Geotechnical Engineering I
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Lecture-11
Particle Size Analysis of Fine-grained Soils

I was talking about the sedimentation analysis in the previous lecture and this is where I went very fast alright.

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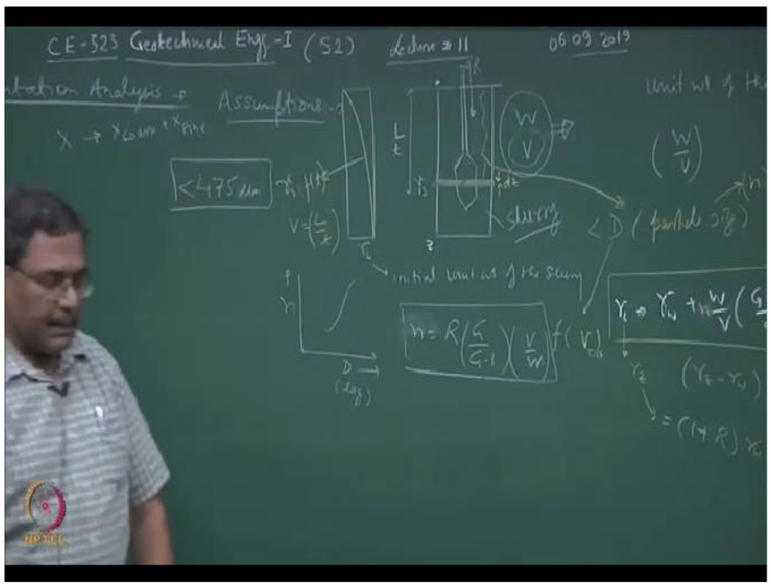

So, whatever you do in the lab, if you can tell me that this has already been done the lab I can skip that portion. So, I can save time alright or I can moderate in such a manner that I can do justice as the course as well as the time. So, I am sure you are doing these experiments in the lab. So, I will not discuss much. So, here we have talked about the assumptions alright. And then we were deriving a relationship based on the fact that you know in hydrometer tests.

What happens is you take W weight of the soil and put it in the V volume and you use a hydrometer air and normally at this point you know, we measure the density of suspension and this is treated as L the length, time is known because you must have done these experiments I am sure in the lab you are done or not, you are done half the batch okay. So, every subsequent time you keep on finding out the readings, which are depicted as hydrometer reading as R.

Normally R increases from 0 to some number depending upon the type of hydrometer you are using. I have talked about the corrections which are applied for hydrometer readings that is the meniscus the application of you know corrections for dispersing agent. And I have also talked about the displacement of fluid because of the hydrometer. So, these are the 3 correction that you normally apply that is the correction, meniscus correction and displacement of it because of the hydrometer.

Some of them are additive, some of them are negative, and then you apply and get the readings. This is what the philosophy of the whole test is. Now, what you should be doing is, see it is a very interesting application in most of these production engineering related jobs. There, you are working with slurry particularly those of you who might apply for a position with the hydrocarbon industry, drilling fits, alright oil and natural gas, hydrocarbons and all those things.

So, normally they do this type of work, where they talk about the density of the slurry. And what you should be proving is if I want to find out the unit weight of the slurry. Now, this would be what, I can measure the unit weight of slurry by using a hydrometer or I can find out the total volume of the solids which I have used plus volume of water. And I can assume that the total volume of the system is unity.

And based on this I can derive the total unit weight would be w upon v and this w upon v would be having components as volume of solids I think you can compute, this would be w upon v over G into gamma w. Is this okay, is this correct, nice. And you have the volume of water. So, 1 minus volume of water would be equal to this term. Now, how would you complete the volume of water. That is a big question, is it not.

So, volume of water I can compute either if I take this on this side, so this will be 1 minus this and then if you do some computations to compute the weight of the water, what I will have to do I will have to multiply this by gamma w this whole term. Now when we deal with the hydrometer the concept here is the density of the fluid keeps on changing with respect to time.

So, if I define this as gamma i where gamma is the initial density, initial unit weight, I will write of the slurry.

And remember, if I am using hydrometer, I am getting the value of gamma slurry corresponding to this point. So this I can measure, this I can compute, I can do both the things. If I leave this against in the gravity over a period of time, what is going to happen, the density of the suspension is going to change from let us say 0 to Z. And this is how the profile of unit rate will look like. So this is the time dependent unit weight of the slurry.

So if I go back to the calculation which I was doing over here. And if I say gamma i equal to try to prove this. Once you have these expressions, you can define this as w upon v G – 1 over G. Now, the concept which I was discussing the last lecture is at this point which is at the depth of z, if I can see that a plane which is of taken as v z, now what hydrometer is going to do is, it is going to give the density of the slurry at this point. So, what I am assuming or what in physical sense is correct is that all the particles which are finer than d fraction okay less than d size, this is the particle size, they will not be present in this column of water, is this okay.

So, because of the settlement or because of sedimentation process, when the gamma is changing from here to here the particle less than d size will not be available alright, now we call this as a percentage final then. Now, if I use the term n for defining what is the fraction of particles which are less than d, what I have to do is I have to multiply here by 1 because n into w takes care of the percentage of the particles which are finer than d.

And this d, if you remember is a function of critical velocity or terminal velocity alright. I can also use a function that v can be defined as L by t if required. So, gamma i at an instant would be equal to gamma Z, because this is what you are missing at this point alright. Let gamma Z - gamma w is sometimes defined as R. Now, R is the hydrometer reading. So, that means gamma that can also be written as 1 + R times gamma w.

So, this gamma w is just for the balancing so that this becomes a density term w upon v is a density terms so I am just writing 1 + R into gamma w, where r is the hydrometer reading. So, if

R is let us say 0.025 the specific gravity would be 1.025 multiply by gamma w. This becomes the density of the slurry. This is okay. Is this fine, you must have done this in your lab. I can prove from here that n = R times G over G - 1 into w upon v ohh sorry, v upon w, spend half an hour whenever you get time try to prove all these functions.

And see whether you can derive this or not, from hydrometer analysis what we wanted to do is we wanted to get the n, n is the fraction of the particles which are less than d diameter is this okay. Specific gravity of the soil is known, volume of the suspension is known, how much weight of the soil mass has been used known R you are measuring from the hydrometer reading. You get the value of n and this n can be plotted again on the scale.

If you remember the last time the scale on which I plotted this is x axis is normally a log scale and this is the graph which you get. I do not know whether you are being taught this or not in the laboratory, this analysis is done on the fine fraction where we are filtering out 475 micron particle size. The rest of the analysis was done on the coarse fraction. So, now you have to join both the graphs.

So, as if suppose if I take the x amount of the soil, out of which after filtering from 475 micron, I will be getting x coarse and x fine alright. So, this curve I can obtain from CV analysis, which I was discussing the last lecture, percentage finer than log of the diameter not block of the sorry, it is on a log scale, not the log of the diameter, x fine I am going to get from here. And the inbuilt assumption is this n finer is less than D.

So you club the 2 graphs and get the complete particle size distribution curve. Many people do the mistake in assimilating the information from the 2 tests alright. So this part, sit down and practice the problems which I will be giving you today and try to solve them. How many of you falling a book on solid mechanics, very good, which one excellent. So, what are the problems which are solved there, at least solve them.

A lot of example problem they have given and try to be conversant with this, any question you have, yes please. Sorry expression of the solution this one yeah, yeah. You know weight volume of the solids can be computed this much is the w upon v and what about this G into w. This is the unit weight of the total suspension and G into gamma w is the density of the solids which are present. So, this is all I am getting the solids.

Total suspension means, total suspension volume will be unity 1000 cc. So, volume of solids plus volume of water, how will you compute the volume of solids. So, if I know that total weight of the soil which I have added in certain volume v divided by G into gamma w. So, this is the component which gives you the dry component of the solids which are in the suspension form. So, this becomes the solids.

So, and hence you can compute 1 - gamma w equal to this or v w will be this expression, weight of water I can compute by using multiplying this system by gamma w. So, this becomes the weight of the water these total volume, yeah the total volume of the cylinder in which you have taken the suspension. So, normally what you do is you take 50 gram of the soil in 1000 cc. So, this v becomes 1000 cc right.

Now, what we have done is we have talked about the particle size decision analysis for coarse grain and fine grain soils. Now moving on to the classification of the soils yeah. Oh, hydrometer reading is I will tell you these are the graduations on the hydrometer stem. So, if you go to the lab next time, and when you perform these experiments, you will observe that the hydrometer is like this.

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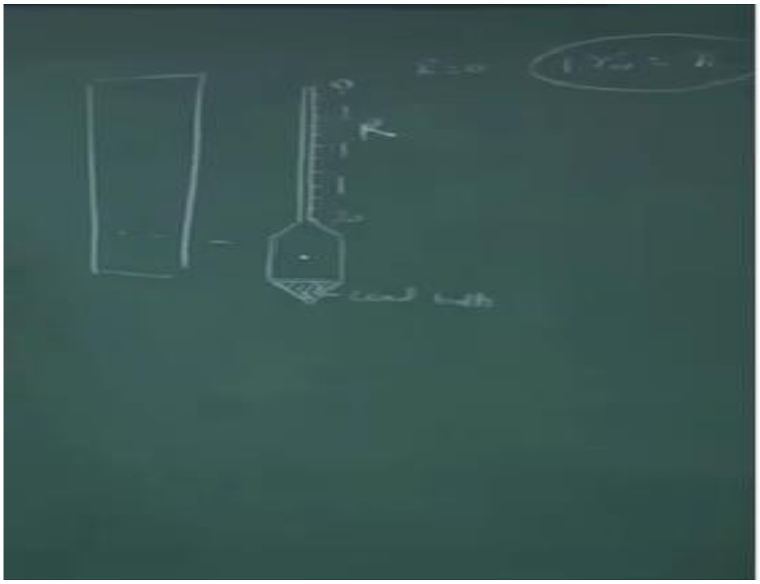

This is the stem of the hydrometer and this is the body of the hydrometer alright, and then the bottom motion is filled up with lead balls. This is a cc of the thing. R is the graduation on the hydrometer so 0 to 20. So, this is R value it is okay, what you read in real life, because you have asked this question. So, I will explain this further as the suspension process goes on in the hydrometer column, what will happen to R, it will increase or it will decrease.

Sorry think again look at this density distribution. So, when you started with the initial density of gamma i and then you left the cylinder for settlement what is going to happen all the particles are settling down. So, top portion of the liquid column is becoming alright. So, if this becomes lighter what happens to R, it goes up alright. So, R = 0 will indicate 1 into gamma w is the gamma i is a unit of water is it okay.

Now why we have studied this particle size distribution for the coarse and fine grain soils is because we wanted to characterize them, classify them. So now I will be moving on to the classification system for soils particularly fine grain soils.

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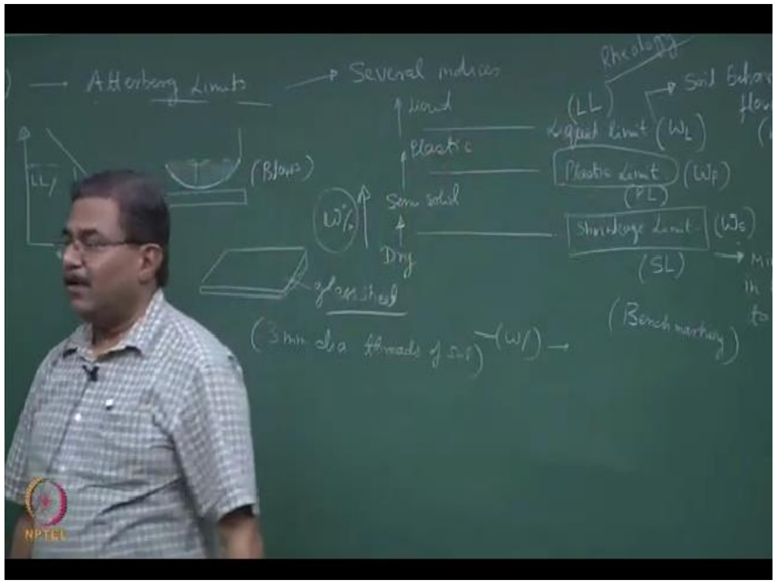

And what we do normally is use the term known as Atterberg limit. Have you done this in the lab Atterberg limit, not yet. We talked about several indices. This part of the subject is slightly monotonous, but factual. So, you have to remember these things. You see, as I said in the first lecture or second lecture soil is something which changes the characteristics when it comes in contact with water.

So, suppose if I start from a dry soil mass and if I add water to this, what is going to happen. The state of material keeps on changing. So, from dry it will become semi solid. And if I further add water from semi solid, it will become plastic. And if I go further keep on adding water to this, this will become liquid and all this is happening just by addition of moisture. The interfaces between these states are known as the indices or Atterberg limit.

So, these are defined as you know this will be liquid limit. In other words, this is the minimum amount of water which is present in the system when the soil just starts behaving like liquid alright. This is what is known as plastic limit. Those of you who are good in making clay potteries or artifacts normally use this concept of keeping these indices intact unknowingly, you are good at making artifacts who is good.

So, you take dry soil and start adding water. So, state of the material keeps on changing alright and this is what is known as shrinkage limit. Though these indices look very primitive, but they have lot of applications in science and technology. In the second course and I will be teaching what we be talking about the shear strength, that means this is the limit of the moisture content beyond which the system starts flowing.

It has no shear strength organism yes. Yeah can you writing bigger fonts, please. Can I write in bigger fonts okay alright, sure. If I dictate that is better okay. I will try to follow what you are saying see liquid limit is the limit beyond which the soil behaves is this okay, behaves like a flowable material that means the minimum possible shear strength, in laboratory normally what we do is we use a classical index apparatus.

You must have seen it how many of you have performed this experiment. No, not anybody. So, there is a cup sort of a thing and there is a flat platform in this cup is a made up of brass, we fill the soil and then with the help of a spatula, we make a small grove. So we remove this part portion of the soil. And then what we do is we allow this cup to fall on the platform and several tamps we give tamping.

Now because of the tamping process, what happens is these 2 cleavages which have got created, they tend to get filled up. We call this a caving in, particularly in case of tunnels. Now, this is the limit when these 2 cleavages, they have just tried to close up at this point we find out the liquid limit. So, what we normally do is we plot percentage moisture as a function of n, this n is also on the log scale, remember these are the log scales.

These are not the log of the number alright. So, the logic says the more the moisture we require less number of blows we call this as blows or tamps okay. So, more the moisture less number of blows are required to close the cleavage which you have created. However as you keep on increasing the number of blows and the moisture content decreases. If I find out at n = 25 what is the moisture content.

Now, this is what corresponds to liquid limit alright. This is one way to characterize the soil, these are ancient ways of classification, but they are still valid and people are using them and these are just like Brahma Bhagya you have to follow it. So, we have obtained the liquid limit normally we define liquid limit as w L, sometimes we write it as LL also. So, this is the liquid state of the material, the next state is the plastic limit.

What we do is take the soil add water and roll it on a this is a plate made up of glass sheet. So, make threads of soil by mixing water to the soil and you roll it in this way you know, just using your fingertips and convert the soil mass into very thin 3 mm diameter threads, the logic behind using your fingers for remodeling this to this state is body has some heat. So truly speaking when we roll it on a glass sheet, we are imparting lot of heating by your body heat.

And at the same time we are trying to convert this material into a thread. So this is the plasticity, how plastic the material is clear. So, this is state of the material which defines how easily the metal can be remolded into a plastic state. When these threads start crumbling, you find out the moisture content by putting these threads in oven and finding out the moisture content and this moisture content will correspond to the plastic limit.

And sometimes we define this as p L. Now, if you want to understand what is the concept of shrinkage limit, you have to be bit focused on the board. The guys who are working in the field of let us say, Unilever type of people who are designing cosmetics, different types of toiletries and all Colgate Palmolive alright anything which is flowable where the minerals you want to flow by applying a pressure, we call it the restoration process.

I would be working in the range of the moisture which is allowing material to flow rheology becomes important. So those of you who might get a chance to work in the field of let us say dredging industry, where we want to create artificial islands and you want to create a paste of the soil and you want to throw alright the way you do paintings on the wall, that is also a good example of rheology of paints and varnishes. So their liquid limit becomes important, plastic limit is sculptures, making pottery and so on.

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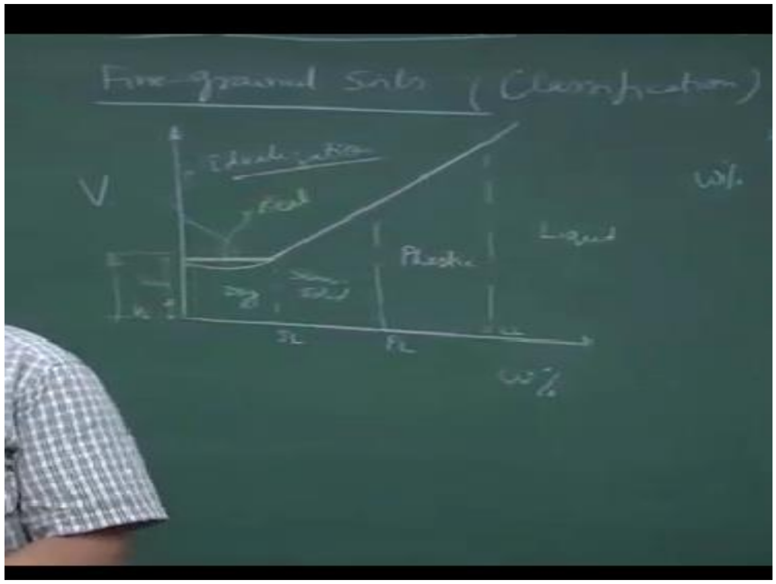

So, this is the model which is normally used. If I plot total volume of the soil with respect to the moisture content alright. It is so happens that up to a certain limit of moisture, the volume does not change. And beyond this there is a linear variation in the volume of the soil. Now, this is where I can define the 3 and this is the first one is liquid limit, this is your plastic limit and this is shrinkage limit alright.

One of the interpretations of these graphs is if I extend this portion back and if I find out the intercept on the volume access, this is the volume of the solids clear. So, to complete this discussion, anything below the shrinkage limit is going to be in the dry state. Now, if I translate it over here this is going to be the dry state of the material. This is going to be the semi solid state of the material. This is going to be the plastic state of the material.

And this is the liquid state of the material. Normally, these states are done starting from right hand side. So, you make a slurry of the soil and start drying it. So, you are traversing opposite to the moisture content, you are decreasing the moisture content and you are crossing over these boundaries. Now, when you have dried the soil mass, what is going to happen this volume becomes constant. So, this much portion of the volume will be volume of air is this okay.

Truly speaking, this graph is nonlinear in nature. But this idealized form this would be something like this in real life, but we idealize this as a constant value. So, this is the idealization. So, I have to define the shrinkage limit also. So, shrink a limit is normally defined as SL and this is the moisture content as SL or WS you may right. This is a very interesting parameter, which talks about the drying process of the soil.

And this is the state of the material where the soil remains saturated. This is the minimum moisture content present in the soil to make it saturated, that means we do not allow any air to enter into the system. Normally this type of testing is done under very slow conditions. We start from here take a pot, make a slurry of the soil and normally we do not overheat it, we keep it for air drying and sometimes once I have crossed the limit of the plasticity, I will keep it on the top of the oven, so that it gets heated up slowly fine.

So, these are the moisture contents which become benchmark moisture contents. So truly speaking, what we are doing is we are doing benchmarking of the soil mass. So, in whatever field of engineering and technology are working you have to consider the state of the material and sometime back if you remember I had said the soil is a funny material, it can behave like a solid and it can behave like a liquid material. So, both the laws are valid, I can use solid mechanics, I can use fluid mechanics to model those material is this okay, any questions. Now, what you have to do is you have to remember a few things.

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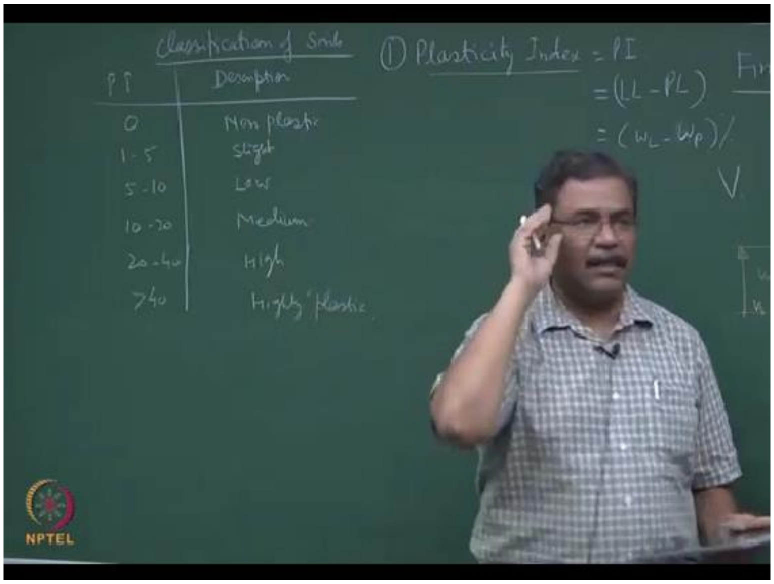

The first concept is that something known as plasticity index, we call it a PI. This is liquid limit minus plastic limit okay, everything is in percentage. There is something known as the flow index. I hope you will realize after doing different types of classifications of soils, their origin their deposition, geographical shape, morphology, mineralogy. Now, this is the first time we have started talking about the tamping which is given to the soil mass.

So, this is a sort of engineering property, you are inducing vibrations and you are trying to see what is the state of the material whether this material becomes it is loses strength shear strength, yeah, we are inducing some tamping or the vibrations in the system. So, this is a sort of a mechanical property of the material liquid limit. Here also you must have noticed in plastic limit I was telling you that take soil and roll it into threads.

So, you are allowing deformations, very gentle deformation and heating from your fingers shrinkage limit. So, shrinkage limit is the one where the volume remains constant there is no loss of moisture, soil remain saturated fully, no air enters into the pores. So, these are the basic assumptions which we use for defining the whole thing alright. So, the slope of this line is known as sorry flow index.

And normally we define this as If alright based on shrinkage limit there is a classification of the soils because shrinkage is limited something which is normally used in engineering designs. So, if you have plasticity index sorry not shrinkage limit, classification of the soil based on plasticity index, fine grain soils remember. So if it is 0, this is non plastic 1 to 5 this is slight plastic, 5 to 10 low plastic, 10 to 20 medium plastic, 20 to 40 high plastic.

And greater than 40 it is a highly plastic material. Now the tricks would be in your examination which you will be writing the examiner will not define any state of the material alright he will simply say a soil of plasticity 10 to 20 and you assume the data got it. So, these are the tricks where somebody will say the plasticity index is more than 40. So, it is understood that this material is going to be highly plastic.

And hence the settlements are going to be much more when the buildings are constructed on the top of this. Try to remember this part at least. Now, the question is about the shrinkage limit. Are you doing these experiments in that determination of liquid limit, plastic limit and shrinkage limits not yet.

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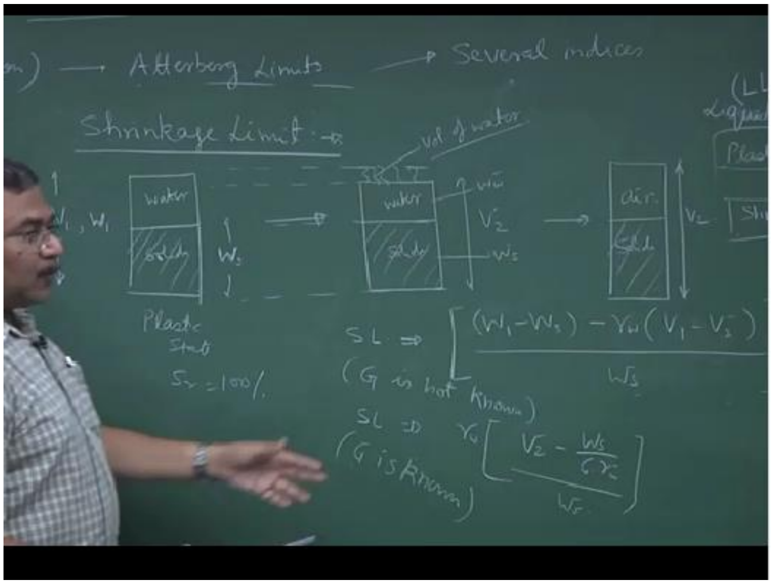

Those of you who are very fascinated with THMC modelling, thermo hydro mechanical coupling and all those new concepts which are coming up in the market right now, where the soil gets exposed to extreme heating conditions, or extreme volumetric deformation because of air drying in a nuclear industry particularly. A shrinkage becomes very important that means, this is a state of the material where soil still remains saturated with a minimum moisture content.

And that is the fundamental attribute of the material. So the models normally we use this we have a 2 phase system, we have water, we have solids in the soils. Remember the soil is saturated. So this is a plastic state of the material. Where saturation is 100%, v 1 is the volume of the soil mass. W 1 is a sweat and W s is the weights of the solid. This W s should not be confused with W s this W s is the moisture content shrinkage limit.

So, this is a W s weight of the solids. Now, if I slowly heat it what happens is some amount of water goes out of the soil. So this portion becomes solids, volume does not change. And here this is the reduced volume of water. And suppose if I define this as v 2 the weight of the water is ww, weight of solid is w s. And if dry it what is going to happen is that this system will get converted to solids and air, the volume remains constant as v 2 okay.

So these are the solids, this portion V s is not going to change further. This is what we define as v dry. Now, if you solve this previous system and if I define the shrinkage limit as SL. There are 2 philosophies of defining the shrinkage limit, one is weight wise. Another one is volume wise. I am sure in your laboratory they will ask you to use the mercury column, what is known as mercury displacement.

So, you dry the soil mass, the dried portion, you put it in the mercury dashpot, whatever volume of the mercury oozes out, measure it that is equal to the weight of the soil alright and then put this pot into the oven and find out this moisture content. So, there are 2 ways of defining the shrinkage limit, as I said shrinkage limit is a critical parameter. And what normally we do is we define shrinkage limit as w 1 = w s is the weight loss of water starting from v1 to v2 after this volume remains constant.

So, v 1 - v 2 is that total limited information, the amount of water which is that is spell out is this much, this is the volume of water which has gone out alright due to drain. So, the weight of the solids would be the w 1 sorry weight of the water would be w 1 - ws and there is a loss of water which is taking place within the water itself to make system v 1 to v 2 correct, this is okay there are 2 processes, one is the water is evaporating out of the system you are drying it.

So, there is a loss in the water, weight itself because of drying, solids remain as it is and there is a volume shrinkage which is taking place. So, these 2 effects have to be clumped together. So, we can write this as w 1 - w s - gamma w v 1 – 2 divided by w s, please make sure that this w s does not get reflected over here, this is the weight of the solids. So, whatever way you define this is a shrinkage limit alright.

So I can weigh w 1, I can read w s, I know the v1 and v2 by using the mercury fact and the weight of the solids is known I can get the shrinkage limit. Now, this process is normally or this equation is normally used when G is not known, specific gravity however there is one way of finding out the gravity of the soils if you know the shrinkage limit and vice versa. In that case we utilize the concept of the volume.

So, the shrinkage limit would be gamma w v 2 is the final volume of the soil mass minus weight of solids divided by G into gamma w upon w s. The way you would like to read it is, final volume of v 2 and in this volume w s upon G gamma w is what. This is the specific gravity of solids multiplied by the unit weight and this is the weight of the solids. Yes so, this is the volume of the soil mass at this stage at a shrinkage limit state divided by the weight of the solids.

So, this equation is used when G is known, mostly these equations are used for calibration of the G, suppose there is a discrepancy in finding out the G and if you can limit is known I can compute the specific gravity. So, these are class of problems which normally are asked in your competitive exams. You should mug it up fine.

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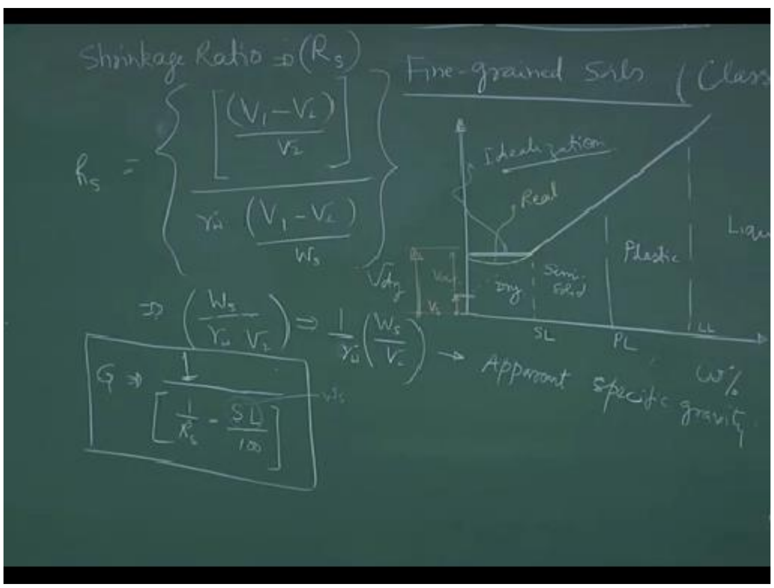

There is something known as shrinkage ratio which is defined as R s and this shrinking ratio is defined in terms of the volume loss underground by the material. So, I can say v 1 – v 2 upon v 2, this is a percentage loss in the volume of soil mass from v 1 to v 2 divided by v 1 - v 2 into gamma w upon weight of solids at this stage. So, this becomes the shrinkage ratio R s. If you solve this expression, what will be getting is you will be getting as weight of solids divided by gamma w into v 2.

That means after drying if I have achieved the state of volume v 2, I can substitute it over here, W s is the weight of the solids, I can dry the soil in oven, I can compute w s gamma w is known. This term can also be written as 1 upon gamma w into w s upon v 2 alright, this is defined as apparent specific gravity. Weight upon volume is a density term and this is normalized by the unit weight of water.

So this becomes apparent specific gravity of the soil. Try to correlate G and R. You will have to do it G can be written as 1 upon R S – shrinkage limit divided by 100. As I said this function is used to calibrate the G value is the relationship between shrinkage limit and G the shrinkage limit I have been defining as w s, hope you have enough mathematics now. Start solving these problems you will become an expert is this okay, any questions. What you should learn in the laboratory is how to determine the moisture content number 1.

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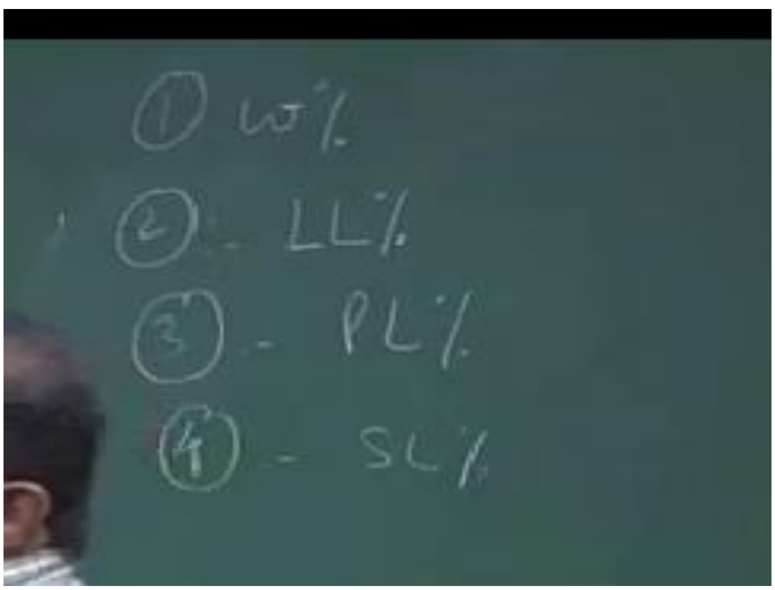

The first exercise you should do is compute moisture content by oven method, number 2 liquid limit of the soil, number 3 plastic limit of the soil, number 4 shrinkage limit of the soil and when you are doing this matrix you will come across the method which is also known as mercury displacement method. I hope you understand why mercury is being used to compute the weights of the solids because this is a non meeting fluid okay.

So, I can displace the equal amount of the volume of the mercury, which is the volume of the soil at the drying state dry the state or at the shrinkage limited state, again come to the v 2 value, I can substitute it over here, initial volumes are known, initial w 1 will be known, W s can be obtained and you can use this expressions is it okay. The last part of today's discussion would be in 10 minutes I like to finish the classification of soils.

This is based on plasticity index and for a quick review plasticity is the one which dictates how easily the soil can be molded plastic material. Some of you might be using this term instruction analysis that plasticity of the system plastic analysis, formation of injuries and virtual worlds principles and all those things. In geomechanics we use this term plasticity index to define how easily a material can be molded alright clays.

You just mix water and start playing with them you know this molding clays available in the market, you keep on playing with them, you keep on compressing, make chapatti out of it or do whatever you want. So, this defines the state of the plasticity, how easily I can work on this material, how much I can deform this give it a shape. So, what we have done until now is we have talked about the experiments which are done to characterize coarse grain materials and fine grain materials alright. And then I would like to characterize the soils by putting them in a classification scheme.

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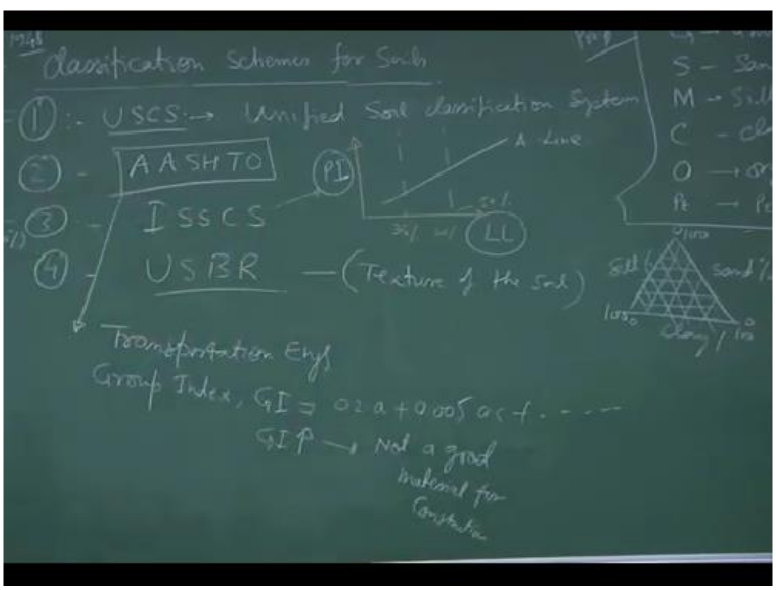

So the classification schemes are known as it is a normally used for soils. The first one is known as USCS unified soil classification system. The second one is AASHTO. How many of you are doing transportation engineering course all of you third year. So, you must be know what is AASHTO is it not. No American association of state highway a state and surface transport officials or organization officials fine.

The third one is which is used in Indian context we call it that is as ISSCS Indian standard soil classification system alright. There is a small difference between USCS and ISSCS, we will discuss this today. The fourth one is what we call it as a USBR, this is based on the texture of the soil, not very much used in the engineering practice, but those of you who might be interested in to modern agriculture engineering would be using it much more.

So this depends upon the texture of the soils. We talk about sand fraction, silt fraction and sand, silt and clay. So, this becomes a 3 dimensional graph hope you know how to check the 3 dimensional graphs is it not. We normally do not use it in geomechanics, 0 to 100, 1 to 100 1 to 100, alright 3 dimensional plotting mostly. Now the one which is used quite significantly in our context is the unified soil classification system.

This is a graph between velocity index versus moisture content and we use the other concept of A line. Now A line is named after author Casagrande. He is the guy who invented this author Casagrande alright 1948. And the equation for this A line is 0.73 liquid limit - 20%. So that means this line starts from there is a break over here I will show you. So this starts from 20%. The significant part of this USCS technique or the classification scheme is here we consider 2 types of moisture contents.

One is greater than 50% and another one is less than 50%. In Indian standard, what we do is we have divided this category of 2 soils based on their moisture content in 3 parts. One is 50% another one is 35%, that is the only difference. The A line remain same, this is A line, this is the PI on the y axis. So, basically these plots are relationship between velocity, index and the moisture content. There are typical symbols which are used.

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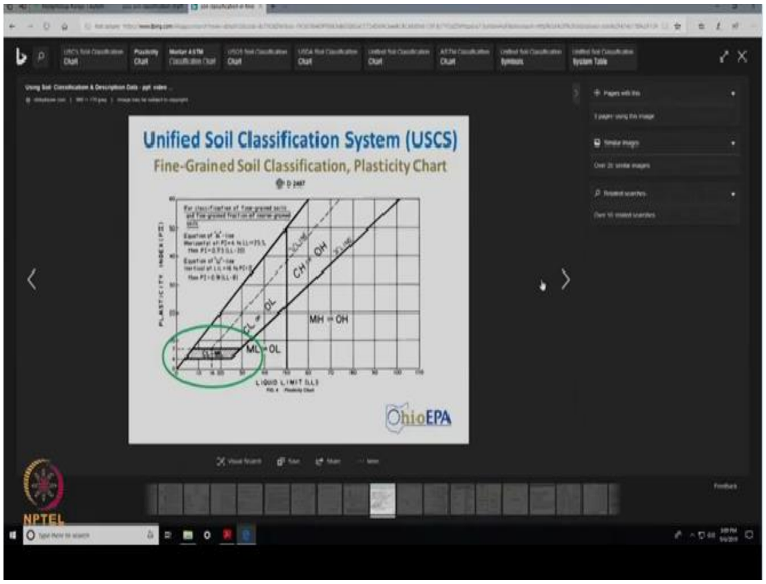

So the symbols which are written over here as per USCS classification G is used for gravels, S is use for sand, M is used for silt. In Swedish language silt is known as mo and hence M is used, for clays we use C, for organic matter we used O and PT is use for Pete's. So, this is a nomenclature which is used. This is followed by the sub group, we call them a suffix. These are the prefixes, prefix and the suffix would be W is for well graded.

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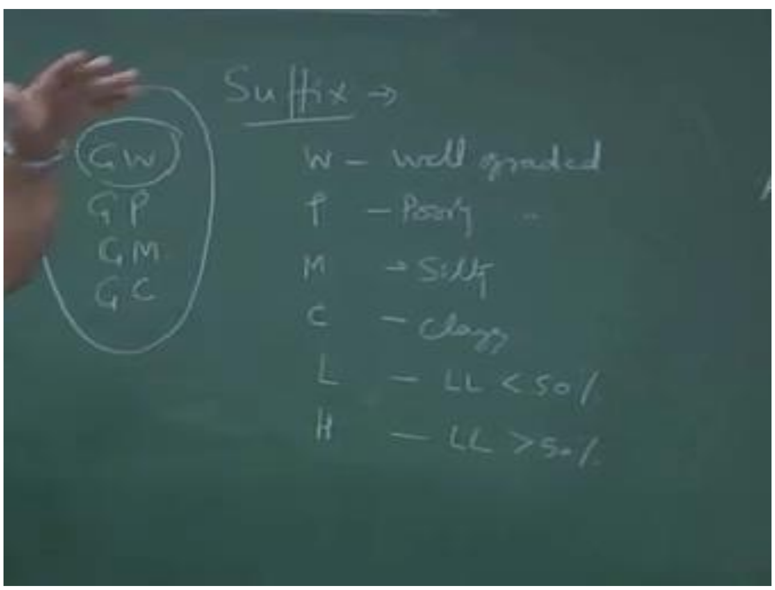

We discussed about this in the previous lecture. What is the well graded material, poorly granted material, we use p for silty soil we use M. So, M is for silt as well as for the silty material. For clay material we use C, L is used for liquid limit which is less than 50% and H is used for liquid limit which is more than 50%. So, suppose if I say G W. So, GW is a universal language, which will be defining we read it from right hand side well graded gravel alright.

GP poorly grated gravels, GM silty gravelly, silty gravelly soil alright, GC clay graveling material alright. So these other combinations. So what you are seeing in this graph is so what you are observing here is there is a A line they are talking like U line does not matter, this is the A line, liquid limit versus velocity index. MH would be high liquid limit silty, OH would be high liquid limit organic matter clear.

What you are observing here is a dual coarse CL ML. So, these are the soils which are not well defined by one scheme of classification. So these are also known as interface soils. What it indicates is the organic matter is always going to give more plasticity to the soil. And hence you will observe most of the organic clays which are very notorious as far as trust which is concerned will show you very high plasticity index for a given liquid limit alright.

So, you follow any standard textbook where you will get these type of relationships in course also, these are the parts of the course where you can define the soil mass. Please remember when you use plasticity index and liquid limit, this is for fine grain soil. If I change this moisture content to liquid limit this becomes for fine grain material. So these classification systems are for fine grain materials.

And for course, the material we have utilized see CUCC by using D 10, D 60, D 30, the edify D 15 and so on alright. This becomes the common language which is used internationally to define the soil mass. Now what remain there is the AASHTO, AASHTO is normally being used by the transportation engineers very incomplete sort of a classification, where they create a big index like you know this what is known as group index defined is a GI.

And GI will be equal to some parameters multiplied by some coefficients. Do not try to remember all this plus so on, where these parameters corresponds to different states of the material alright. So, the thumb rule is if GI is very high is not a good construction material. So, what we will do now is with this discussion we are going to define our soils mostly based on ISSCS and sometimes based on USCS.

So, when you do research and when you publish papers in international arena. So, there ISSCS is not more much. So, mostly international researchers they use the USCS classification scheme, plot plasticity index or liquid limit and then classify the soil as far as Indian practices are concerned, we follow ISSCS where we differentiate between high liquid limit and low liquid limit. So, high liquid limit is 50% and low liquid limit is 35%.

So, in this graph what I was showing you MSCH type of system you know this soil will become low liquid limit organic matter, low liquid limit silt, high liquid limit organic matter, CH. Now, tomorrow when you come across these terms as a practicing engineer you should be knowing how this material is going to behave. So, the moment MSCH comes in the picture a geotechnical engineer becomes quite happy, why.

Because everybody cannot deal with it except for him or her and this becomes your speciality. So, most of the money which comes out of the profession, in the art of consulting is when you deal with the soils which are above A line you got it. So, these are the challenging problematic soils which you are talking about highly plastic material, they will shrink deform, settlements will be there.

You remember the slides which had shown you the type of distresses with the system undergoes, would be in the soils which are sitting at the same liquid limit, but with very high plasticity index. Now, how to negotiate with the situation is an art that we will be studying slowly.