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Geotechnical Engineering Laboratory

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Lecture no – 07
Atterberg Limit

Welcome I am Mr. J N Mandal, Department of civil engineering, institute of Indian technology Bombay. I will now discuss the Atterberg limit test.

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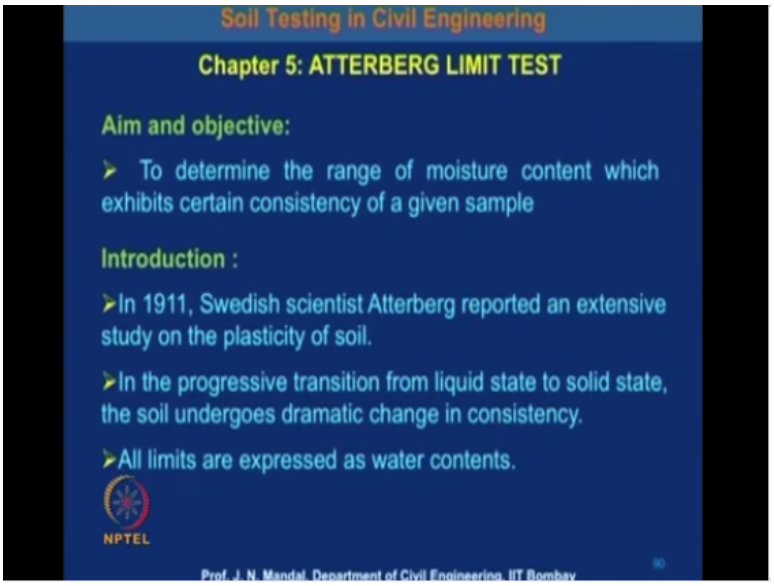

And the main aim and objective of this test is to determine the range of moisture content which exhibits certain consistency of a given sample. In 1911, Swedish scientist atterberg reported an extensive study on the plasticity of solid soil. In the progressive transition from liquid state to

solid state, the soil undergoes dramatic change in consistency. All limits are expressed as water contents. Now what is the liquid limit?

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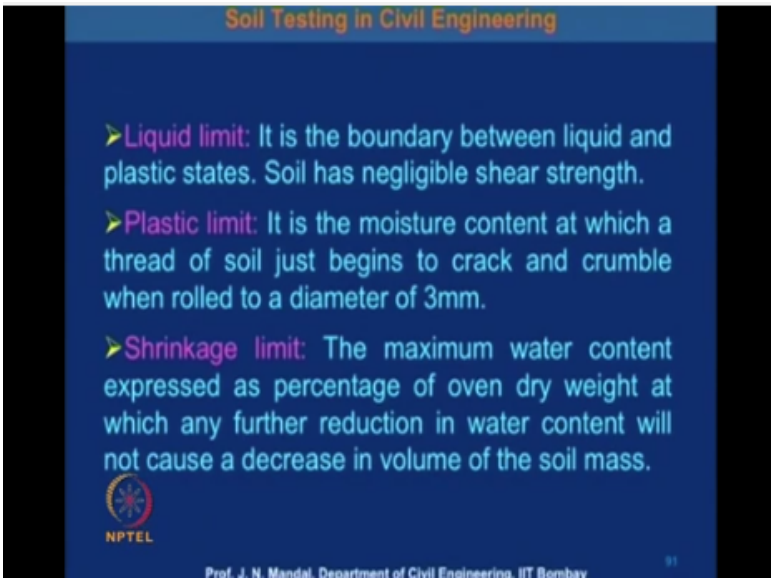

It is boundary between liquid and plastic states. Soil has negligible shear strength. Now what is plastic limit? It is the moisture content at which a thread of soil just begins to crack and crumble when rolled to a diameter of 3mm and what is shrinkage limit? The maximum water content expressed as percentage of oven dry weight at which any further reduction in water content will not cause a decrease in volume of the soil mass. So you know what is the liquid limit and the plastic limit and the shrinkage limit.

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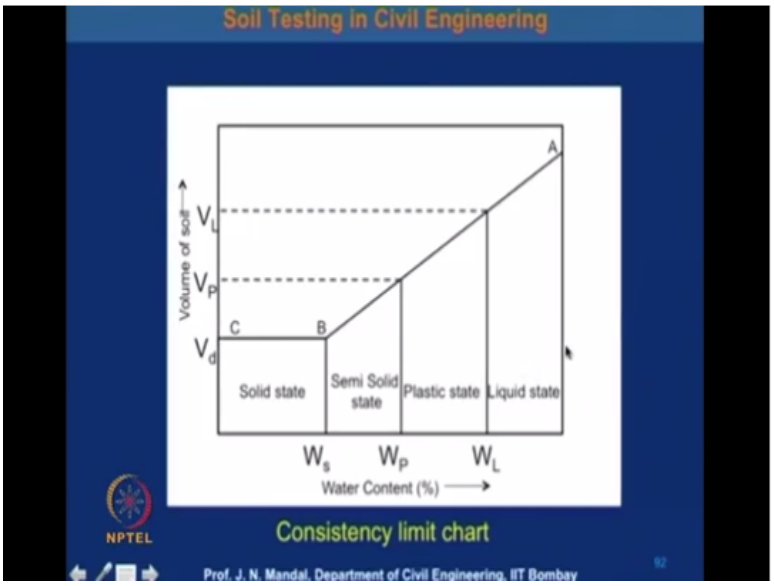

Here we can see that water content is the percentage and this is the volume of soil, so this part is the volume and this is the water content and this is called a state. When the water content within the soil and the plastic state it is called as semi solid state. When the water content between the plastic and liquid limit and it is a plastic state, so this chart shows the consistency limit chart and when it is beyond that liquid limit then you called a liquid state.

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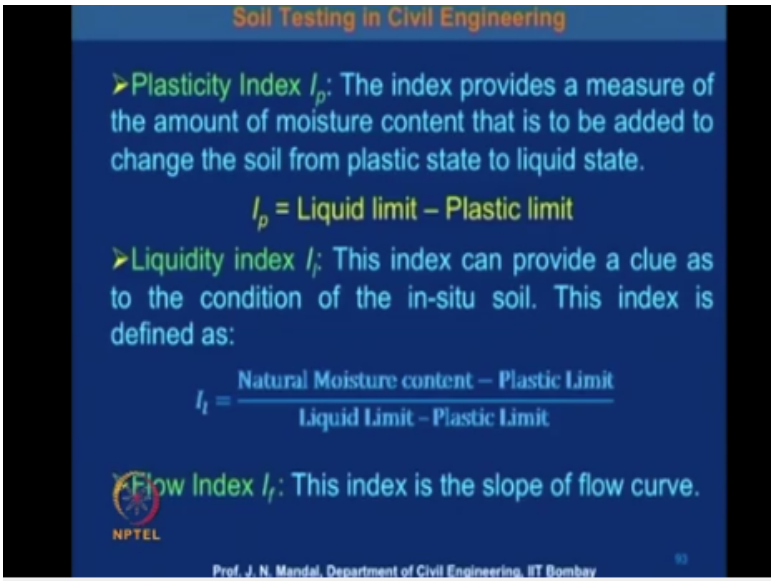

Then there is certain term which is called plasticity index, and the index provides a measure of the amount of moisture content that is to be added to change the soil from plastic state to liquid state. That plasticity index is l_p = Liquid limit - Plastic limit. So if you can determine the liquid limit and if you can determine the plasticity limit, then you can determine the plasticity index and there is another term which is called liquidity index, and that denotes i. This index can provide a clue as to the condition of the in situ soil.

This index is defined as I = Natural Moisture content – Plastic limit / Liquid limit – Plastic limit, and the another term which is called flow index, the index is the slope of flow curve, so these are the terms which are very important. Now all the determination of atterberg limit we require some apparatus, so we required liquid limit device and the grooving tool.

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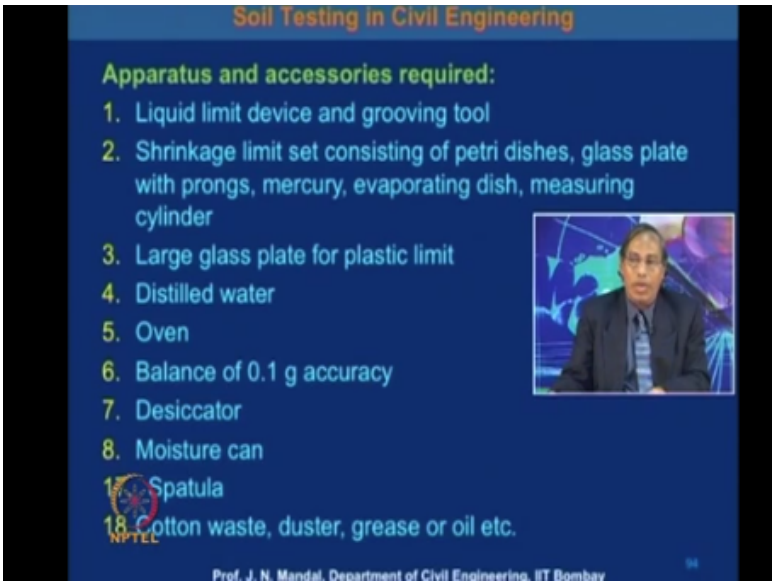

Then we have shrinkage limit set consisting of petri dishes, glass plate with prongs, mercury, evaporating dish, measuring cylinder. Large glass plate for plastic limit, it require distilled water, require oven, balance of 0.1g accuracy and the desiccators, moisture can, spatula and cotton waste, duster, grease or oil etc.

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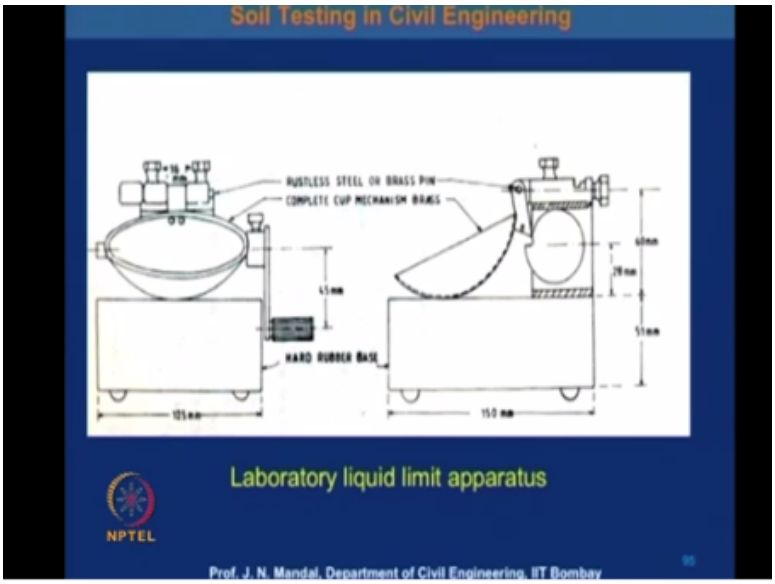

These are the some that are necessary for the determination of liquid limit. First of all we have to determine what would be the liquid limit of the soil? To calculate the liquid limit of the soil we require the liquid limit apparatus. So this is the liquid limit.

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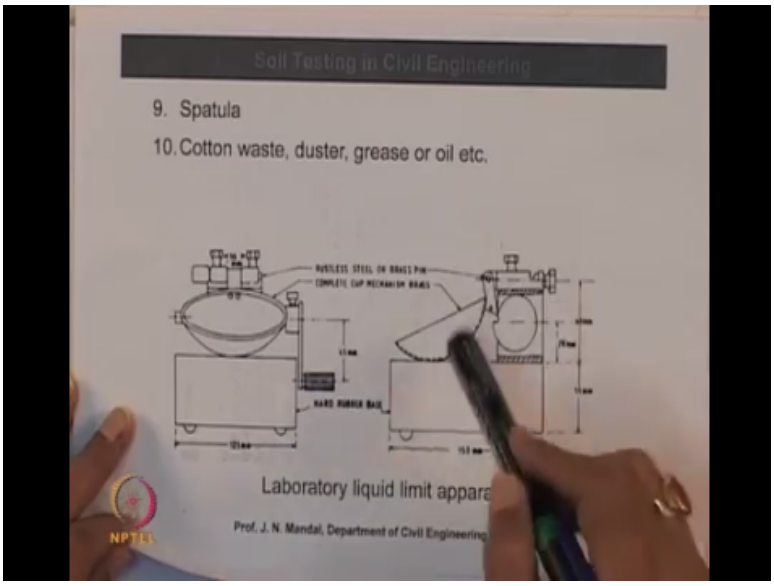

Apparatus and you can see here the brasses steel or brasses claf and this is the concrete cup and this it can be rotate and you can beat the soil into this cup and then you can rotate it, so this I will show you in detail about this, how you can perform these details.

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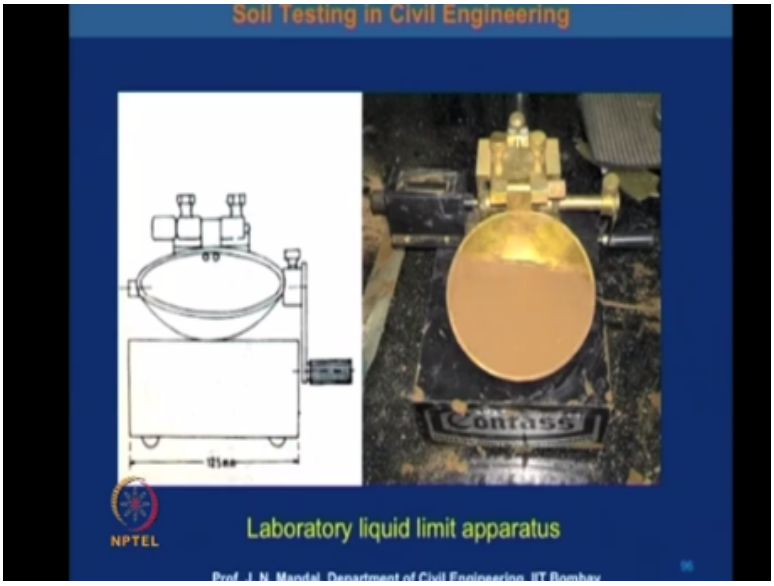

And here it is more details is given, these are the cup and this is the soil at a particulate moisture contain, and then.

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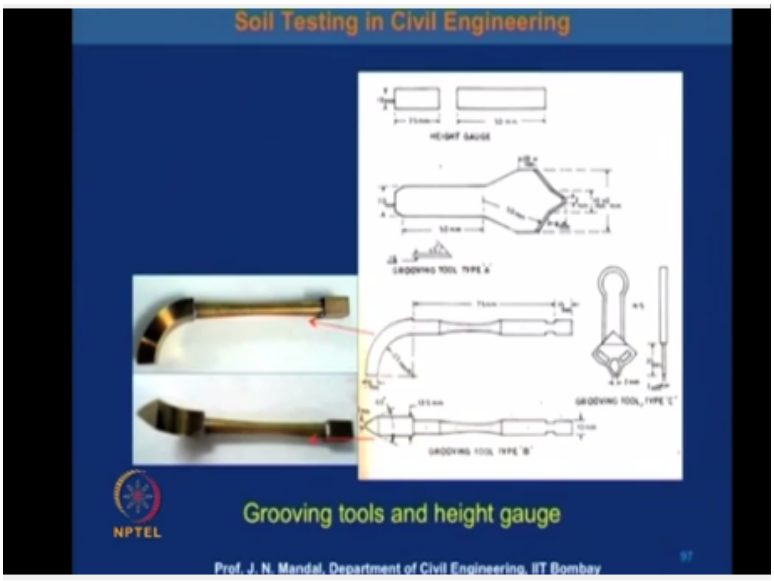

You can use this.

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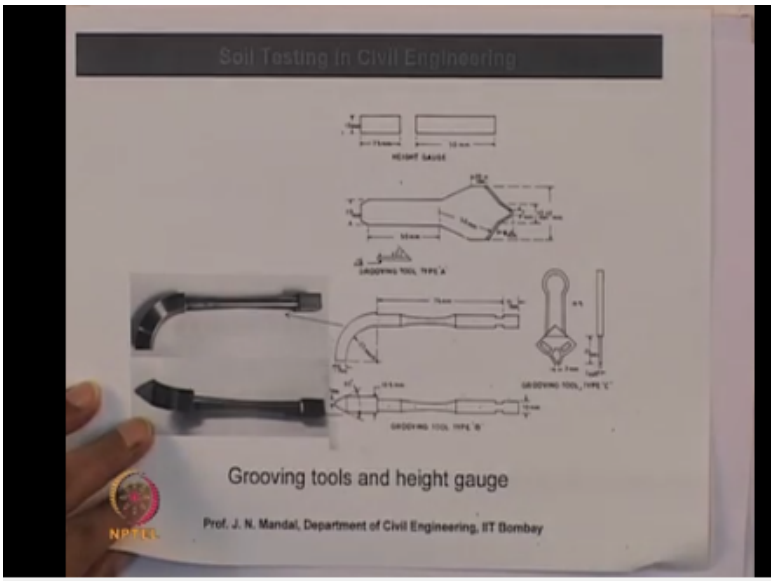

This is the height of the gas, this is the grooving tool in use to cut the soil and this is all the dimension of the grooving tool and height of the gadget is given here, so this grooving tool then you can cut the soil okay.

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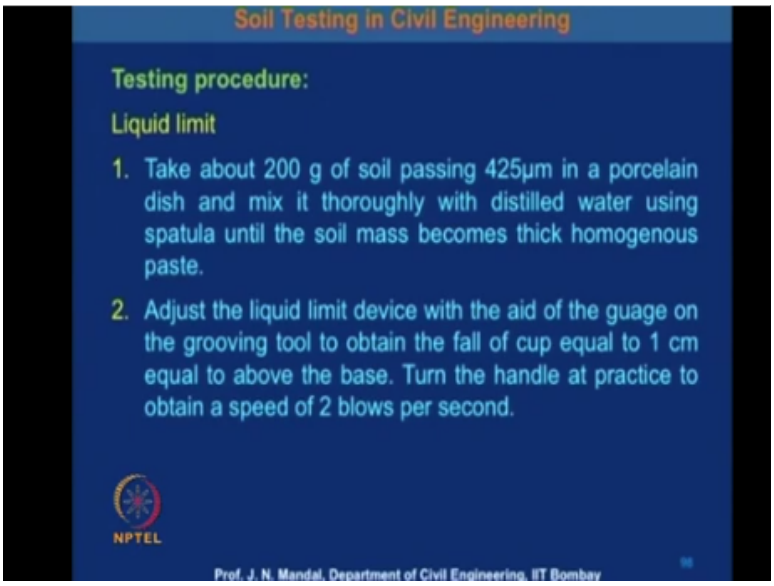

And here this way you can precede further for the liquid limit and the procedure is back, it take about 200 g of soil passing 425μm in a porcelain dish and mix it thoroughly with distilled water using spatula until the soil mass becomes thick homogenous paste. Next adjust the liquid limit device with the aid of the gauge on the grooving tool to obtain the fall of cup to 1cm equal to above the base, then turn the handle at practice to obtain a speed of 2 blows per second. Now turn the handle at the rate of 2 revolution per second and count the blow necessary to close the group in the soil for a distance about 12.7mm.

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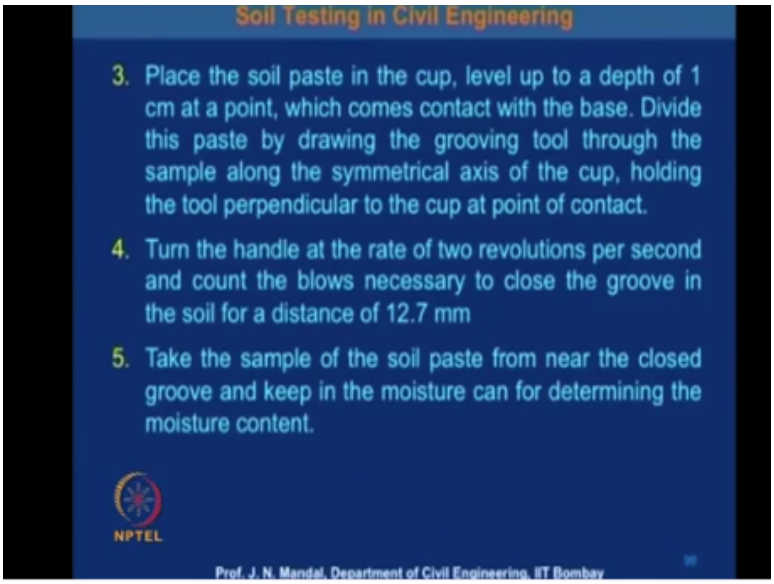

Now take the sample of the soil paste from near the closed grove and keep in the moisture can for determining the moisture content of the soil. Next we have to repeat.

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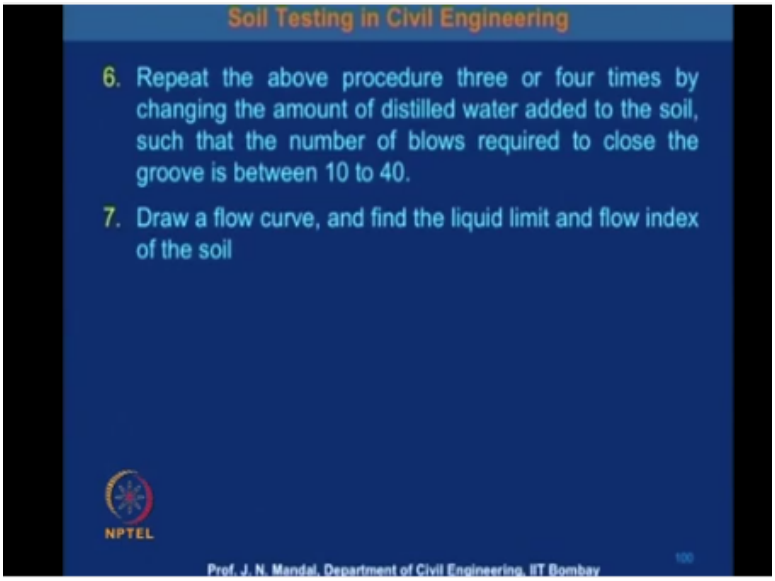

The above procedure three or four times by changing the amount of distilled water to the soil, such that the number of blows required closing the grove is in between 10 to 40. So here to grow in such a way that this number of flow should be lie in between the 30 and then you can drawn the graph and find the liquid limit and flow index of the soil sample now here.

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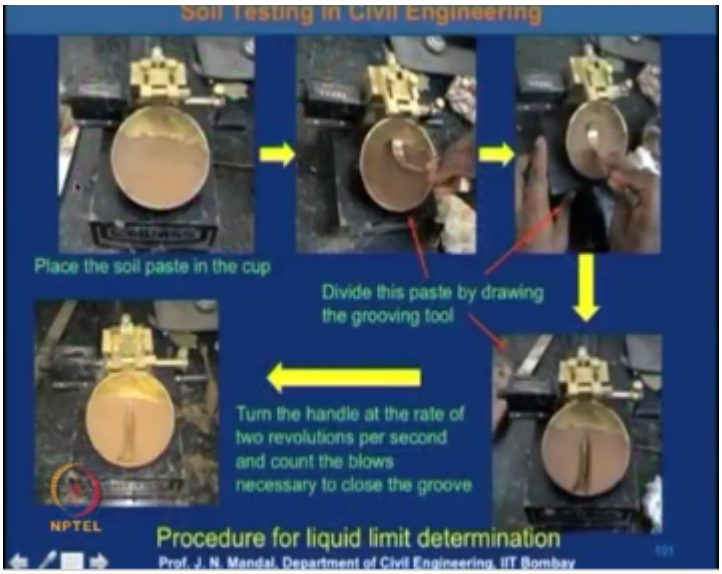

That proceed you for the liquid limit determination each shown ,so initially it is ere initially place their soil then in the next okay ,and then is divide this waste by drawing the grooving to they are just pushing like this and this enter the divide this place by drawing this groove and it then you can turn the handle at the two revolution per sec and town the blow necessary to close the groove this will come in the that then you take the solid sample from these bowl and then fluctuate in to the and then you can determine bottle with the moisture content .

Like that you can then again you can change the moisture contain and then you flow the soilo sample in to this and then you divide again this by drawing the grooving full and then at the end at the turn at the angle at te rate of two revolution parts so again town the blow repeatedly to close this groove. So therefore that you take to different moisture content then you determine what will be the moisture content of the soil.

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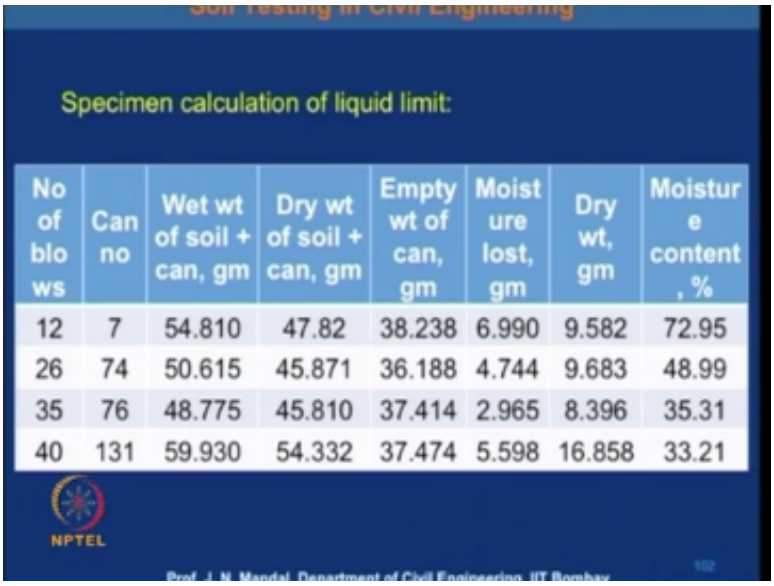

Now here we have been given in the liquid limit and how to calculate this so we have taken in the different number and take the different weight soil and the can and you calculate what the weight of the soil is. Then after dying the soil you can take the die weight of the soil and then you see in the gram in the in the you know that what will be the specific weight of the can and this s the 33.238, 36.18.36.414 and in the determine the moisture content you know what will be the die weight of the soil and you know than the weight of the can and detect.

And can determine at what should be the moisture content of the soil for this number 7 moisture content 6.990 can number 74 and 2.965 then you calculate what will be the die weight is the 9.582 and 9.683and in the you know the moisture content you know the die weight then you can calculate then what should be the moisture content in the terms of the percentage.

So you know that what should be the moisture content okay the die weight you know the moisture content so if you know this moisture content.

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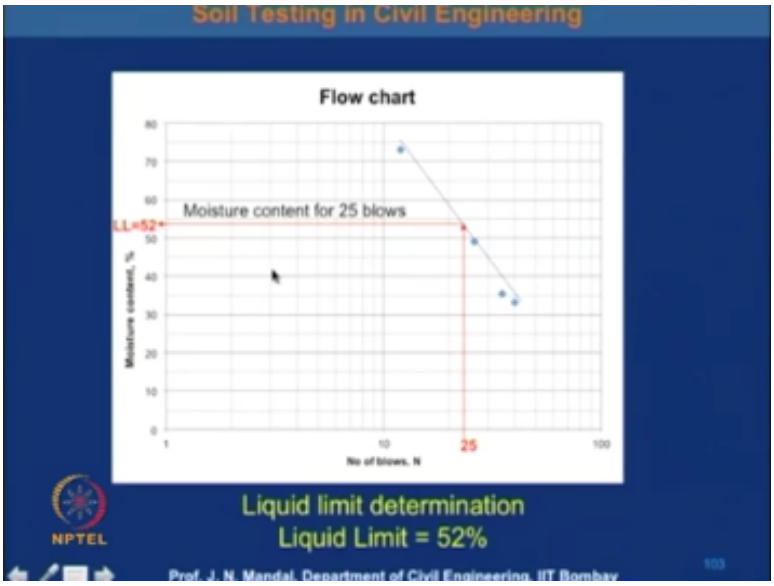

Then you can draw also this flow chart so this is the flow chart using here using the flow chart this is further liquid limit.

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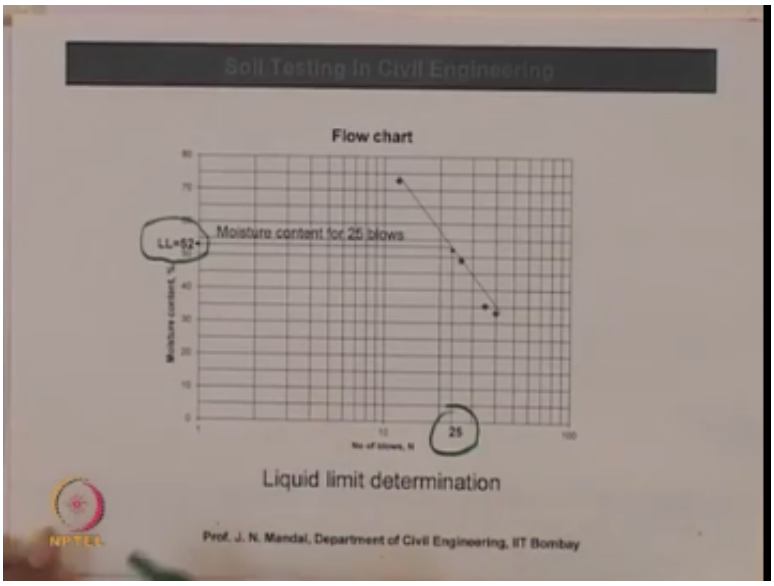

It will be the determination so this is the number of the blows and this is thin and this moisture content ni terms of the percentage, so you know that how many number of the blow we have given so it is known it is between two the 30 number of the blow and then you have determine corresponding in the moisture contents you know that the corresponding moisture will be what it should be so it is the moisture content.

So in the particular the number of the blow let us see this 25 and then you can determine the moisture content or the liquid limit for a particular number of blow 25 you can determine and what will be the liquid limit of the soil, so here the liquid limit of the soil is 52% so from the flow chart you can determent the what will be the liquid limit of the soil sample so from the flow chart you can determine what will be the liquid limit of the soil surface here the liquid limit of the soil sample is determine in the flow chart .

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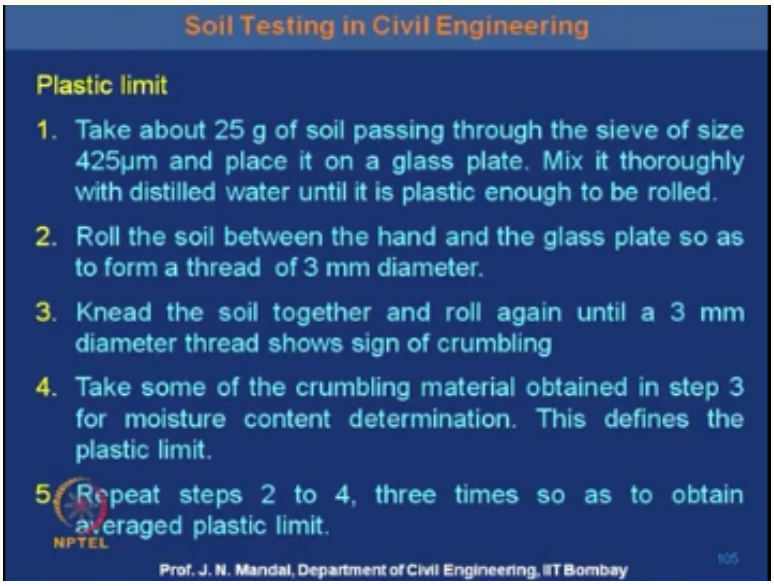

So next we can determine the particular limit take about the twenty five grams about the soil and passing through the size and find out in the glass plate and mix it thoroughly with the distilled water and until the it to be alone next role the soil between the hand and the glass plate so have you formed in the shade about the seriously limited diameter now need the soil together and you roll again until the female limited diameter thread so iron so that convey take some of the culming material of then and in the audience for the 3 of all the determination of the moisture and this defined the plastic limit.

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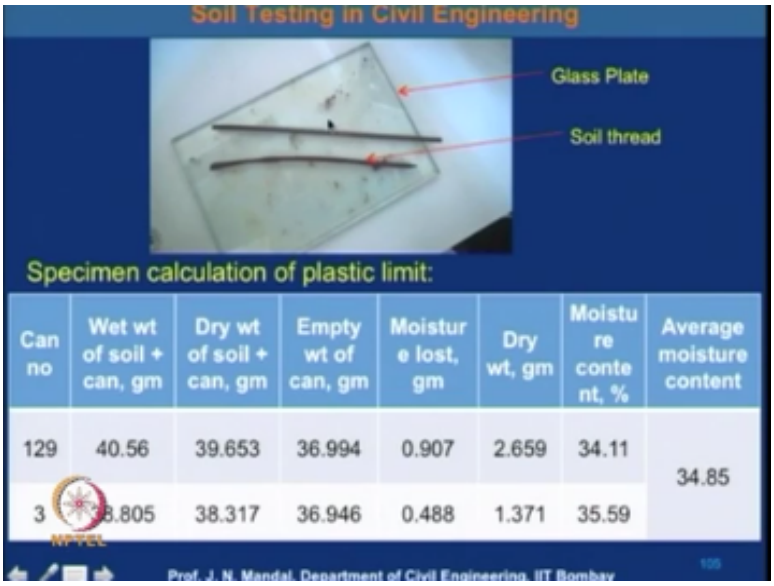

So had to so you can states the take the soil sample in that determine the and this is the determination of the electron in the soil flood so here some specimen calculation is given this is the first can number 129 and 3 the weight soil of the can number45 56 and the die weight of the can of keeping it when the die is 39. 63 and the same weight of the can and in the gram 36. 994 and the moisture 20 is 6.907, and the die weight is 2.659.

And the moisture content is it can determine 34 .11 similar you take another can and another soil sample and then you calculate what will be the weight of the soil and the can divert of the soil and the can then the empty weight of the can moisture contains the n the last the moisture contain height weight and then the moisture contain it can determine and the evolution and these value then you can calculate the what will be to evolution moisture contain.

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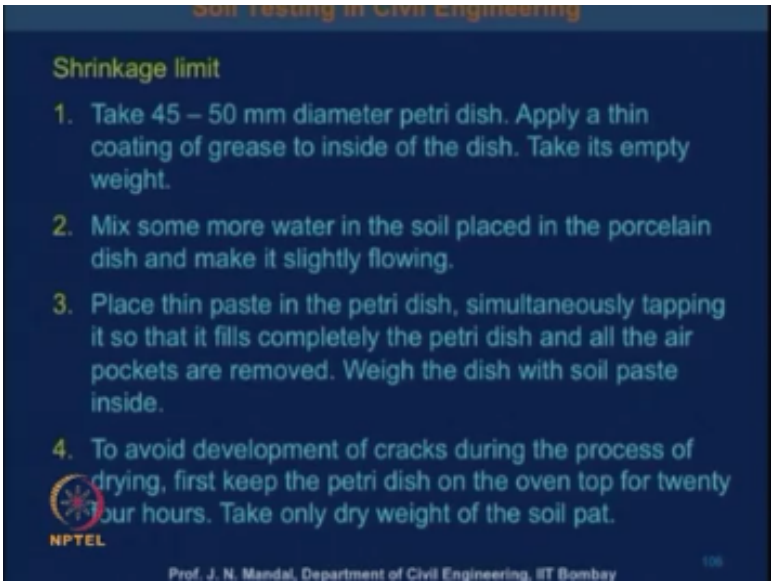

I will talk about the sink age limit take 45 -50 mm diameter Petri this and apply a thin to the in empty weight with some more water in the porcelain and make so in force and may kept slightly plane thin I the Petri place an/d simultaneously tapping it so that it fills completely it is the Petri dish and all the air pockets are removed weight dish with the soil paste inside to avoid the development of cracks during the process of dying first keep the petri dish on the oven top for twenty four hours and take only dry weight of the soil pat.

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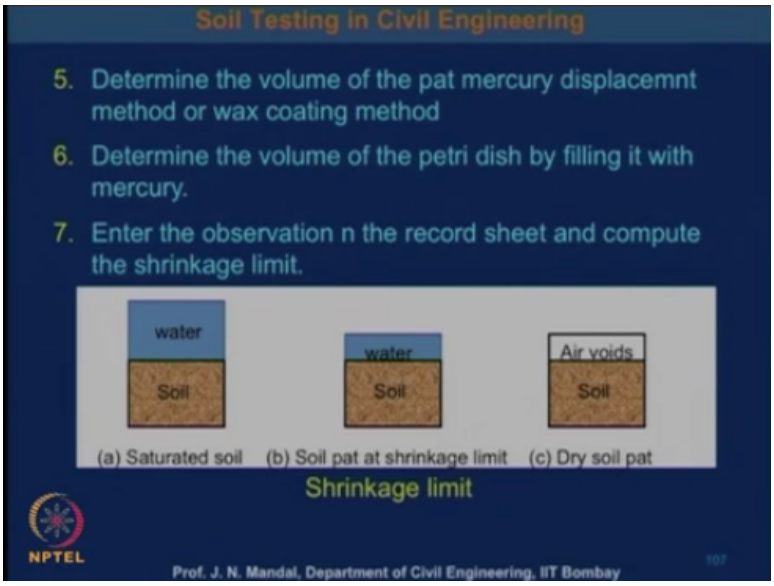

Next determine the volume of the pat mercury displacement method or wax coating method determine the volume of the petri dish by filling it with mercury enter the observation n the record sheet and compute the shrinkage limit here we can see that this is the soil water saturate condition and then second which is the soil at water this is soil pat at the simple unit.

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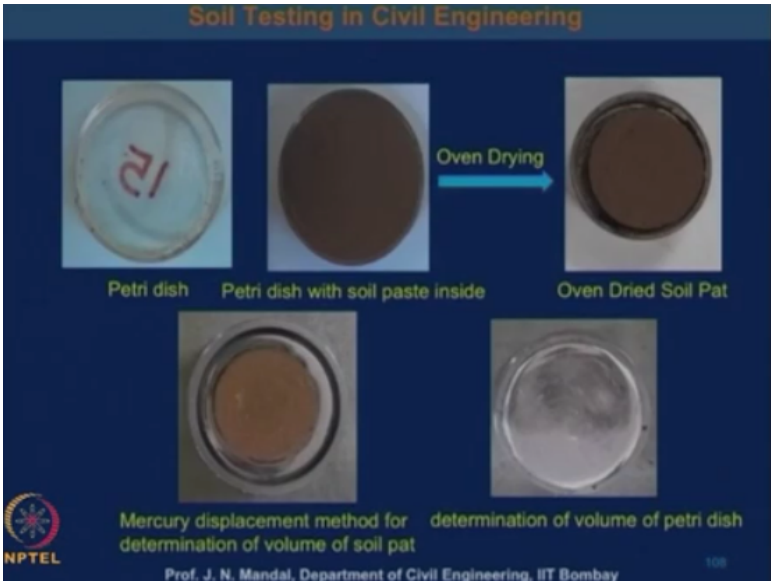

And thereafter that you can keep the oven for the 24 hours and then all the voidage we can remove the we can take the dry soil pat now here we have see the soil petri dish and then petri dish with soil paste inside this is the soil paste inside and then you can keep this petri dish in the oven dried and keep it in oven dried we can see the size of the sample also reduced.

There means this is the oven dying soil pat this oven drying soil pat you have to place in the mercury displacement method for determination of volume of soil pat and then it determining the volume of the petri dish.

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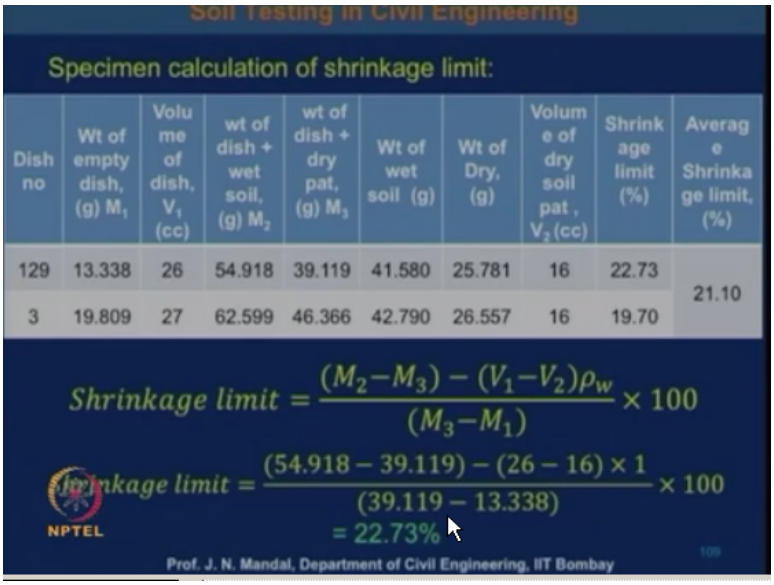

So now you that how that specimen calculation can be done let us say that weight of the empty dish how to calculate the specimen calculation and saying that specimen calculation of shrinkage limit okay first of all we have to take that what will be the weight of the empty dish let us say weight of the empty dish.

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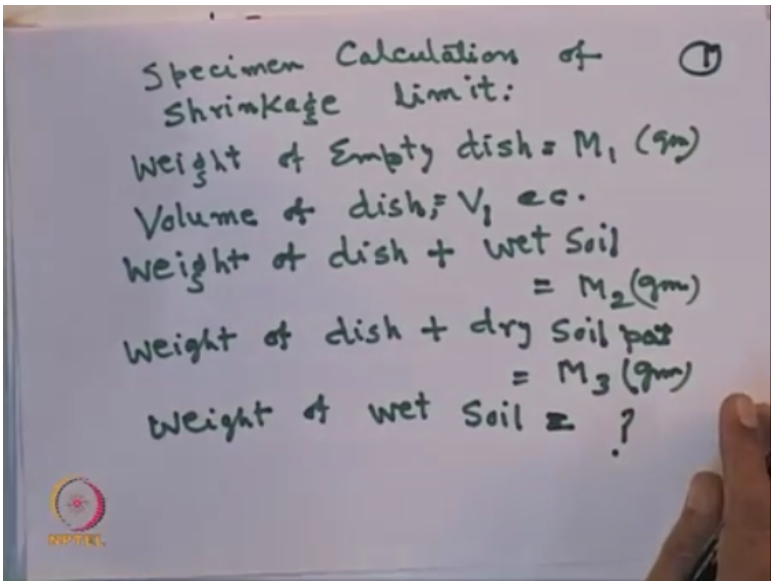

The weight of the empty dish let us say M_1 and this is a gm and now we can take that volume of the dish so we can calculate the volume of dish that let us say V1 this is V1 that is ec. Now weight of the dish + wet soil is equal to M_2 gm now weight of dish + dry soil pat is equal to M_3 gm then you can determine that weight of the wet soil is equal to we can calculate whet will be the weight of the wet soil so knowing these data we can calculate the pat of the wet soil.

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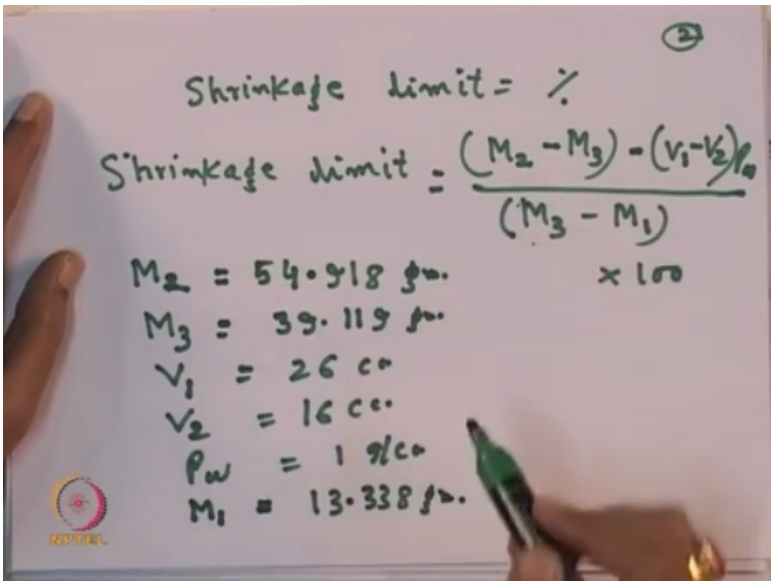

Now you can also calculate that what should be the weight of dry soil also we can calculate you can calculate that volume of dry soil pat that is V_2 that is cc. Then you can calculate the shrinkage limit we can calculate the shrinkage limit in terms of the percentage so the equation for the shrinkage limit is equal to M_2- M_3- V_1-V_2 this divided by M_3-M_1 this into 100.

So here from the data sheet we can say that here M_2 value is equal to 54.918 gm and M_3 is equal to 39.119 gm V_1 is equal to 26 cc and V_2 is equal to 16cc and Pw is equal to 1 g/cc so you know that M_2 M_3 V_1 V_2 and this also M_3- also M_1 and here M_1 is equal to 13.338 gm. Now you substitute this value in this equation and then we can determine the shrinkage limit.

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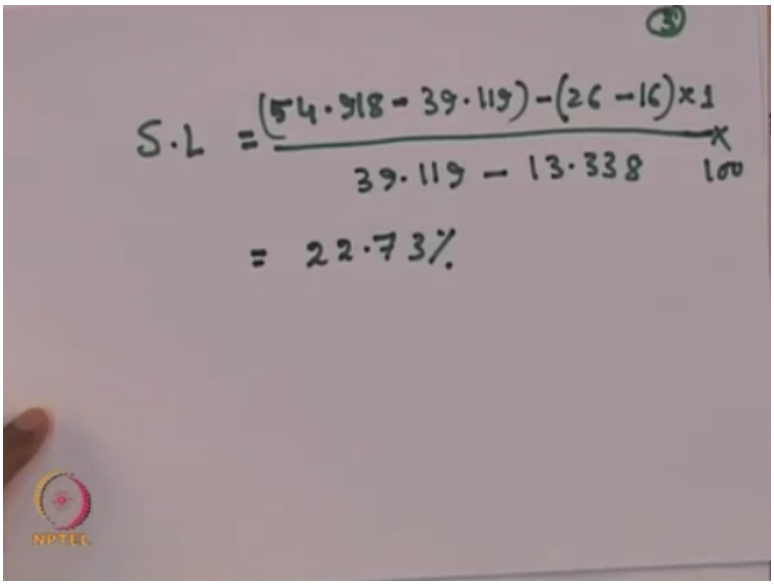

So what we can write here that shrinkage is denoted by The M_2-M_3 is 54.918 and let us see that you can take that let us say that shrinkage limit SL=M_2-M_3 so you can write (54.918 – 39.19) – (26-16)*1/39.119-13.338*100 so this comes from 22.73% so in this we can calculate that what would be the shrinkage limit of soil pat. So you know that how you can calculate the liquid limit gas limit and as well as the shrinkage limit and this are the parameters are very important and for the soil testing this are the very basic properties if the soil. Thank you.

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