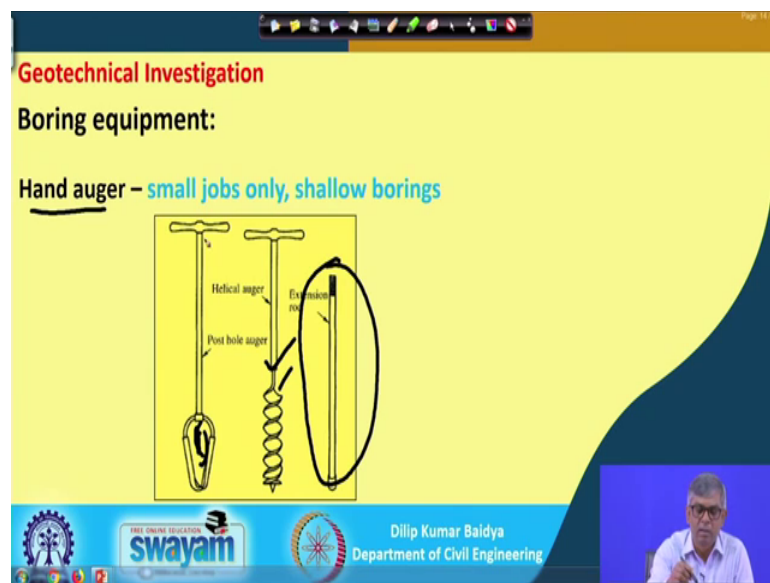


Geotechnical Engineering II / Foundation Engineering
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Lecture - 24
Geotechnical Investigation (Contd.)

Once, again welcome you to this lecture series on Geotechnical Investigation. And just now our in my previous lecture I have mentioned about the boring and sampling that means, at what all the steps and what are the initial information required is the while doing boring we have mentioned. And now we will try to discuss about the boring equipments and many other aspects related to geotechnical investigation. And let me go to the first slide of this.

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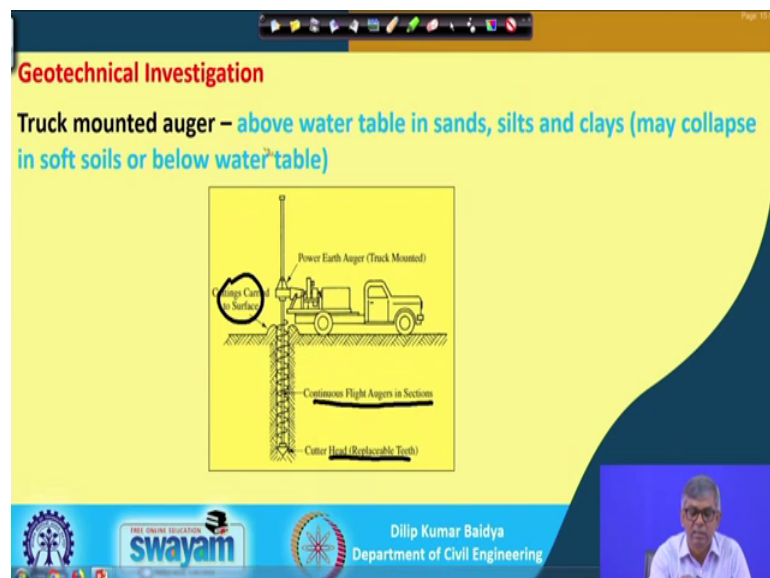
You can see here that boring equipment first thing is when we do the boring the most important thing is boring equipment and you can see here, I have mentioned first is Hand auger. And of course, I have written here all Hand auger and you can see this is a the handle and there is a cutting edge and with the handle at the surface if you holding like this if you rotate and because of this blade sharp blade at the edge it will cut the soil, and that cut soil will be entered into this zone. And when it will be filled up you have to bring it outside of the hole and remove the soil and again further you have to put into the

borehole and further again you rotate like this, and you have to do again and again this by this hand auger. And in fact, this is a not suitable for most of the big job.

For a small job suppose you want to 5 to 6 meter bore hole is required sometime we can manage with these hand auger. So, this is one type of hand auger that mean that will blade at the end and there will be some space to while cutting soil to enter, and when it will be filled up it will be taken out of the hole and then removed, and then further subsequently again you have to the cut the soil and go downward like that. So, this is one type of hand auger.

Another type hand auger is this is helical. So, when you loop because of the helical if you rotate it will cut and continuously and go downward and through this helic your soil will come out at the surface, that has to be taken out. And then suppose this is having a definite length about 3, 2 meter or something and if you want to go deeper then this handle can be removed and this extension rod can be added and to enter into the particular depth and then again further go deeper. So, this is hand auger and most of the time it is suitable for small job not for any good job big job. One can manage a small job with this type of hand auger.

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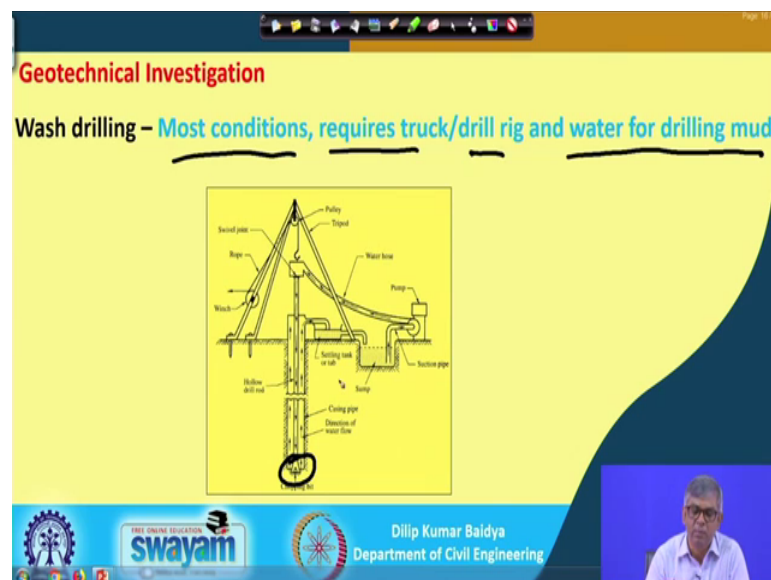


Then it is a truck mounted auger actually and here actually you can see that the same thing this one is a cutter head is there, and then it is a continuous flight augers in section; that means, you have to and cuttings will be coming in the in the surface. It will come

here, and this can be attached to the truck and then previously whatever we have shown that is actually basically by hand operated.

Now, through this truck there may be some machine will be there generator will be there through which this can be operated. So, you can go quite deep. So, it is much better than the standard hand auger. And this is actually suitable for above water table in sand, silt and clays make collapse in soft soil or below water table. So, these are the because when you are doing this the side soil may collapse actually, so may not be suitable in that case. So, that is one thing.

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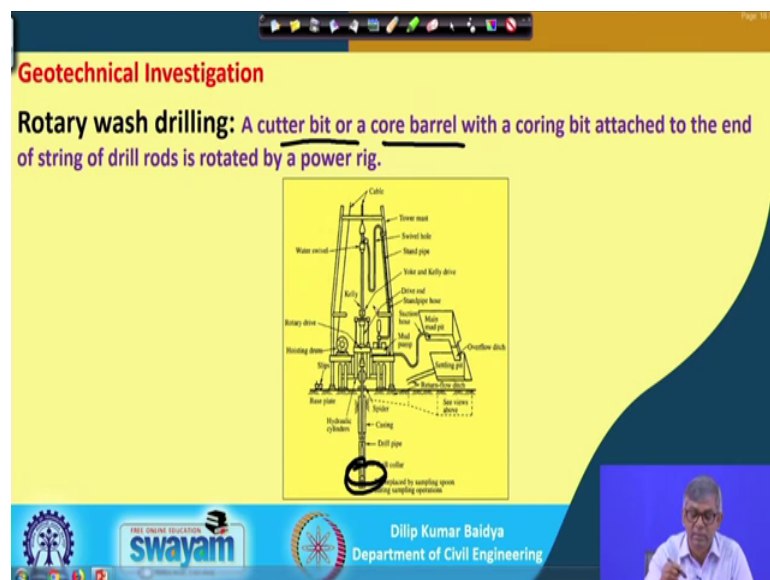
And next one is wash drilling actually. This is another type of thing you can see that will be chipping bit here at the end and there, water will be forced through this here and because of that the soil in this will be soil in this area will be cut. And because of this pressure of water the soil will cut and it will become mix with water and become mud and those mud will be in the form of mud will come out and it will be put in a particular basin tub.

And when you put this mud in the tub then what will happen? Some of the soil will settle there and clean water will overflow from here and that water can be reused. So, this is a wash boring and most of the time it is used in the soft soil and easy to do. Actually, most conditions it will be used requires truck drill rig and water for drilling mud, so that water

is required for drilling mud otherwise it cannot be done because this water only helping the cut the soil and finally, in the form of mud it is coming out here.

And this advantage of this type of again what you have to do for doing this type of borehole, how to find out the stratification then; the continuously this fluid is coming out mud is coming out, you have to observe the mud colour and you have to take the composition of the mud, sometime you have to collect and see what it is carrying, ok. And based on that whenever there is a change then you immediately you have to note that there is the change of layering.

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Similar to this sorry, similar to this there is a rotary wash drilling actually, you can see is little stronger and bigger equipment and almost similar. It will be bit will be there, a cutter bit or a core barrel with core bit attached to this and then again same thing the in the form of mud actually water will come out, it will main pit and then from the settling, settling pit and then it will go to the main pit and from there again it can be used. This is slightly complicated but it is almost like wash boring only, but its cutting for the cutting the little stronger arrangement is require actually the cutter bit or core barrel is required to cut this one. And also, it will be powered not by hand operation.

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Geotechnical Investigation

Percussion drills (Becker) – gravels or soils with boulders

Casing – used to support the hole and prevent caving

Wire-line drilling – deep holes and off shore drilling

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Next one actually the other type of drill actually percussion drills are there that is actually suitable for gravels or soils with boulders and casing used to support the hole and prevent caving. So, that means, if it is a boulder type of things. So, if you make a bore hole or something like that. So, those boulders etcetera they will come into the bore hole and it will collapse, so because of that generally you have to put some casing.

In fact, wash boring I have missed the actually this point, while making wash boring actually initially you have to by auger actually you have to go little depth and then afterwards you have to put the casing and then through that casing you have to do continuously wash boring. Otherwise, it will not be otherwise surface collapse will be there, possibility of collapse. And then wire line bore drilling this deep holes and off shore drilling this is the method used. So, all details are there in most of the test book if you are interested can read further about this.

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Geotechnical Investigation

Sampling equipment (sampler): /

Disturbed samples (thick walled) - Used for routine jobs to identify soils and determine index properties

- Split barrel SPT sampler ✓
- Augured samples ✓

Handwritten notes: A vertical line with a circle at the bottom, and a checkmark next to the 'Split barrel SPT sampler' bullet point.

Diagram of a Split Barrel SPT Sampler:

- Total Length: 32 in.
- Left Section: 7 in. (Flat for Wrench)
- Center Section: 22 in. (Split Lengthwise)
- Right Section: 3 in. (Flat for Wrench)
- Water Ports: 1/4 in. Diameter
- Thread for Wash Pipe
- Tool Steel Drive Shoe: 1/4 in.
- Center Section Diameter: 2 in.
- Left Section Diameter: 1 3/4 in.
- Total Weight: 15 lb

Logos: swayam, Dilip Kumar Baldya, Department of Civil Engineering

Next thing is sampling equipment, sorry. Sampling equipment we can have actually sampling equipment nothing but a sampler actually. And you can see the as I have mentioned before that disturbed samples. How to get actually? If the wall thickness is very, suppose there is a sampler wall thickness is this much and if you this is a sampler suppose circular in section or whatever may be and if you push in the soil because of this thickness actually when soil enter into it there will be lot of disturbance.

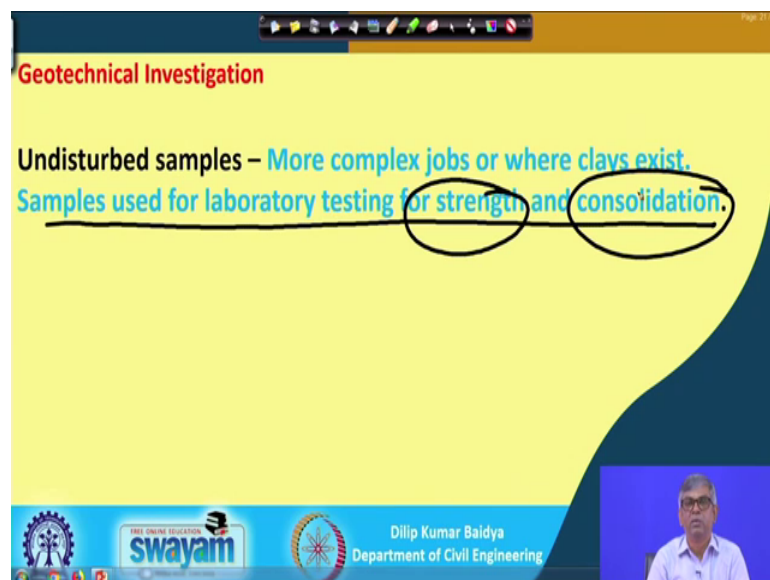
So, disturbs either thick wall sampler if you use generally, we get disturb sample and used for routine job to identify soil and determine index property. That means, what actually? If I get undisturbed sample or disturbed sample you cannot carry out test for finding out strength or compressibility and all, it is only to identification purpose; that means, what is the (Refer Time: 09:45) regain size, what is the liquid limit, (Refer Time: 09:48) limit, etcetera, to find out those only disturb sample is required and you can collect.

And disturb sample collection there will be that split barrel or SPT sampler. SPT I have not discussed, SPT is a, while carry out SPT test there is a SPT sampler. Those sampler is a SPT mean actually split spoon sampler, ok. So, that one that type of sampler actually that is that itself is a quite long and you have to drive and to penetrate inside the soil and while penetration it will collect some sample. So, that is the one, so SPT. And another auger you know that when you are doing you are when you are rotating like this by that

with a blades at the end soil get cut and that soil you are removing that soil also can be used as sample for identification purpose.

So, augured sample and split barrel sample. And split barrel actually one photograph is shown one case is shown here you can see actually 32 inches long actually total length what is the diameter and different parts actually is shown and this is this can be actually after coming into bringing into the sampler it can be divided it will split. And if it is split then we can one part if you remove, then inside the sampler how the soil is one can see visually and then afterwards you can collect that to do other further testing. So, this is one SPT sampler actually while carry out SPT test, it will actually through this soil will enter actually and that soil can be used for identification purpose also.

(Refer Slide Time: 11:45)



The slide features a yellow background with a dark blue curved shape at the bottom right. The title 'Geotechnical Investigation' is in red. The main text is in blue and black, with 'strength' and 'consolidation' circled. Logos for 'swayam' and 'Department of Civil Engineering' are at the bottom, along with a small video inset of a man speaking.

And then undisturbed sample you can see. Undisturbed sample actually you have to collect un-disturbance soil almost in the filled condition has to be collected and this is essential for most important job where like where clays are also exist, clays also exist. That means, if the clay soil is there soft soil and it will be having some compressible characteristics and because of that to find out the compressibility characteristics you need actually undisturbed sample. You disturbed sample it will not helpful with lot of error you will be getting and sample used for sample used for laboratory testing for strength and consolidation. That means undisturbed sample; that means, we collect for

doing this testing for strength and consolidation characteristic this two important things you find out by undisturbed sample.

And how to get undisturbed sample? A disturbed sample very easy you collect sample for the (Refer Time: 12:51) or auger, it will be give you the materials for looting investigation work. But if you want to find out the strength and compressibility unit undisturbed sample and part how to find out this undisturbed determine, how to get your undisturbed sample.

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Geotechnical Investigation

Requirements of sampler for undisturbed sample:

Area ratio, $A_r = \frac{(D_o^2 - D_i^2)}{D_i^2} \times 100$ (10%)

Inside clearance ratio,

$$C_r = \frac{100(D_i - D_e)}{D_e} (1\%)$$

Well designed sampler should have are ratio around 10%

Diagram labels: D_o , D_i , D_e

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So, it depends on the sampler actually. You have to device or you have to make a fabricated sampling device in such a way that while collecting the sample it will give you minimum disturbance.

So, there are some guidelines actually you can see here it is given, that requirements of sampler for undisturbed sample. So, that one actually is given or two things have given area ratio and inside clearance ratio. So, how it is defined actually? It is suppose I will very a large one I will draw, this is the one. So, it is not correct actually I will remove this one. So, suppose a sampler is like this. So, how it is defined area ratio? So, D naught actually it is from outer to outer is the D naught, is the D naught and e naught to e naught this is D i, D i.

So, A_r actually area ratio is $D_o^2 - D_i^2$ by D_i^2 multiplied by 100 and to satisfy the sampler as a undisturbed as an undisturbed sampler that the value area ratio should be less than 10 percent. So that means, you have to fabricate the sampler in such way the inside diameter and outside diameter you measure and then based on that you calculate this one, if it is less than 10 percent then that satisfy as a undisturbed sampler. And now next one is the inside clearance ratio you can see D_i and this one is the D_i already I have shown and D_e .

So that means, at the end little bend will be there to cut the soil. So, that edge what is the diameter? So, that is suppose D_e . So, then 100 times D_i multiplied D_e by D_e if you compute come this one and if the value comes less than 1 percent then only it will satisfy as a as an undisturbed sampler, sampler. So that means, so to collect undisturbed sample you have to first of all fabricate the sampler in such a way that area ratio become less than 10 percent and inside clearance ratio become less than 1 percent. How? What is the area ratio? What is the inside clearance ratio? From this case actually I could have got some better case but anyway that it will have some wall thickness because of that inside diameter and outside diameter will be different.

So, that actually based on that is area ratio. And though the sampler is almost vertical but at the edge little sharpening will be there little bend and sharpening because of that at the edge diameter will be little less. So, that is the one shown here D_e . So, $D_i - D_e$ by D_e multiplied by 100 if comes less by 1 less than 1 percent, that is also called that is also satisfactory for undisturbed sampling.

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Geotechnical Investigation

Sampler type

- Hydraulic piston – Thin walled or Shelby tube pushed ahead of device
- Pitcher/Denison Barrel – hard/dense soils removed by advancing tube while cutting
- Hand cut block samples – highest quality, most expensive, only retrieve from excavation

Diagram: A hand-drawn sketch of a sampler, showing a vertical tube with a cutting edge at the bottom and a piston above it.

Footer: Swamyam logo, Dilip Kumar Baldya, Department of Civil Engineering

Now, there are few names are mentioned here the sample sampler type the Hydraulic piston, Pitcher, and Denison Barrel and these are actually sampler by which we can get the un undisturbed sample.

Another actually very good way of collecting undisturbed sampler Hand Cut Block Sample, ok. Suppose there is a area, suppose this is area, ok. So, you first of all you excavate deep and suppose this is the excavation level, but what I do I will keep excavate all around I will keep this soil, ok. So, then remove some portion for the top and then from here to here I can collect one block, that big block as it is I will take it to the laboratory from there I can prepare the sample to testing; so that is also undisturbed sample.

And undisturbed sample means what actually? When you do this take this block again if you keep it is exposed then moisture lose and many things will happen. So, because of that there will be some mechanism to correct they have you have to put in the polythene bag, and when you are taking in the sample tube there actually you have to put wax both side, so that it will be still no moisture will be lost.

So, that is another way of make the prevent from change because of the change of weather, because from the field you have to bring into the laboratory may be sometimes it may take 2-3 days time sometime it will be because of distance or sometime you collect together and bring it. So, because of that time you may it my lose, it may lose

some amount of moisture and all. So, that has to be also prevented by proper clear like, you have to put it in the polythene or you have to wax like that. So, this is a difficult ways of collecting undisturbed sample.

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Geotechnical Investigation

In-situ Testing

Extensive use, especially in ground improvement evaluation
(SPT, CPT, Geophysical testing, vane shear)

Resistivity

Advantages:

- Use in soil that can not sampled easily
- Tests in correct environment
- Continuous profile (CPT)
- Cost effective

Sand/gravel soft soil

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Next is in-situ testing and you can see while doing this geotechnical investigation, soil exploration if there is any scope you had to additionally can carry out the field test and that will helpful. And there are certain areas where they are very useful particularly you can see that extensive use that in-situ testing during boring is very very commonly used.

And particularly when ground improvement work is carry ground improvement is scheme is taken for a particular area suppose a particular site is weak then we have a recommended some ground improvement technique. And when you ground improvement technique is recommended, so after improvement how is the how is the condition, that has to be test in-situ itself. So, that actually you do different types of in-situ test. So, that is also is in ground improvement evaluation that is we use different types of is in-situ test they are in CPT, SPT and geophysical testing, vane shear test, then resistivity test, there is one name resistivity test, resistivity, resistivity test also.

So, there are these are the different types of field test we carry out very commonly during boring and process. And it is more suitable particularly suitable for evaluating ground improvement site. And of course, for doing this there must be some advantage, there must be some disadvantage, and they are listed here you can see that advantage is first

use in soil that cannot be sampled easily. But this is actually very interesting because particularly when sand and all collecting undisturbed sample very very difficult, it is almost impossible. So, in that case it is better, to get a field test to get the to evaluate the soil properties, so that means, first thing is advantage as used in soil that cannot be sampled easily.

So, particularly sand is one, then your gravel is another one, if it is a very soft sensitive soil also it is another point. Soft sensitive soil what will happen? During because of the sensitivity while sampling it will be disturbed so much that when you carry out test to the laboratory it will not be of representative to the site.

So, those condition; that means, your sand or gravel sand gravel, then your soft soil where your undisturbed sample is difficult it is useful and test in correct environment; that means, you can see that is another important thing; test in if you advantage of field test is we are testing the correct environment. That means, when you take in the laboratory environmental change environment means site environment and the site environment means because of this depth at different dept actually because of the confinement and all, will change water table many other things are there which laboratory you are doing control condition. But here actually there are so many uncontrolled environmental effects are there under which we are testing. So, that is way it is beneficial.

And continuous profile; that means, CPT sometime we get profile something like this, ok. So, zigzag profile (Refer Time: 23:31) advance to the depth you will continuously get the profile and whereas, in a this is advantage of CPT. And whereas, is if you do SPT, SPT also will do carry out some intervals of 1.5 meter interval that SPT number of suppose this is the depth and SPT number at different depth you are carrying out different depths of numbers if you plot, also you will get by a large a continuous profile like. So, how SPT number is varying we can get and that variation of SPT number itself will be giving indication of the variation of the soil profile.

So that means, continuous profile you are getting from field test. Similarly, to carry out field test sometime cost effective, you have to go to the site and in very minimum time you can carry out a large number of test which will be correlated to different soil properties, most of the time it will be very very economic.

(Refer Slide Time: 24:41)

Geotechnical Investigation

In-situ Testing

Disadvantages:

- No samples for identification
- Some unknown test conditions →
- Need empirical correlation →
- Tests only current conditions →

Triaxial

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Next part is there must there are advantage, there must be some disadvantage also. You can see first thing is mentioned here no samples for identification. If you carry out some test like CPT type of test and then or if you bench a test if you carry out if the side or plate load test in the side you do not have any soil or a sample for identification. Of course, you have to do differently, so that is the advantage, disadvantage that means, if you carry out field test you do not have sample to for identification purpose.

And some unknown test condition, like in soil mechanics you have done that suppose triaxial test, you carry out triaxial test. And in the triaxial test you can stimulate different condition very easily and suppose I have collected the sample at 5 meter depth. And 5 meter depth what are the component pressure? Accordingly, I can put the cell pressure and all I can simulate the field condition. But here particularly in-situ test we do not have that control. There are many unknown condition, will be there under which you have to carry out the test and you have to get the results. So, that is the second disadvantage.

And need empirical correlation actually need empirical; that means, I get SPT number only from that site. Of course, initially many people investigated that suppose SPT test is carried out and then sample also collected from the sample there, and then that soil might have tested in the laboratory and got the strength properties or compressibility properties. And then from the SPT number and the strength and compressibility property is finally,

they have correlated, and there are number of correlations available, and so we have to rely on that;, that is one thing.

So, need empirical correlation; that means, if you carry out test but now this type of some of the test are used so long, so many years people are experience they know what type of correlation will be useful and that is available but still this is the drawback that, only by carrying out the test will not get the soil property. We have to use the help of correlation then to find out the soil properties; so that is another disadvantage. And if the correlation is not fitting, most of the time correlations are developed for a particular site of soil condition and may not be suitable for other condition but those type of things (Refer Time: 27:22) sometime it will give you some problem.

And tests only current condition; that means, in the field test what are we are doing, when you are carrying out the test that is currently what is the condition the under that conditional only your testing. But this condition may be after 6 month may change, after 3 months may change, after 1 year may change, like that. So that means, because of this variation what should be the change that we do not know. So, that has to be again incorporated by some other means.

So, this is also another disadvantage that we are testing only on the correct condition, ok. So, suppose if the water table like variation and all those things because of that some changes will be there which will not be able to get from this type of in-situ testing. So, these are the different advantage and disadvantages of field testing.

Now, next thing I will discuss about the different type of field testing about CPT, SPTs are in detail. And then what are the different correlation unavailable to find out the soil properties and design of foundation, and that part perhaps I will take in the subsequent lecture.

Thank you.