Geology and Soil Mechanics
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Lecture - 08
Classification of Soils- B

Welcome back to the course Geology and Soil Mechanics. So, in the last lecture we just started the discussion on Indian Soil Classification System and we have understood that what for we need the soil classification and how we proceed for the soil classification. So, we talked about something some prefix and suffix. I hope you have understood that thing. So, for your better understanding I just repeat that thing once again.

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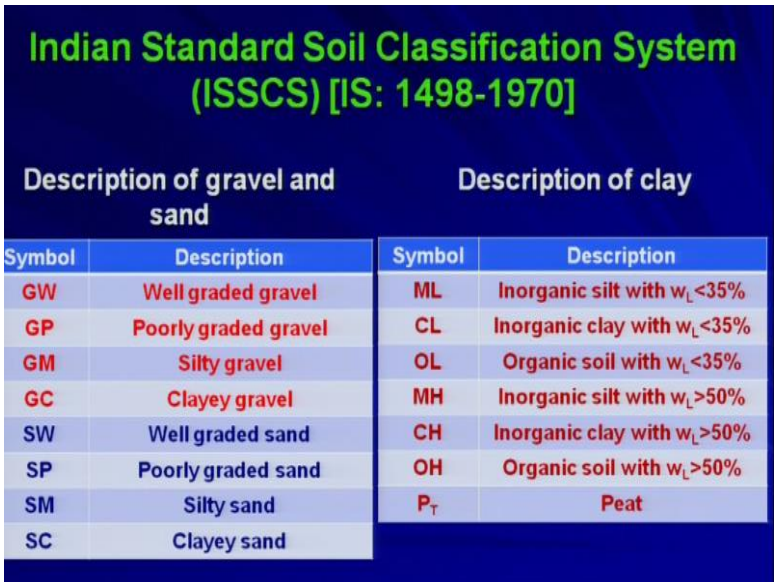

So, if you try to define or if you try to denote the gravel and sand, so basically you have a few symbols like if you want to denote the gravel fraction, so it will be well graded gravel and it will be denoted as GW. Similarly, poorly graded gravel it will be denoted as GP, then silty gravel GM, and clayey gravel GC.

Now you see that G is coming as a prefix as we have discussed in the last class and W that is the gradation as well as the clayey or silty, this nature will be coming as suffix. Similarly, for sand if you have the well graded sand it will be denoted as SW because S is coming as prefix and W will be coming as suffix, W is nothing but your gradation indication.

Whereas poorly graded sand will be denoted as SP, then silty sand will be SM and clayey sand will be denoted as SC. So, I hope it is now very much clear to you. Then similarly we have the

description for clay. If you have inorganic silt basically this is the description for clay as well as silt. This is the description for basically the fine-grained soil. So, if you have the inorganic silt with liquid limit less than 35% then that will be denoted as ML.

Inorganic clay with liquid limit less than 35% CL and organic soil with liquid limit less than 35% will be denoted as OL. Whereas inorganic silt with WL greater than 50% MH. Then inorganic clay with liquid limit greater than 50% CH and organic soil with greater than 50% with liquid limit greater than 50% will be OH.

Now from this could you please tell me that what should be the notation for say inorganic silt with WL within 35 and 50 percent. So, it will be something like MI right. Similarly, if it is inorganic clay with liquid limit coming in between 35% and 50% then it will be CI that is the intermediate plasticity. So, because I H L they will be coming as suffix as we discussed in the last class and M C O they will be coming as prefix and if it is simple peat then it will be denoted as P T.

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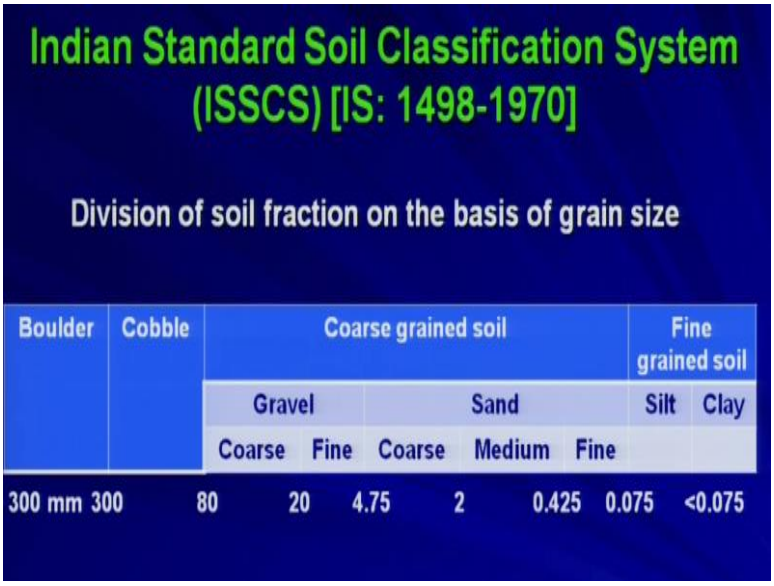

Now coming to the division of soil fraction on the basis of grain size as per the Indian Standard Soil Classification System, so if you have the soil particle which is greater than 300 mm and within 300 mm then it will be denoted as or it will be classified as boulder. Then 300 to 80 mm it will be classified as cobble. Then we come to the coarse-grained soil and coarse-grained soil is consisting of 2 material that is gravel and sand.

So, again gravel will be classified in 2 categories. One is the coarse gravel, another one is the fine gravel. So, coarse gravel fall between 20 mm and 80 mm whereas fine gravel falls between 20 mm and 4.75 mm. Similarly, sand will be classified in 3 categories. One is coarse sand, medium sand, and fine sand.

So, coarse sand falls within 2 and 4.75 mm. Medium sand will be falling between 0.425 mm and 2 mm. Whereas fine sand falls in between 0.425 mm that is 425 micron and 0.075 mm that is 75 micron. So, anything comes below 75 micron that will be classified as fine-grained soil and you have 2 guys in fine-grained soil that is silt and clay. So, this is the I mean based on the particle size basically you have classified the whole domain of the soil.

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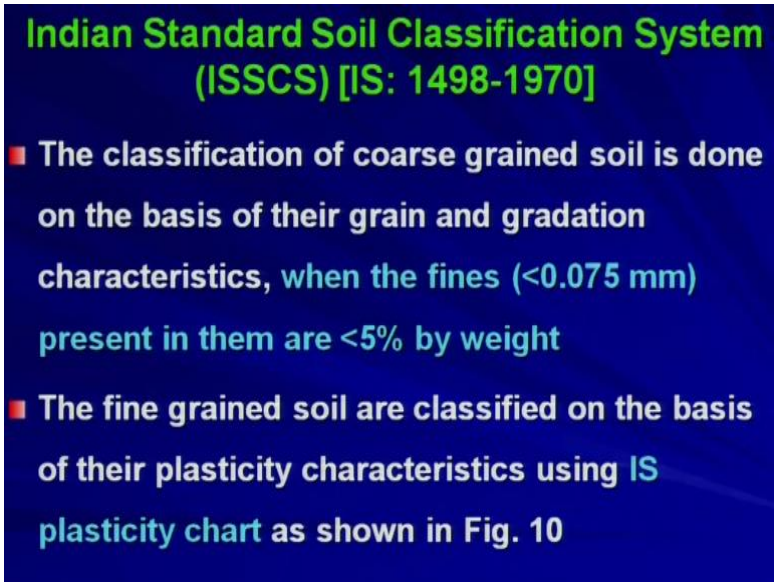

Now the classification of coarse-grained soil is done on the basis of their grain and gradation characteristics, when the fines that is which is less than 75 micron present in them are less than 5% by weight. So, basically what does it say? That means if you have the coarse-grained soil and that means when the fines that means because I mean if you get the soil, the soil will consist of coarse-grained as well as the fine-grained right.

So, now how to classify that as coarse grained? How, when, at what situation we will be saying okay this soil is coarse-grained soil and this soil is fine-grained soil though some fine particles are mixed with that kind of soil sample but still we will be saying that coarse-grained soil if that fines that is present in the sample say fines means less than 75 micron that is less than 5% by weight of the sample.

If that situation arises then we will be saying that as coarse-grained soil and coarse-grained soil is done on the basis of their grain because of the grain size as we have seen I mean if you deal with gravel or if you deal with sand so basically the grain size is very important is coming into the picture and the gradation characteristics how it is graded like well graded or poorly graded or gap graded, based on that basically you will be classifying the coarse-grained soil.

Whereas the fine-grained soil which is less than 75 micron are classified on the basis of their plasticity characteristics because I mean so far we have discussed this thing the plasticity and all because already we have seen that plasticity is the property of clay. However, this plasticity will be governing the property of the fine-grained soil right and we will see why it is why this plasticity and other things is coming in the fine-grained soil. It depends on the clay mineralogy. That will be coming later on, but as of now, one thing you have understood that plasticity is very important parameter or factor to define the clay property or the clayey type of soil or the fine-grained soil.

So, the fine-grained soil are classified on the basis of their plasticity characteristics whether it is highly plastic or low plastic or intermediate plastic based on that you will be classifying that and now for that basically there is some chart and that is defined as IS plasticity chart which can be seen in the next figure.

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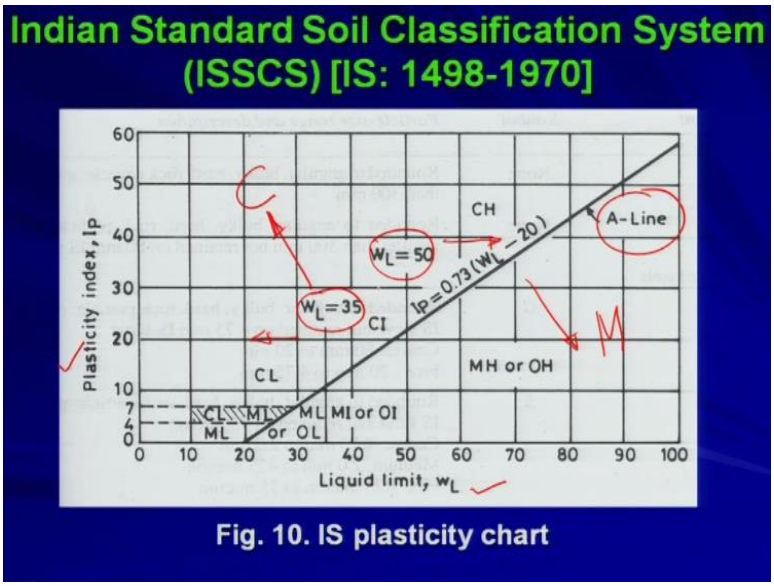

Fig. 10. IS plasticity chart

So, this is your IS plasticity chart. So, we plot the graph between plasticity index and liquid limit. So, basically any fine-grained soil you take it and then you determine the liquid limit and you

determine the plastic limit, of course you need to calculate plastic limit to determine the plasticity index. So, once you know the plasticity index and the liquid limit of that particular fine-grained soil then basically you can get the coordinate of that particular soil in that plot.

So, now we have a very typical line and very important line that is known as A-Line which is defined by this expression IP equal to 0.73 into W L that is your liquid limit minus 20. So, this is the line, this is a straight line basically which will be I mean separating 2 materials. One is if something coming on top of a line that will be classified as clay whereas if something comes below a line that will be classified as M. So, broadly this is the situation and later on we will see that how we can get other things from this plasticity chart.

Now if anything comes within this hash zone basically so we have some special kind of notation for that and then basically you have the boundary of liquid limit that is when liquid limit is equal to 35% and when liquid limit is 50%. So, anything below 35% will be classified as low plasticity soil. Anything above 50% will be classified as high plasticity soil and anything comes in between these 2 will be classified as intermediate plasticity that is I okay.

So, you have understood broadly what is the plasticity chart and later on we will refer this chart for our soil classification system, particularly for the fine-grained soil.

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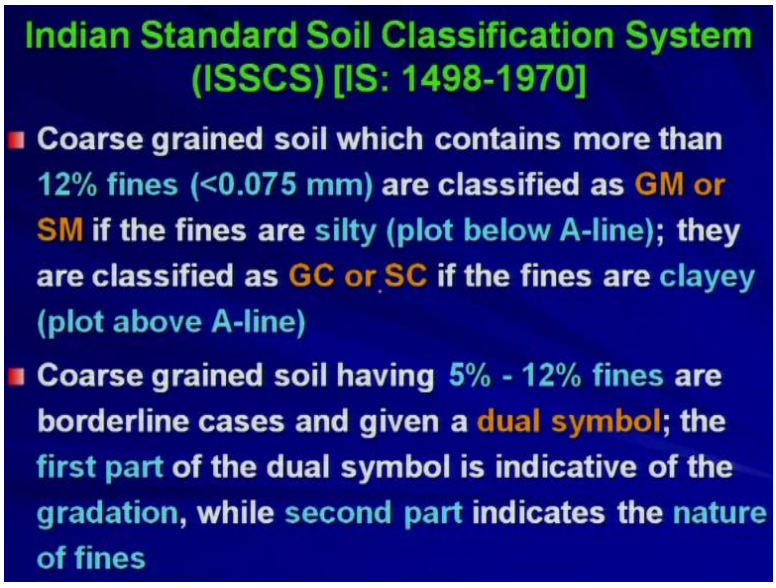

Now coarse-grained soil which contains more than 12% fines okay. Please try to understand each and every word of this statement because it is very important. Based on that we go for step by step classification system. So, coarse-grained soil which contains more than 12% fines, fines

means whenever I will be talking about fines means that will be less than75 micron so I need not to say this thing again and again. So, once I say fines that means less than 75 micron. So, 12% fines are classified as GM or SM.

If this is the coarse-grained soil and you have only 2 options in the coarse-grained soil either gravel that is G or sand that is S so it will be classified as GM or SM that means silty gravel or silty sand if the fines are silt. So, fines means whatever fines you are collecting that means less than 75 micron.

If the fines are silt that means if the fines are getting plotted because you are collecting that fines, you are making the gradation, you are collecting the fines which is which are passing through 75 micron sieve and then you do the I mean liquid limit test and find out the plasticity index and then you go to the IS plasticity chart and if that plots below the A-line then it will be classified as silt.

So, if that is that situation arises then it will be classified as GM or SM; if it is gravel then GM, if it is silt, if it is sand it will be classified as SM okay or they are classified as GC or SC if the fines are clay. So, if you see the fine particles are clayey fine particles that means if you obtain the liquid limit as well as the plasticity index and if you go to the plasticity chart and if you see that plots above the A-line then that will be classified as clayey soil. What is the clayey soil, because already you are dealing with the I mean coarse-grained soil so clayey gravel or clayey sand that means GC or SC. I hope you have understood this thing clearly.

Now coarse-grained soil having 5% to 12% fines are borderline cases because you have 3 categories in the course grained soil. If the fine particles are more than 12%, if the fine particles are less than 5%, or if the fine particles are in between 5% and 12%. So, this category is coming here. So, if it is more than 12%, already we have seen from this category that is if the fine particles is more than 12% then it will be classified as GM, SM, or GC, SC depending on the I mean fine content that is clayey or silty.

Now if the coarse-grained soil having 5% to 12% fines are borderline cases because this is coming within I mean it is not fully coarse-grained or not fully fine-grained so it is basically the borderline case and this is governed I mean this is of course the coarse-grained soil but this borderline cases and given a dual symbol because it is not governed by the fine content or it is not governed by fully by the gradation of the coarse-grained soil so that is why it will be given as dual symbol and the first part of the dual symbol is indicative of the gradation.

First you understand this thing, the first part will be giving dual symbol like GW we will see that what are the different possible dual symbols available with us. So, it will be given as dual symbol. The first part of the dual symbol is indicative of the gradation, that means whether it is poorly graded or well graded. While the second part indicates the nature of fines, so what type of fines are available in the coarse-grained soil whether it is clayey or silty.

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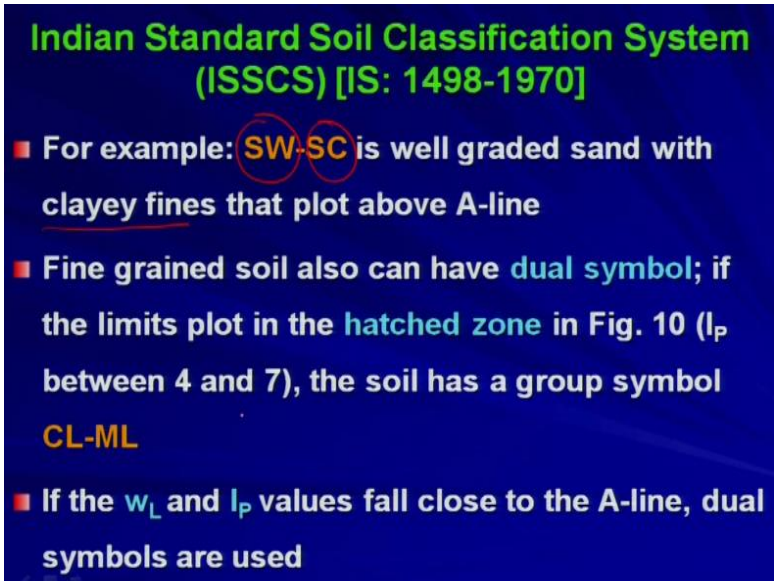

Now let us see, for example, so in the borderline you are proposing the dual symbol SW-SC. What does it mean. So, from this whenever you will be saying the gradation is I mean notation is SW-SC then immediately it will come to my mind the soil is coarse-grained and the fine particles that is which is less than 75 micron, it is coming between 5% to 12%, and it is well graded because the as I as we have seen in the last statement that is the first part will be telling about the gradation of the coarse-grained soil.

So, SW means well graded sand. From this we will be understanding this thing with clayey fines and that will be coming from the second part that is SC, so that plot above A-line. So, now it is very clear right. So, dual symbol means SW-SC that will be known as dual symbol whereas that SW will be telling much about the gradation of the coarse-grained soil whereas the SC will be telling much about the fine contents of the coarse-grained soil.

Now fine-grained soil also can have dual symbol because already we have seen the coarse-grained soil is having the dual symbol. Similarly, fine-grained soil also can have the dual symbol if the limits plot in the hash zone in figure 10 that is in the plasticity chart where IP between 4

and 7, the soil has a group symbol CL-ML as I told you. So, let us go back to your plasticity chart. As I told you that if the plasticity index is between 4 and 7 and if your point is coming within this hash zone then it will be classified as CL-ML right, though low plastic clay and low plastic silt. So, basically the dual symbol is getting used if the I mean condition falls within this hash zone.

Apart from that, so this is the dual symbol for the fine-grained soil. Apart from that if the liquid limit and plasticity index values fall close to the A-line dual symbols are used.

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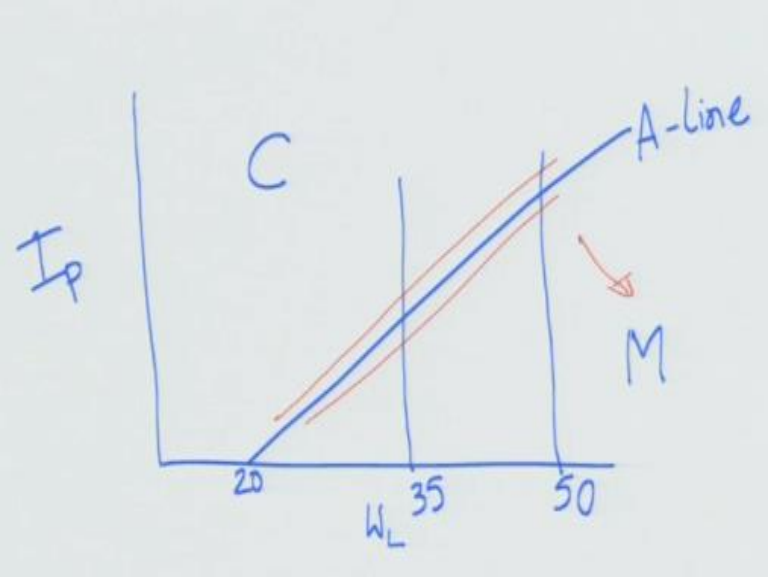

So, that means if you come back to the plasticity chart basically what the statement says that if you if you travel or if you go very close to your A-line so your fine-grained soil will be getting the dual symbol. Whereas I mean say suppose if something very far away from the A-line which is above the A-line then basically that will be considered as clay whereas if anything goes below the A-line that will be classified as silt but if something which is coming very close to A-line so that is the borderline basically for 2 types of soil that is clay and silt. So, all the times it will be getting the dual symbol. So, I mean the statement says if the liquid limit and plasticity index values fall close to the A-line as I showed you dual symbols are generally used.

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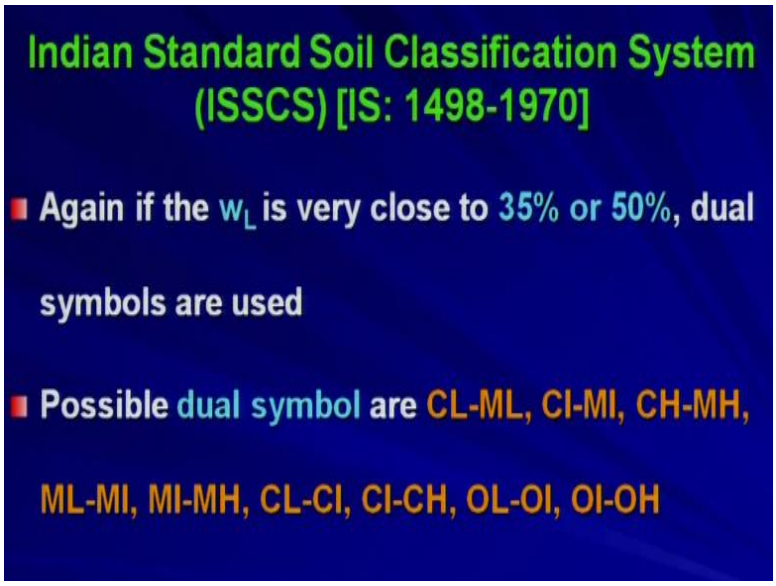

Now again if the liquid limit is very close to 35% that is the vertical line if you remember, if you recall that is the vertical line or the parallel line of plasticity index or 50% then dual symbols are used like if we look at if we go back to plasticity chart once again we will see that how they will be classified as dual symbol. Say the second statement says that if anything comes very close to this 35% liquid limit line or 50% liquid limit then it will be classified as dual symbol.

Now why it is like that? So, this vertical line basically makes the separation between low plastic soil and I mean intermediate plastic soil. So, it will be getting the dual symbol. It could be low or it could be intermediate. Similarly,, if it is very close to the 50% liquid limit line then also it may be highly plastic because if you just cross 50% liquid limit then basically you will enter the high plastic zone whereas below 50% you will be entering the intermediate plasticity. So, it will get the dual symbol.

It could be either high plastic highly plastic soil or intermediate plastic soil. So, these are 3 boundaries where you will be getting apart from that some hash part whatever we have seen in the previous picture, actual picture that the hash zone as well as these 3 boundaries wherever your point is coming you will be getting dual symbol in fine grain soil classification system.

So, then what could be the possible dual symbol for fine-grained soil? The possible dual symbols are CL-ML, now what do you mean by CL-ML? CL-ML is basically it is low plastic clay or low plastic silt. Similarly, CI-MI that means intermediate plastic clay and intermediate plastic silt. Similarly,, CH-MH highly plastic clay and highly plastic silt. So, basically this these things CL

when the prefix, please try to understand, when the prefix is different like CL-ML, C and M both are different right.

Similarly, CI-MI, C and M both are different. So, these points, these basically these dual symbols will be denoting or will be indicating that the point is very close to A-line okay. It could be either clay or it could be either silt. So, it is getting dual symbol because it is coming very close to A-line. Similarly, ML-MI. Now could you please tell me what should be I mean where the point should be?

So, ML-MI when here actually you are dealing with the silt because your prefix is not getting changed whereas your suffix that is L and I they are getting changed. So, that means it is the borderline of 35% liquid limit because that is the vertical line whatever we have just seen. So, it could be low plastic or it could be intermediate plastic. So, it is pretty close to your 35% liquid limit line okay.

Similarly, MI-MH. So, it is pretty close to 50% liquid limit line. So, it could be either intermediate plastic silt or high plastic silt. Similarly, CL-CI, CI-CH, OL-OI. What do you mean by OL-OI? The soil is organic but it could be low plastic or it could be intermediate plastic. That means organic soil but it is coming pretty close to the 35% liquid limit line. Similarly, OI-OH. So, these are the possible dual symbols for your fine-grained soil.

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Now we will go step by step procedure for Indian Standard Soil Classification System as per IS: 1498-1970. So, now we will be talking all the steps involved in the soil classification system and

few things maybe clear or may not be clear to you at this point of time. However, when we will be taking a particular problem example okay, at that time it will be completely clear that how these steps are getting exhausted, how these steps are getting used to classify the soil.

So, first step says, determine whether the given soil is of organic origin or coarse-grained or fine grained. So, first you need to determine whether the soil is organic or coarse or fine. Now how we will find the soil is organic? An organic soil is identified visually by its colour. It should be brownish black or dark and characteristic odour okay. So, based on these 2 properties you can classify this soil is organic. If the soil is organic that will follow the different path. If the soil is coarse or fine that will be following different path as we discuss now.

If 50% or more of the soil by weight is retained on the 75 micron sieve, it is coarse grained. If not, it is fine-grained soil. So, first you have classified the organic soil by seeing the colour as well as by feeling the characteristic odour you classify organic soil. If it is not organic soil then you go for the sieve analysis. If 50% or more, generally more than 50% of soil by weight is retained on 75 micron sieve then it is coarse grained. If the 50% or more is passing through 75 micron then it is fine grained.

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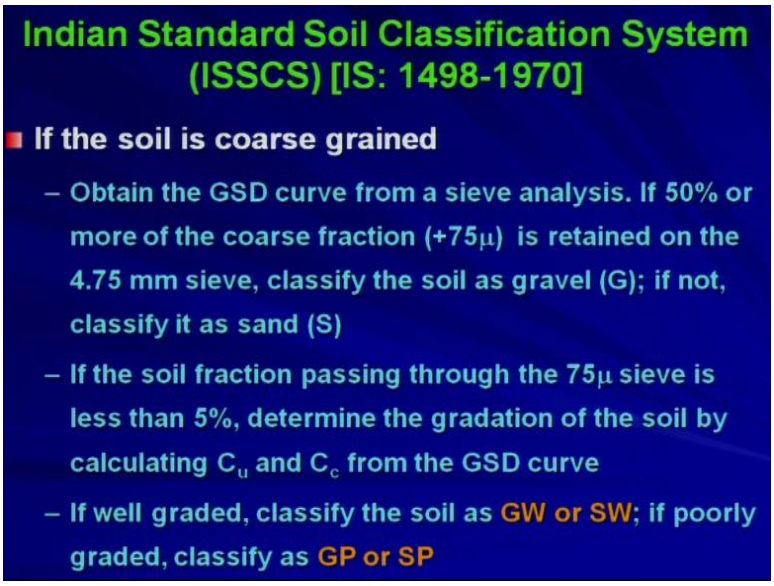

If the soil is coarse grained. So, you have classified these 3 basic classification, organic soil or coarse-grained soil or fine-grained soil. So, once you know the soil is your soil is coarse-grained then you come to this category. If the soil is coarse-grained then obtain the GSD that is the grain size distribution curve, whatever we have seen before from a sieve analysis. So, you do you

perform the sieve analysis because you are dealing with the coarse-grained soil so you need to perform the sieve analysis for getting the gradation. So, obtain the GSD curve from a sieve analysis.

If 50% or more of the coarse fraction that means higher than 75 micron is retained on the 4.75 mm sieve, please try to understand, if 50% or more of the coarse fraction that means whatever was retained on 75 micron you take out that part the whole part now you are doing sieve analysis and then if you see if you observe that 50% or more of the coarse fraction, that is known as coarse fraction which is retained on 75 micron sieve, so is retained on the 4.75 mm sieve, classify the soil as gravel okay.

If not then classify the soil as sand because in the coarse-grained soil you have 2 categories. One is gravel another one is sand. So, if it is retained on 4.75 mm that will be classified as gravel. If it is retained on I mean if it is passing through 4.75 mm that will be classified as sand and the quantity will be 50% or more. So, if the soil fraction passing through the 75 micron sieve is less than 5%, determine the gradation of the soil by calculating C u that is coefficient of uniformity and C c that is coefficient curvature from the GSD curve.

So, what does it mean? If the soil fraction, so you have classified whether it is gravel or whether it is sand. Now if the fraction, soil fraction passing through the 75 micron sieve is less than 5%. Now whatever the fine contents of course some fine contents will be there, if the fine content is less than 5% then you need not to bother for that then you then basically the thing you will be getting the soil will be dominated by the coarse grain fraction.

So, please try to understand, any soil say suppose I am mixing gravels or I am mixing some amount of sand in a large quantity of clay but the representative sample will be always behaving as clay because the major amount of soil sample is made of clay. Similarly, if you if you take a large quantity of sand and if you mix little bit of clay in that sand then the property of that sample will be as good as your sand because the clay will not be dominating factor in that.

So, that is the way. So, this 5% will be defining that whether it is dominated by the clay fine fraction or not. So, if the soil fraction passing through the 75 micron sieve is less than 5% determine the gradation. So, gradation will be the important parameter by which you can determine the classification system. So, determine the gradation of the soil by calculating C u that is coefficient of uniformity and coefficient curvature from the GSD curve.

If well graded, classify the soil as GW or SW based on whether it is gravel or sand. If poorly graded classify as GP or SP. Now you already know how to classify the soil as well graded. If it is gravel, what should be the criteria for well graded gravel. If it is sand you know what is the criteria for well graded sand. So, thank you very much. I will stop here today. So, we will be seeing the next things in the subsequent lectures.

Thank you very much.