport and highways, if there is a soil to be used in the bituminous layer, which means in the bituminous aggregate gradation, if we have finer particles, then we have to ensure that the materials that are passing 425 micron sieve does not have a plasticity index value greater than 4 it should be less than 4.

Similarly, if we are using soil in granular base course, if it is a WBM, we have to ensure that the fine fraction has liquid limit less than 20 and plasticity index less than 6. In granular sub base we have to ensure that the final soil particles have a plasticity index less than 6 and liquid limit less than 25 and if the soil has to be used in embankment then we have the values are relaxed more we can go up to we can use soil sample up whose liquid limit is up to 50 and plasticity index is up to 25 but should not exceed these values.

So, this is how the liquid limit and plasticity index can be used to choose or to decide if this soil can be used in pavement construction. So, now, we understand that what is the use what is the importance of consistency limits and how do we determine them in the laboratory. Now, let us move forward and discuss about the classification process of soil. Now, one process we already know is based on the grain size.

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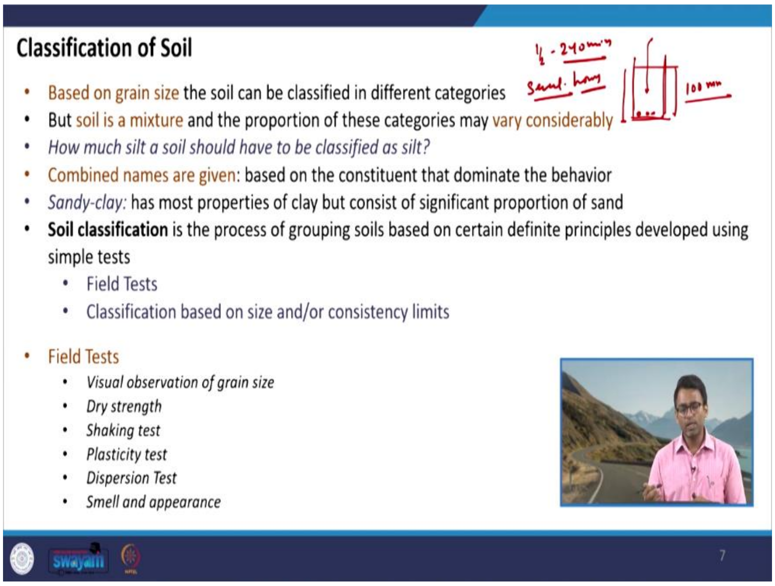

We have discussed that based on the grain size how the soil can be defined as a granular material as sand we have as coarse grained material, we have discussed about the sizes of sand, we know that what are the size range for silt, we also know what is the size range for clay. So, this is based on the grain size distribution.

But, for a given soil mass which we see in the field which we see at the site, the soil will not necessarily consist of only one type of material which means that soil mass can will have a mixture of sand, will have a mixture of silt, will can have a mixture of coarse grained material, it can have a mixture of clay also I mean all the types or the all the sizes of material can be present in the same soil mass.

And the proportion of these category also can vary considerably. For example, we can have a soil where most of the proportion or the maximum amount of soil comprises of coarse grained material and only some percentage of that soil has some amount of silt or clay later say. We can have a soil where the maximum percentage of that volume which we are looking at or mass which we are looking at comprises of silt and clay and only we have a minimum fraction of let us say sand and coarse grained material.

So, you can imagine that for since it is a mixture the proportion of different sizes will vary and it will be very difficult for us to tell that what will be the characteristic of the soil I mean will the soil behave like a coarse grained material or the soil will behave like a sand or the soil will have characteristics related to clay soil. For example, another important question which we have to answer is suppose you see a soil and I asked that tell me whether the soil is a silt or clay or a coarse grained soil, so, what answer will you give me.

So, it depends on our definition that how are we defining the type of soil which means how much silt, let us say if it is a silty soil then how much silt should be present in that particular soil to classify it as a silt, if it is a clayey soil, how much percentage of clay should be present to classify it as a clayey soil, so that becomes a challenge which needs to be answered in some form in order to classify different types of soil.

Sometimes combined names are given, now, these combined names can vary based on the constituent that dominates the behaviour. For example, we can have a sandy clay, so, sandy clay our soils which contains a large proportion of sand, but the properties are dominated by the presence of clay. So, again it depends on what is the proportion of different materials and which material is controlling the property of that particular soil mass.

So, if we want to define the soil classification system, it can be defined as a process of grouping soils based on certain definite principles. So, we have to first decide that what are those principles or what are those factors based on which I am defining the classification system. And these principles or these factors need to be developed through some simple laboratory test, which can be done on that particular soil mass. So, in this category we have two groups, so, the classification can be done.

Now, this is an approximate classification based on field tests and one classification system, which is a more accurate form of classification can be done based on size on one hand and also based on the consistency limits, which we have discussed. Now, field tests becomes more important when we are trying to approximately determine or we are trying to quickly understand at the site that what is that particular type of soil maybe we are not ready with the equipment which are required to do a detailed classification.

So, we want to do a quick assessment the engineer wants to do a quick assessment just by looking at the soil or by doing some simple tests at the site to understand what is that particular type of soil. So, the first field test is the visual observation of grain size. Now, this can be done specially for coarse grained soil, because visually we can see and understand what is the size of that particle and we know that if the particle is let us say more than 4.75 mm, it will be a coarse grain material, they will be gravels.

If the size is less than again we have subdivisions for example, we will have coarse sand, fine sand, medium sand. So, up to understanding about the coarse grained material or gravels it is still easy by visually observing the grain size, but when you talk about fine materials, fine grained soils, as the size decreases, it becomes very difficult to visually assess the soil and tell about the properties or the type of soil in that case some indirect test can be done in the field the first test let us say the dry strength test.

So, in this test what we will do we will take a 3 mm of small soil particle dried soil particle and we will try to press it between the fingers if for breaking the soil sample I am applying large force or greater amount of force or greater effort to crush the soil between my fingers which means, this will be a cohesive soil. If the amount of force which is required is relatively less than which means the soil contains some amount of silt in it.

The other test next test is the shaking test again a very simple test what we do here we take a small amount of soil sample mix it with water to a low consistency and we will keep it at the top of our palm and then we will try to tap the bottom of our palm or will do a shaking of our palm. So, once we tap if it is a cohesionless soil if it is a silt let us say not cohesionless but let us say if it is silt, we are trying to distinguish between silt and clay.

So, if it is silt the permeability of silt is higher than the permeability of clay. So, once we tap it the water which is present here it will quickly try to move at the surface and we will see a shiny appearance and once we stop doing that, the water will quickly move down and again you will see a dull surface which means that is a silt, that is silt. If it contains clay, then even if you tap the hand you will not see any change or you will not see any movement of water because the permeability is very less and you will see a similar surface like the initial one which means this tells you that this is a clay soil.

If it contains clay soil as well as some amount of silt, then depending on how quick this process is appearing, you can approximately define whether it has large quantity of silt or large quantity of clay. Then we have this plasticity test which again is a simple test here what we do we will take a let us say approximately 100 mm water in a beaker let us say and then what we will do we will just drop the soil mass here.

Now, if it is sand, we are trying to distinguish between sand silt and clay. If it is sand, then this will quickly drop in this beaker it will quickly come to the bottom of this beaker in few seconds. If it is silt, then it may take somewhere around half a minute to somewhere around 240 minutes depending on the type of silt the size of the silt and if it is clay, it can take several hours because clay will remain in suspension because of large specific surface area and very small size.

So, it will it can stay in suspension for several hours or sometimes several days before it can touch the bottom of the beaker. So, this is again a quick test to understand whether the soil is sand contains large amount of sand, silt or clay. So, these tests that is dry strength test, shaking test, plasticity test and dispersion they are mostly done on inorganic fine grained soil. If you have organic fine grained soil for example, you have peat, so, those soils can be identified at the site by smelling the soil sample.

So, it will have a very distinct decaying smell and also the appearance which will be more of dark brown in colour because of the presence of organic matter. So, we will stop here today and we will continue our discussion on the classification of soil in the next class. And in the next class we will specifically discuss about the other methods of classifying soil which will include criteria based on the grain size as well as based on the consistency limits. Thank you