Soil Mechanics
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Lecture - 10

Welcome to index properties and soil classification systems - V. In the previous lecture we have studied about activity and we also introduced soil classification systems. We also have discussed about AASHTO classification system and unified soil classification system. In this lecture we will be studying about unified soil classification system, the classification of coarse-grained soils and fine-grained soils basically by using Casagrandes plasticity chart and then we will look into certain problems. This is the lecture with index properties and soil classification systems - V.

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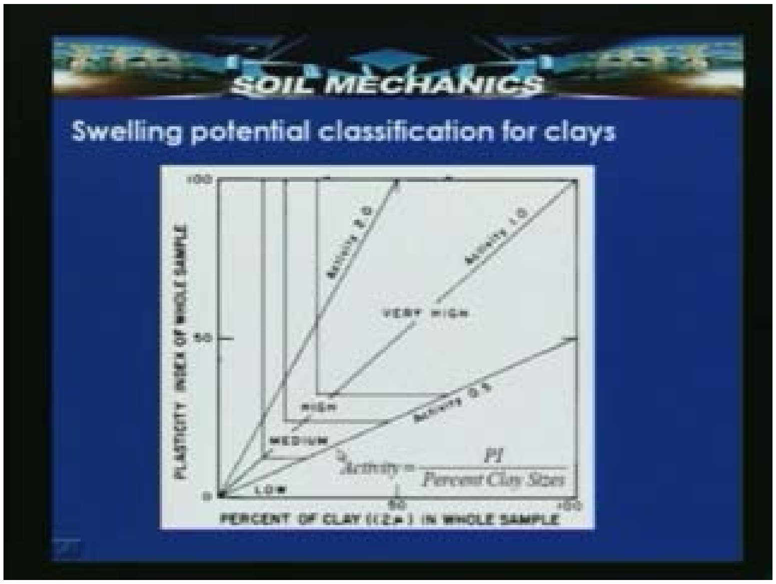

In the previous lecture we have defined activity value or activity number and this is useful for classifying soils according to their swelling potential. So the question is whether the soil is assertable to swelling or not? To some extent, the activity value will give the information. Here we said that the activity is equal to (plasticity index by percentage clay fraction). In this figure on the x axis the percentage of clay is less than 2 microns, that is passing 2 micron in whole sample is plotted and along y axis the plasticity index of the whole sample is taken. By using this chart one can classify the soils for their swelling potential.

For example, if the activity value is less than 0.5, then it is said that the activity value is less. Activity 1 is very high in this region and activity 2 in this region is very high. So low, medium, high and very high zones are indicated. Based on that once we get the percentage clay fraction and the plasticity index for the given soil then if you plot those values in this chart we will be able to give the swelling potential of a particular soil. To some extent this will also give the probable clay mineral in the soil.

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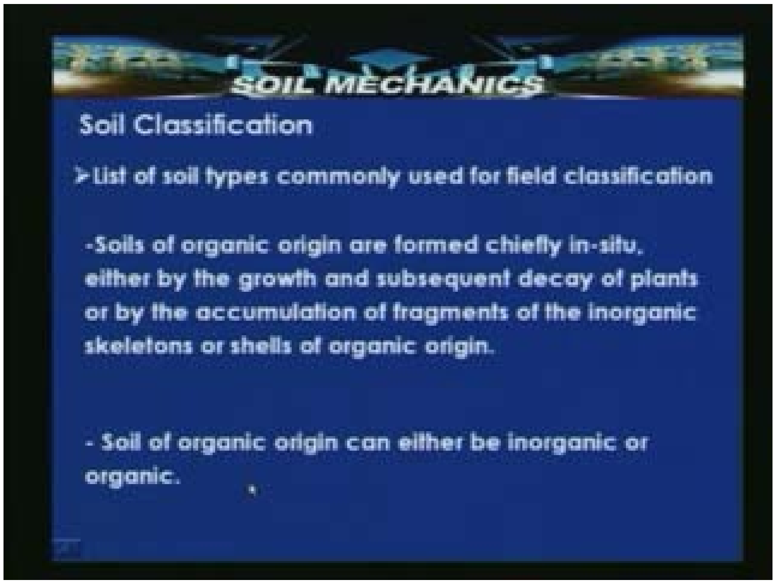

In the soil classification we said that there is a list of soil types commonly used for field classification. So, generally in field classification we use typical soils based on their origin like inorganic soils or organic soils. So before introducing the unified soil classification system and plasticity chart let us discuss about different soil types which are used in the field classification system. Here in this slide soils of organic origin are formed chiefly in-situ either by the growth and subsequent decay of plants or by the accumulation of fragments of the inorganic skeletons or shells of organic origin. Soils of organic origin can either be inorganic or organic.

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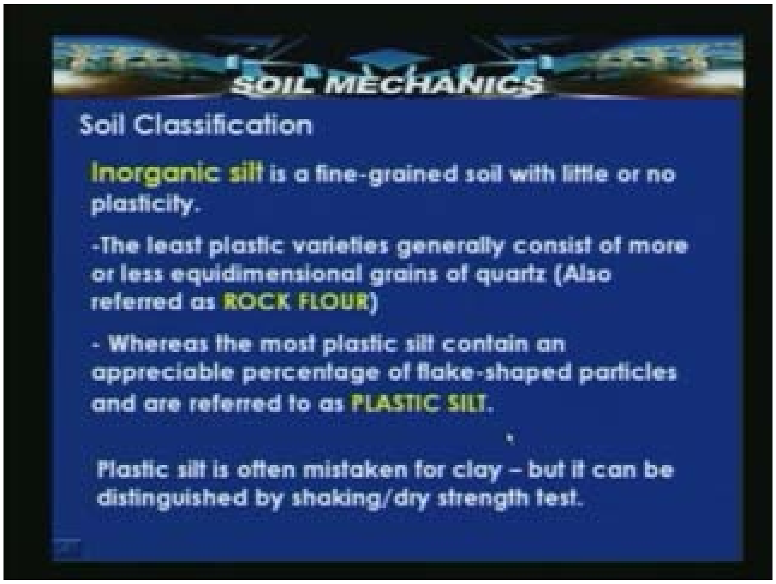

Inorganic silt is a fine-grained soil with little or no plasticity. Generally we come across this like inorganic silt which is a fine-grained soil with little or no plasticity. The least plastic varieties generally consisting of more or less equidimensional grains of quartz is also referred as a ROCK FLOUR whereas the most plastic silt contains an appreciable percentage of flake-shaped particles and is referred as PLASTIC SILT. Therefore, in inorganic silt one can be non-plastic silt and the plastic silt. The one with non-plastic silt is also referred as a ROCK FLOUR. The one with more plastic silt and flake-shaped particles is referred as plastic silt.

Plastic silt is often mistaken for clay, but as discussed in the previous class it can be distinguished by shaking or dry strength test. So we are able to conduct a dry strength test or shaking. We will be able to distinguish between the plastic silt and a given soil clay. In the soil classification, we have seen here, the first type of field classification system. The inorganic silt is a fine-grained soil with a little or no plasticity. The one with least plasticity is referred as non plastic silt which is also referred as a ROCK FLOUR. The one with most plastic silt containing appreciable percentage of flake shaped particles is referred as plastic silt.

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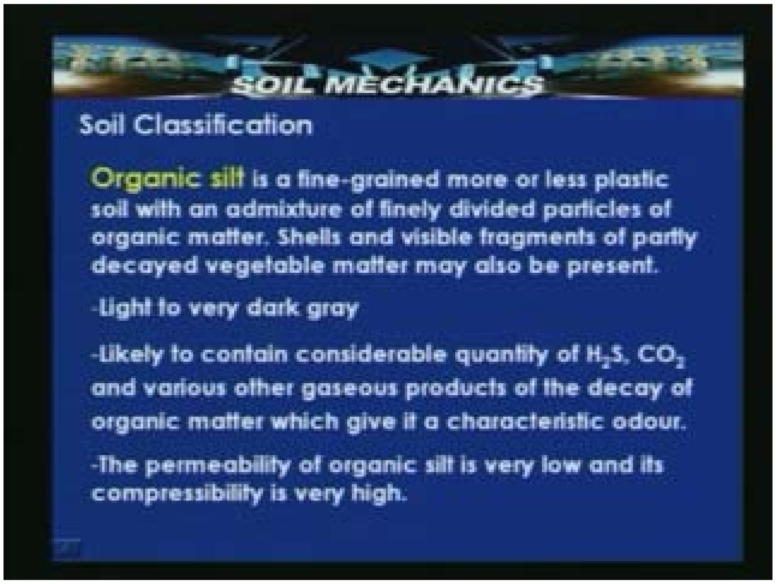

The other part is organic silt, organic silt is a fine-grained more or less plastic soil with an admixture of finely divided particles of organic matter. Shells and visible fragments of partly decayed vegetable matter may also be present. This is an indication, for example if we come across this particular soil in the field then one indication is that this shells and visible fragments of the organic matter will indicate a particular type of organic silty soil. Basically the color of this organic silty soil varies from light to very dark gray color And likely to contain considerable quantity of hydrogen sulphide, carbon dioxide and various other gaseous products of the decay of the organic matter which give it a characteristic odour to the soil. The permeability of the organic silt is very low that is the capacity of the water to allow to flow through the soil is very low and its compressibility is very high.. So far we saw organic silt and inorganic silt. Now, let us try to look into the other type called as the organic clay.

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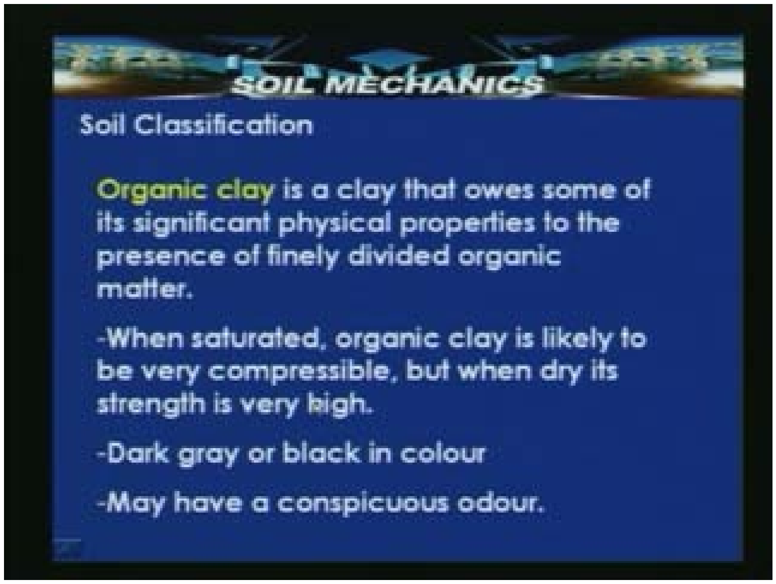

The organic clay is a clay that owes some of its significant properties to the presence of finely divided organic matter. When the organic clay is saturated, it is likely to be very compressible, but when it is dry it exhibits very high strength. So, the dark gray to black color is an indication and it may have a conspicuous odour. Organic clay is clay that owes some of its significant physical properties to the presence of finely divided organic matter. When it is saturated, organic clay is likely to be very compressible, but when dry its strength is very high. Under saturated conditions, the organic clay exhibits very high compressibility. But in dry conditions, it exhibits very high strength and its color varies from dark gray to black color and may have a conspicuous odour. The other thing is that depending upon the degree these soils namely sand, clay and gravel exist in mixtures and depending upon some proportion sometimes we call it as silty sand, clay sand, sandy clay or gravelly sand or gravelly clay. Let us look into how a nomenclature is used to describe the soil which we come across in the field.

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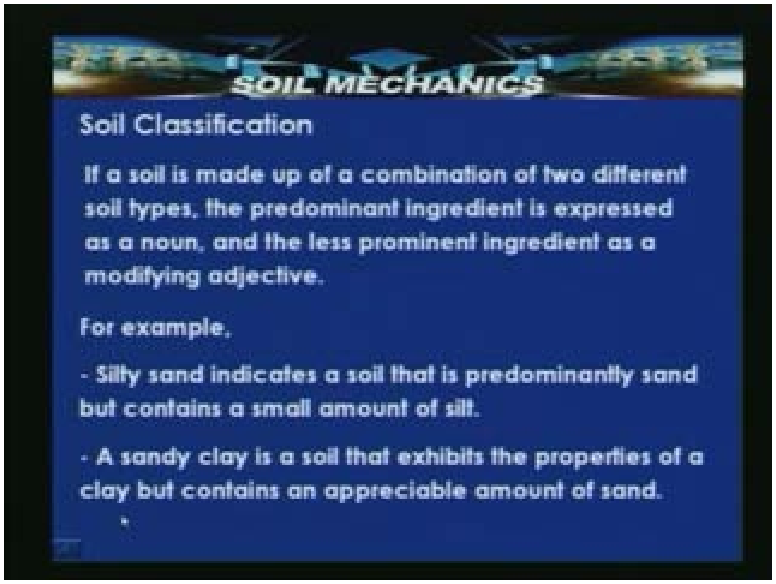

If the soil is made up of a combination of two different soil types, the predominant ingredient is expressed as a noun, and the less prominent ingredient as a modifying adjective. For example, let us consider a silty sand that is silt and sand with a different portion in mixtures. Silty sand indicates a soil that is predominantly sand, but contains a small amount of silt. So, that is the reason why we are calling silty sand where sand is here is noun and silt is a modifying adjective.

Similarly, sandy clay is a soil that exhibits the properties of clay but contains an appreciable amount of sand. So if a soil is made up of a combination of two different soil types, the predominant one is expressed as a noun and the less predominant one is expressed as a modifying adjective. The examples are silty sand or sandy clay. Now, let us come back once again to the soil classification systems and we will discuss about the most widely used soil classification system that is unified soil classification system. In the previous class we have discussed about AASHTO soil classification system which has been developed especially for the highways, roads and highway works. Universally this unified soil classification system is being used by geotechnical engineers for different applications.

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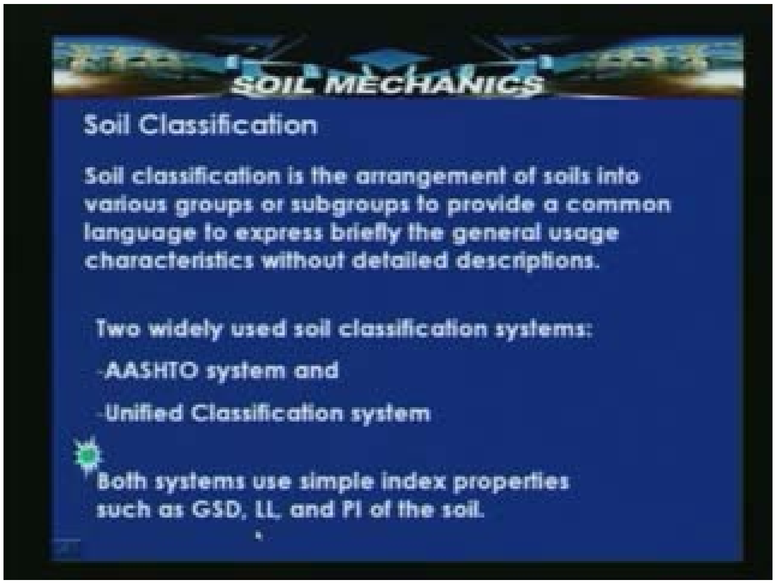

Again if you look into whatever we have discussed the soil classification is the arrangement of the soils into various groups or subgroups to provide a common language to express briefly the general usage of characteristics without detailed descriptions. We are actually grouping the soils which are having identical properties. For that a number of classification systems have been developed and used.

Therefore, the two most widely used soil classification systems are: AASHTO soil classification system and unified soil classification system. Basically they are based on the Grain Size Distribution and Atterberg limit properties of a given soil. We have discussed that, though we are able to determine the Grain Size Distribution characteristics of coarse-grained soils when it comes to fine-grained soils we thought that fine-grained soil exhibits different physical states with water. So with that in mind we also discussed and determined different atterberg limits of a soil. So these atterberg limits will be able to give unique values for the given soil. Based on those values and Grain Size Distribution we will be able to combine all these properties whatever we have discussed to classify the soil.

The two widely used soil classification systems are: AASHTO soil classification system and unified soil classification system. Both systems use simple index properties such as Grain Size Distribution GSD, liquid limit and plasticity index of the soil. We have discussed that one of the requirements of a soil classification system is that it should be simple and it should be able to do with limited experiments. Further once the soil has been identified and classified then extended experiments can be carried out to characterize the soil.

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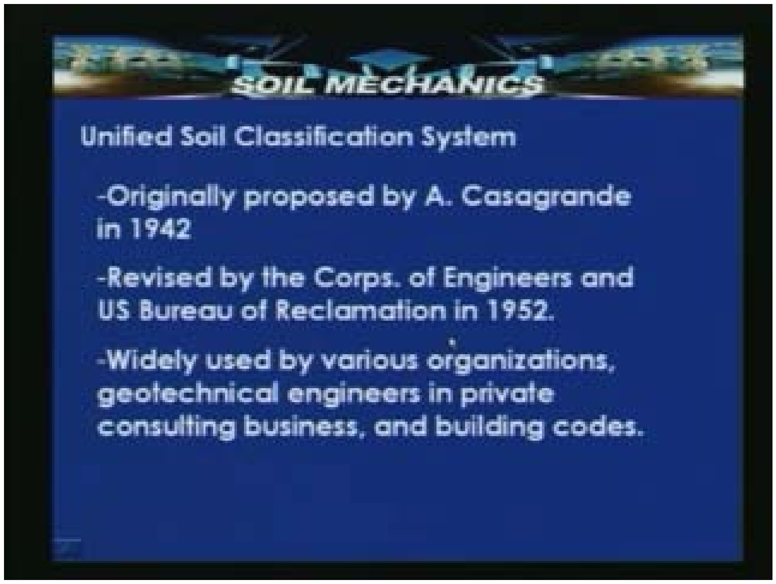

The unified soil classification system was originally proposed by Arthur Casagrande in 1942 and they are revised by the Corps. of Engineers and US Bureau of Reclamation in 1952. This soil classification system is widely used by various organizations, geotechnical engineers and in private and consulting business and building codes. Different building codes have this particular classification system and it is widely used by geotechnical engineers.

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When you look into this unified soil classification system initially Arthur Casagrande has divided the soil into two major types. One is the coarse-grained soil and the other one is fine-grained soil. And further coarse-grained soil is divided into gravel and sandy soils and fine-rained soil as silt and clay or inorganic clay, organic silt or clay. But later, the extended classification system of Casagrande has included highly organic soils like peat and muck, peaty and mucky soils have also been added. The Casagrande extended soil classification system says that soil is predominantly divided into a coarse grained soil, a fine grained soil and a peat soil.

If the peaty or mucky soils exist in a particular site the peat soils are highly fibrous soils which are required to be replaced or to resort to a ground improvement technique.

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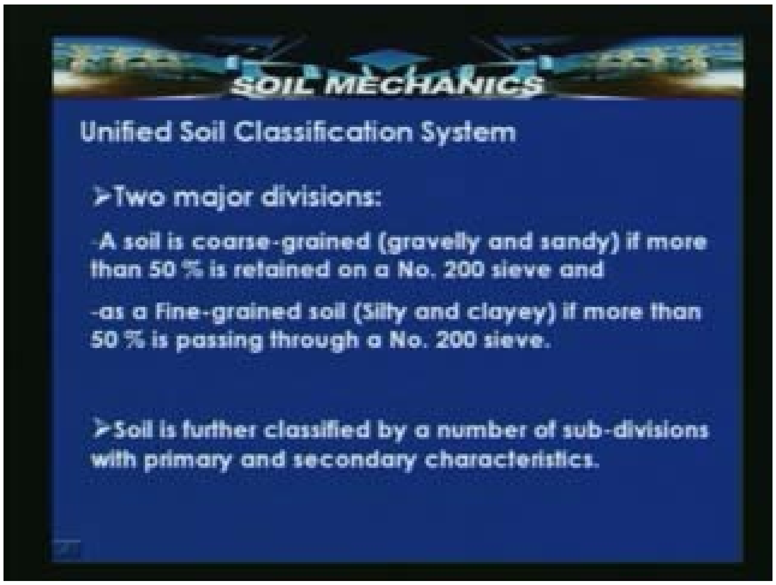

When we look into the two major divisions put forward in the unified soil classification systems, they are: coarse-grained soil or fine-grained soil. A soil is coarse-grained (predominantly gravelly and sandy) if more than 50 percent is retained on a number 200 sieve. That is, if 50 percent of the soil is retained in number 200 sieve. Number 200 sieve as per ASTM is nothing but 75 micron or 0.075mm sieve. The soil is treated as a fine grained soil that is silty and clay soil if more than 50 percent of soil is passing through a number 200 sieve. So, if a soil is passing through a number 200 sieve that is passing through 75 micron sieve or passing through 0.075mm sieve it indicates that the soil is of silty or clay or fine-grained in nature. So soil is further classified into number of subdivisions with primary and secondary characteristics and because of the classification system requirement, groupings have been done with primary and secondary characteristics.

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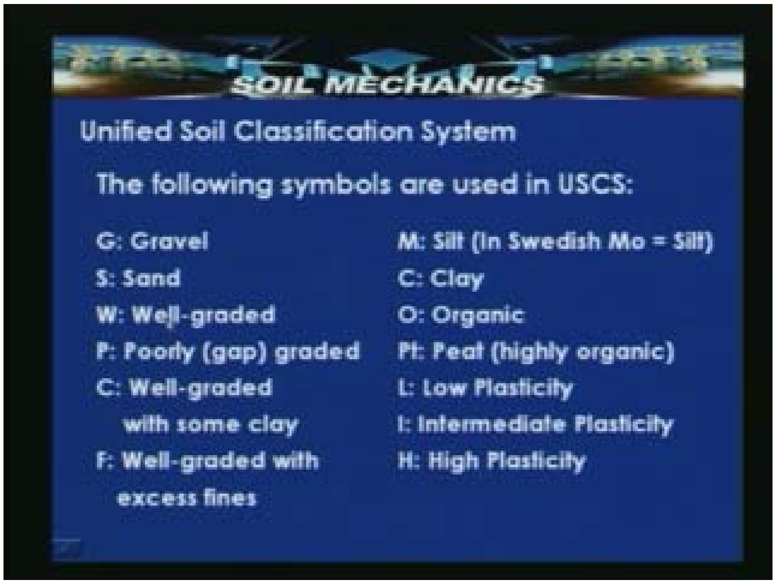

The following symbols are used in unified soil classification system (USCS). G indicates gravel, S indicates sand, W indicates well-graded, P indicates poorly graded or gap graded where some of the particle sizes are absent, C is well graded with some clay, F is well graded with excess fines.

Suppose, if you find gravel with well graded excess fines that particular type of soil predominantly behaves like a clay soil because the fines which are present in between gravel particles will not allow these gravels to come closer and finally they inhibit in mobilizing the strength. Then M is silt which is the symbol for silt.

In Swedish Mo means silt, so that is the origin and we use M for indicating silt. C for clay, O for organic, Pt for peat or highly organic soils, L represents low plasticity, I indicates intermediate plasticity and H is for high plasticity which is depending upon the liquid limit. For low plasticity the liquid limit is less than 30, for intermediate plasticity 30 to 50 and for high plasticity greater than 50. So based on the liquid limit, this low, I and H plasticity are divided. Depending upon whether the soil is well graded or poorly graded, coarse-grained soils are divided. Sometimes the gravelly soils can also have some clay and excess amount of fines. In that case this particular secondary characteristic symbols are used. The criteria for the classification of coarse-grained soils are given. Basically the coarse grained soils are classified into four groups. Later we will see the chart.

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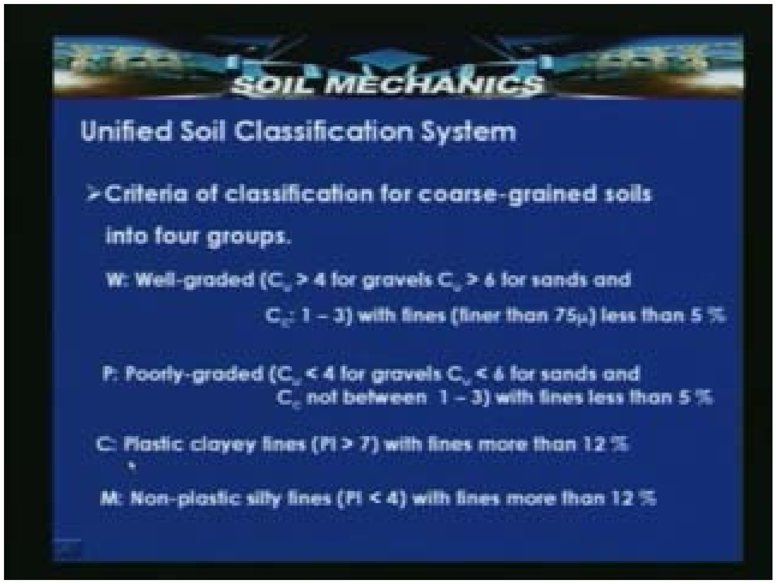

W is well graded that is what we have discussed. Once we know the gradation of a given soil that is D_{30}, D_{60} and D_{10}, we can determine quotient of uniformity and quotient of curvature. Quotient of uniformity is D_{60} by D_{10}. Quotient of curvature is (D_{302} by D_{60}) into D_{10}. If the C_u value is more than 4 for gravels and C_u is more than 6 for sands and Cc is 1 to 3 with fines(finer than 75 micron) which are less than 5 percent, then it is called well graded. P is poorly graded when the C_u is less than 4 for gravels less than 6 for sands and C_c is not within1 to 3. If the above criteria are not met, then it is called poorly graded with fines less than 5 percent. C is the plastic clayey fines. For C the plasticity index PI is greater than 7 with fines more than 12 percent. Then it is called C. M is the non plastic silty fines with plasticity index less than 4 with fines more than 12 percent.

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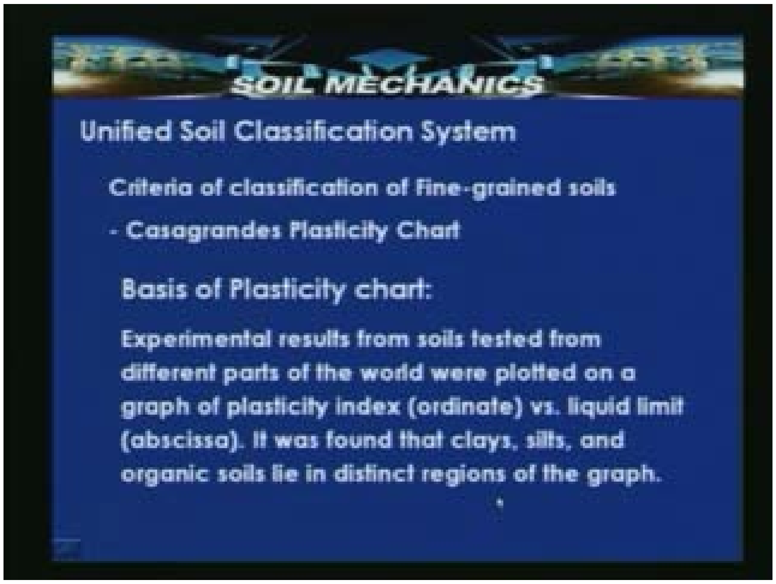

If you look into this, predominantly four groups are there, namely W, P, C and M. The criteria for the classification of the fine grained soils are entirely based on the plasticity chart and this is also developed by Casagrande. Basically this is a part of the unified soil classification system for classifying fine grained soils. What has been done is that the basis of origin of this plasticity chart is the correlation of the number of soil properties collected from throughout the world.

Experimental results from soils tested from the different parts of the world were plotted on a graph of plasticity index as an ordinate that is on y axis and liquid limit and abscissa that is on x axis. It was found that clays, silts and organic soils lie in distinct regions of the graph. So when these soils are tested from different parts of the world and are plotted against plasticity index and liquid limit, plasticity index on the y axis and liquid limit on the x axis then it was found that clays, silts and organic soils lie in distinct regions of the graph.

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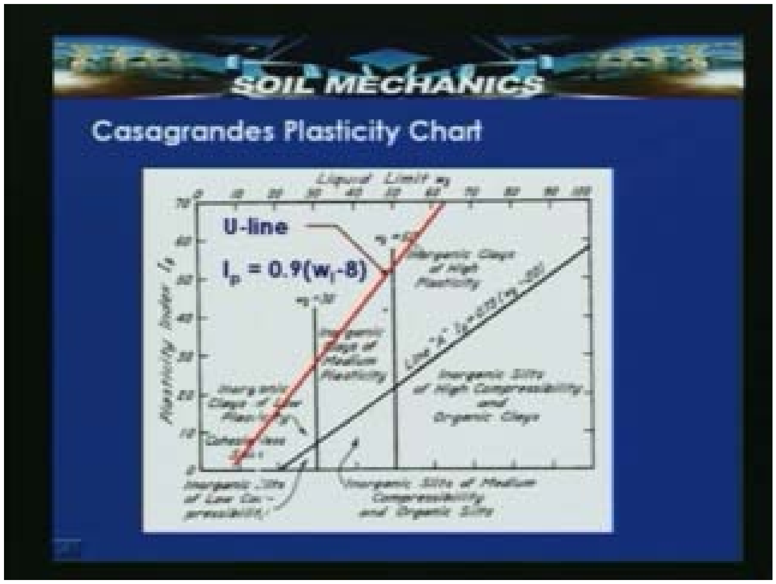

This slide shows the Casagrandes plasticity chart. Liquid limit is plotted on the x axis and plasticity index is plotted on the y axis. If you see here the main features of this Casagrandes plasticity chart are shown. In this graph line A is called Casagrandes A - line. This is called U - line that is Casagrandes U - line. If the correlation equation for the A - line is: plasticity index is equal to 0.73 into [W_L (liquid limit) - 20].

If you look into it here, some cohesion less soils with low plasticity index lie above the A line. If you see that, predominantly this has got six regions 1, 2, 3, 4, 5, 6. As you go towards the right, inorganic silts of high compressibility and organic clays are below the A - line. Inorganic clays of high plasticity lie above the A – line, inorganic clays of medium plasticity are above A - line but in between the liquid limit 30 and 50. So what has been done is that, it has been subdivided into liquid limit 30 and liquid limit 50.

For low plasticity the liquid limit is less than 30 and for medium plasticity it lies between 30 and 50 and for high plasticity the liquid limit is greater than 50. Some cohesion less soils fall here and some inorganic silts of low compressibility fall here, inorganic silts of medium compressibility and organic silts fall here and inorganic silts of high compressibility and organic clays fall below here. This is the equation of A line and this is an equation of U line where I_P is equal to $0.9(W_L - 8)$. But this is the upper limit for the values which are used for correlation. If our tested values fall above this line it indicates that we are required to repeat Atterberg limit test.

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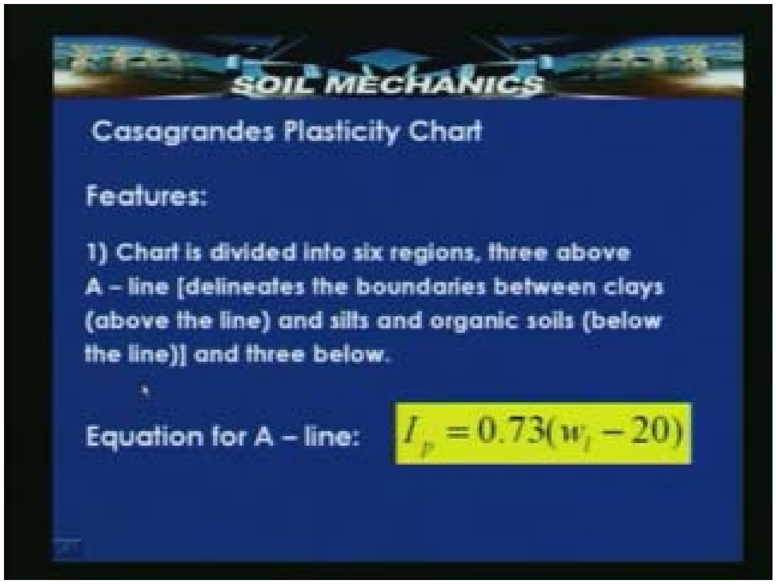

Let us look into the features of Casagrandes plasticity chart. We have introduced Casagrandes plasticity chart which is developed based on the correlation of the number of soils with plasticity index plotted on y axis and liquid limit on x axis. Basically it has been divided distinctly into six zones to classify different soils of different origin.

The chart is divided into six regions that is what we have discussed, three above A - line. This A - line delineates the boundaries between the clays and the silts that is what it is doing (above the A line) and silts and organic soils (below the line) and three below. The equation of A line which has been obtained after the correlation is I_P is equal to 0.73 into (W_L - 20) where W_L is the liquid limit which is expressed as a percentage. The chart is divided into six regions three above the A - line and three below the A - line and above the A - line delineates between clays, and silts and organic soils are below the line.

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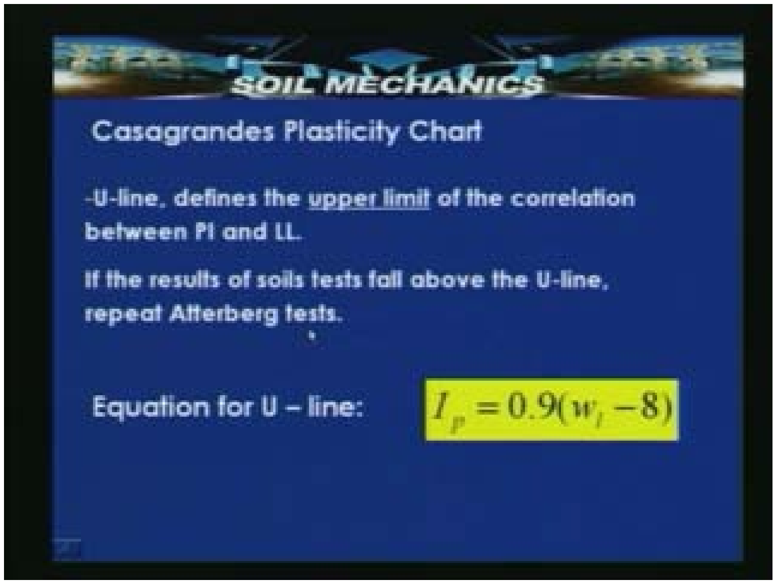

We are discussing about U - line which is shown in this chart, it defines the upper limit of the correlation between the plasticity index and liquid limit. If the results of soils tested fall above the U - line then repeat the Atterberg limits. That indicates there is some error with the Atterberg limits which has been carried out. Equation for U - line is: I_P is equal to 0.9 into (W_L - 8) where W_L is again expressed as percentage. So U - line defines the upper limit of the correlation between the plasticity index and liquid limit. If the results of soils tests fall above the U - line then it is indicated that the atterberg limits have to be repeated.

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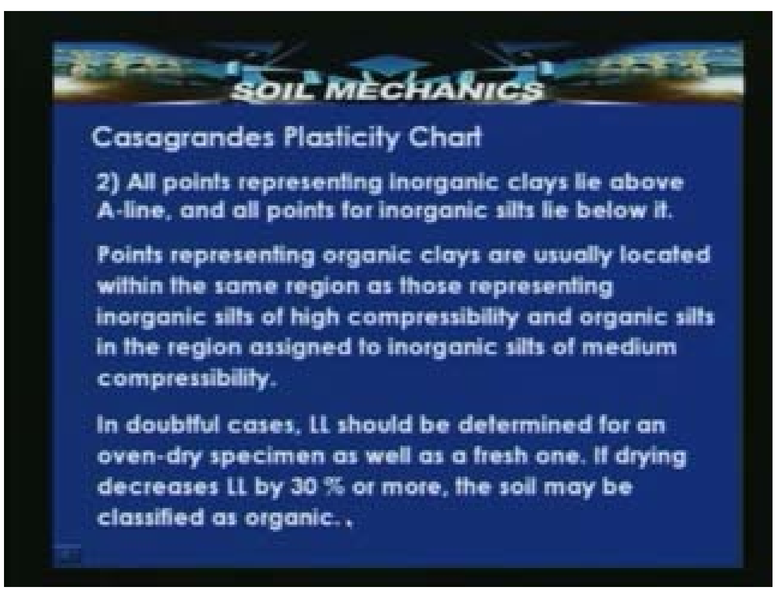

Second feature is all points representing inorganic clays lie above A - line, and all points for inorganic silts lie below it. All points representing the inorganic clays whether low plasticity or medium plasticity or high plasticity they lie above A - line or all inorganic silts of low compressibility, medium compressibility or high compressibility they lie below it. Points representing organic clays are usually located within the same region as those representing inorganic silts of high compressibility and organic silts in the region assigned to inorganic silts of medium compressibility.

In the doubtful cases, sometimes we will get a doubt whether the soil is really inorganic or organic, to verify that it is suggested to carry over liquid limit test on a fresh and then dried sample. You conduct a liquid limit test on a fresh and dried over dried sample, if the drying liquid decreases the liquid limit by 30 percent or more the soil may be classified as organic. During the drying process the soil may be subjected to some irrequirable changes which affect the liquid limit. So if the drying decreases the liquid limit by 30 percent or more then it indicates that the soil is organic. In the doubtful cases it is suggested to check by conducting a liquid limit test with sample which is fresh and collected from the field. The second one is that the same sample which is oven-dried and then conditioned to carry out liquid limit test.

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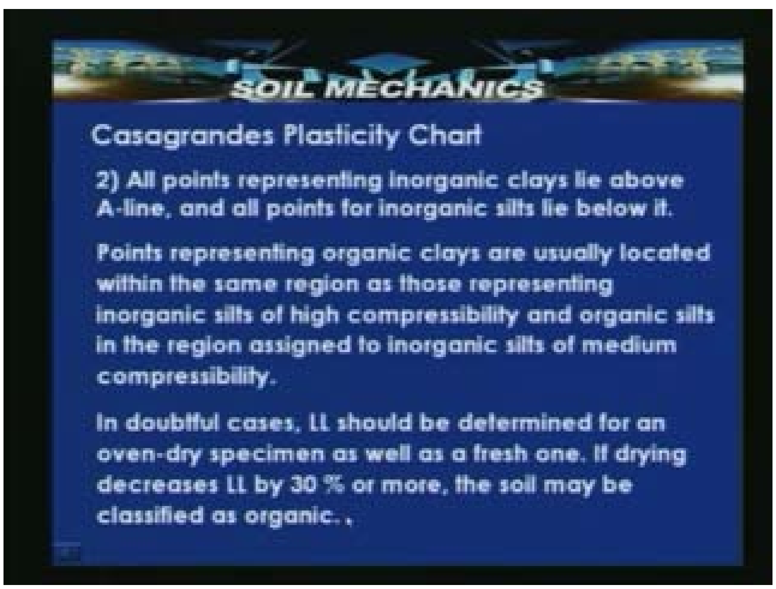

In the third feature as the liquid limit increases on the x axis we go towards the right the plasticity and compressibility of soils also increase. If you see on the chart as the liquid limit increases the plasticity which is medium plasticity or low plasticity on the left hand side increases to high plasticity. Similarly, the compressibility increases from low to high compressibility. As the liquid limit increases the plasticity and compressibility of soil also increases.

The dry strength of the inorganic soils represented by points on lines located above A - line increases from medium to samples with a liquid limit less than 30 and very high for samples with liquid limit greater than 100. If you look into this the plasticity and compressibility are increasing as the liquid limit is increasing on the chart. The dry strength of inorganic soils represented by points on lines located above A - line increases from medium to samples with a liquid limit less than 30 to very high for samples with a liquid limit greater than 100.

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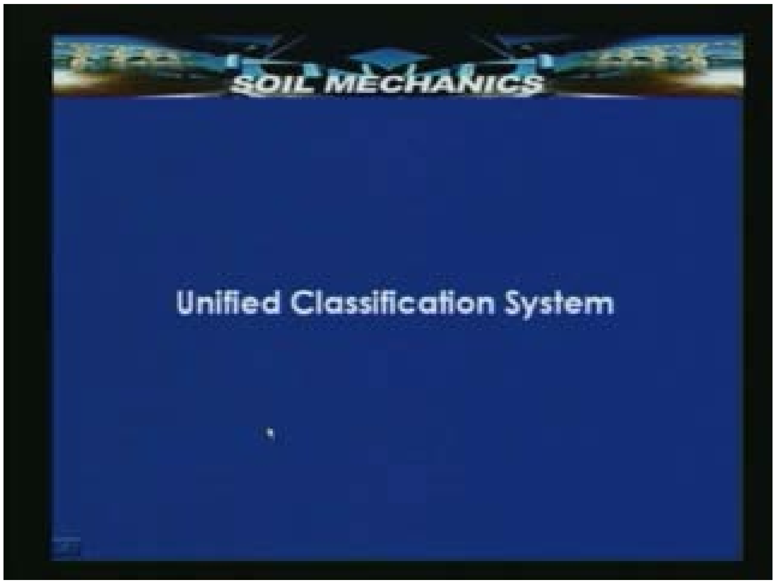

Now having seen different criteria for unified soil classification system let us look into the detailed chart then we will try to use this unified soil classification system and try to solve some problems with different gradations and then atterberg limits and to whatever we have discussed about soil classification groups. So Casagrande plasticity chart is basically used for classifying fine-grained soils and is inbuilt in the unified soil classification system to arrive at soils of different types with different combinations which means that clay of low compressibility or silt is indicated with M. Suppose if it is highly compressible then it is indicated with MH. Like this the groups have to be arrived.

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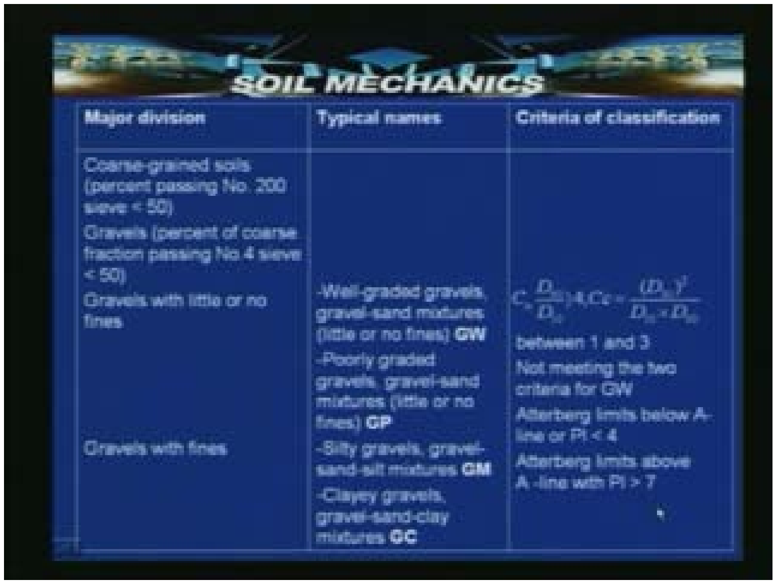

If you look into this chart basically we have discussed that the percent passing number is 200 sieve for coarse-grained soils that is 75 micron sieve is less than 50. For gravels the percentage of the coarse fraction passing number 4 sieve is less than 50 and gravels with little or no fines, gravels with fines. So these are the different subgroups here. The basic division is coarse-grained soils.

We are discussing about gravels with no fines and gravels with fines. The typical names, they workout like this: well graded gravels, gravel-sand mixtures, little or no fines, it is qualified as a group G W. If C_U is equal to D_{60} by D_{10} is greater than 4 C_C is equal to (D_{30}) squared by $(D_{60 \text{ into }} D_{10})$ is between 1 and 3. So C_u greater than 4 and C_C in the range of 1 to 3, then the mixture is well graded gravels with gravel-sand mixtures little or no fines is GW. The gravels which are percent of the coarse fraction passing number 4 sieve is less than 50, and then gravels with little or no fines then it is called GW.

Poorly graded gravels or gravel sand mixtures little or no fines is called GP. That means that if you are not able to meet these well graded criteria, it indicates that it is not meeting the two criteria means C_U greater than C_4 , C_C in between 1and 3. If it is not meeting, then it is called GP. Gravels with fines that is silty gravels, gravel-sand silt mixtures, it is called GM. If atterberg limits fall below A - line that means we have just discussed if the plasticity index is less than 4 then if it is falling below A - line then it is called GM where M indicates the presence of silt but it is a low plastic silt and that is why it is falling below the A – line.

For Clayey gravels, gravelly-sandy-clay mixtures, the criteria of classification is given that Atterberg limits of this particular soil with the clay fraction soil which is having a plasticity index greater than 7 and which is above A - line indicates that clayey gravels, gravel sand mixtures indicates with GC. So gravels with fines the group now is GC with Atterberg limits are falling above A - line with plasticity index greater than 7.

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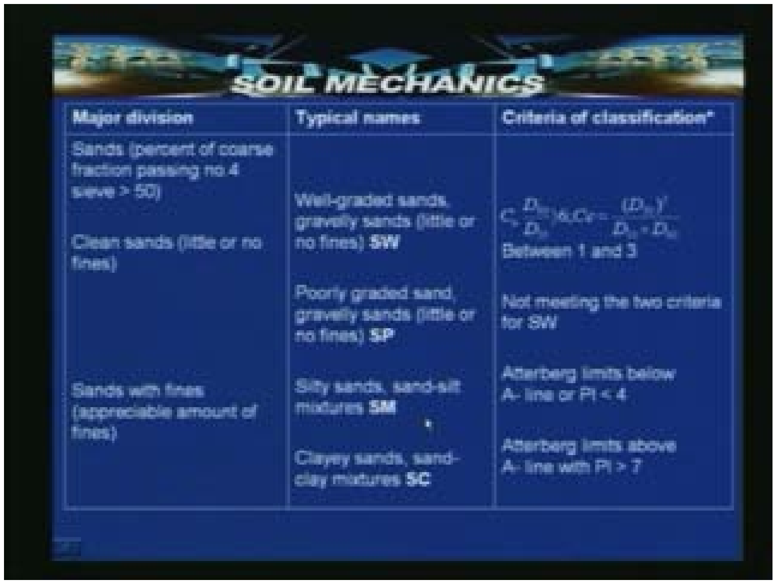

Next is, sands, the subgroup in the coarse-grained soil, previously we have seen gravelly soils. Now, similarly with the sandy soils the percentage of coarse fraction passing number 4 sieve is greater than 50. Clean sands little or no fines, sands with fines (appreciable amount of fines) means that the fines indicate an appreciable amount of fines, so it cannot be neglected. Similarly for well-graded sands, gravelly sands (little or no fines) C_U is greater than 6 and C_C is in the range of 1 to 3 where if you are able to satisfy both the criteria then the particular sand is indicated as SW that is well-graded sands or gravelly sands with little or no fines.

Similarly, the poorly graded sand, gravelly sands (little or no fines) is indicated as a legend SP. The reason for deduction of SP is, if you are not able to meet the above two criteria like if the C_U is less than 6 and C_C is not in the range of 1 to 3 then it is not actually meeting the criteria for qualifying SW. Then that indicates that the group or legend should be SP. Sands with fines (appreciable amount of fines) means silty sands, sand-silt mixtures indicated as SM where again the plasticity index is less than 4 and falling below the A-line in that case silty sands or sand-silt mixtures SM.

Clayey sands and sand clay mixtures indicated as SC because the Atterberg limits above A-line with plasticity index greater than 7. That means if you take the plasticity index and liquid limit it falls above A-line and the origin of SC is that the plasticity index is greater than 7 that is clayey sands and sandy clay mixtures. So SC group indicates clayey sands or sand clay mixtures. Silty sands, sand-silt mixtures are indicated by SM.

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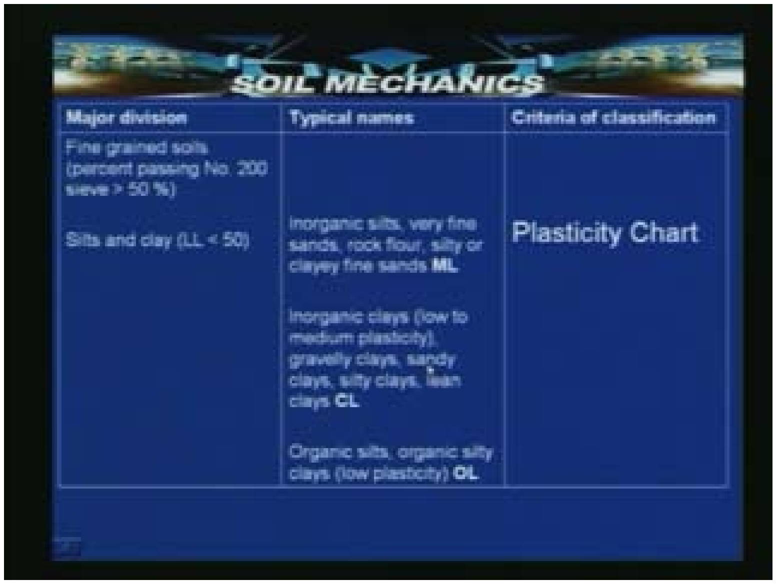

Now, having seen coarse-grained soils let us look into fine-grained soils. The fine grained soils are again the percentage passing number 200 sieve is greater than 50 percent. We said that there are two groups called coarse-grained soils and fine-grained soils. In the previous two slides we have seen the criteria of classification for coarse-grained soils.

Now we are looking for the classification chart for fine-grained soils. For fine-grained soils, the percentage passing number 200 sieve is greater than 50 percent. For silts and clay the liquid limit is less than 50. Inorganic silts, very fine sands, rock flour, silty or clayey fine sands are indicated with ML that is silt of low compressibility. The criteria for ML are plasticity chart. Inorganic clays (low to medium plasticity), gravelly clays, sandy clays, silty clays and lean clays are indicated with legend CL. Organic silts, organic silty clays (low plasticity) are indicated by OL. So OL indicates that organic silts with low plasticity fall under this particular classification with legend OL. CL indicates inorganic clays of low to medium plasticity.

Sometimes the borderline cases do exist, basically the plasticity chart is known for some low plastic soils CL-ML. CL-ML indicates a border line case which lies above the A-line. CL-ML exhibits with low plasticity as well as some clay fine characteristics. The criteria of classification are plasticity chart which we have already discussed. The same plasticity chart is used to arrive at these classification systems. Depending upon the silt, clay, liquid limit and Atterberg limit test results, when putting these values on the plasticity chart we will be able to describe the soil type and for what type of legend it is eligible for.

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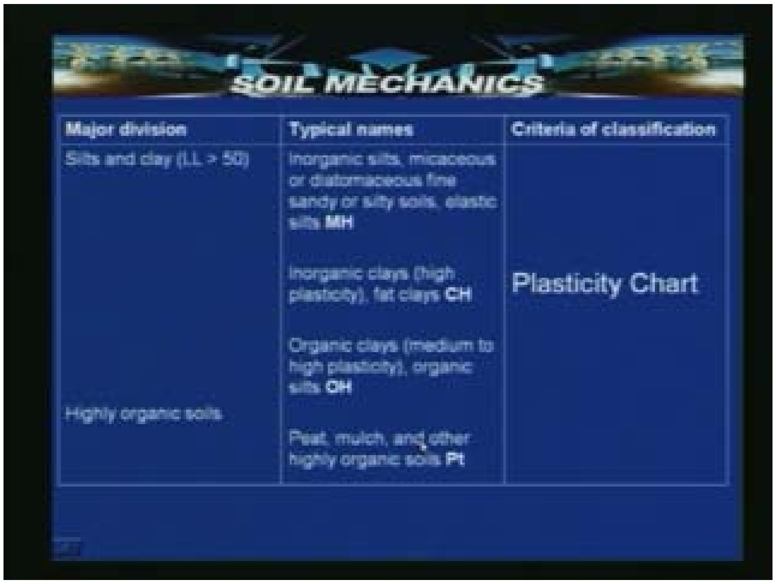

The next major division is silt and clay (liquid limit is greater than 50). Previously we have seen the fine-grained soil with liquid limit less than 50. Now we will be seeing silt and clay with liquid limit greater than 50. Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts are indicated by MH. Inorganic clays (high plasticity), fat clays are indicated as CH. Organic clays (medium to high plasticity), organic silts are called OH. If the liquid limit is greater than 50, then they are divided again into MH, CH and OH subgroups and with different soil classification symbols.

Similarly, highly organic soils such as peat, mulch and other highly organic soils are indicated as P_t. Highly organic soils are the third subgroup which we have discussed earlier in the extended Casagrandes classification system. We have seen the criteria of classification for coarse-grained soils and fine-grained soils.

Based on the Grain Size Distribution and Atterberg limit test results, by using this criteria, one can classify the soils into different groups like CL, ML or CL-ML depending upon the eligibility for the border line cases or CHOH, whether they are above the A-line or below the A-line. In doubtful cases to distinguish whether the soil is organic or not one can conduct liquid limit to find out whether decrease in the liquid limit is there or not. If the decrease in the liquid limit is more than or equal to 30 percent it indicates that the soil is organic.

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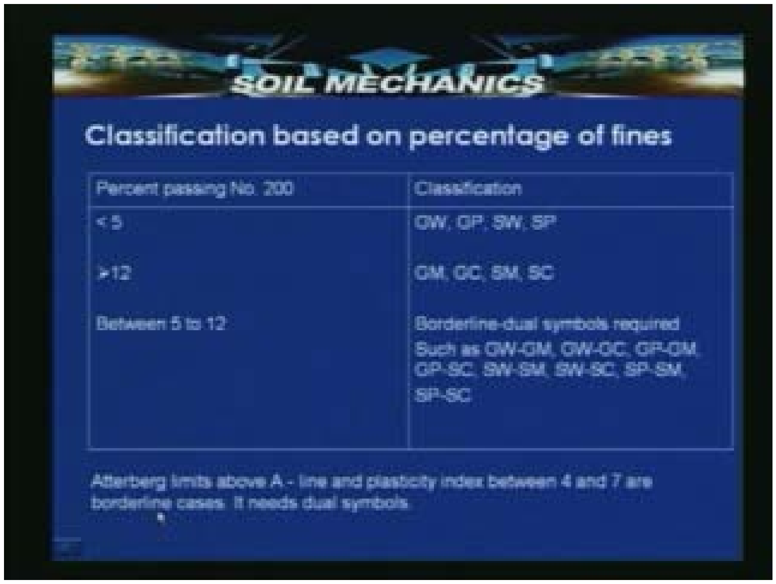

Now we look into the classification based on the percentage of fines. The percentage passing number 200 sieve, for example while discussing relative density test we said that if the fines are more than 12 percent, then different field testing criteria are required to be used. If fines are less than 12 percent they may not be required to carry out hydrometer test analysis. Look at the column percentage passing number 200 sieve, if it is less than 5 then the classification deduces to GW, GP, SW SP and if it is greater than, then it is 12 GM, GC, SM and SC. If the percentage passing number 200 sieve is in between 5 and 12 that is they are called the border line cases, border line dual symbols are required.

Suppose if you have got 5 to 12 then such as GW-GM, GW-GC, GP-GM, GP-SC, SW-SM that means well graded sand and sand with some amount of silt, SW-SC, SP-SM and SP-SC. These are the border line cases which are indicated for the percentage of the passing is in between 5 to 12. If it is less than 5, then it is a clear cut state for us GW-GP and SW-SP. If it is more than 12, then GM, GC, SM and SC. Atterberg limits above A-line and plasticity index is in between 4 and 7 are the borderline cases and it needs dual symbols. So that is where the CL-ML classification will come into picture. So having discussed about the Casagrandes plasticity chart let us look into this chart once again.

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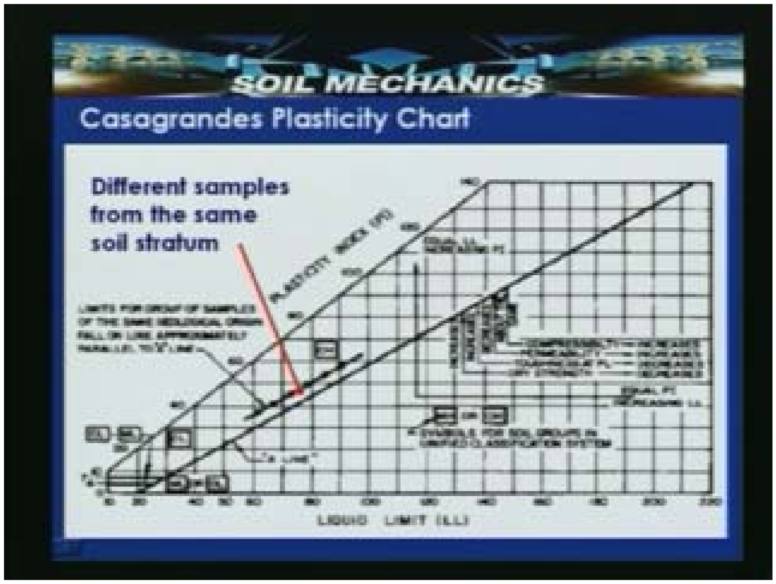

We have seen that the plasticity index is indicated here and the liquid limit is indicated here. Along this line, there is an equal plasticity index but increasing liquid limit. Here it is equal liquid limit and increasing plasticity index. For a liquid limit of 120 percent soil is exhibiting and there is an increase in the plasticity index. Here, this line above A-line limit for the group of the samples of the same geological origin, fall on line approximately parallel to A-line.

Different samples from the same soil stratum are exhibiting the similar characteristics as you can see here. CL, ML, OL is that borderline case with plasticity index between 4 and 7. CL-ML is the borderline case here, some coarse-grained soils or sandy soils also fall here. CL is clay of low plasticity is indicated here, ML or OL is indicated here and CH clay of high plasticity is shown here. OH is an organic silt of high compressibility and MH is inorganic silt of high plasticity which is placed here.

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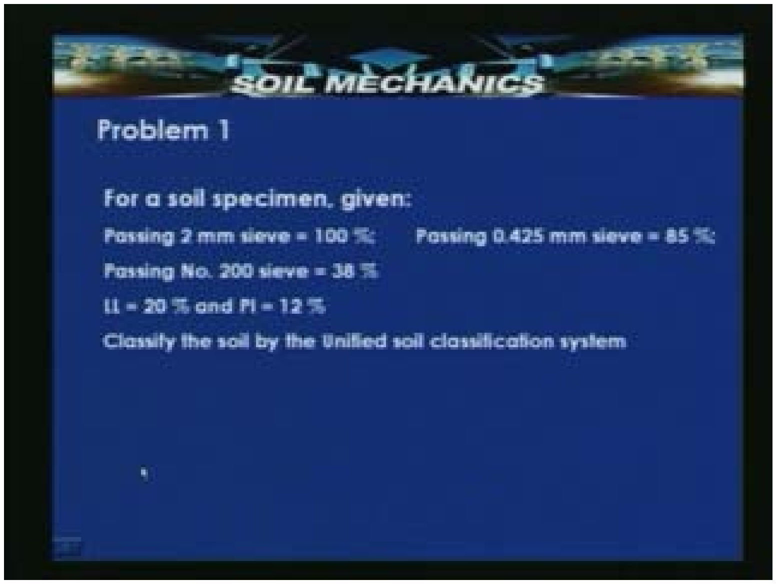

So having seen the soil classification system, let us apply this knowledge for solving three typical problems. So problem 1 is basically the results of Grain Size Distribution analysis are given and some Atterberg limit test results are also given. In this problem 1, the statement is as follows: For a soil specimen, the given are: Percentage passing 2mm sieve is equal to 100 percent, passing 0.425mm sieve is equal to 85 percent, passing number 200 sieve is equal to 38 percent that is less than 50 percent and liquid limit is equal to 20 percent. Plasticity index is equal to 12 percent so classify the soil by the unified soil classification system. We are asked to classify the soil for the given data, this has been obtained from the laboratory analysis.

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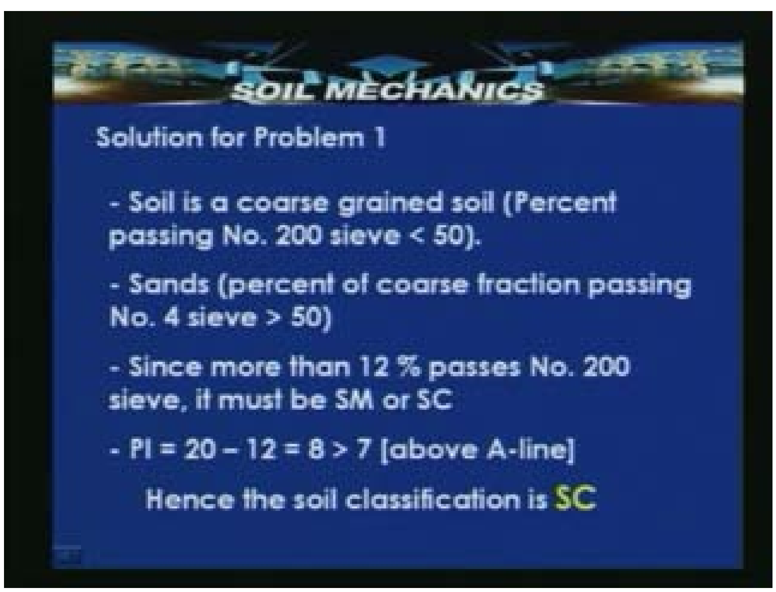

So the solution for the problem works out as follows:
The soil is a coarse-grained soil because the percentage passing number 200 sieve is less than 50 percent. If it would have been more than 50 percent, then the first step itself would have divided that into a fine-grained soil. But this is eligible for the coarse-grained soil.

Basically it is sand because percentage of coarse fraction passing number 4 sieve is greater than 50, so that is eligible for sand. Since more than 12 percent passes through number 200 sieve that is 75 micron sieve, then it must be SM or SC. Now we have to decide which one is eligible for the classification legend.

Here, plasticity index is equal to 20(liquid limit) – 12(plastic limit) is equal to 8 which is greater than 7. If it is greater than 7 that is above A – line. The above A - line carries with a group called C so the soil classification is SC. SC indicates the soil classification which is obtained here. This is the problem which is having a coarse-grained soil. The percentage of passing number 200 sieve is less than 50 percent and sand with percentage of coarse fraction passing number 4 sieve is greater than 50.

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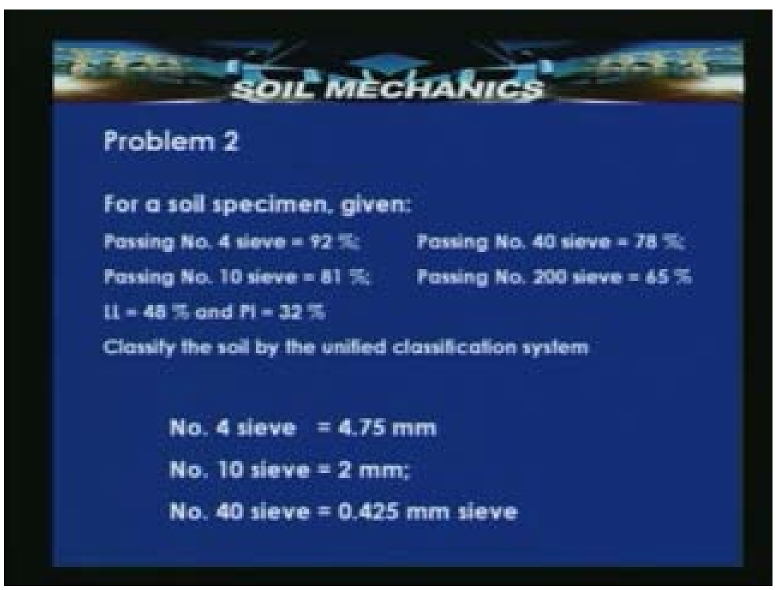

The problem 2 is a typically different problem. For a soil specimen the given are: Passing number 4 sieve is equal to 4.75mm that is 92 percent; passing number 40 sieve is equal to 0.425mm is 78 percent; passing number 10 sieve is equal to 81 percent; passing number 200 sieve is equal to 65 percent and Atterberg limits are: Liquid limit is equal to 468 percent and plasticity index is equal to 32 percent. We are required to classify the soil based on the unified classification system.

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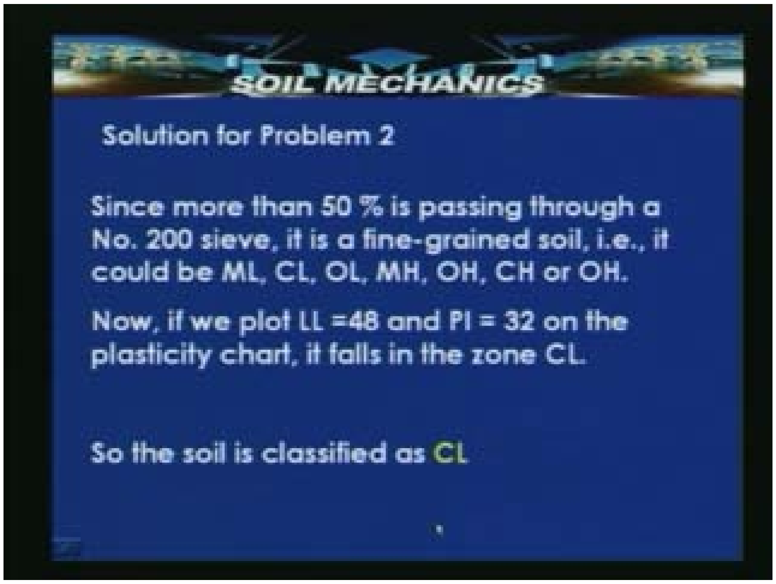

If you look into it, since more than 50 percent of the soil passing through a number 200 sieve, it will choose for a fine-grained soil that is it could be ML, CL, OL, MH, OH, CH or OH. In the beginning we will not know what type of soil classification it is going to get. Now, by using the liquid limit and plasticity index values we can ascertain the group of the soil. If you plot liquid limit is equal to 48 and plasticity index is equal to32 on the plasticity chart, then it falls in the zone CL so the eligible soil classification is now CL, so soil is classified as CL.

Now we have seen these two problems we were discussing about; the type of a coarse-grained soil and fine-grained soil. We should use similar types for classifying border line cases also like two eligible symbols like GW, GM and other cases. One should use this criteria and strictly follow this criteria and to arrive at the classification legends of the soils. Let us look into the third problem.

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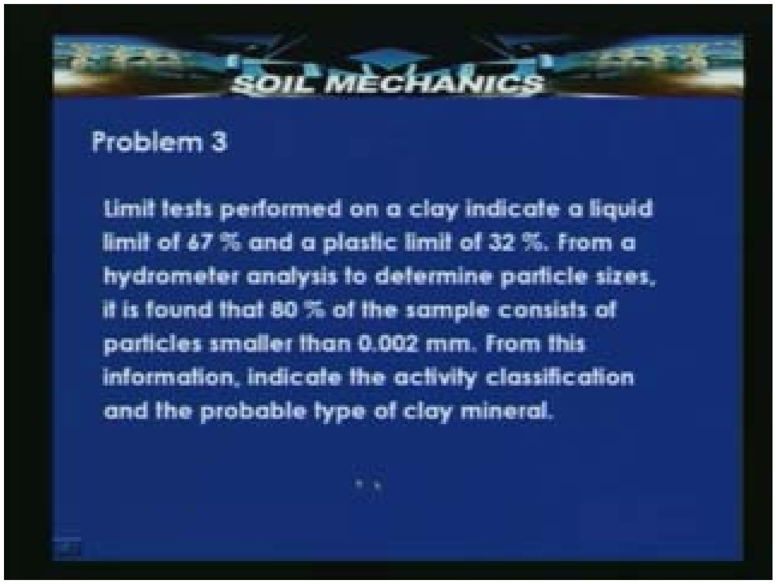

This is the soil classification system by using the activity number. Here we are given a liquid limit of a given soil as 67 percent and plastic limit as 32 percent. The clay fraction was given which is 80 percent of the sample consists of the particles smaller than 0.002mm. From this information we are required to classify the soil based on the activity and indicate the probable type of clay mineral.

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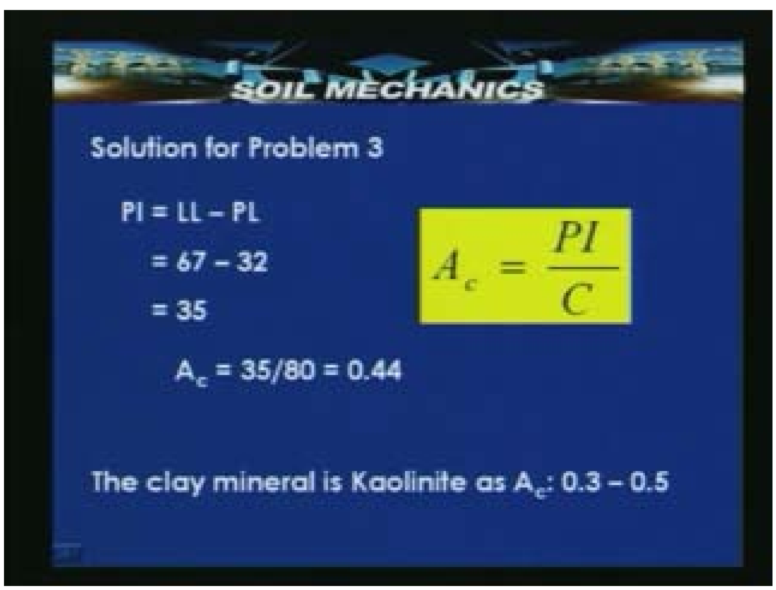

The solution works out like this: We knew that activity is equal to (plasticity index by clay fraction). Plasticity index is equal to (liquid limit – plastic limit). From this you can determine plasticity index which is 35 percent. The percentage clay fraction is given as

80 percent so activity is equal to 35 by 80 is equal to 0.44. If this value is in the range of 0.3 to 0.5 we have discussed that this value also indicates the probable clay mineral as a kaolinite. Based on this data, the indication is that the probable clay mineral in the soil is kaolinite because it exhibits low activity with ratio of plasticity index to percentage clay fraction.

In these lectures we have seen with index properties with soil classification systems. Totally we had five lectures, what we have tried to see is that we tried to determine the different index properties of soils like specific gravity, water content, other index properties of a soil, Atterberg limits for fine-grained soils.

We also discussed about different methods for determining coarse-grained, arriving at the sieve analysis or a mechanical analysis or gradation of the soils. We also discussed about sieve analysis and fine sieve analysis and hydrometer analysis for the fine-grained soils. Then we used all this data which we generated from these properties to classify the soils or to group the soils which are exhibiting identical characteristics. With this information it will be possible for us to classify the soil.