Foundation for Offshore Structures
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Module-1
Lecture-3
Basics of Soil Mechanics III

So we will continue with the ground formation types. Today basically cohesion less cohesive, I think that is what I used to classify. But then sometimes you also have your very strong ground formation like rocks but very rarely used for pile foundation types. Very rarely means sometimes we do encounter such type of formation wherein you might go for pile foundation but very rarely because once you identify this kind of rocky formation be will try to avoid pile foundation in these locations.

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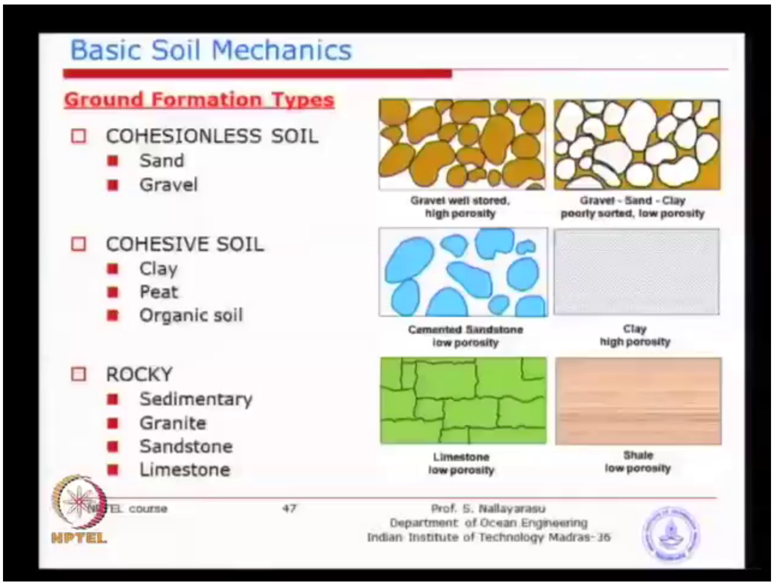

But in any case you identify the better formation and in some locations within the group, sometimes you get boulder, big boulder like one example I was talking about in the previous class. You know among the 4 piles of a jacket, one pile may not be able to drive just because there is a localised rocky formation. So what else can be done in order to get the sufficient penetration to get the, you know the foundation depth. So we may also look at rock as the material for pile load transfer which is slightly different from the other cohesion less or cohesive type of soils.

You can see here cohesion less soil is primarily particle of not having any cohesive, you know the characteristics between the particle to particle. Whereas the cohesive soil is basically fine particles of bonded together which will have a slightly better bonding characteristics. So you see here, with these 2 we can actually find out what could be the difference in behaviour when you apply loading. You know so that is the idea behind trying to find out the characteristics or the properties under loading. And by doing this kind of segregation you need to develop or in fact we need to understand the behaviour and then characterise them such that in future foundation design you can use that, you know basically the properties.

So over a period of time, for the last hundred years, many many devices, many ideas have been devised to identify strength characteristics of cohesive soils and the cohesion less soils which we will be using them sometimes empirical, sometimes based on experiments. So you will have to be very careful in assessing the characteristics because most of them is not easy to derive from 1st principle of physics. So that is why soil mechanics becomes little bit of you know troublesome in terms of mechanics compared to structural mechanics what you normally learned is very straightforward.

You do need to remember anything, you can derive every one of them, the characteristics of deformation of structures very easily. Whereas here, many of them, the principles are behind how the materials are arranged together. Rocky formation basically is quite strong in nature, so one of the difficulties in rocky formation is how you can say solve the foundation, whether it is a shallow foundation or pile foundation because it has got enormous strength against compression and of course you need to make sure that you reach that.

You know every time when we design the foundation, we want to take it to this place but then taking it to that particular rocky formation or a (())(3:23) itself is a big challenge. Among the different types of rocks we got variety of classifications like sedimentary rocks, granite, blue granite you will see, sandstone, limestone, slightly reduce characteristics which are different formation types. I think if we are looking at the geological process of formation of these types of frocks you will be able to understand which I think we will leave it here.

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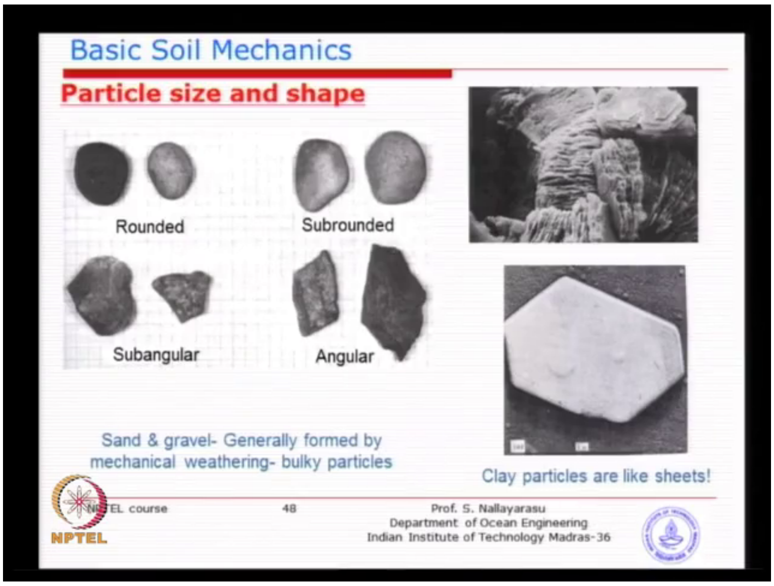

So among the cohesive soil and cohesion less soil, you can see sand, gravel and slightly bigger particles. The cohesive soils are fine particles of different sizes ranging from microns to a few millimetres. So you can see, I think one of the slides I have given the sizes of the ranges. So you can see the particle shapes because these are formed by nature, so you cannot have a predetermined size and predetermined shape. So you can have many types, depending on the type of weathering, I think we were looking at in the previous class, depending on the type of weathering and the mixture of weathering cases you might find different different shapes and sizes, just enlarged photograph of particle sizes.

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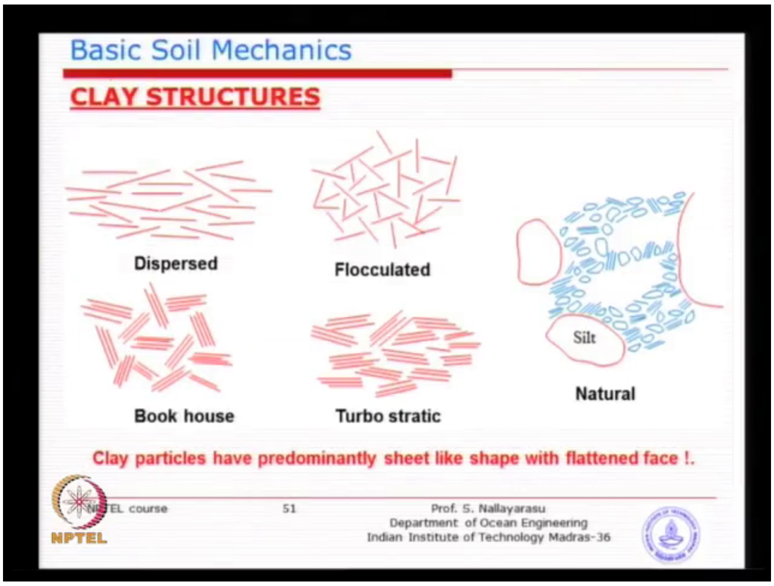

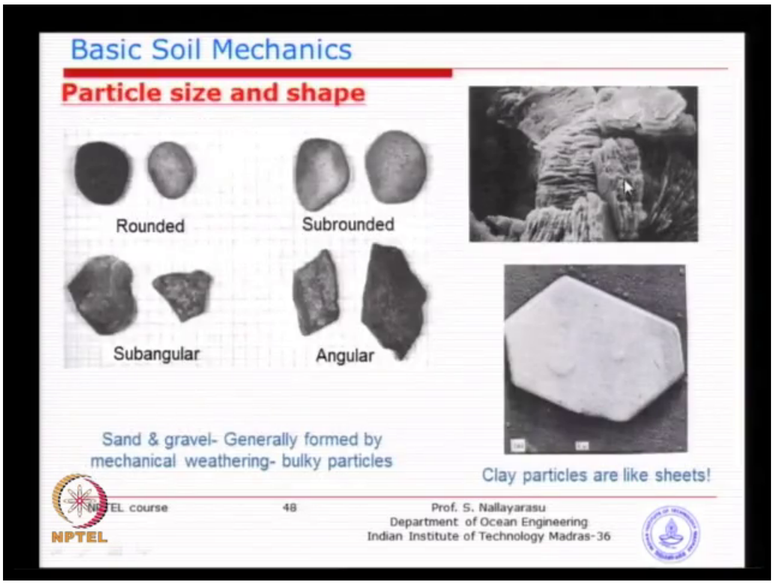

So mostly the clay type of structures or the clay type of particles will have a flat base, you will see that it is elongated, I think you will see in the next picture, something like this. Most of the clay particles, if you go into a microscope, you will see that it is elongated, it is not going to be something similar that you see here in this particle. That is why, this is a magnified picture which is easily seen that the seeds of particle are arranged together which makes you know basically the basic characteristics of fine particles.

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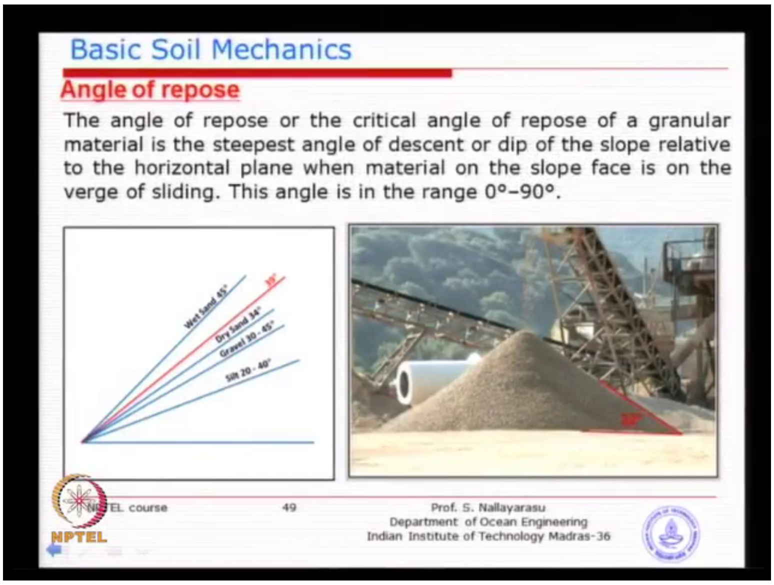

One of the important property that we can easily and physically understand is the particles when you arrange in nature without any influence of external forces, how they get organised themselves. For example would take a case of dried particles of sand, gravel or any material, in fact to take any natural material of grain sizing different sizes, just pour them, just drop them from a slight height, which will raise themselves and slide. So you can see, you see the shape of this particular fine grained gravel, it is not very big ones, probably 20 MM-30 MM.

So you can see it takes shape of particular angle. Now you can realise, you take water and just pour, what will happen, it will just go flat. So that is exactly the 2 extremities, so if you take a rock, solid rock and just cut into 2 pieces, you can see the vertical face, is not it, it does not go, it is not going to slide down and basically that rock has got into granular bonding and it is not allowing the particles to drop. Whereas if you take sand or gravel, it does not have a bond but it has got only frictional resistance against sliding. So it forms a certain angle, so what are and rock and in between you got the particles of different size, different groupings.

So if we have a very very equal size particles of same in that group, it will form certain angle, if you have mixed particle of different sizes, you know it goes in between the space between the bigger particles, then you get a slightly different angle because it gets packed well and probably will not allow sliding that easily. So you can see of granular particles of different size will have different angle of sliding resistance which we call them angle of repose or natural behaviour of the material against you know sliding and failure.

Nice to add water, what will happen, slightly, not too much, because submerged vessel, the partially saturated, you may actually create a slight bonding. So that is why, the wet sand might actually stand slightly bigger angle than dry sand. You can see this is what we wanted to see, if you actually look at natural when you are excavating trench for example for your shallow foundation, I think most of the small buildings you do the trench. So you will not cut, normally we do not want to cut the bigger one because more effort is required, so you just do a vertical cut.

If the soil particles are slightly saturated, not fully saturated, you will be able to actually make a vertical cut and the particles will not slide down. But if it is a dry sand, you will never be able to make a vertical cut, it will keep on sliding. That is just the idea behind how the soil behaves depending on the moisture content, depending on the particle sizing. At the same time if we have clay for example, very soft clay. You go to some places in the East coast, I think marshy areas, you go and step on that type of area, what will happen, your legs will easily penetrate and you will just go down.

Such type of clay, if you try to pour like this, it will almost go very flat, probably will not even form an angle. So you can see it is one of the very simplest ideas, the strength of soil can be understood and this is one of the parameters, you know the past researchers have come up with a measuring device or a measuring parameter which can be used to relate how strong against failure in terms of frictional resistance. And that is why we want to use this parameter predominately for the particles of some size, we call it coarse-grained soil or cohesion less soil, basically because it does not have any cohesion, primarily friction.

So there is angle of repose is a measure of how the soil is going to behave when you leave it to disperse itself. As I mentioned here, 0 to 90 degree normally is too extreme cases because it is solid rock versus water. But typical range is somewhere between 10 degrees to 40 degrees, something like this but most of the soil, if you have very good dense sand, you may get 40 degree, loose sand you may get 10 degrees, 15 degrees, 30 degrees. So this is one of the parameter, very easy to measure, is not it because if you just do this natural exercise you can get it.

Of course in terms of actual soil we do not do this, we actually come up with several methods of characterisation and empirical methods of relationship between angle of repose to what was measured at site. So that will be empirical. Of course if you have a very good sand, you can do that in laboratory as well in the site.

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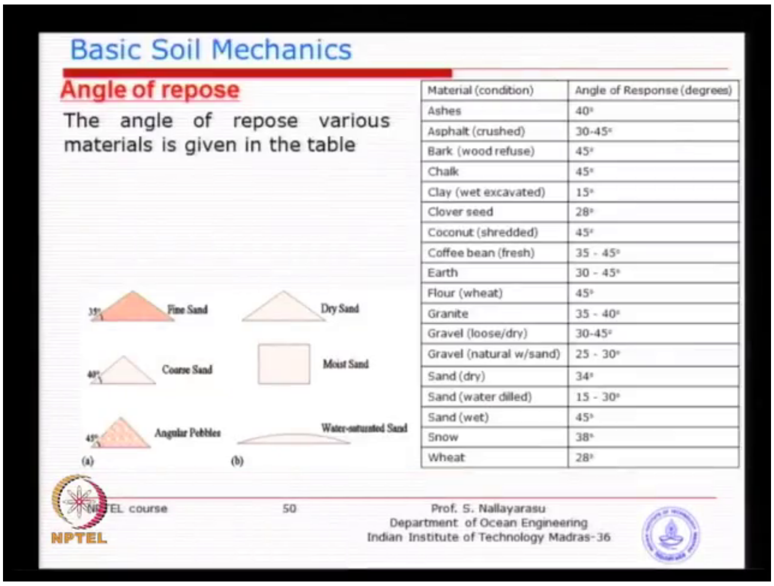

Some typical examples of you know values, you could just read it, what is of our interest is basically the sand, somewhere very good sand, 30 degrees, 34 degrees, 35 degrees is a kind of measure that you will normally get for most of the foundation sand available. Of course you could see the comparison, it is a wide variety of numbers that exist for various granular materials.

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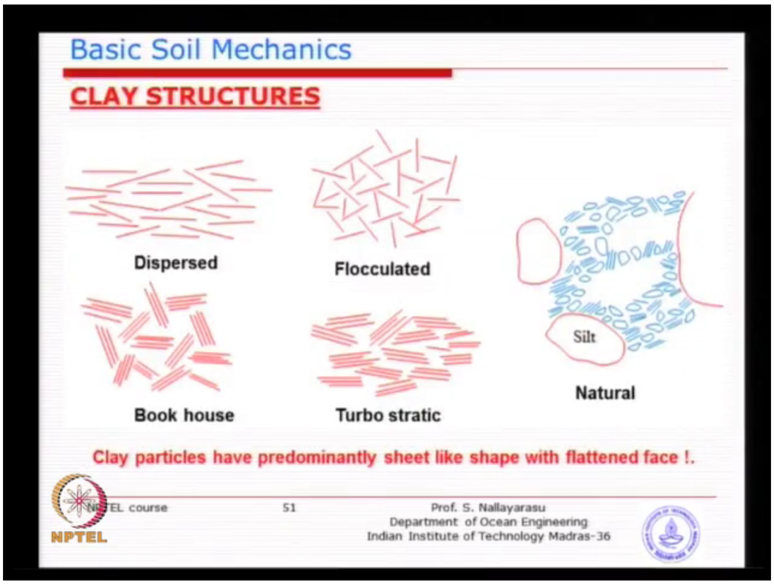

Clay particles, so what we have done is we have just categorised one parameter, one single parameter that gives us an idea that how the sand will behaves depending on you know the basically the size particle size, how well they are packed, we are going to see that one slightly later and how big is the size, whether water is present or not present. So with that we can find out what kind of angle that, from this angle now we need to relate that to strength against failure. So that will be done slightly later. Now let us jump onto the clay structures or Clay particles and their shape and their arrangement and how they are behaving when you apply loading with and without water content.

So basically that we can see just. So you see here various pictures, what you can see here the 1st one is almost flat, you know every one of them is just organised, it is not that we are picking one particle by one and then arranging like this, it is naturally formed, somehow over a period of time it has rearranged itself due to various changes happen during the process of formation and existence. So you can see here it is fully dispersed, when you try to apply loading, it may actually not change form or shape too much, whereas if you look at this book house type, basically in zigzag manner, organised in such a way that it is having larger voids between inter-particles.

So when you try to apply loading what will happen, it will get disturbed, so you will see larger deformation. So you could see the particle arraignment itself is going to give a behaviour different and that is going to be a bigger worry because for some type of clay you will look very nice but then when you actually apply loading, it will disperse laterally or get compressed in this fashion. So what we need to do is, we need to look at what is the formation types and the history where it was located, depending on that you could actually assess whether the clay structure is going to be this type of pattern or is this type of pattern because it is very difficult to get the understand the sample of the soil is loose.

And you may also have many times, not pure clay, except in some cases like coastal areas, river beds, you may get reasonable uniform clay but in the natural deposits over longer period of time, you may actually have mixed particle sizing, Clay particles as well as grain size sand particles or sometimes big boulders like what you see here you know where it is supposed to be a gravel. So you could see mixed particles which makes us little difficult to get the characterisation because when you have all 3 of them together, then which methodology will be used because we were just looking at grain sized particles which is of sand, clay particles, you may just get some property for this but if they are mix, then we need to generalise the whole method and try and figure out what can be used.

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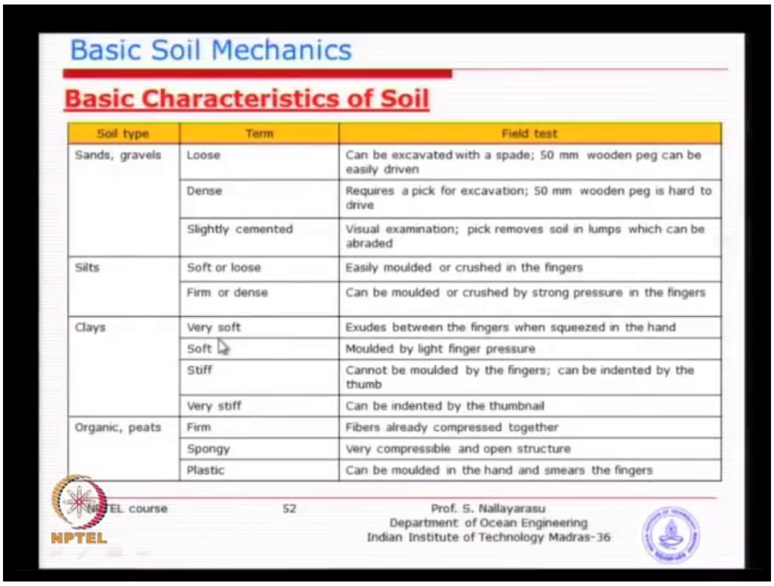

Soil type	Term	Field test
Sands, gravels	Loose	Can be excavated with a spade; 50 mm wooden peg can be easily driven
	Dense	Requires a pick for excavation; 50 mm wooden peg is hard to drive
	Slightly cemented	Visual examination; pick removes soil in lumps which can be abraded
Silts	Soft or loose	Easily moulded or crushed in the fingers
	Firm or dense	Can be moulded or crushed by strong pressure in the fingers
Clays	Very soft	Exudes between the fingers when squeezed in the hand
	Soft	Moulded by light finger pressure
	Stiff	Cannot be moulded by the fingers; can be indented by the thumb
	Very stiff	Can be indented by the thumbnail
Organic, peats	Firm	Fibers already compressed together
	Spongy	Very compressible and open structure
	Plastic	Can be moulded in the hand and smears the fingers

To understand physically to be better geotechnical engineer you just cannot just sit in the home or in the office and just try to design and understand the behaviour of the soil, you need to go very close. So what you need to really do is every time when you actually want to construct a foundation, do it borehole investigation, you need to feel it, you know you take the soil, visually inspect, you could see from the visual inspection itself, if you are an expert, can actually identify without doing any test the type of soil at least because from the colour, from the texture, from the material mixture you could say this is a sandy clay, predominantly sand or predominantly clay, you can find out from the picture or from the material colour itself.

So that is why every time when you do borehole, you have to go and feel the soil, how it can actually behave. For example you take a lump of soil, you try to compress by hand, you can see whether it is brittle or it is having large water content or the particle sizes or it just compress between your fingers, you can see whether it is plastically deforming. So all these characteristics of course you can do in the laboratory but then the 1st and information that you feel and you get it from the site itself without disturbing the soil, you know the samples could easily understand, so that you can write and classify.

Because the reason why we need to do this, many many times we use empirical formulas and foundation design. So once you classify to a particular character size, then you can later look for historical information on such type of material where others have done testing, you are not able to do testing but of course you have realised the material is this colour, this texture, this mixture and then that characteristics of what you feel at the site. Then you can later go and look at your historical data and basically try to assess the strength characteristics from there.

So that is why the 1st information report that you arrive or get from the field investigation site is very very important. That is why the field log is readable important, more than what you actually doing the laboratory because after all laboratory, you are bringing a sample, you do not know how of disturbance has been done or may not be able to get the undisturbed sample. And then you do a testing in a small-scale, the behaviour could be different than actual field behaviour. So you need to be assessing the site, some of the ideas given by past experts over a period of several decades that this soil behaves this way.

So that is what is summarised here, I think it is very easy, so if you look at one of the important idea that if it is a sandy soil, for example, gravel of coarse grind material, the best way is to try to penetrate something. So what these guys have done, penetrate a 50 MM Wooden peg, just take one and just try. So if it is solid rock, what will happen, big big boulders, it will not through, is not it. If it is a fine sized particle of sand, loose loose, so you are able to penetrate for them so that gives you an idea that what kind of, the dense material or loose material.

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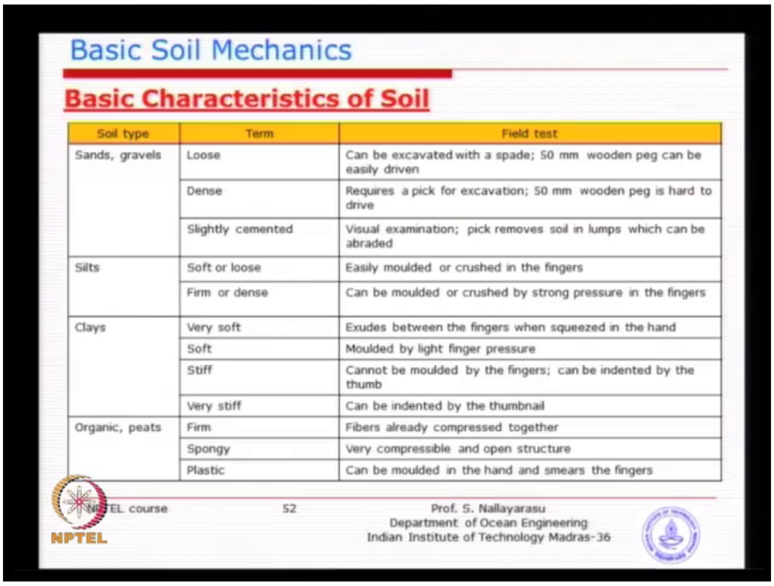

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If we have various sizes of sand, for example 1 MM, 3MM and mixed together with which has got voids less than if you have only bigger particles, when you try to penetrate something is very hard to go so these are some of the ideas that you get, very very important because that gives you a feel of the soil how they are strong. Similarly silt, loose or firm, clay, the difference between silt, clay and peat is only particle sizing under nature of particles, this is organic, this is inorganic, of course and then you have a lower size particle as silt, slightly higher size particle is clay.

So that is the major idea, otherwise the behaviour is going to be almost similar. So clay if we take moulded by light finger pressure, you know just basically you are able to just press, it gets different shape, plastic clay, basically once it is deformed it is not going to come back. So you can see here soft, stiff, very stiff, all of them the characteristics by which you can feel the soil. With different moisture content the clay and the silt is going to behave differently. You know if you have too much of water content, what will happen, you just take it, it will just get flat.

If it is less water content, it will just crumble, it will just become independent clumps, I think you can try at home or outside. You take a small clay particle or clay lumped with very small content of water, when you just try to press or compress, they will break easily. But if you have sufficient enough water, whatever you do, it will become thin but it will not break that is really. So you can see that that characteristics gives you an idea, water content makes the behaviour of the soil different at different percentage.

So that is the idea that devices that is very similar to the idea that we have got for material like steel. We just try to feel that how the material behave under tension loading and you characterise tensile test using strain versus stress. It is very similar, only thing is it is slightly complicated because this material do not have inter-particle bonding. They are individual particles, they are not connected to each other unlike the steel or other materials. So that is where we cannot apply the same principle to this material, we have to find a material which is suitable to be identifying strengths.

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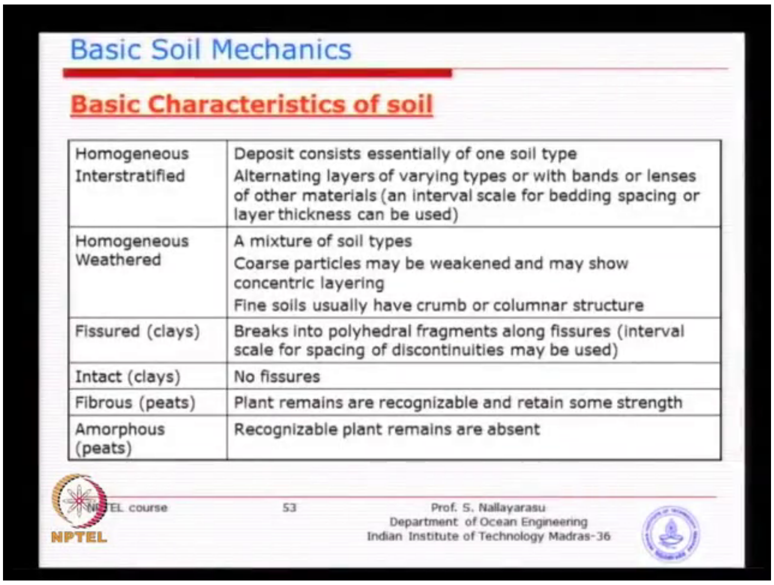

All of you understand very, it is a slightly different technique. So similarly the characteristics also can be identified with respect to whether it is homogeneous. By look itself you can see whether it is very very uniform, have no cracks, inter particle cracks or some facial cracks. You can see here homogeneous interstratified, homogeneous weathered, if you look at a rock, you can see cracks all over. So you can identify because these are the characteristics will help in assessing the basically the strength characteristics in future because sometimes, several times the sample that you bring from site, if you are unable to do the testing, you are helpless.

So identify these and then later relate this to existing literature. Similarly clays, fissured clays, intact clays, intact clays will be like a very fine moulded material, when you cut across you will see no, no voids or cracks, whereas if you see here some of the dried clay, for example in a partly dry area where water was there, if you go to water body in villages or even in outskirts of Chennai. During summer if you go enter into a lake, you will see the clays just broken and if you take just one particle and just open it up, you will be able to see this fissured clays because the water content is getting dried up.

So you can see variety of ideas to identify how the soil will behave at that type of additional properties. So these are required and these are not going to be coming out of any of the testing. When you do a laboratory testing, you will not be able to tell, that results of the test will not tell whether it is a fissured clay or intact clays. This has to be coming from the 1st report or the 1st log the people prepare at site because they should be able to identify whether this type of clay or that type of clay or the material is homogeneous.

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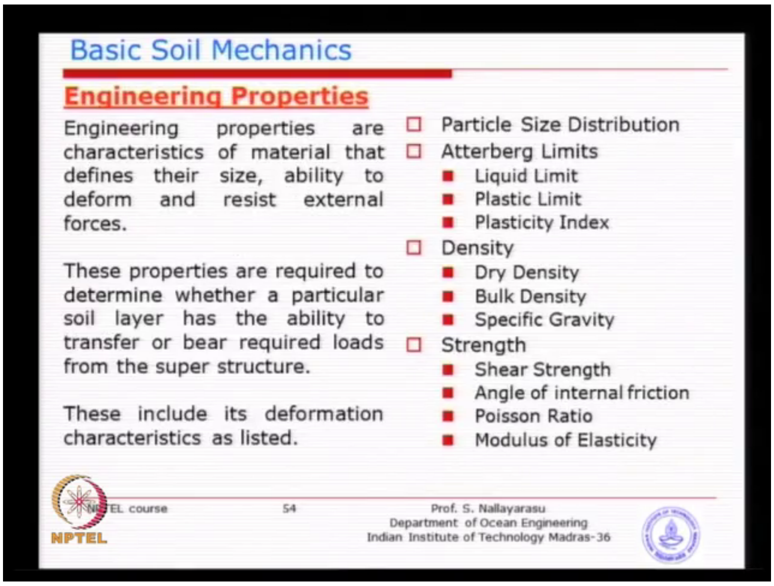

So this has to be identified and written even before you do the laboratory testing. So the idea behind, I think because of the empirical in nature, the relation between the material and the characteristics. Now what are the property that we require for us to you know basically assessed in classifying the soil. You know the 1st one, I think by this time you should have understood coarse grind versus fine grind versus the big lumps. Big lumps is your rocks which I think does not require sizing, it can be small, it can be big space.

Whereas fine-grained versus coarse-grained versus course grind, the 1st and what we require is the particle sizes, of course shape and then basically the distribution of the particles within the given soil mass. For example you take everyone of the particle as 1 MM, it is well uniform, that means. So it is one type of characteristics or you have soil particle of 1 MM, 2 MM, 3M M, 5 MM within that soil mass of certain percentages is going to be a slightly different. So then what we need is particle size and also the distribution of particle size within a given soil mass also needs to be…

So how do we do it, is very simple exercise of sieve analysis which I think is very familiar, I think some of you might have already done. So that particle size distribution will tell us how it is going to be, whether it is a it is a clay type material or it is a sign type of material or mixture of them sometimes you will have many many occasions in Marine deposits you will find you know basically the starting layer may be pure clay followed by sand followed by Sandy clay or clayey sand. You see here there are 2 distinctive trying to give names I was just trying to give clayey sand or Sandy clay.

So you need to see the percentages by which you can say whether it is a Sandy clay or clayey sand. So typically the mixtures needs to be identified which is the predominant material. For example if you have more than 50 percent of sand, then it is actually a sand but with a little bit of clay, so clayey sand. So you can just see the idea behind is as I mentioned we are just trying to classify based on this. So particle size distribution is easy to determine which I think some of you might have done already in your civil soil mechanics lab. Atterberg Limits on that thing but the water content which just I was explaining.

Even if it is sand, water content make them behaviour slightly different. So what we need to find, how much water is present in the particular soil, how do you going to behave liquid liquid, plastic limit, we will see later and then the plasticity index. Then the density, as you can see loose versus dense, you know we were seeing the sand material, if it is loosely packed natural form, when you just poke, it goes very easy but if you have shaken the sand or soil and made them to get well packed, even if it is clay. You now in fact if you look at the clay material, if it was book house form, and you try to apply loading and then deform them, next time when you come and apply the loading, it is not going to deform that much.

So if it is prehistorically have been compressed from the book form to a form where the compression is going to be very less, so the reorganised layer is going to take higher load than the younger clay. We call it younger clay or older clay, basically the clay depositions. So you could see that the density is also playing a major role, so as long as you know the density of the material, you know very well how much Load it can take because it is well packed, very dense, for example you take a rock, it is fully packed, intact rock or porous rock.

If you look at the porous rock, it can actually reorganise under certain loading. So basically it gets compressed because voids are present. So that is why the predominantly and easy to do, density of material is easy to do because you do not need a very scientific idea, what you need is the weighing. Then goes to the strength parameters, as we mentioned angle of internal friction, angle of repose which is what we were talking about for Sandy type of material, which is definitely possible to get. So for coarse-grained material, we will definitely use angle of internal friction, angle of repose, shear strength, because as you know very well the clay does not have angle of repose because when you just have spread, it will just not be able to measure because of water content.

And remember all our marine conditions, we have a fully saturated soil, that means it is always underwater, whereas in onshore, you may have dry soil, you may have partly saturate soil because after rain water percolates through the soil and over a period of time the water evaporates or settles down, so leaving behind partly saturated void space between the voids of the soil particles, some amount of water, some amount of air and remainder is… Whereas in marine conditions you are always going to have fully filled with water, wherever the voids are there, it is always filled with. So we have submerged conditions, fully saturated compared to the onshore conditions of either try or partly saturated with water.

So what we need to see is how do we establish, you take a soil, if it is fine-grained soil, when you try to separate the particles away, somehow, how they will break, the shear strengths. So basically as you know very well, if you try to pull them apart, they are not actually going to take any loading because soil particles are individual, whether it is clay or sand. So what we need to see is what it has got under shear strength. So basically the shear strength has to be established by several means, a lot of methods are available, we will see one by one later, both in terms of, you can do it in laboratory or you can do it in field itself without taking samples.

And corresponding elastic properties, basically the Poissons ratio, all of you understand what is Poissons ratio and the modulus of elasticity, very similar to steel material. So this modulus of elasticity is very important because the deformation characteristics can be determined if you know modulus of electricity. Of course when we move away slightly, you might change from modulus of elasticity to some other parameters during our course of this particular title for vertical deformation, horizontal deformation. So these are some of the parameters have been identified to be useful in terms of strength characteristic of soil and relating the strength characteristics to the foundation capacity.

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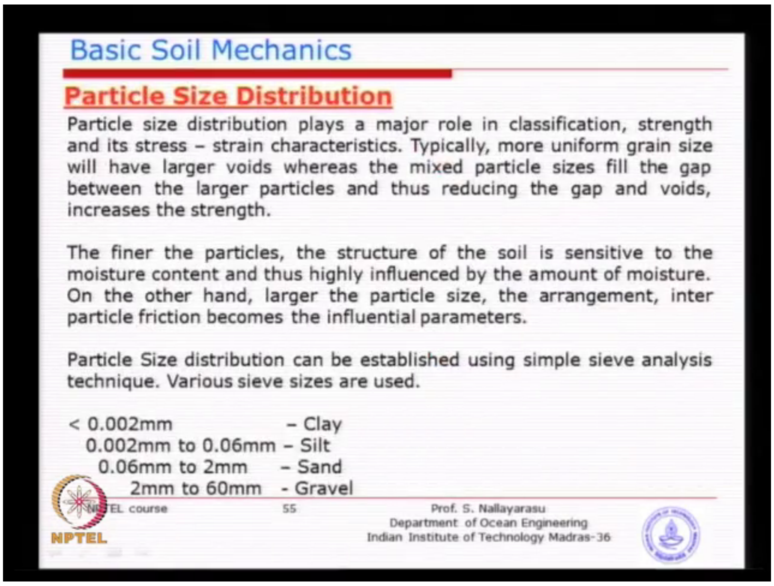

So we will see one by one, particle sizing as I mentioned earlier you see the clay type of particles, less than 0.002 and silt between 0.002 to 0.06 and then sand between 0.06 to 2 MM, typical sizes. If you look at some of the coarse, some numbers could be slightly different but does not matter, that is the kind of you know approximate numbers. So you could see the sand is between less than a millimetre to 2 millimetre, so if we just pick up a sand, you can see 2 millimetre is quite visible size, you know, you are able to identify the particles even by the feel of the fingers we can take it and take one particle separately.

Whereas when you are looking at less than 0.002, is very hard to find individual particle, you know they are so small, micron size and you know they will be , if you pick up, you will pick up few of them together. So that will give you the feel that whether it is actually clay or sand and gravel not to say is quite big boulder, normally we use gravel for many construction activities in concrete, is not it. So but that varies from anything beyond 2 MM to 60 MM or even slightly higher, does not matter, boulders, we call it or than 60 MM, we call it big boulders. Sometimes they do exist in case of some you know soil layers where you will find big boulders and then gravel and basically sand.

Whenever the boulders are existing, pile driving is potentially dangerous. You will see later on, the we can break, while the process of breaking the boulders, the pile will actually fail. So that is one of the dangers where many many places, especially the deeper foundations, like pile foundation fail terribly because of the presence of boulders which cannot be identified even if we do many many boreholes. Because boulders of say 1 metre size, you cannot identify if you do 4 boreholes or 8 boreholes because it can be anywhere, it is very difficult to find out.

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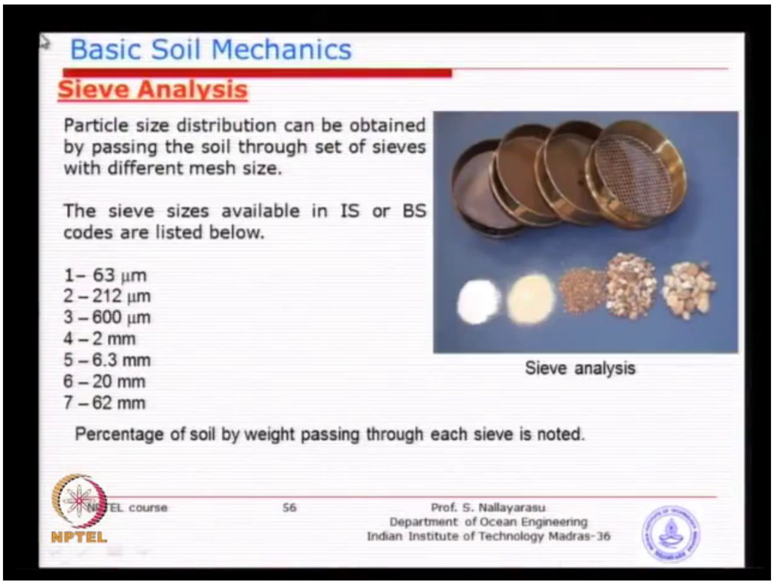

So this sieve analysis, how do we do it, we take a soil mass, I think if you have not seen, we will go to one of the days civil engineering laboratories and see this, it is very easy to do. So you need to just dry the soil and use sieve of variety of sizes, of course you can follow IS sieves or British code sieves, almost similar sized facing if I am not wrong. So you have a different mesh and just pass through each one of them and identify how many percentage of soil by weight passes through each of the sieve.

You know you take one lump of soil mass, 1 KG, 2 KG, 5 KG, as much as you want and just pass through. So if we take the finest sieve for example 63 microns, so you just use that, how much soil go through, if nothing goes through, all of them are bigger, hundred percent bigger, is not it. Every time you change the sieve size, you will be able to find out how much percentage the soil faster through that particular sieve size. So if we take 62 MM as the 1st one, put everything, everything goes on because all the soil particles are smaller than 62 MM.

I think it is very easy test which gives you an idea and then like that if you do it, you will be able to get percentages of soil particles passes through a particular sieve size is called, sometimes we denote by D size, you know D 10, D 30 and all that we will see later. So this sieve analysis is the 1st part of any soil laboratory testing, you know that will give an idea, range of particles present in the soil must.

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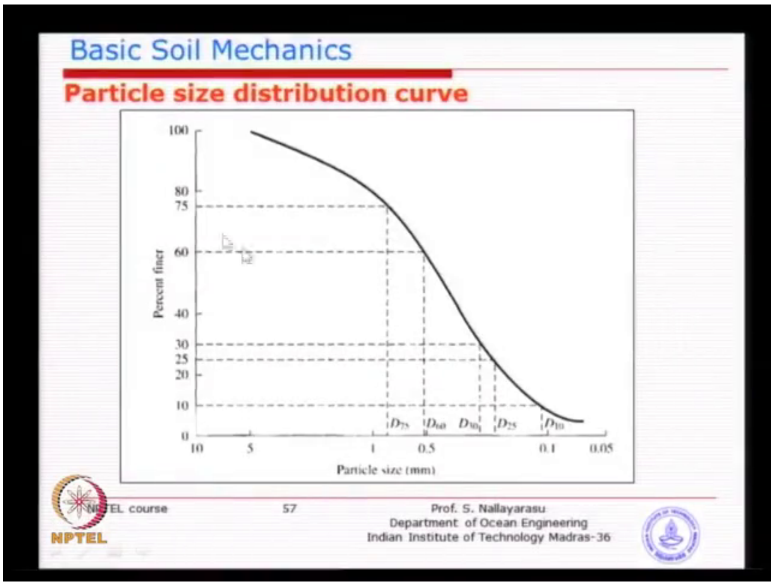

So typically if you look at the graph, particle size versus percent finer, you know you just have a line across spread over all sizes is very good because when soil is having every particle size from micron size all the way to say in this particular case 5 MM, you know. And every one of them have certain percentages, so it is just mixed. This will be a good soil because all the voids is filled with the finer particles.

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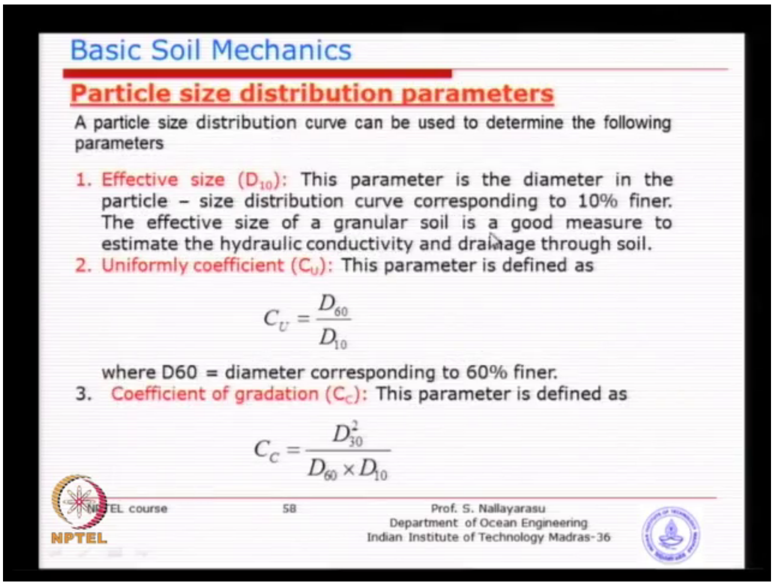

So how do we define, so effective size, of course it is not used for foundation design, several times we use it for you know the hydraulic flow through soil material, especially the dam construction, I think you might have studied, if you have gone through dam engineering. So this effective size, we call it D 10 is the parameter in the diameter, basically the size, the corresponding to 10 percent finer, that means the material size that has a diameter less than this D 10. So basically D 10 is the size, 10 percent is passing through, remainder is not passing through.

So basically 10 percent of the material is finer than this size. So that is D 10 can give you an idea of how the flow or drainage is possible. Too much of fine particles, drainage is not feasible, is not it. If it is having too small size, it is not good. Similarly the uniformity coefficient is devised to identify whether the number is too big or too small. If the range is larger, for example I have got smaller size and as well the larger size, then it is, to the larger uniformity cohesion.

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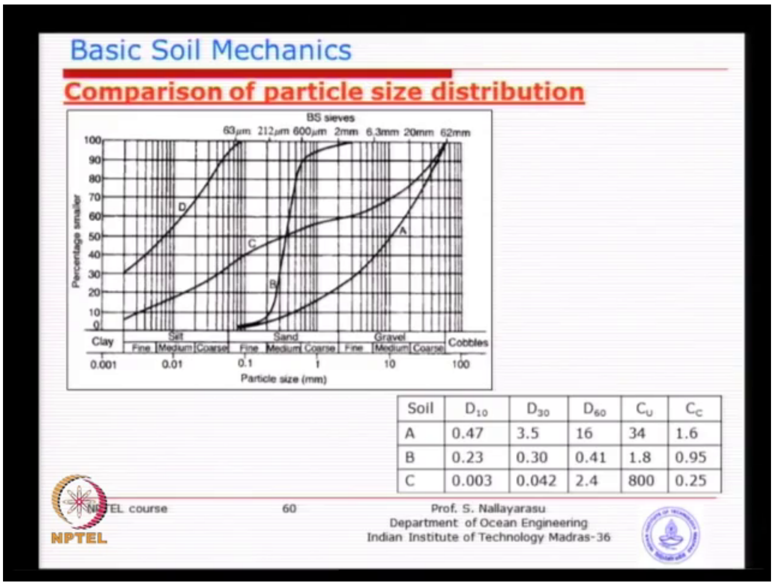

Soil	D_{10}	D_{30}	D_{60}	C_U	C_C
A	0.47	3.5	16	34	1.6
B	0.23	0.30	0.41	1.8	0.95
C	0.003	0.042	2.4	800	0.25

So you can see from this picture, is basically you see here the size for the C type of soil is having fine soil from smaller particle all the way up to 62 MM, cut across all the sizes. So you can see for C type of soil, the uniformity coefficient is very large because it is a ratio between D 60 to D 10. So D 60 is one extreme and D 10 is the other extreme. So when you do that you get a bigger number. So basically that is the idea behind, people come up with this type of you know basically some notation to identify these numbers will give you feel whether the soil is having larger spread, smaller spread or no spread.

For example you take only one particular size, all of them are 2 MM, very good sand like grain sand, then you will have one vertical line, is not it, all 100 percent only one size. So such type of characters sticks is very easy to handle. Similarly coefficient of gradation is another characteristic using D 60, D 30 and D 10, which one you get from your sieve analysis.

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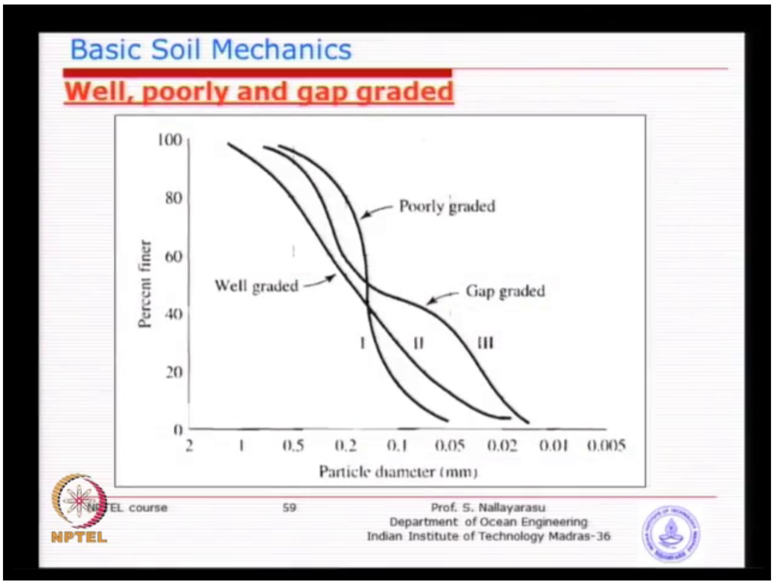

Some pictures to give you you know the Grading, we call it Grading is, for example if you take this one, lower one is well graded having presence of all type of particles from 02 that means clay all the way up to several, each one of them having certain percentages. Whereas if you look at the poorly graded you know it has got little, then it climbs up vertically, that means one particular size is having larger percentage, edited and then some smaller percentages of maybe fine particle, some smaller percentages of the bigger particle but predominantly one particle size.

Gap graded, you see a flat line, some portions do not have, or some particle size is missing. For example you may have 02 and then it between there is no particle of that size, then suddenly you have different particle size, which we call it gap Graded, that means there is a missing particles in that whole lump of soil. So you have well graded, poorly graded or gap graded. This gives you an idea why, why do we need to this is basically to find out whether the soil mass has got more void space, less void space, why.

Because the more the void space, when you apply loading later, what is going to happen, the particles are going to get reorganised because of rearrangement and gets deformation, that means larger displacement, not good for us. So that is why if you are able to assess the characteristics of presence of type of particle sizing and voids and in fact added together, if you can find out whether it is organic or inorganic because that material itself will behave differently and you can find out whether the soil is good soil or bad soil. Because many times you want to make a decision whether we should food what type of foundation here.

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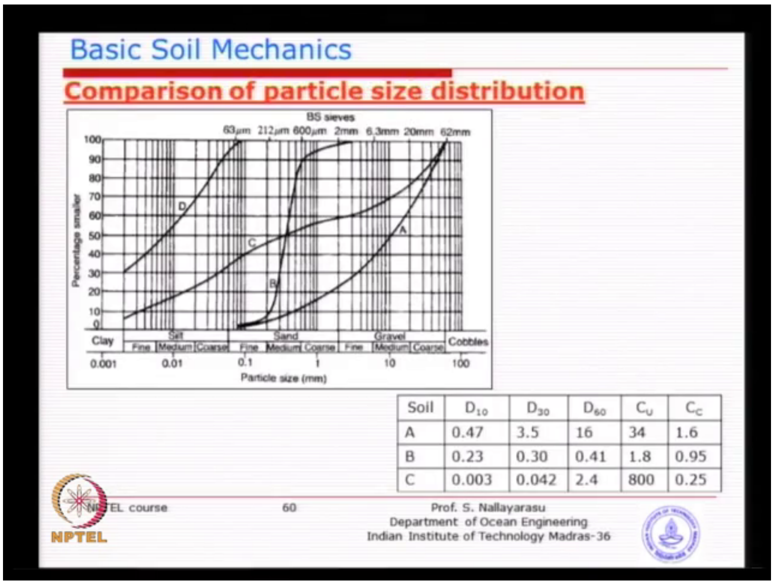

So that is why this Grading gives you an idea that the soil is going to behave to know how much deformation is going to take place. The next one is a similar graph, only just slightly just to get a feel for numbers, you know what kind of ranges of values we are looking at, especially the CU and CC. So CU larger is good, somewhere here, similarly CC is less is basically for the soils having larger spread. If you look at the soil B, soil B is just nearly 1 because it is just vertical line of a particular soil particle presence. So all these properties you should know how to calculate, given this, in fact if you will study soil mechanics, this will be one of the areas where you will be given the particle sizes and you will have to calculate these parameters and classify the soil yourself.

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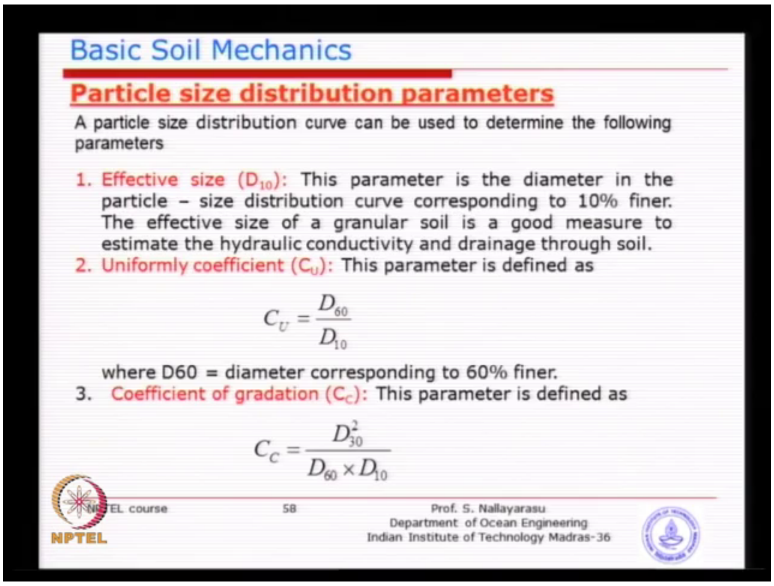

Whereas I think this is not a basic soil mechanics course, so we will not go into that. But you should know, if you are given a soil particle sizing percentages, you should be able to classify soil as well graded or gap graded or poorly graded which gives you an idea that you can apply this principle because later when you are going to look at empirical charts or look at some relationships, you will be looking at well graded well graded sand. Then you go to the table you can pick up the parameters that you need to choose for design purposes. So that is why we need to know this classification. The same information written in a tabular form, so it is for your information.