Soil Mechanics/Geotechnical Engineering I

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Lecture - 05
Soil Classification (Contd.)

So, now in the previous slide, I have previous 2-3 lectures, I have discussed various classification possibilities that is actually for if it is a coarse dense soil I; we can do a sieve analysis and hydrogen analysis combining them I can classify the soil whether it is sand or whether fine sand coarse sand gravel sand all those thing.

Similarly if it is a fine grained sand, I can do the consistency limit test and consistency limit test and then finally, put it in a plasticity chart and how to use this plasticity chart for classifying this classifying the soil completed, I just explained in the last lecture and now I know all classification. Now suppose as a geotechnical engineer and suppose some someone from the site one bag of soil sand to me and I have to classify the soil and how to do that. So, that I have to I have step by step I can. So, when the combined there how to do that I will discuss.

So, this classification system what system actually classify one is actually grain size plasticity chart something we do and in addition to that actual classification means some different countries will have different standard Indian also standard is there. So, based on Indian standard; what is the classification procedure let us see that the Indian standard classification system, the grain size analysis can be done both sieve and hydrometer and plasticity chart can be used for this purpose and finally, doing these all those things combining them, we can conclude with a symbol actually and that symbol a 2 letter system is there for a classification.

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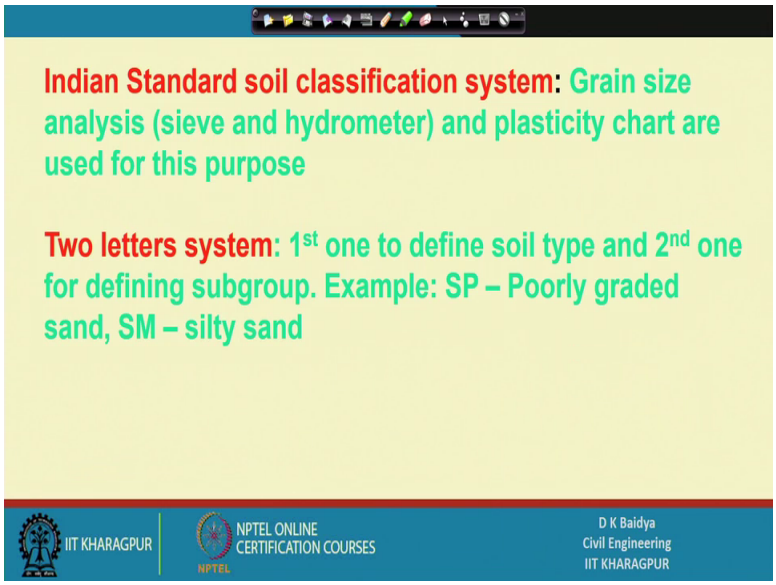

First one define the soil type and second letter defining subgroup an example is like this sp an one soil is classified finally, as sp what it means it means poorly graded sand.

So, first letter is giving the soil type. So, that is why I am using the sand is the soil type and second letter is a subgroup what type of sand it is poorly graded sand. So, this is a subgroup poorly graded is a subgroup. So, SP poorly graded sand that the first one what it is a sand; what type of sand it is a poorly graded. So, first letter will be define the soil type and second letter giving you the subgroup similarly SM; it is a silty sand what it is it is a sand and what type of sand it is silty sand; that means, what it is sand mixed with some amount of silt. So, that is the way actually finally, you have to classify and there are some steps that I will discuss one by one.

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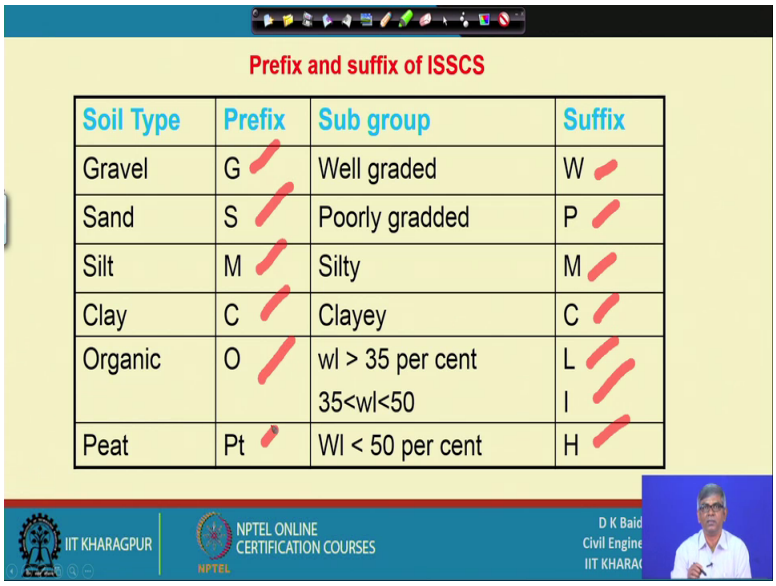

So, this is these are the symbols or letters we use in the 2 letter system prefix and suffix of Indian standard soil classification system ISSCS. So, soil type define the soil type by this letter gravel is defined by G, sand is defined by S, silt is defined by M and clay is designated by C and you can see silt and sand; both are of first letter is we are using mostly first letter sand and silt both are having first letter is S.

So, sand actually it is universally all over the globe actually sand is used as sand S and silt used for M and clay is C and organic soil generally o and peat that is actually Pt though these are the basically we are using first letter gravel sand clay and organic all are first letter only for clay we are using sorry only for silt we are using M and for Pt is a one letter where you are using 2 letter keep P capital and t small peat. So, and small abbreviated and subgroup actually letters actually well graded generally w we use well from their first letter only we are t taking poorly graded P we are taking and silty the again silt is M here also was to represent silty M we are use clay; clay is used C.

So, here to represent clay is sub group the C and then again organic can have low plasticity and intermediate plasticity. So, low plasticity is one when water contain or water that is plastic limit and liquid limit is greater than 35, then this is low plastic and that is designated as L and when it is intermediate; that means, liquid limit between 35 and 50, then that is used by I and wI; that means, it is greater than 50 percent at peat organic and what is the difference between organic and peat; peat is a fully decomposed

that is what that organic clay then is it will be highly plastic. So, that is liquid limit is greater than 50 and is used by letter H.

So, w means here w means well graded P means poorly graded M means silty clay means clayey L means low plasticity I means intermediate plasticity, H means high plastic similarly if soil type G means gravel, S means sand, M means silt, C means clay, O means organic, Pt means peat; like that these 2 letters in different combination to be used to name the soil steps.

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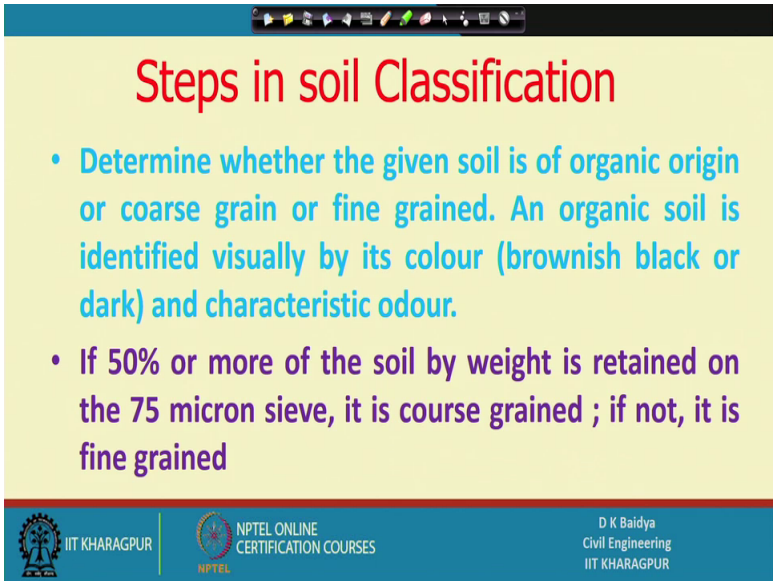

Steps in soil classification you can see determine. So, first of all we have to give one bag of soil comes as I have mentioned this few minutes back that if the one bag of soil then whether we will start doing sieve analysis or do something. So, that there are some steps. So, the steps of that or whether first of all you have to examine what type of soil if it is whether it is organic or not that to it determined first.

Determine whether the given soil is of organic origin or coarse grained or fine grained these few things first of all initial inspection we can differentiate and organic soil will be identified principally by its color; generally, it will be dark color and down brownish black or dark and it is characteristics odor, there will be smell also and organic color clay there will be a smell. So, first of all you have to initially whether you have to find out this is a organic clay or coarse grained soil or it is a fine grained soil if it is a organic clay treatment is separate, if it is a coarse grained soil sieve analysis if it is a fine grained soil

then it is plasticity analysis these three things you have to do next is; next step is a 50 percent or more of the soil by weight is retained on the 75 micron sieve, it is coarse grained; that means, more than say 50 percent it retained on 75 micron then it is a coarse grained if not then it is fine grained.

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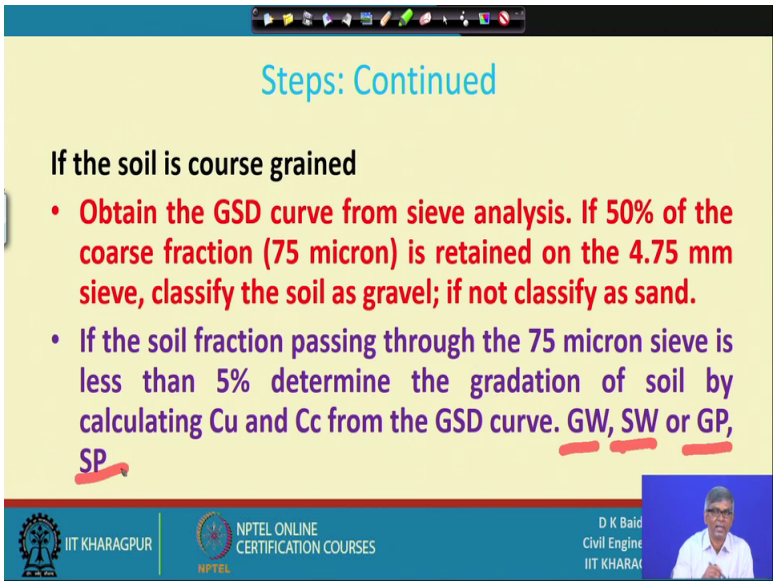

So, that is the thing to be considered and next step is if the soil is coarse grained suppose if it is more than 50 percent retained by 75 micron, then you have decide it is a coarse grained then coarse grained soil if it is coarse grained immediately what is your next action next action will be after in the GSD means grain size distribution curve from sieve analysis.

If 50 percent of the coarse fraction again is written on the 4.75 millimeter sieve classify the soil as gravel; that means, 75 percent retained soil 75; 50 more than 50 than 50 percent that is a test we have done with based on that you have decided it is a coarse grained. Now that coarse grained soil I am trying to do GSD and we find that again more than 50 percent in retained on 4.75 millimeter then the soil itself will be classified as a gravel and if not if it is more than 50 percent passed through that then this to be classified as silt.

And if the soil fraction passing through the 75 micron sieve is less than 5 percent determine the gradation of the soil by calculating Cu Cc from the GSD curve so; that means, first step what we have done we have we are checking whether passing through

75 micron if the passing through 75 micron is less than 5 percent, then what you have to do it is a sand type of soil the Cu, Cc, etcetera will be calculated based on that we can classify the soil as like well graded gravel well graded sand poorly graded gravel poorly graded sand like that. So, classification can be done based on that, if it is less than 5 percent.

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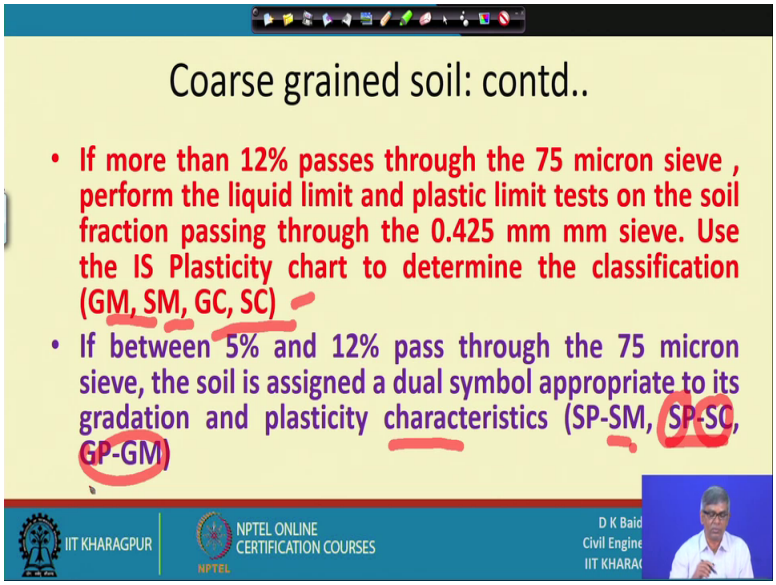

And if the more than 5 by 12 percent sorry more than 12 percent passes through the 75 micron that 75 micron process material, if it is more than 12 percent then perform liquid limit test those passing material or soil and liquid limit plastic limit test on the soil fraction passing through 25 micron sieve and use the plasticity chart to determine the classification and finally, that this type of classification can be done combination of a gravel and present of the presence of gravel in addition to whether it is clay or silt that from the plasticity chart can be there and that combining them we can classify the soil like GM SM; that means, silty gravel silty sand or clayey gravel or clayey sand like that we can classify.

Now, if the between 5 and 12 percent fine particles less than 5 percent only grain size distribution G that Cu Cc; all calculation between more than 5 percent you are doing plasticity and doing this type of analysis and if between 5 and 12 percent then again the soil is assigned at dual simple appropriate to its gradation and plasticity characteristics again that passing through 75 micron that has to be grain size distribution based on that

whether this is poorly graded sand or well graded sand that is there. In addition to that plastic material also, whether it is silty or sandy or all those things this dual symbol; that means, 4 letters will be there; one is sand, another is again clayey sand, this type of dual symbol to be used.

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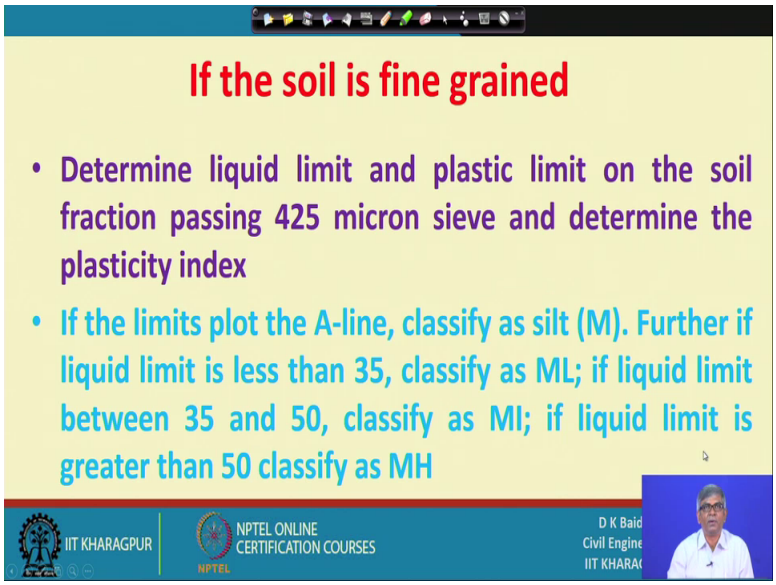

If the soil is fine grained then determine liquid limit plastic limit on the soil fraction 425 micron sieve and determine the plasticity index and now if a fine grained actually; that means, more than 50 percent past to 75 micron, then it will be treated as fine grained and then you have to do pass through 425 micron take that that sand soil and do the plasticity test and after doing the plasticity test do plastic limit and liquid limit and plastic limit and refer the plasticity chart where there is a line ;what one side is the plasticity index one side is liquid limit and then based on plasticity index and the liquid limit plot particular soil you have tested you will get a data set the pi and ll pi and ll you can plot in a plasticity chart.

And we can find out the presence of point with respect to a line whether it is above the line or below a line if it is above a line then the soil is clay or plastic and if it is below a line then soil is silt or non plastic moreover plastic silt can be plastic also further if liquid limit is less than 35 classify as a ML and liquid limits say. So, if the limit plot the a line plot a line if the aim below line actually some line or point is missing letter is void is

missing if the liquid limit is less than 35 classify it as ML, if limit is between 35 and 50 mi and liquid limit is greater than 50 classify MI.

So, if that limits plot below the A-line here actually something missing. So, below the a line if it is coming below the A-line which I have shown before below a line all are silt and above a line all are clay and if again less than what liquid limit less than 35 percent is something that is actually silt of low plasticity that is ML if the liquid limit between 35 and 50; that means, silt of intermediate plasticity that is MI and if it is greater than 50; that means, MH; that means, silt of high plasticity.

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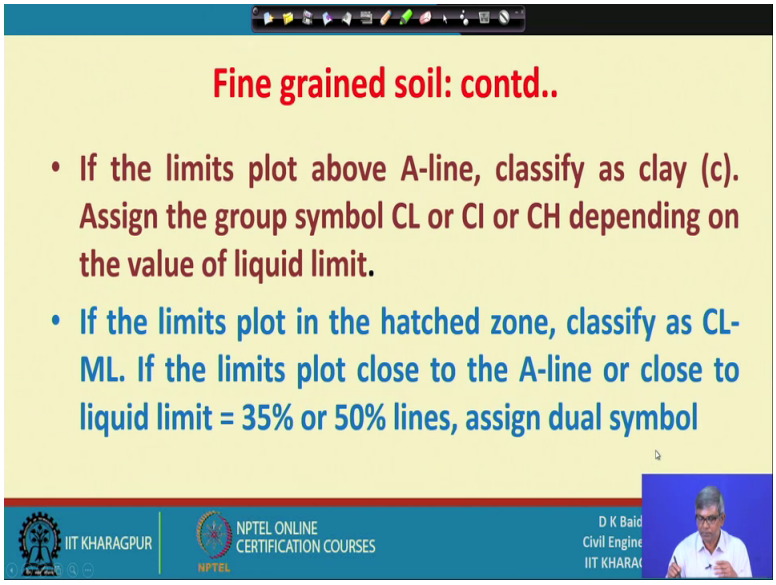

And if the limits plot above a line that is the thing next step that a line if the points comes above a line then classify as clay and assign the group symbols CL, CI or CH depending on the value of liquid limit; that means, if it is less than 35 liquid limit than CL, if it is between 35 and 50 that is CI and if it is greater than 50 that is CH and if the limits plots in the H zone classify it as CL and ML if the limits plot close to the a line or close to the liquid limit 35 percent or 50 percent line assign dual symbol that is if it is very close this are the decision and can take as geotechnical engineer.

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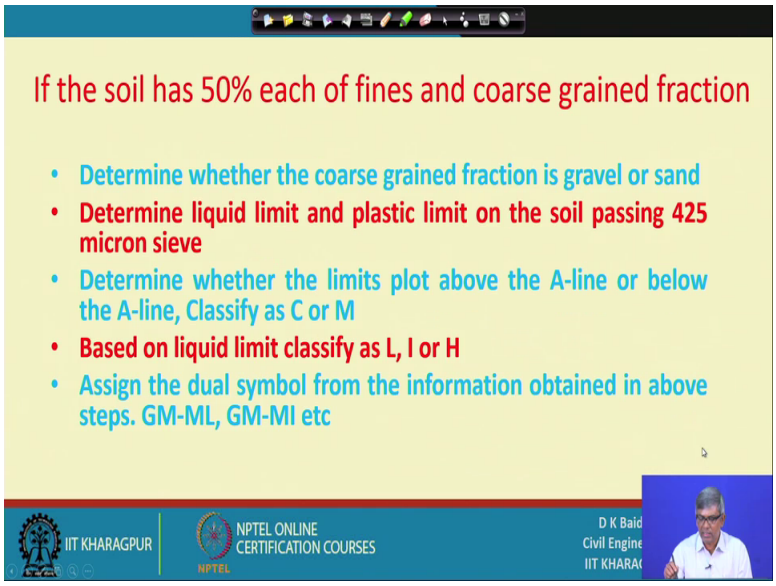

So, this is about the steps in classification if the soil has 50 percent each of fines and coarse grained fraction both are 50; 50 equal in that what to do; determine whether the coarse grained fraction is gravel or sand determine liquid limit and plastic limit or the soil passing 425 micron sieve, then determine whether the limits plot above the a line or below a line classify as C or M based on liquid limit classify as whether it is L, I or H assign the dual symbol from the information obtained in above steps GM-ML, GM-MI etcetera, etcetera, so; that means, if 50 50 you have to do both and then finally, you have to take this type of classification.

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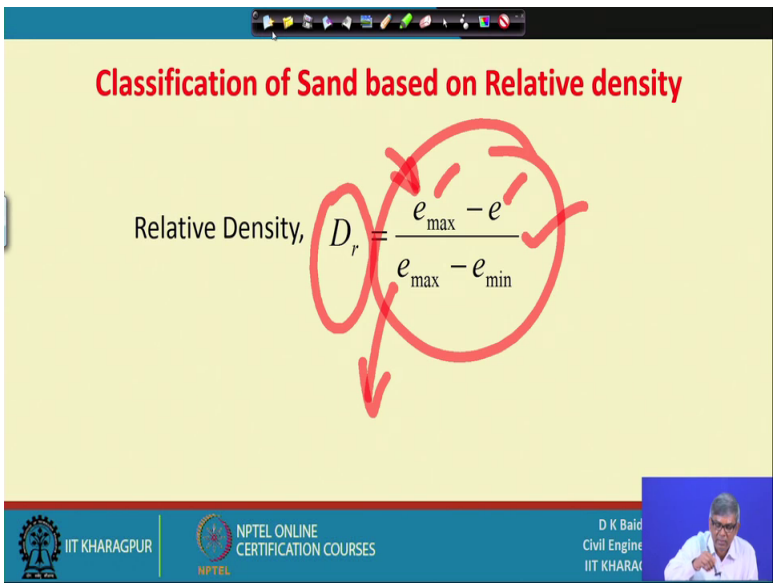

and next is when there is a granular soil, then sometime granular soil can be classified another way that is by relative density and what is the relative density the expression for relative density is given here this expression is given of relative density and relative density universally it is used a notation Dr and that expression Dr related equal to e max minus e divided by e max minus e minimum.

What are those actually e max is what the soil when at a particular soil suppose collected from a soil from a site what could be its maximum void ratio e max e is the void ratio this is also uniformly universally used everywhere void ratio e; e max means the soil which is collected what is the maximum possible void ratio of the soil and when actually we can expect the maximum void ratio in the soil when the soil will be in the loosest state; that means, when you collect sample from a site we can pour in a container in a loosest possible state and from there, we can find out density

And from density, we can find out the void ratio that will give you the e max. Similarly e minimum means what the minimum void ratio of the soil how we can get the same soil when it will be in the densest state if you keep in a densest state, then the soil will have the minimum void ratio and how to get this minimum void ratio; that means, if you whatever soil you collect from the site that soil can be pour in a another container again in a densest condition, there are some procedure, I guess code has given how to do that to achieve loosest state and to achieve densest state and from there you can find out e max and e minimum. In fact, we can find out density gamma max and gamma minimum from there we can find out that e max and e minimum and also and what is this e; e is actually is the field void ratio.

So, if you know the field void ratio and if you know the soil type then we can determine the e max and e minimum and putting in this expression I can get a number which is in percent finally, can be expressed and it will be vary between anything between 0 and 100, but 0 cannot be achieved 0 means nothing is the all voids and 100 means there is no voids and both are impossible 0 voids also difficult to achieve and without any voids also is impossible to achieve. So, this is a relative density and this relative based on these relative density the soil granular soil also can be classified another way that is given here.

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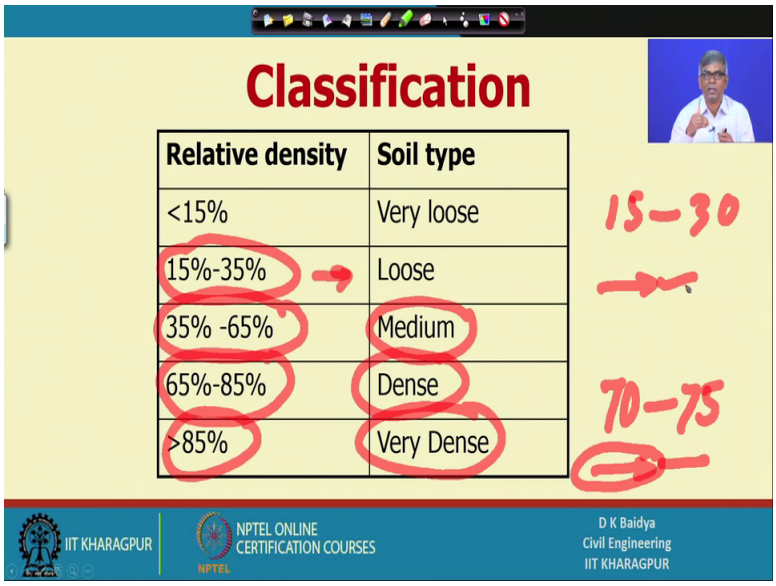

This is the one the state relative density less than 15 then soil will be classified as very loose; that means, if the soil if the at a particular site sand is there then what type of sand it is a very loose sand if it is at less than 15 percent.

Similarly, if the relative density; that means, you collect the sample find out the minimum void ratio find out the maximum void ratio find out the void ratio put it in the expression and finally, find out this finally, find out for these value of relative density Dr it falls between 15 to 35 then the soil will be treated as loose; that means, loose sand. Similarly if that value comes 35 to 65, the soil will be classified as medium dense sand or medium loose sand. Similarly, if the value falls between or the percent between 65 to 85, the soil will be classified as dense sand and with this.

And if it is better than 85, then it is called very dense and in fact, very dense beyond very dense actually that achieving beyond very dense state is very very difficult and another thing is the amount of effort required from improving the relative density suppose from 15 to suppose 30, the amount of the you are increasing the relative density; suppose 15 percent, but effort required to change this much of relative density the amount of effort required and if you suppose another relative density seventy and changing to 75; one is suppose 15 to 30, the effort required here and effort required; here the effort required here will be much bigger than this.

So, the; that means, loose side to improving the soil is comparatively less effort is required, but when is it a denser side the improving by one or 2 percent effort required is extensively very high. So, this is the one sort of state; that means, if you find in a particular site the soil is in this state then we can we can actually find out your state of the soil; that means, whether it is loose or very loose or dense or very dense.

So, like that with this by a large actually I am completing the my origin and classification module; that means, how the soil and how we understand by different people and then before soil we find what are the state and how that state to soil is formed for transform and then after getting the soil how the we can classify the soil in based on the different types of soil like whether it is a granular or it is a cohesive it is granular something if it is cohesive something else and then based on this classification actually once you know the classification though as I have told at the beginning that we will understand many things qualitatively.

For example I am telling once again that if it is a soil; a cohesive soil and then the soil your weight will be highly compressible strength will be compressible led less and a permeability will be compressively comparatively less and if you find suppose granular soil strength will be comparatively high compress it will be settlement will be comparatively less and it will be highly permeable again some classification we get suppose some soil classified as a CI or CL, etcetera based on that also which soil be settle more or less that also we can get it.

So, by classification of the soil to understand the soil by understanding the soil we can guess some quality or characteristics of the soil, but ultimately when we design something we need some quantity what is the strength value a number is required similarly what is the permeability a number is required how much it will settle that is number is required. So, to find out those number. Now we will do different analysis different mechanics we will use and subsequently one by one we will treat those sections.

With this today I will close this classification.

Thank you.