Foundation Engineering
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Lecture - 08
Types of Samples

So, in the 7th lecture; So, I have discuss about the cone penetration test, then pressure meter test, then the dilatometer test when I have solved one problem on the dilatometer test then how to use the dilatometer test data to determine the soil properties.

Now, here I will give solve one or two problems to show that how we can use the other test data to determine the soil properties. So, and then I will discuss about the type of sampler that we generally use to collect the soil sample from the field; so, and so, first if I.

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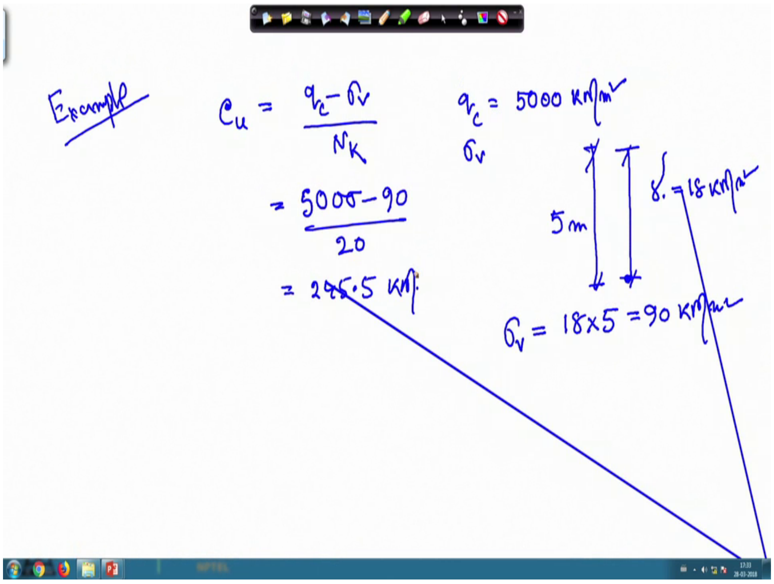

So, use a typical example to solve that our cone penetration test data that. So, suppose for a clay soil, undrained cohesion of the soil can be determined is by qc minus sigma v divided by u N k and N k value.

So, if a particular test that our qc value is given 5000 kilonewton per meter square and sigma v we are you have to calculate suppose the unit weight of the soil is 18 kilonewton per meter square and we have a depth of say 5 meter. So, here this is remember that this is the total stress. So, you have to calculate 18 into 5. So, that is 90 kilo newton per meter square.

So, we can write this is 55000 minus 90 and N k value is taken as 20. So, if I take these things; so, the undrained cohesion of the soil 45.5 kilonewton.

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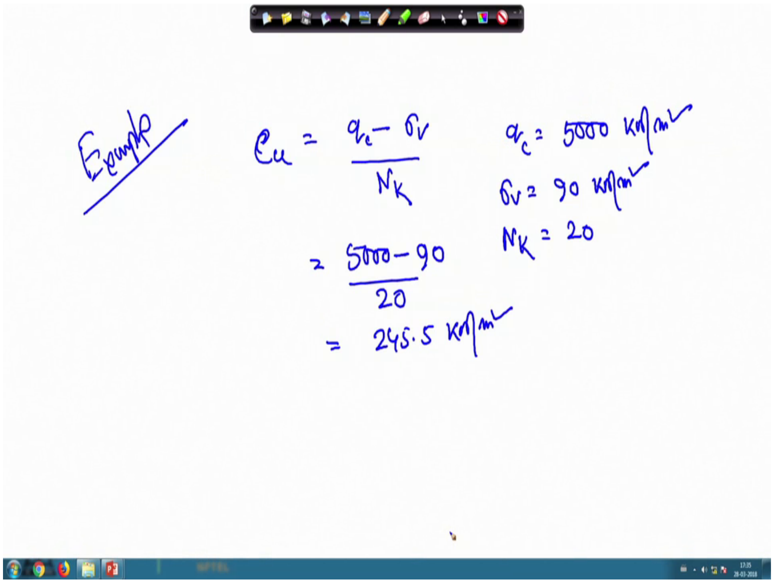

So, again q c is q c minus sigma v N k. So, q c value is given 5000 kilonewton meter square, sigma v we have calculated 90 kilonewton meter square N k is taken 20. So, if I put these values, then it will become to 45.5 kilonewton meter square. So, this is the undrained cohesion of the soil.

So, automatically if qc value increases; that means, soil has less strength. So, automatically C u value will also decrease. So, a q c value if q c value decreases for the less strength. So, automatically C u value will also decrease and then if I this is the one example for the cone penetration test or a SEPT test now another example I can give you for the pressure meter test.

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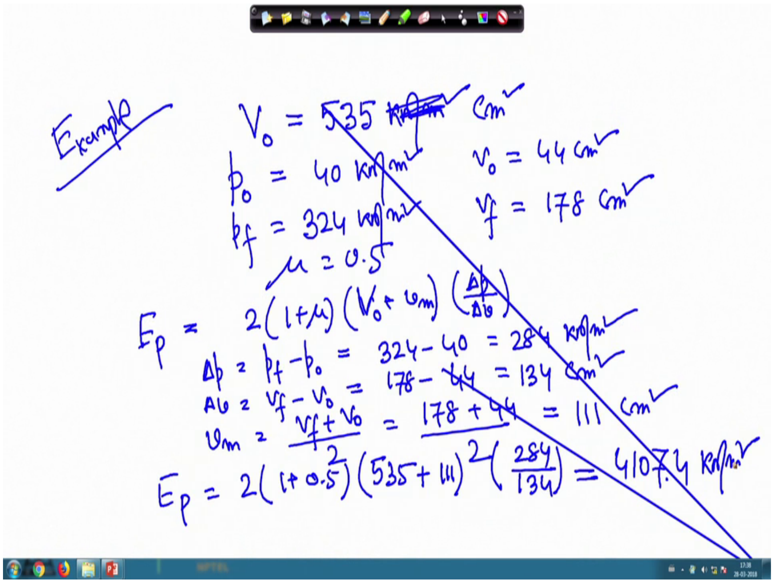

So, if I give you another example that is for the pressure meter test. So, values are given that the capital V 0 is as I mentioned 535 kilonewton per meter sorry this is centimeter square and p 0 that is the stress is 40 kilonewton meter square p 0 is the pressure, corresponding v 0 is 44 centimeter square then p f is measured as 324 kilonewton per meter squared and vf is equal to 178 centimeter square and mu is taken as 0.5.

So, we have to calculate the pressure meter modulus that is E p is 1 plus mu v 0 capital V 0 plus small vm into del p divided by del v. So, del p is the pf minus p 0. So, that is 324 minus 40. So, that is 284 kilonewton per meter square, del v is the vf minus v 0 and this vf is 178 minus 44. So, that is equal to 134 centimeter square and this capital a small vm is equal to vf plus v 0 divided by 2. So, that is equal to 178 plus 44 divided by 2 that is equal to 111 centimeter square.

So, finally, E p value is equal to 2 1 plus 0.5 into capital V is 535 then vm is 111 then del p is 284 divided by 134 and so, that value will be equal to 4107.4 that is kilonewton per meter square because this centimeter will cancel and this is the kilonewton per meter square. So, these value will be 4107.4 kilonewton per meter square.

So, this way we can calculate the E p and then if you have the other data is also we can calculate the other soil properties.

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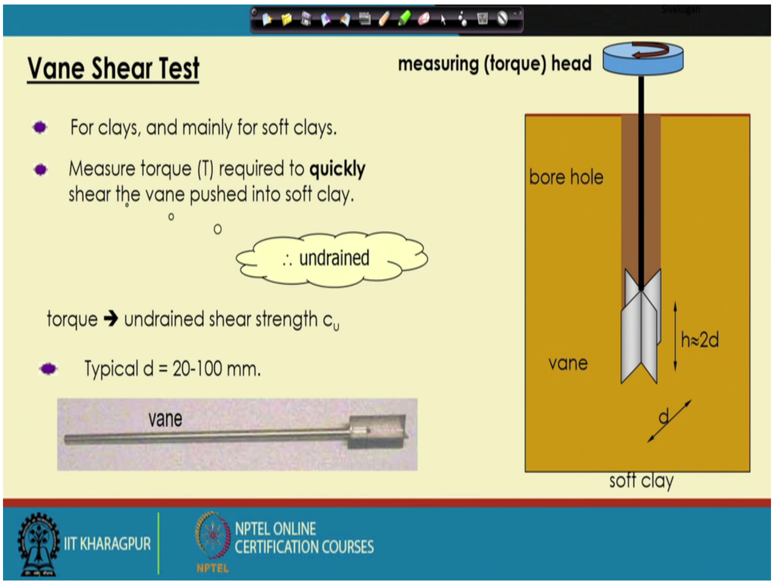

So, next test that will discuss about the vane shear test; so, this is the last one of the all in situ test that I have discussed. So, this is suitable for the clays mainly for the soft clays and here we insert this vane into the soil up to the required depth. So, your bore hole is required and then we apply the torque and this torque is measure and the based on that we calculate the undrained shear strength of the soil C u.

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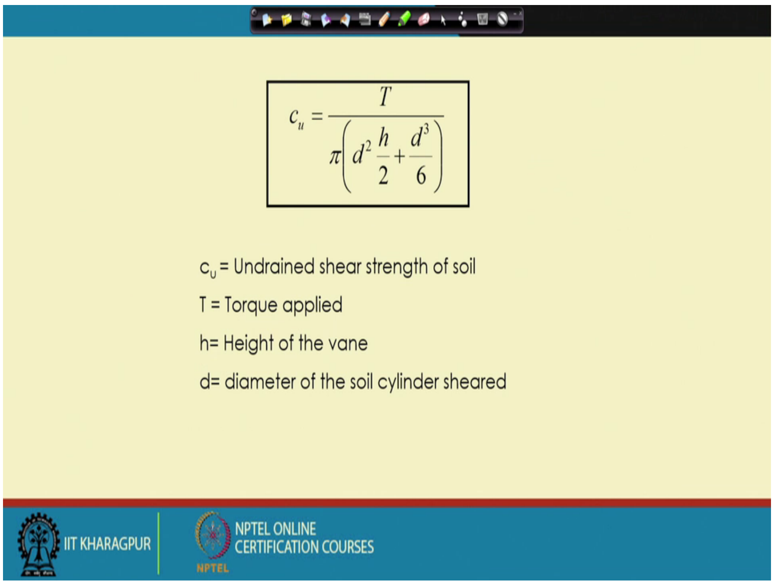

So, this is the T is the torque applied, C u is the undrained shear strength of the soil or undrained cohesion of the soil and d is the diameter of the soil cylinder sheared and h is the height of the vane.

So, if you look at these things. So, this is the diameter of the of the vane, and this is the height of the vane. So, I am. So, if I generally h is approximately two times of the diameter. So, if I know the d if I know the h, and if I know the measure torque that we are applying into the soil. So, we can get undrained cohesion of the soil by using this expression.

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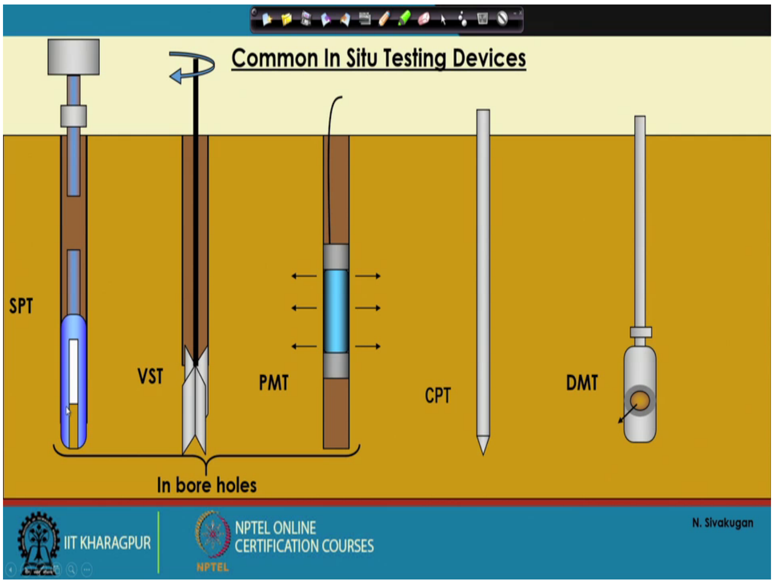

Now, if I now summarize all the test that are discuss. So, I discussed the SPT, I have discuss the vane shear stress, I have discuss the pmt pressure meter test and this is the CPT or the cone penetration test and DMT dilatometer test.

So, here we can see for the first three SPT and then the vane shear test and then the pressure meter test, these are conducted into the bore holes. And whether CPT and DMT these are these are pushed into the soil and this gear the bore hole is not required.

So, here so, any cone penetration test and DMT bore holes are not required, but other three is bore holes are required here we are apply a torque, here we apply the hammer blow, here the this we apply the pressure and volumetric expansion is measured, here we push it or apply the blows and here again this is the expansion is done for a thin membrane which is pushed into the soil with this setup.

So, these are the common in situ testing device, that we use in the field to determine the soil properties.

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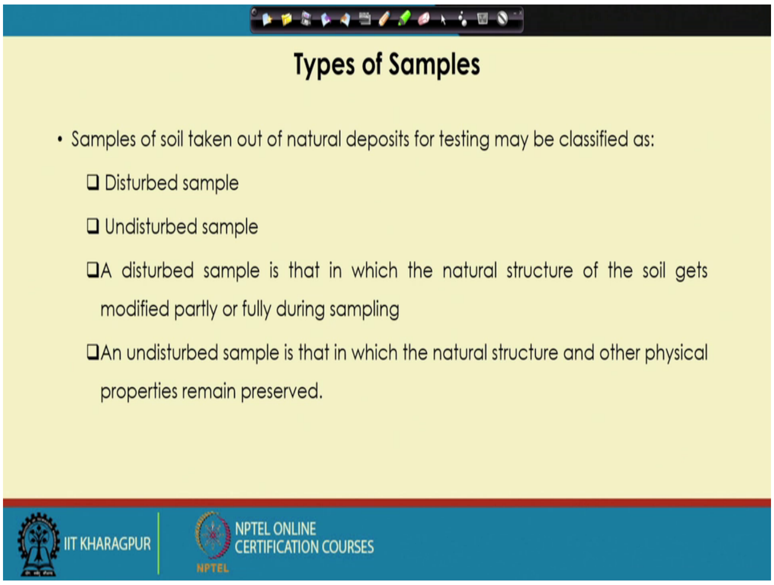

So, next one we will discuss about the type of sampler. Because as I discuss about in the boring part also that all the process that we are using we are using the auger boring, we are using shell and auger to construct the bore hole ok. And it is also mentioned that whenever the sample is required, we collect the soil sample from different depth depending upon our requirement.

So, there is a two ways we can collect the soil sample one by boring, whether either it is a auger boring or the wash boring or the shell and auger or the other boring techniques. So, we can collect the soil sample in that form also during the boring. So, that we will give you the highly disturbed soil sample and other ways if required, we can collect soil sample using the sampler tube.

So, these are the there are different types of sampler tube by which we can collect the soil sample. So, today I will discuss about these sampler tubes and what about the or a disturbed and undisturbed soil sample. So that means, there are two types of soil samples either the disturbed soil sample or the undisturbed soil sample. So, now, the disturbed soil sample is that, in which the natural structure of soil gets modified partly or fully during the sampling.

And in the undisturbed sample is that in which, natural structure and other physical properties remain preserved. So, but as I mentioned when in during the disturbed soil sample collection, that we also use these disturbed soil sample to determine the soil properties. Now, what are the properties where we use the disturbed soil sample and where we use the undisturbed soil sample.

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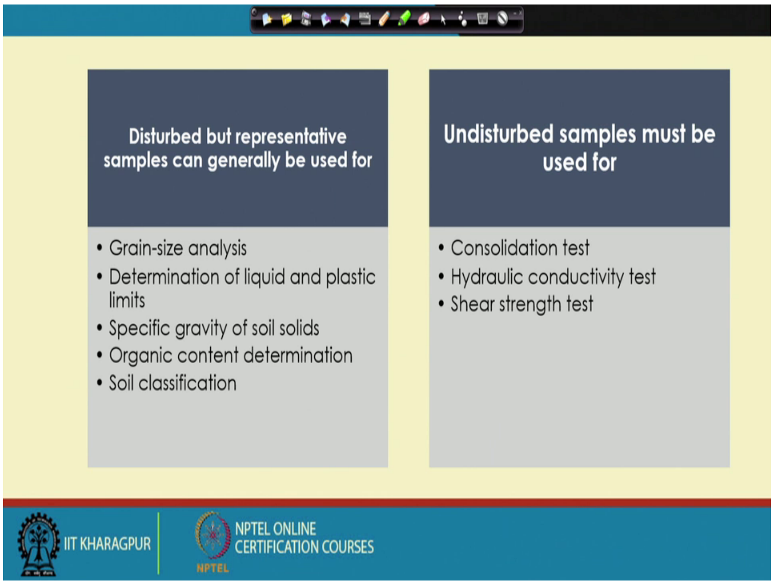

So, disturbed soil sample or the representative soil sample generally be used for grain size distribution analysis, determination of liquid limit, plastic limit or the atom limits specific gravity of the solids, then organic content determination or the so, the or in thus for the soil classification. And, but as I mentioned the major properties of the foundation design are the strain property of the soil and the drainage property of the soil.

So, that is why this drainage property and in intent terms of the consolidation properties. Because when you calculate the bearing capacity we need the shear strength properties. So, when you calculate the settlement for the foundation we need the consolidation properties.

So, this test where the use of undisturbed soil sample must, because other here we cannot use the disturbed soil sample. So, this test are consolidation test, hydraulic conductivity test and shear strength test. So, shear strength test as I discussed we can do it by the triaxial, we can do it by unconfined compression test or by direct shear test.

So, well for the shear strength calculation, the use of undisturbed soil sample is masked in addition to the consolidation test and the hydraulic conductivity test; consolidation test will get the value of cc and the compression index. So, that cc will use for our settlement calculation. So, that is why these test work we have to use the undisturbed soil sample.

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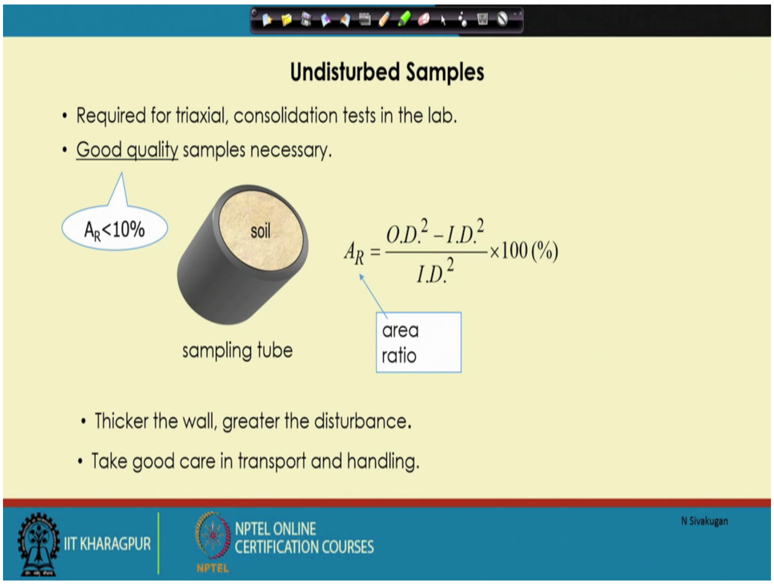

So, now the what are the criteria's for the collection of undisturbed soil sample? So, required for triaxial consolidation test in the lab and good quality sample recovery necessary is area ratio should be less than 10 percent.

So, now what is area ratio? So, this is a typical sampler tube, this is basically a hollow cylinder where it is a outer diameter or the internal diameter. So, area ratio is the outer diameter square minus internal diameter square divided by internal diameter square. So, this area ratio should be less than or around 10 percent so, that we can get good quality undisturbed soil sample. So, it is expected that if the wall thickness is more; So, we have the greater disturbance and if the wall thickness is less. So, we have the less disturbance.

And the then once you collect the undisturbed soil sample, you have to take care during the transportation and during the testing in the lab or during the handle of all these process of this sample.

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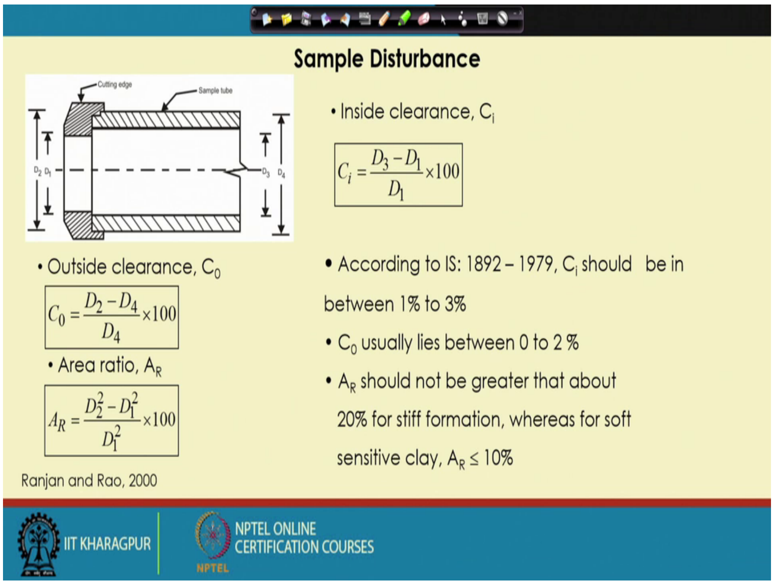

So, next one is the sample disturbance IS code also recommend some additional guidelines. So, this is a particular sampler tube, in sampler tube in front of that a cutting edge is attached. So, this cutting edge basically help to penetrate this sampler tube into the soil.

So, I have already shown you in the during the SPT test, that a speed put sample is attach in the front of the rod. So, on the top bottom of the rod; So, that sampler tube is penetrated into the ground by blows; So, here also. So, this is the where the cutting edge is there. So, that will help to penetrate the soil sample into the or penetrate the sampler tube into the soil. So, and we are applying the blow.

So, depending upon that, there are other criteria's to collect the undisturbed soil sample that if the this is the D1 is the internal diameter of the cutting edge, D2 is the outside diameter of the cutting edge and D3 is the internal diameter of the sampler tube and D4 is the outer diameter of the sampler tube. Then the C 0 we can get by these expression area ratio as I mentioned that area ratios will be D2 square here as there is a cutting edge is attached.

So, use these diameters because these are the diameters, but if the other things we have mentioned that if there is no cutting edge only the sampler tube then basically the diameter of this cutting edge we are considering as the area ratio here and C i is we can get by using this expression. So, these are the these are the conditions that for which or if we satisfy these conditions, then we can get a good undisturbed soil sample. So, this is the range between of the C i C 0 and area ratio should be greater not greater than 20 percent for stiff formation for the soft formation area ration should be less than 10 percent.

So, it is less than 10 percent for soft soil or around not should not be greater than 20 percent for the stiff soils; It should be around 10 to 20 percent for the these stiff formation and soft clay it is less than 10.

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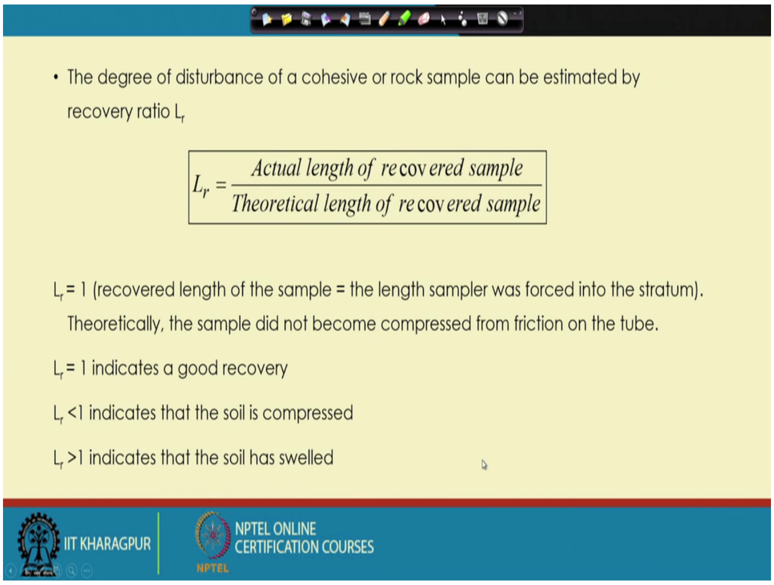

So, now when is you collect the soil sample. So, there is a recovery also. So, how we can get the recovery? So, with this recovery ratio L r; So, this recovery ratio is actual length of the recovered soil and theoretical length of the recovered sample.

So, this is the actual theoretical length of the tube and then how much length of the soil sample you have collected inside the tube. So, that is the actual length of the recovered soil and then if it is, which integrates a good recovery if it is less than 1, which indicate the soil is compressed and if it is greater than 1 which indicates the soil has swelled.

So; that means, for the good recovery the recovery ratio should be 1 otherwise it will indicate whether it is being compressed or soil depending upon the recovery ratio.

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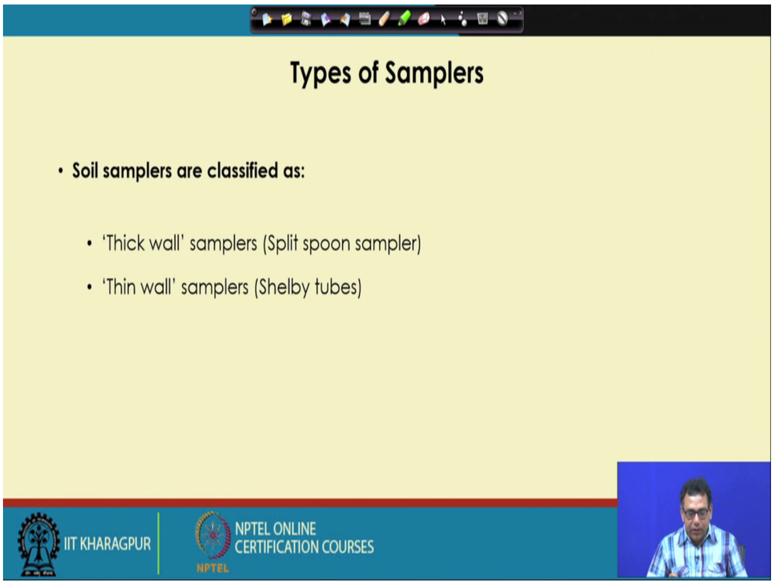

And then so; that means, there are two types of samplers. So, these are samplers are thick wall sampler or split spoon sampler. So, these sampler tube, thick wall sampler or split spoon sampler this tube is used for the SPT to collect the soil sample.

So, and this another one is the thin wall samplers or Shelby tubes.

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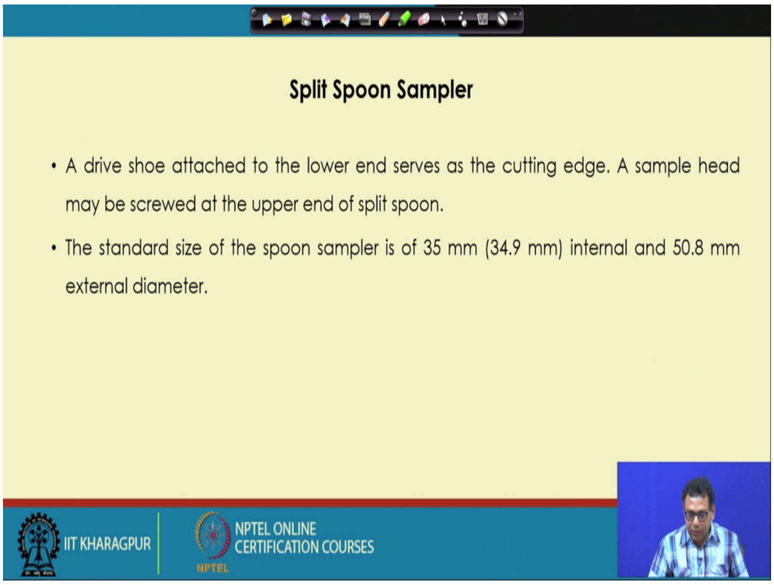

So, now the split spoon sampler its drive shoe attached to the lower and serve as a cutting edge. So, as I mentioned there is a cutting edge which is attached into the into the sampler and when sample head may be screwed at the upper end of the split spoon, and the this is the standard split spoon sampler diameter is 35 millimeter internal and 50.8t millimeter external diameter. So, this is important. So, we have a 35 millimeter internal diameter of the sampler and the 50.8 millimeter is the external diameter of this split spoon sampler.

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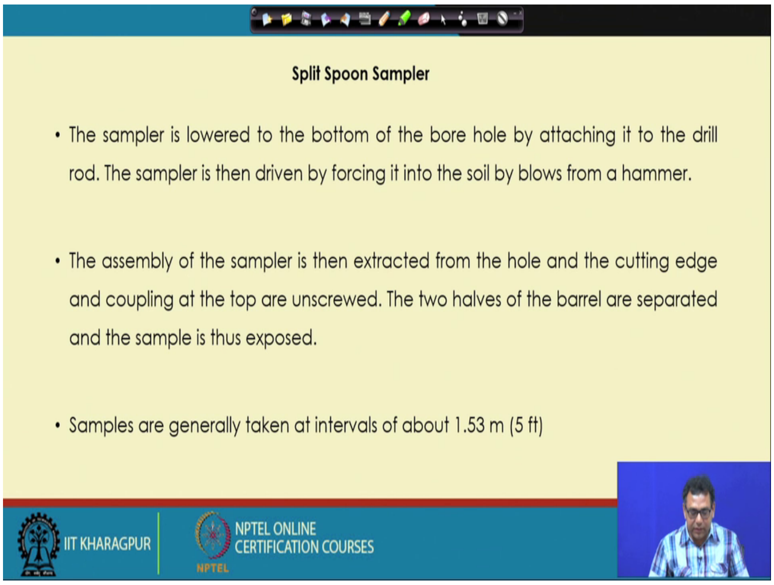

So, this is the other description that I have given that the sampler is lowered to the bottom of the bore hole attaching a drill rod and the sample is driven drawing by forcing into the soil with hammer blow. So, that is done for the spt. So, we attach the sampler tube with a rod and then we lowered it to the required depth, and then apply the blows and sampler tubes is penetrated into the soil and the soil sample is collected through the sampler tube.

And then the assembly of the sampler then extracted from the hole, and the cutting edge or the coupling at the top of the top are unscrewed. So, I will show what is coupling and then the two halves of the barrels are separated, and sample is exposed and will collect the sample.

So, I am shown these during the during the SPT that how the soil sample is a sampler tube is remove from the soil and the cutting edge is removed, and then we have there is a two halves and the inside the there will the soil samples. And samples are generally taken interval; So, 1.5 meters or not more than 1.5 meters so, and a mentioned during the SPT.

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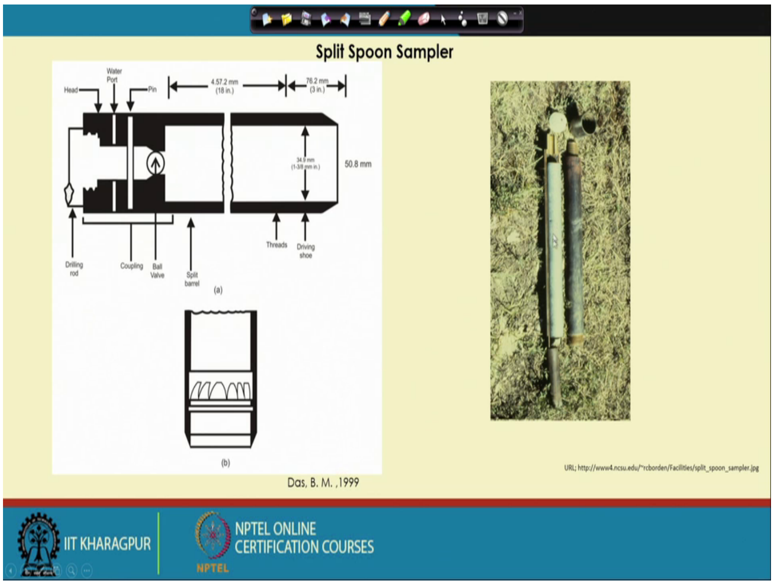

So, this is the typical sampler split spoon sampler tube as I mentioned there is a two halves and this is the soil sample.

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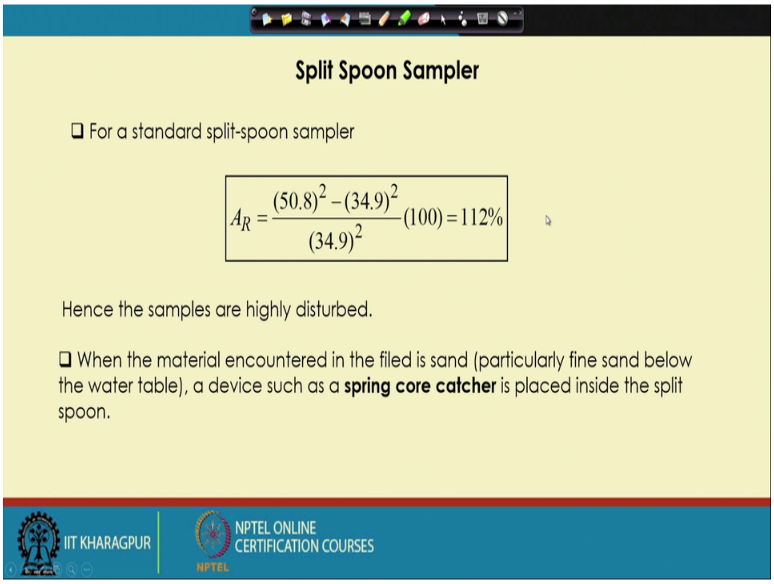

This is the soil sample and these are the others arrangement though this is the as I mentioned this is the cutting edge, where the internal diameter is 35 point, 34.5 millimeter or roughly 35 millimeter and the this is actually the outer. This one is the outer diameter of the this cutting edge. So, this is 50.8 and this is 35 millimeter. And this is total is the coupling, where is up this is the drilling rod which is a attach with this head. So, there is a water port and there is a in a one way valve is also attached here and there is a pin. So, these are the total assembly of this split spoon sampler and then this is the figure.

And so, as I mentioned. So, what with the area ratio? Because internal diameter is 34.9 or 35 millimeter or external diameter is 50.8 millimeter. So, the area ratio is 112 percent, which is very high with the with the as compared to the required area ration to collect a undisturbed soil sample. So, if I use the split spoon sampler or the soil sample that is collected which is disturbed soil sample.

So, hence the samples are highly disturbed because your area ratio which is around 10 percent for a good for collection of a good undisturbed sample is 10 percent, then here it is 112 percent. So, which is which is a disturbed soil sample which is the and then when we use it for the sand, then we use spring core catcher. So, this is the spring core catcher, this is attached to collect the soil sample for sand.

So, but all the cases the soil sample which is collected by using this split spoon sampler is disturbed soil sample.

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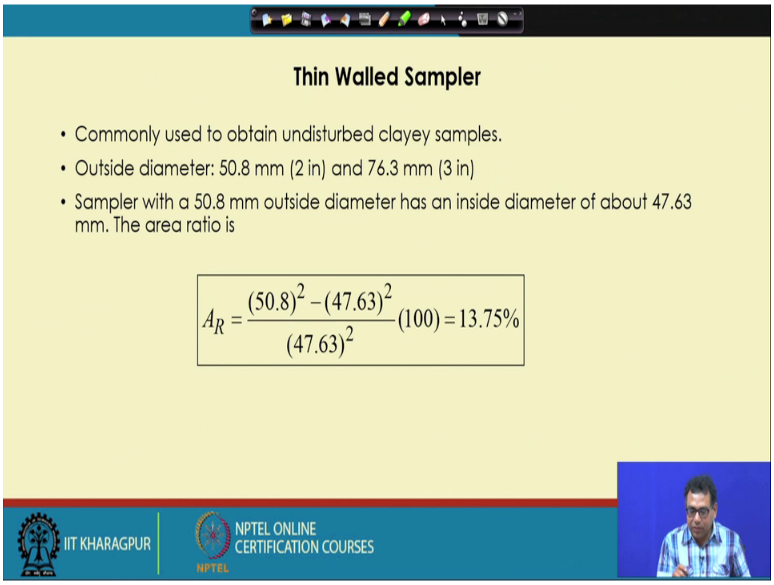

So, next one the thin wall sampler. So, as I mentioned if the thickness increases the disturbance will increase. So, here the thickness will reduce so; that means, here this these are the two types of sampler with in terms of diameter. So, if the one is 50.8

millimeter outside diameter, on this 76.3 outside diameter. Now the sample are with a 50.8 millimeter outside diameter has the inside diameter is about 47.63 millimeter.

So, the inside diameter is 47.63 millimeter, outside diameter is 50.8 millimeter. So, the area ratio is 13.75 percent. So, which is close to the 10 percent.

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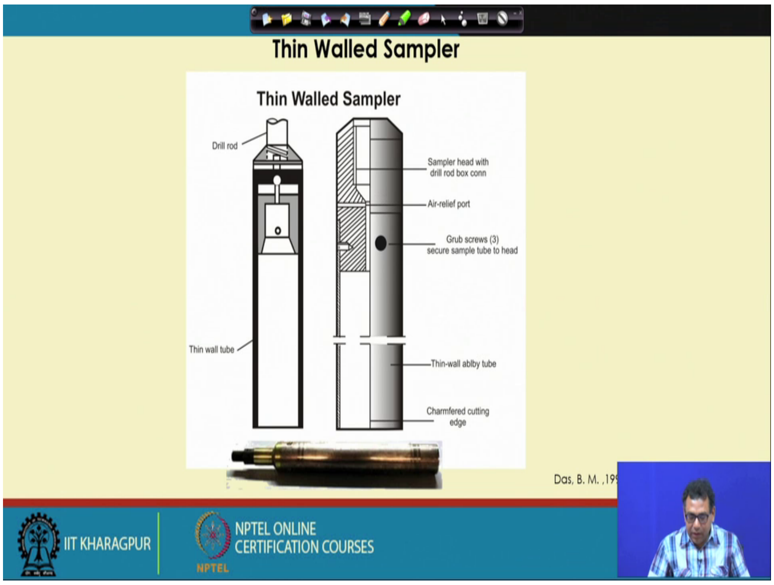

So, we can get a undisturbed soil sample, if I use the thin wall simpler to collect the soil. So, now, you see the typical photographs of a thin wall sampler or this is where the thickness is least and area ratio is also around 10 percent. So, we will get a good undisturbed soil sample.

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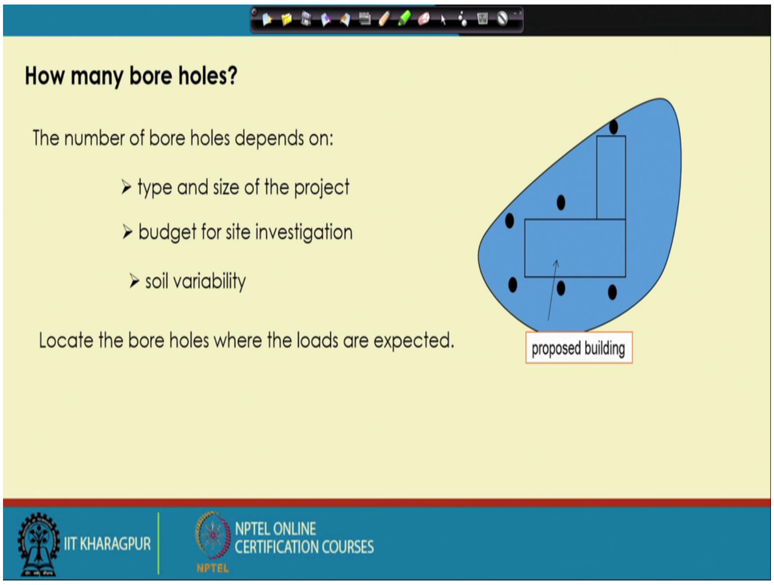

The next one that I will discuss about that that how many bore holes will decide for a particular proposed building or particular site. So, now, this number of bore holes that depending upon the type and size of the project, budget of the site investigation and the soil variability; So, this very important.

So, now, if we find that for a particular bore hole, there is a particular two bore holes or 2 3 bore holes data, there is a huge variation of the soil sample. So, then we have to increase the number of bore holes in between those bore holes, if the in such cases.

So, that depends on the variation of the soil property, soil in different number of bore holes, the budget of the site is your budget is more you can use more bore holes and if the typical size of the project and type in the type and the size of the project that also that also indicates that how much what is the number of bore holes you will consider.

So, another is you look at the bore holes, where you are expecting the more loads are coming in a particular building.

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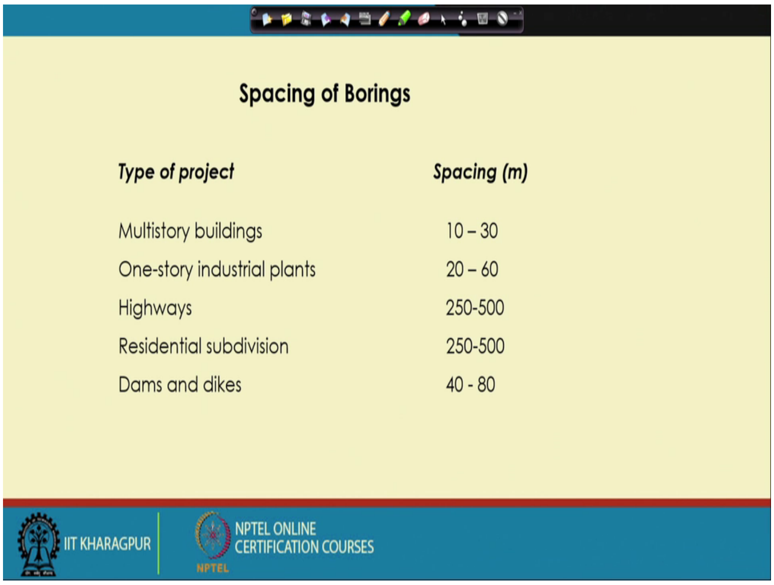

So, then the spacing of the bore holes, this is a typical example is given that for the multistoried building the spacing between bore holes is 10 to 30, one story industrial plants 20 to 60 meter, for highways, residential and dam or dikes these are the spacings given then for the minimum depth of the.

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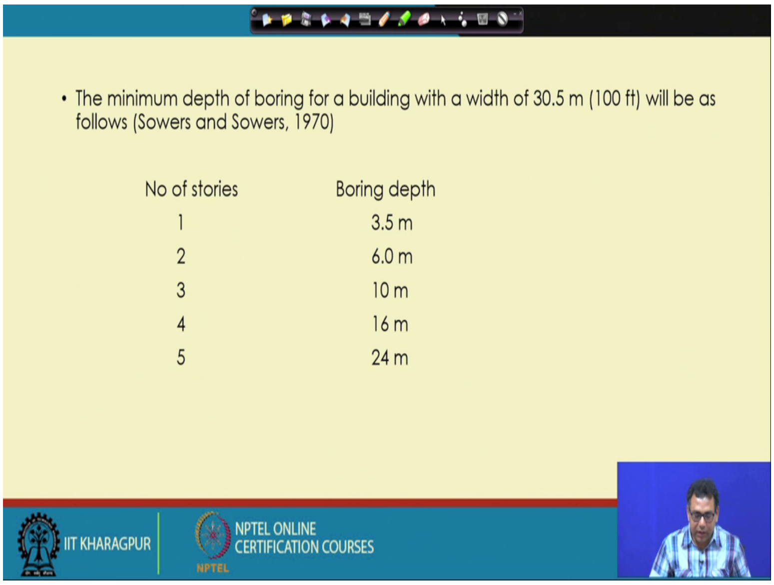

So, one is the spacing of the bore holes another is the depth how much depth will go to collect the soil sample in a bore hole.

So, and so; that means, this is the typical for a building with of 30.5 meter that, the number of stories if it is 1, the bore hole depth will be 3.5 meter if it is 2 6 meter, 3 10 meter, 4 16 meter and 5 24 meters. So, these are the approximate values are given. So, it is suggested by Sowers and Sowers in 1970.

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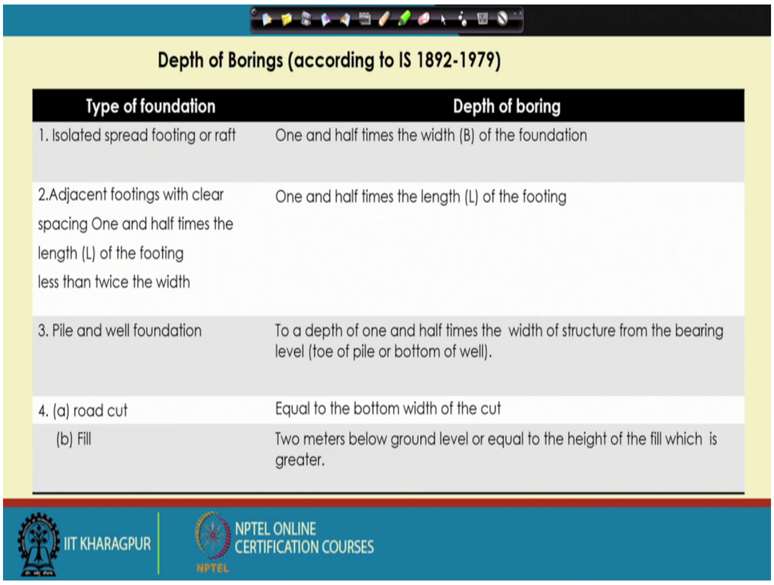
Depth of Borings (according to IS 1892-1979)

Type of foundation	Depth of boring
1. Isolated spread footing or raft	One and half times the width (B) of the foundation
2.Adjacent footings with clear spacing One and half times the length (L) of the footing less than twice the width	One and half times the length (L) of the footing
3. Pile and well foundation	To a depth of one and half times the width of structure from the bearing level (toe of pile or bottom of well).
4. (a) road cut	Equal to the bottom width of the cut
(b) Fill	Two meters below ground level or equal to the height of the fill which is greater.

So, but our IS code also recommends the depth of bore holes. So, this is the IS code recommendation is code 1892 1979, where if the footing is isolated footing or the raft foundation. So, later on I will discuss what is isolated footing what is raft so, but here these are some guidelines are given. So, for right now we just see those guidelines. So, later on I will discussed these what is raft, what is the isolated spread footing, what is stiff footing of all these things.

So, here for the isolated spread footing or the raft; So, this the depth of the bore hole should be 1.5 times the width of the foundation. So, if your foundation width whether it is spread footing isolated or raft is b, then depth of the bore hole will be 1.5 times of the b as far the IS code; So, these about the depth of the bore hole.

So, now, when we are talking on the raft and will mainly talk discuss about the rapt will discuss about the isolated footing then that the bore hole requirement is 1.5 times of the b minimums borehole requirement.

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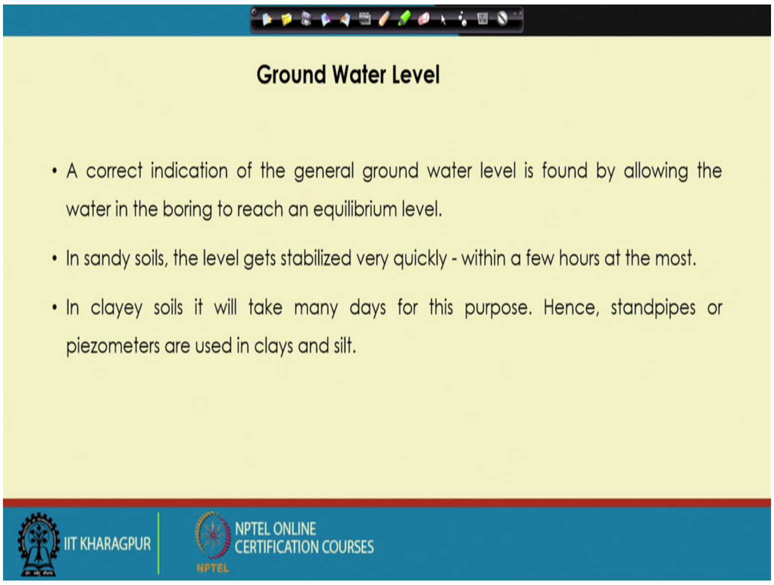

So, next one that how we will identify the water level location that is also very important; So, that the correct indication of general ground water level is found by allowing the water in a bore hole, to reach the equilibrium condition.

So that means, we construct a borehole and you put fill it with the water and then after certain time, depending upon the type of the soil the water will water level will come into equilibrium. So, it gets very quickly within few hours if it is a sandy soil, if it is a clayey soil it will take many days for this purpose. And for the clayey soil the standpipes or the piezometer are used in clay or silt to determine the water level location.

So, these are the. So, this class I am finishing this class with that note that that we have discussed of the all the penetration test and the other in situ test and we compare them and or discuss how we will get the different properties by using the different methodology, described in different in situ test and then we discuss about the various samplers by which we can collect the soil sample.

Whether it is a disturbed or undisturbed which sampler tube you will use, to collect the soil disturbed sample and the undisturbed sample where you will use the undisturbed sample to determine the soil property and where you will use the disturbed sample to determine the soil properties. And then what would be the spacing and the depth of the bore hole and how will look at the water level location.

So, in the next class I will discuss the last topic of this soil exploration that is the geophysical exploration and in the next two classes, I will discuss about these geophysical exploration.

Thank you.