ADVANCED GEOTECHNICAL
ENGINEERING

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Lecture No. 05

Module – 1

Clay Particle – water interaction
&
Index Properties

Welcome to lecture number 5 of module 1of advance of geotechnical engineering, in the previous lecture we understood about different clay minerals like kaolinite, illite, and montmorillonite in this lecture we will discuss about clay particle water interaction and index properties.

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So as we discuss if were collect and review once again all clay particles are said to be begatively charged and they are basically having plate reshape or they are called as platy particles the electrical nature of clay particle is said are attributed to electric charges and the two faces of all played a part occurs I have a negative charge this is resulting mostly due to the isomorphous substitution that is not neutralized by interlayer cation bonding.

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The edge of the clay particles usually have a positive charge at low to moderate pH value with increasing pH the edges of the clay particles can actually have negative charges, hence the net charge of clay particles is always negative this particular example of you know the formation of bentonite cake in the borehole walls in soil investigation projects.
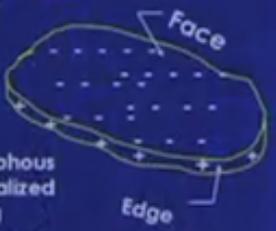
We use a bentonite which is predominantly having sodium based montmorillonite having different grades if you leave the bentonite for some time it actually forms a thin cake and actually supports the borehole walls from collapsing it is said that it is actually the pressure which can actually exert on the borehole walls by the hardened bentonite is about of the order of 10 kilo Pascal's also.

This particular phenomenon of is due to or it is set as electrophoresis here whatever what happens is that the negatively charged clay particles always have a tendency to move towards the positively charged particles that is actually which are there in the surrounding particles along the peripheries of the borehole walls, so this is also visible in the phenomenon called electrophoresis. So the electrical nature of clay particles is mainly attributed to electrical the natively charge which is available along the two edges two phases of the Leticia particles and at the low pH low to moderate pH values the edges actually generally have positive charges but with increasing pH that can lead to have negative charge.

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The another reason is that exchangeable ions since the soil must be electrically neutral the negative faces attract exchangeable cations like sodium plus calcium plus calcium 2 plus mg 2 plus etc, so the positive just attract exchangeable anions are cations if neatly charged in case of a high pH.

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Another the reason is that the surface charge density which is surface charge density which is actually called as Sigma not and which is nothing but number of charges per unit area if you look into this table the for a clay mineral click you light the cation exchange capacity that is milligram equivalents per hundred grams which is fine and the specific surface area is about 15 meter square per gram.

So by using Sigma naught is equal to CEC / SSA the kill net actually have 0.32 charges per meter square whereas sodium based on montmorillonite with the CEC of 100 milligram equivalence per hundred gram with a SSA a of 800 meter square per gram the surface charge density is about 0.18, 0.18 charges per square meter this is low because of the higher surface area.

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So the structure of the clay soils this makes actually the clay soils have to have some different patterns of structures for especially for fine grained soils forces between clay mineral particles if the two particles which are plate shaped particles approach each other in suspension the forces acting on them are predominantly the van der Waals forces of attraction and the repulsion between the two positively charged ions absorbed water layers that is if you have got a absorbed water layers the ions in between the two positively charged absorbed that is a repulsion between the two positively charged ions the absorbed water layers.

So here in this figure the clay particle with this with the negative charge and with the cations this is the absorber layer which is actually shown here.
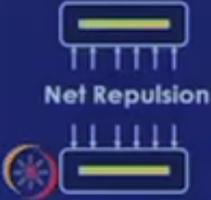
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So this makes actually a very small separations the van der Waals forces are always larger and particles which approach sufficient closely will adhere our over the van der Waal forces decrease rapidly with increasing separation, if the absorber layer is thick the repulsion will be large at a distance from the surface which the Van der Waal forces are small. So this makes actually the because of these the particles will remain in a state called dispersal this particular the they settle independently and the particles will be very difficult to bring together because of the net repulsion which is actually happening between the two clay particles.

So here you are seeing a plate shape with clay particles and this is adsorbed layer and here because of the net repulsion which is actually happening in the cations present in the soil then they actually particles remain in the dispersal state and then they settle independently, if you wanted to the contact between the dispersed particles will only be establish if an external force is applied.

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Particularly in case of clay soil if in this possible only if an expansive soil is if an external force is applied which is large enough to overcome the net repulsive forces. So in order to bring the particles closer you need to apply higher external forces so that to overcome these repulsive forces if the absorber layer is thin and there will be little or no net repulsion at any distance and random movements on the particles will be enough to bring them in contact so this process of is called flocculation.

So here what will happen is that because of the prevalent positive charges along the edges of the plate shape of particles and it and some resulting attraction between the edges of the clay particles and the faces of the clay particles face to each and some face-to-face orientation takes place, so because of this what will happen is that the groups of particles will flock together and this is said as with this result this is resulted because of the resulting net attraction.

So the group of particles settled together and our flock together and this state is actually a structure is resulting as a flocculated structure.

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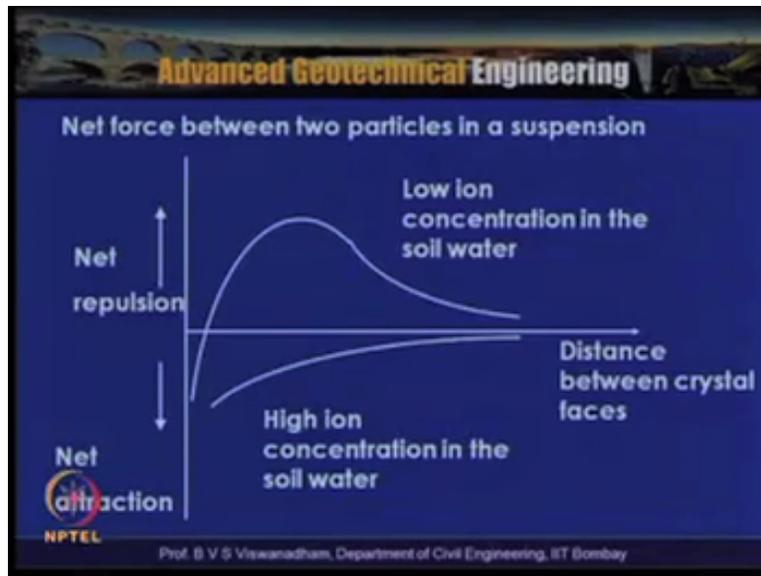
So here it is explained in this graph the net force between two particles in a suspension in case of if you take the distance between the crystal faces with the it close to the face with an increase in the ion concentration what is actually happening is that the net attraction will keep on decreasing close to the face it is very high but in case of low ion concentration the net repulsion is very high.
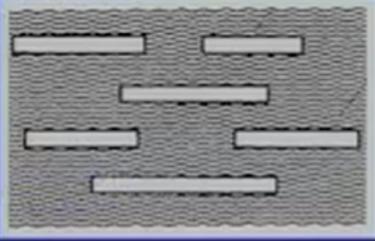
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So as I said the dispersed structure of the clay soils which is resulted predominantly because of the net repulsion the net forces of repulsion are greatest in the case of particles approaching face-to-face this example for this is that lacustrine clays deposited in fresh lakes generally have a dispersive structure in this case few of the particles are in direct contact most being separated by the adsorbed water layers.

So here schematically the dispersive structure of clay soils is shown here the net forces of repressions are greatest in the cases of particles approaching face-to-face so this is actually predominant in liquid stream Clay's basically they are deposited in freshwater lakes and generally they have a dispersive structure.

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Another structure which is called as flocculated structure which results because of the net attraction the B C's this is predominantly happens in for the marine soil deposits particularly for marine clays deposited in seawater in which ion concentration is high so that the adsorbed water layers are themed and generally how if rocket structure with the AG to AG orientation or edge to face orientation.

So this results in a wide space formation a trust like structure and where the flocculated structure has an open structure with the large wide spaces and with particles attracted to each other with the edge to the edge or edge to face contacts so this is resulting as a flocculated structure of the clay soils and this is predominantly occurs in marine clays deposited in seawater in which ion concentration is high.

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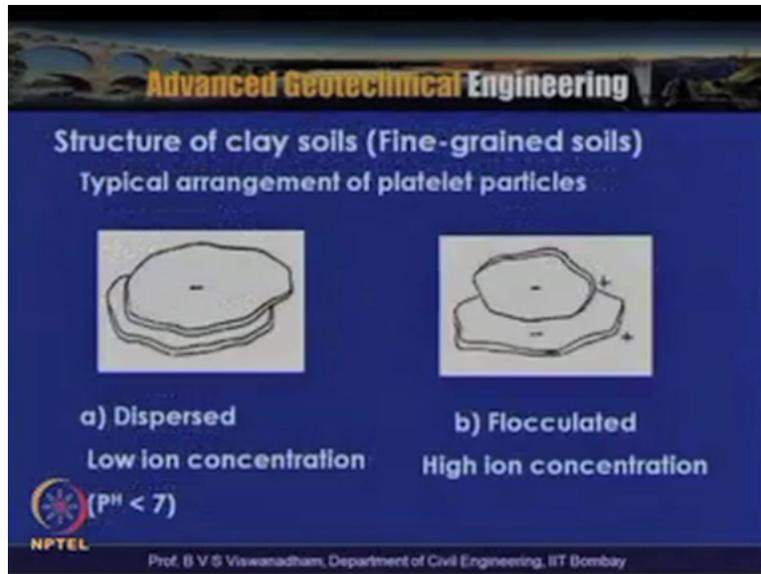
So here once again the structure of the clay soils fine-grained soils a typical arrangement of the platelet particles is shown here with the low ion concentration when the pH is actually less than 7 there is a possibility of the prevalence of the dispersed structure with high ion concentration because of the age to phase attraction or the resulting of the net attractive forces between the particles there is a possibility of the flocculated structure.

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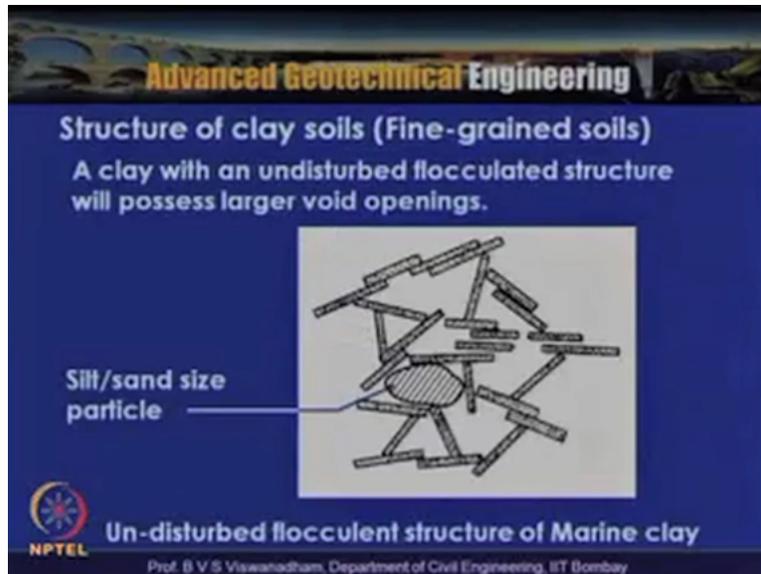
So structure of the clay soils here predominantly undisturbed flocculent structure of the marine clays stones typically a cleave a clay with an undisturbed flocculated structure will possess large voids wider opening spaces and here in between the silt particles are shown here schematically so this is an undisturbed flocculent structure of a marine clay which predominantly has large wide openings and it has a edge to face orientations and some sort of edge to edge attractions here which are actually shown in this soil structure.

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Structure of clay soils (Fine-grained soils)

When platelet particles are carried into fresh water lake, they do not flocculate and settle along with silt particles as they do in salt water.
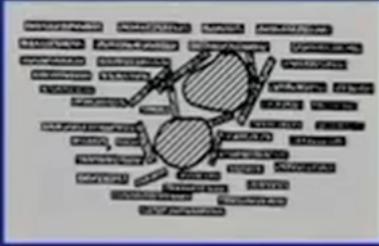
Remolding of flocculated structure results in dispersed structure

Remolded or dispersed structure of Fresh water deposit

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When plated particles are carried into freshwater lake they do not flocculate and settle along with seed particles as do as they do in salt water so the revolting of the flocculated structure results in dispersed structure so if you remove the flocculent structure the orientations of the clay particles takes place and it results in the dispersed structure so remolded or dispersive structure of the freshwater deposit which is actually shown here.

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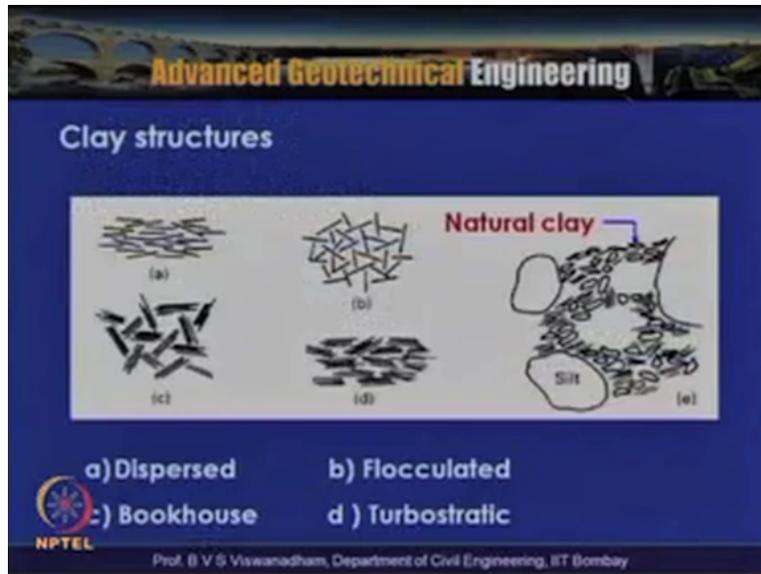
So here typical clay structures along with disperse which is shown here flocculated which is shown here and these are also which are in vogue they are booked house structures where you have got several particles attracted to each other and they have a similar to a flocculated structure and then you also have the turbo static clay structures and here schematically once again a natural clay play structure which is shown here with the large particles which are actually silt and then you have the flocculation which actually have taken place and these are the voids in the shown in the particular arrangement.

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So in order to identify this particular arrangement there are many methods are there like one of the predominant method which is actually used is by ordinary microscope basically used for cause grain soils only when you look you can see the coarse particles but if you wanted to look into the particle arrangement and possible cut fabric of these different types of soils one should actually use electron microscopy Scanning electron microscopy (SEM) it is popularly called and this is ideally suited for clay soils as the resolution is sufficiently high as it is possible to go for higher magnifications were up to10 to power of 5 times magnification is possible.

So SEM is a type of electron microscope that image images a sample by scanning it with a beam of electrons in a raster scan pattern the electrons interact with the atoms that make up this sample producing the signal and then that contained information about the sample surface topography composition and other properties such as electrical conductivity etc so here the basically the output results in arrangement of the particles.

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So in this slide scanning electron microscopy of a coal ash blended with the sodium bentonite is shown here so as you all know the coal ash particles are predominantly called as Zeno spheres and they are basically spherical particles and sodium bentonite which is actually having about 80% of mineral is a macro light which is actually having a gel-like structure so you can see here the combination of coal ash blended with the sodium Internet up to 15% by dry weight also is actually shown with the magnification of 650 times.

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So here in this it is a typical example SEM of coal ash blended with sodium bentonite is shown in this slide for understanding SEM of locally available silt which is actually shown here in natural form when we see it will be like this but when you look into the SEM through with the help of the SEM you can actually see the large the green particles in the soil with a 500 times magnification.

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Now having discussed it about you know the particular arrangement particularly because resulting due to clay water interaction how and also we also understood that clays have predominantly consists of different minerals and their properties are actually influenced by the mineral present in the clay particles see if you wanted to identify that there are three different methods are there for the identifying clay minerals the first method being accelerated a fraction it is called XRD method.

The third method the second method is differential thermal analysis DTA and third method which is used which is also used called by using Casagrande's plasticity chart but we will discuss about the Casagrande plastic plasticity chart in the latter part of the lectures one , one thing one we must understand is that no one method is satisfactory for identification this is partly because of the interference of minerals in mixture the range of composition and crystal structure of place from different sources.

So these methods will give an indication about the type of the clay minerals present but no one method no one method is satisfactory for identification this is attributed to the interference of minerals in a mixture and the range of composition and a crystal structure of place from different sources.

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Now let us try to understand about the x-ray diffraction method the most widely used method of identification of clay minerals is from an x-ray diffraction pattern basically of a powdered sample of the clay size fractions of a soil minerals can usually be identified from diffraction lines so the basic principle of the XRD is minerals with regular or repeating patterns of crystal structures diffract x-rays so this is actually used and based on that the different types of minerals are identified so the schematic diagram of the accelerator diffraction unit for crystal identification is shown in this slide.

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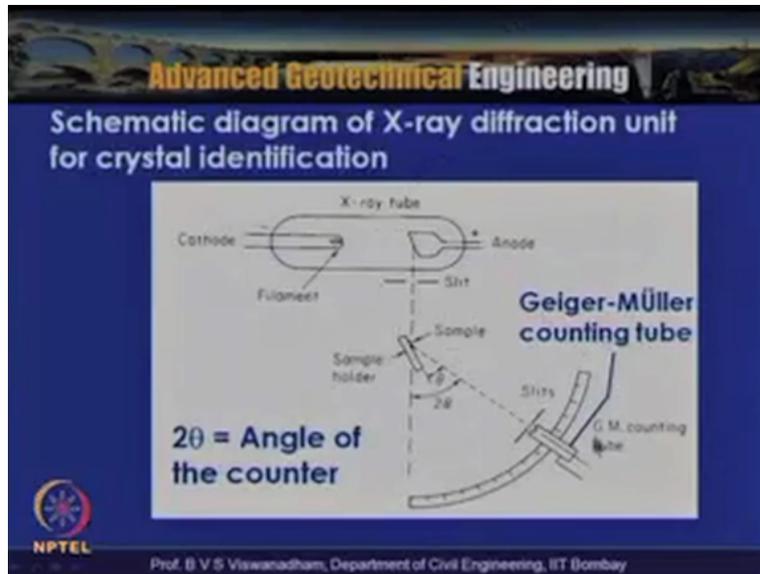
So the schematic diagram of the accelerator diffraction unit for crystal identification is shown in this slide so here the sample is actually kept and this is called as the Geiger Muller counting tube and this is that angle of the counter that is called as 2θ.

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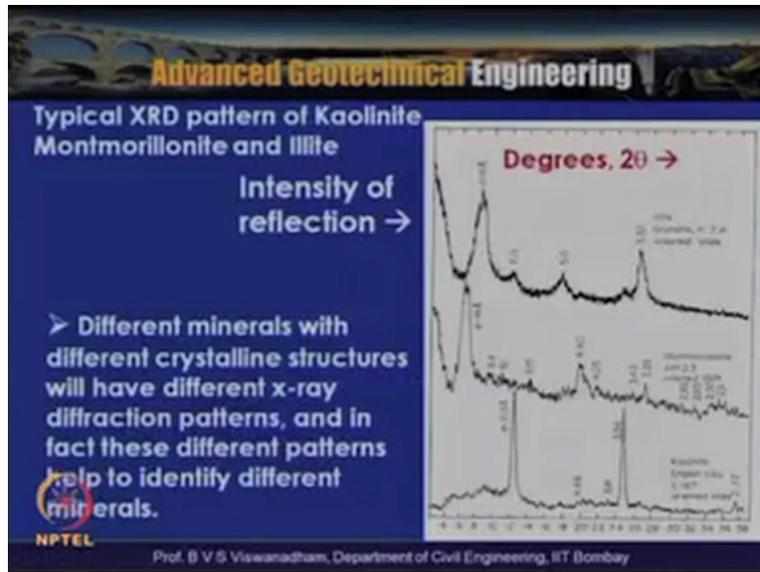
So with this the resulting you will get the XRD spectra which is actually shown here along this axis degrees 2 theta and then this here the intensity of the reflection on the y axis is plotted so you have different peaks here so this is the typical XRD pattern of Kaalinite Montmorillonite and Illite so this is for Kaalinite and this is for Montmorillonite and this is for Illite mineral so you can see different types of the XRD patterns for different minerals present in the soils.

So different minerals with different crystalline structures will have different x-ray diffraction patterns that are shown here and in fact these different patterns help to identify different minerals so this is actually used to identify different minerals.

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Typical XRD pattern of locally available expansive soil
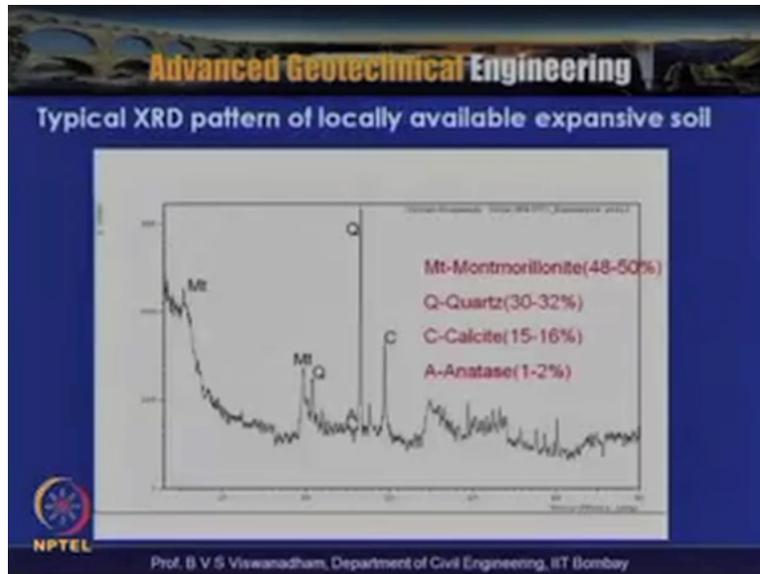
So in this light a typical XRD pattern of locally available expansive soil and which is also called as black cotton soil is shown here on the y-axis the intensity of reflection is shown and here on the x-axis to θ which is plotted so the interpretation of this XRD pattern reads as MT that is multiple light has 48 to50% and quartz about 30 to 32% calcite 15 to 16% and to say about 1 to 2% so this is atypical XRD pattern of locally available expansive soil which actually has got 50% of minerals mineral proverb predominant mentally is Montmorillonite.

So this is this could be one of the reason for expansive soil for exhibiting shrink and swell characteristics that means that incase of exposed to water the expansive soil tend to increase its volume and incase of devoid of water then there is a possibility of shrinking of the soil here in this slide to the x-ray diffraction spectra for bentonite is shown here.

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X-Ray Diffraction spectra for bentonite: Cu-kα radiation
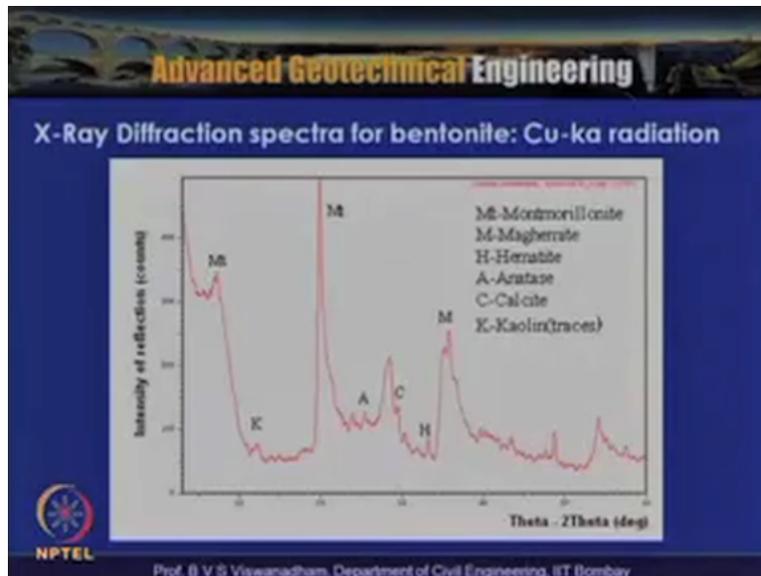
And here the intensity of reflection in counts this is about 400counts with the different diffraction pattern it can be seen here so Montmorillonite and mega-mighty and hematite and calcite respond to have very low peaks of calcite that is the low peaks of KO light that is kaolin traces are actually reported so these peaks which are predominant peaks are one peak and second peak multiple light.

And then here another this is Montmorillonite this indicates that about 80% of the mineral clay mineral present in this bentonite is maximal light then followed by Montmorillonite and hematite and say and calcite and some traces of curing so what we have seen is that we actually try to understand how x-ray diffraction can be used to identify different clay minerals with an example of expansive soil as well as some bentonite with the grade gave it is called which is actually having about 85% of Montmorillonite.

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As I said earlier so the demerits which are reported they are not suitable for soils with mixtures of clay minerals organic matter and non clay mineral constituents and basically they have the inability the two it is inability to specify proportions of each mineral in a mixture so the typical artists we can say demerits of XRD method not follows not suitable for soils with mixtures of clay minerals organic matter and non clay mineral constituents and inability to specify the proportions of each mineral in a mixture.

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Then the second method which is differential thermal analysis method DTA method which determines the temperature at which the changes occur in a mineral when a when it is heated continuously to a higher temperature so the intensity of change is proportional to the amount of the mineral present in the soil so the clay lose water or go through the phase changes at specific temperatures.

So different when the clay soils have different minerals they actually have got they change their phase at different temperatures so the temperature at which these reactions occur are the characteristics of the mineral and can therefore be used for identification so this principle is used for identifying clay minerals by using the differential thermal analysis.

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So in this slide the DTA apparatus is shown here and associated in the recording and controlling mechanisms for DTA measurement a sample of clay and a sample of inert material are slowly heated in a furnace which is actually shown here schematically and Calcined aluminum oxide or ceramic are used as the reference material so the reference materials here are Calcined aluminum oxide or ceramic, ceramic or basically they are used as the reference material.

So when a temperature is reached at which the clay looses water by vaporization the sample temperature will drop below the inert material and that is actually used as a reference indication.

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So when you look into the review basically we try to understand about the particular arrangement in coarse grain soils and fine-grained soils and we said that in the particular a particular arrangement for coarse grain soils because of the large particles they actually have bulk structures when it comes to finder and soils two prominent structures which are actually possible are dispersal structure and flocculent structure or displaced dispersed or flocculate structures.

And then because these for the particularly bulk, bulk structures can I also have lose bulk structure or dense bulk structure and so the a parameter called relative density has been defined and forces between the clay mineral particles depending upon the ion concentrations they can actually have net attraction or net repulsion net attraction results in a flocculent structures net repulsion results in a dispersive structure.

So this dispersant flocculent structures are actually discuss now having introduced understood about the clay minerals and their so called we understood that soils are strongly influenced by the presence of the minerals or the influence of by the, the type of mineral in case of a sandy soil you know the type of mineral it may not have much influence now in order to classify the soil basically we need to understand about the index properties when particularly with the two different types of soil again here large particle sizes and define particle sizes.

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So the index properties refers to those properties of a soil that indicate the type and the condition of site they basically provide a relationship to the structural properties such as the strength that is capacity to take the load and compressibility or tendency for swelling how swell able they are and appear inability which is nothing but a property of the soil which indicates the ease with which soil will allow the water to flow.

So these index properties can be broadly classified into two heads one is soil grain properties other one is soil aggregate properties.

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The development of the availability to think of soils in terms of numerical values of their index properties should be one of the foremost aim state of every engineer who deals with soil mechanics so here once we have these index property values it is possible to understand about can understand about the type of soil or one of the foremost aim for anybody every engineer who deals with the soil mechanics.

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So the soil grain properties are the properties of individual particles of which the soil is composed without reference to manner in which these particles are arranged in a soil mass particularly example mineralogical composition that we just now understood specific gravity of solids and size and shape of the grains so soil grain properties are the properties of the individual particles of which the soil is composed without difference to the manner in which these particles are arranged in the soil mass.
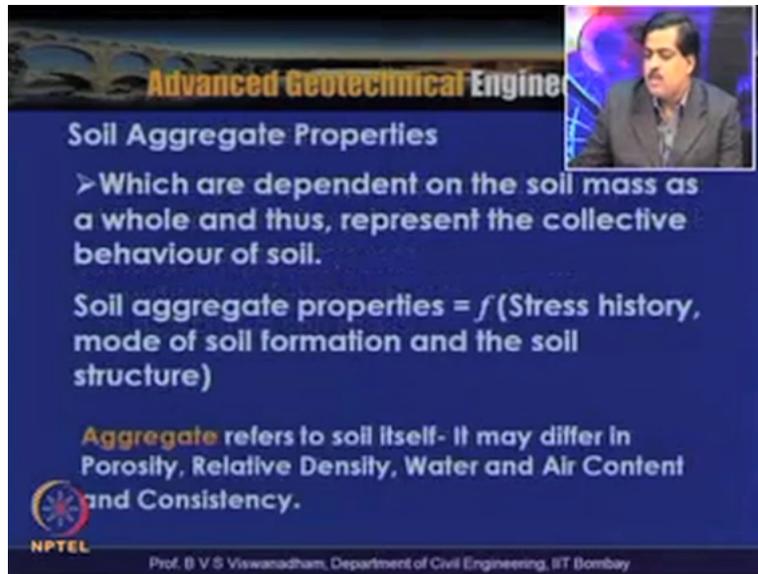
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Aggregate properties or soil aggregate properties which are dependent on the soil mass as a whole and thus represents the collective behavior this file the soil aggregate properties are function of structure stresses tree that is the type of loading the soil has been subjected mode of soil formation and the soil structure that is the particular arrangement that is whether the dispersed structure or flocculated structure or whether it is a bulk structure in loose condition or bulk structure in a dense condition these aggregate refers to the soil itself it may differ in porosity 32density water and air content and consistency.

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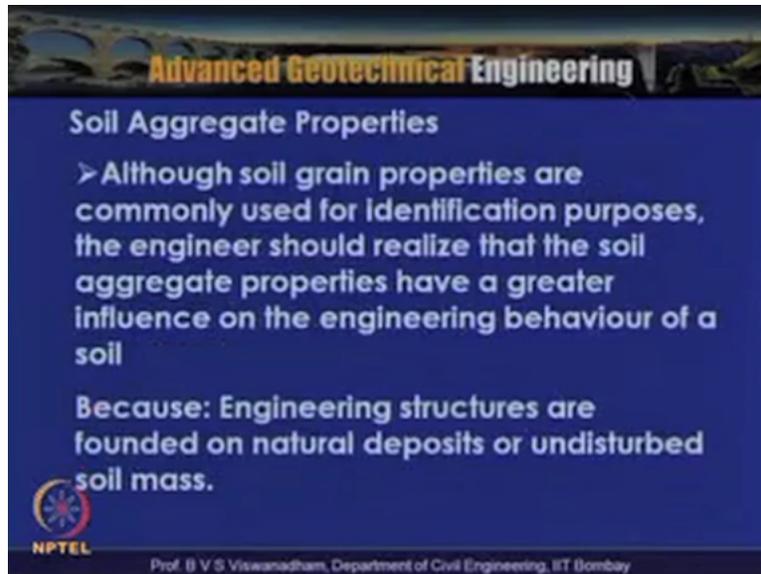
Although the soil grain properties are commonly used for identification purpose the engineer should realize that the soil aggregate properties have greater influence on the engineering behavior soil because the engineering structures are founded on the natural deposits are undisturbed soil mass so although the soil current properties are commonly used for identification purpose the engineer should realize that the soil aggregate properties have a greater influence on engineering behavior of a soil mass because the engineering structures are founded on natural deposits are understood soil mass.

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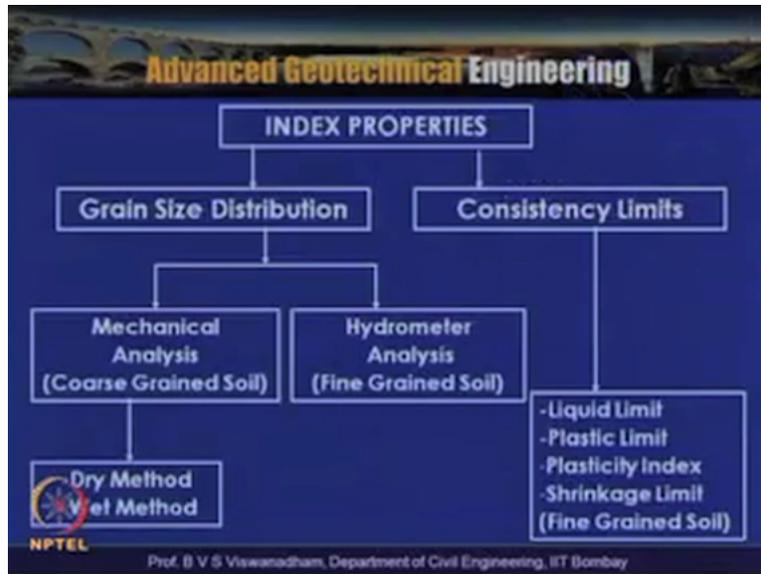So the index properties are broadly divided into the grain size distribution particularly the gradation of the soil and consistency limits and in order to get the particle size distribution the two hits one is the mechanical analysis or sieve analysis which is actually done for coarse grain particles and hydrometer analysis which is basically done for fine grained particles generally in a given soil.

If the percentage points that is particles passing 75 micron that is 0.075 mm if there are more than 12 percent then it is mandatory to do hydrometer analysis basically to assess the percentage points because the presence of present as fines can influence the properties of the soil so mechanical analysis particularly the coarse-grained spur soil cause grades for coarse grained soils it actually has got dry method and wet method and the consistency limits basically liquid limit plastic limit and plasticity index so shrinkage limit.

So these are the nothing but water contents at different states of physical states of the soil these are basically for fine-grained soils and if you have these things these properties then it is possible for us to group the soils having identical properties so when grouping of the soil takes place it is easy for soil engineer or a geotechnical to understand and use these soils according to their function and requirement.

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So the grain size distribution GSD in soil mechanics it is virtually always useful to quantify the size of grains in a type of soil since the in a given soil will often be made up of grains of many different sizes, sizes are measures in term measured in terms of grain size distribution and the soil can actually have possibility of wide range of particles so the distribution particularly the particle size is indicated in on the plotted on the similar on the plot which is on the x-axis particle size which is plotted on the logarithmic scale and on the y-axis the percentage finer is plotted.

So that this is basically done to considering the wide range of the particles in the soil and GSD assisted in providing the rough estimates of soil engineering properties so if the if you have the GSD characteristics it is possible to estimate the you know some rough estimation of the engineering properties of this soil.

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And nowadays the actual research interest is that the accurate prediction of the soil properties based, based largely on the GSD is and wide ratio and soil particle characteristics so nowadays is being attempted in unsaturated soil mechanics that by using grain size distribution the properties of soils are being attempted to be predicted so when measuring the GST is for soils two methods are generally used for grains larger than 0.075 mm sieving method.

Or sieve analysis is use for grains in the range of 0.075 to 0.5micrometers the hydrometer analysis is used so the sieve analysis their known mass of soil which is actually taken and the soil is the place in the set of sieves having different sizes and it is not possible exactly to determine the shape of the particles because the size which is actually predominantly nothing but the size of the mesh which is actually used for receiving the particles.

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So here the particle size is nothing but the approximate size which is which is actually prevalent in a particular soil mass so if this soil particle is smaller than the mesh use then there is a possibility of the soil particle passing through the particular if the particle size is larger than the misuse then there is a possibility mesh size use there is a possibility that it will actually retain their so here the set of sieves run from, from higher sizes to lower sizes.

And here the percentage retained on the 75 micron if it is less than 10 per 12% then there is a possibility of where one can actually ignore in performing the sieve analysis in performing hydrometer analysis but in otherwise it is required to carry out the hydrometer analysis to assess the percentage points.

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So here typical grain size distribution curves are shown here the, the soil particles which are actually sealed through set of seams here it is said that the grain sizes are larger this site and the smaller sizes are here that means that the fine particle sizes are somewhere down the line here and this is the well graded soil basically the well graded soils are very much required for construction and, and this is uniformly graded soil so the and this is a gap graded soil or is also called as a bimodal soil so gap graded soil where some size of the grains are tend to missed.

So that we in the gap rated soil which is also called as the bimodal soil and a fuller theoretical curve which is actually shown here in the idealized a fuller packing it says that in the large spaces which are actually filled by their small particles and so in the process actually what will happen is that there is a possibility of having a this type of a fuller theoretical curve so the, the particle sizes actually vary from large size to small size and the soil mass actually can have different range of particles.

So if the soil mass soil, soil mass has uniformly sized particles then it is called as poorly graded or uniformly graded soil and if the soil that means that the slope of this curve is almost equal to unity and when the slope is actually very flat here then that means that there is a well distribution of all the particles and when the nature of this curve is like this then it is called gap graded or by a model soil.

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In order to determine the, the finer fraction of the soil that is passing 75 microns sieve the sedimentation and all sieve is widely used so this is basically based on the principle of the Stokes law it is a zoom it as a first approximation that fine-grained soil particles can be visualized as small speeds though we actually have discussed the soil particles are pretty shaped particles but here it is assumed as, as they find in particles as Spears and spherical particles falling in a liquid of infinite extent and all particles have the same unit.

So the particles are actually assumed to have identical unit weight and the spherical particles are assumed to fall in a liquid in a having any having infinite extent so that means that without any boundaries the particles reach at constant terminal velocity within few seconds and afterwards often it is allowed to well that means that once the particles are suspended in a suspension the particles reach a constant terminal velocity within few seconds offer it is after it is allowed to fall so all the although the clay particles are you know far from spherical though we said that we are in this channel in this sedimentation analysis we assume clay particles are spherical particles the application of Stokes law based on equivalent diameters provide a basis for arriving at the CSGSD of the fine grain particles is appears to be sufficiently realistic.

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So here when you consider the particles a spherical particle of diameter D when it is releasing in a medium having certain dynamic viscosity and then it is subjected to two forces predominantly one settling force that is because of the self weight of the particle or in this case the bionerd weight of the particle and it is opposed by a drag force which is actually acting on the periphery of the particles so the drag forces act along the periphery of the depart casts.

So according to Strokes law the viscous drag force FD f is affix D on a spherical body for body moving through a laminar fluid at a steady velocity V is given by FD=$3\pi\mu vd$ where D is the diameter of the sphere which is which is representing the particle size and V is the study velocity of the body and μ is the dynamic viscosity of the fluid in which the particle is suspended now if you drop a grain of soil into a viscous fluid.

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Sedimentation Analysis

If we drop a grain of soil into a viscous fluid, it eventually achieves a terminal velocity **v** where there is a balance of forces between viscous drag forces, gravity weight forces, and buoyant forces, as shown below:

Falling particle

v (steady velocity)

F_D

$F_g - F_b$

$$Fg - F_b = (1/6)(G_s - 1)\gamma_w \pi d^3$$

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It eventually Q's at terminal velocity V where there is a balance of forces between the viscous drag forces that is gravity weight forces and violent forces, so once you have that one F_G - F_B the net force is nothing but one-sixth of G_S minus 1 into γ_w x $\pi_D{}^3$, so from equilibrium of the of the soil grain F_D which is that is drag force is = F_G is nothing but the self weight that is the gravity force F_B is nothing but the violent force. See from the equation if you solve the for the equilibrium or terminal velocity V of the soil grain, as can be obtained as V= G_S - 1 γ_w / 18 μ d^2.

So this is said that Stokes law this is after George Stokes which is a given in 1891, so they say this indicates that the larger the soil grain, the faster it settles. That means the V is proportional to d^2, in Stokes law the 10 velocity of the particle is proportional to particle size square, so the larger the size oil grain the faster it settles in water. This critical fact is used in the hive analysis to obtain the grand solution for the prime grain soil.

So that means that if you have got the finer particles particularly having say betonies the terminal velocity is proportional to will be very low, that means that they have a tendency of taking large time for undergoing the sedimentation.

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See the process of sedimentation of dispersive specimen the theory of this sedimentation is based on the fact that large particles in suspension in a liquid settle more quickly, than small particles because we said that V is proportional to d^2 assuming that all particles have similar densities and shapes. If all the particles were of single size with effective diameter D by knowing the terminal velocity we can determine time for time it will take for the particle to settle, that is T D can be given as $G_S - 1 \gamma_w$.

So if you see here TD is inversely proportional to TD of directly proportional to $1/d^2$, so this indicates that the larger the particle size the less time it takes the smaller the particle size the more time it takes to sedimentation.

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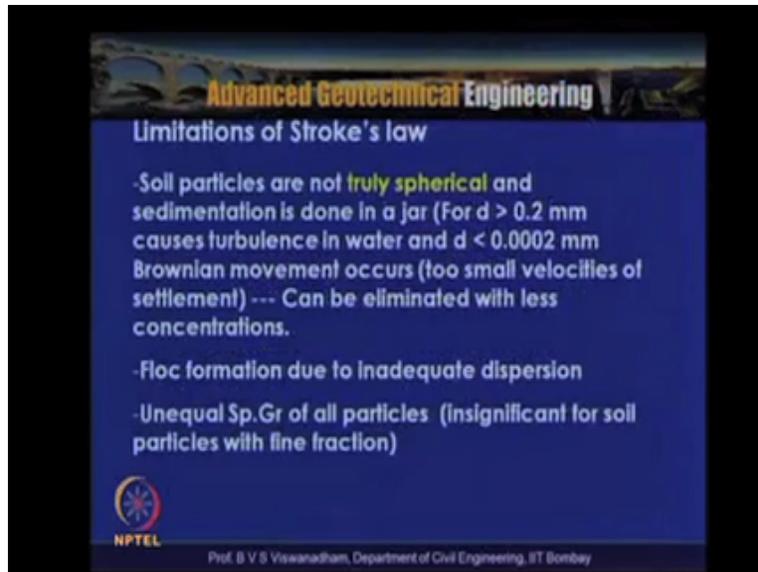
The limitations of Stokes law can be understood the soil particles are not truly spherical and sedimentation done in a jar having D > 0.2 mm and causes turbulence in water and D < 0.02 mm that is 0.2micron causes Brownian movement, the two small velocities of settlement can be eliminated with less concentration. That means that the soil particles are basically are not truly spherical and the sedimentation is done in a jar with a confined walls and further this causes turbulence in water and the Brownian move occurs and the two small velocities of settlement can be eliminated.

This can be related with the less constant this Brownian movement particularly for betonies can be eliminated with less concentration and another limitation; we said there is that flock formation due to inadequate dispersion. The because of the attraction of the these particles net attraction the particles falsely some flocks are actually formed generally in doing the sedimentation analysis it is before preparing, the soil specimen for hydrometer test.

The soil is required disperse, an unequal specific gravity of the all particles also as possible that means, that when you have got a clay particle like, for example we have discussed it about co lash blended with the betonies. So we have got one particle one type of particle is actually having very low specific gravity that is to lash and another side we have betonies which is actually having a specific gravity of two point seven or two point eight.

So but this is formed to be insignificant for soil particles with the fine fraction, so in the present in this lecture we try to understand about the clay particle interaction and the index properties

particularly about, how to actually perform you know see you diode particularly the try sieve analysis and wet sieve analysis for getting the large particle sizes, which are for the force for the cause grain soils.

So in the next lecture we try to understand about the hydrometer analysis and different errors which are actually used different coefficients, which are actually used in interpreting these drama tree analysis results and the reasons for the same. And then we will try to look into you for assessing our understanding about the different index properties namely liquid limit, plastic limit and plasticity index and the shrinkage limit. Once you have these things then we will try to attempt in the next lecture after having discussed with these issues we will try to do some couple of problems as well as, attempts to do the discuss about the soil classification systems.

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