

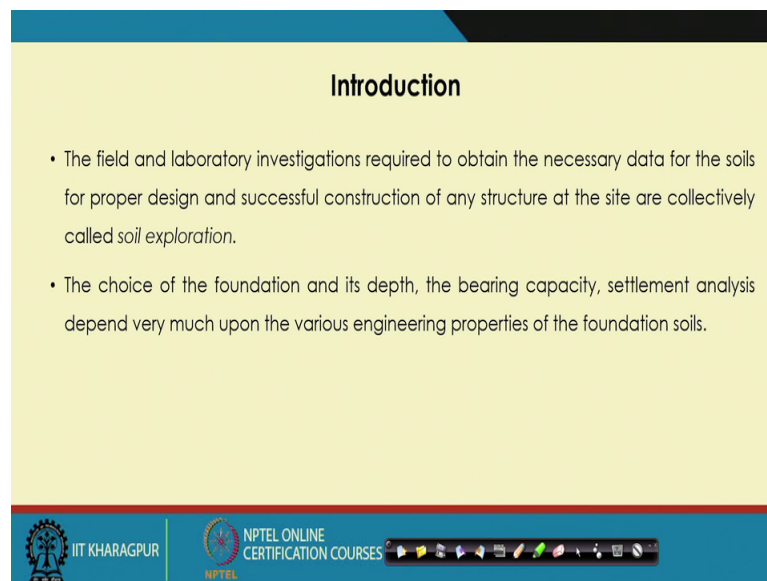
Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture - 04
Soil Exploration: Boring

So, in this lecture 4, I will discuss about the Soil Exploration. So, in lecture 3; So, I have discussed about what are the different laboratory methods or experiments, we generally conduct to determine the strength parameter of the soil and the consolidation parameter of the soil. So, those values are required for determining determination of the bearing capacity of the foundation and the settlement of the foundation.

So, now in this lecture I will discuss, what are the field tests generally we conduct to determine the soil properties, which will be used or will be required to design the foundation.

(Refer Slide Time: 01:12)



Introduction

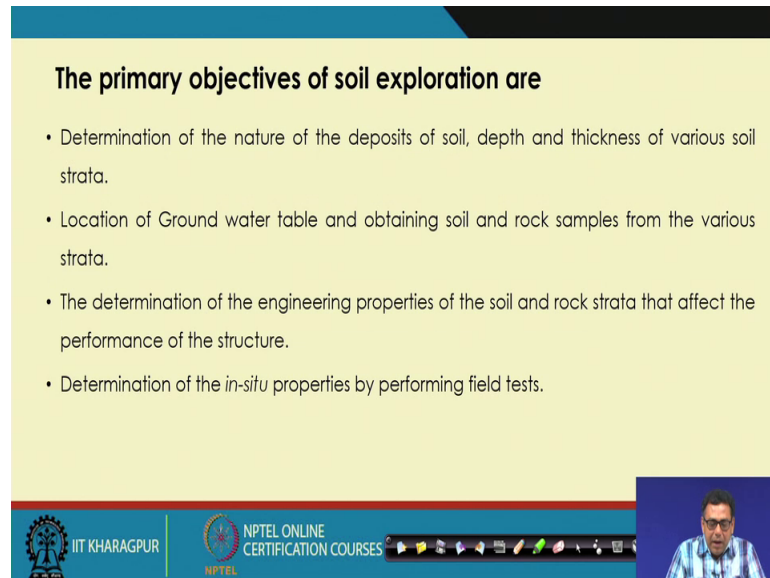
- The field and laboratory investigations required to obtain the necessary data for the soils for proper design and successful construction of any structure at the site are collectively called *soil exploration*.
- The choice of the foundation and its depth, the bearing capacity, settlement analysis depend very much upon the various engineering properties of the foundation soils.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES | NPTEL

So, first what is the definition of soil exploration. So, this definition is the field and laboratory investigation, required to obtain the necessary data for the proper design and successful construction of any structure or foundation on a particular side is collectively called as soil exploration.

So, the choice of the foundation, the bearing capacity of the soil settlement analysis of the soil, those all depends on various engineering properties of the foundation soil. So, these properties are to be determined by some field as well as the laboratory test. So, the here in this lecture, I will discuss mainly on the field test those are conducted to determine these required properties.

(Refer Slide Time: 02:10)



The primary objectives of soil exploration are

- Determination of the nature of the deposits of soil, depth and thickness of various soil strata.
- Location of Ground water table and obtaining soil and rock samples from the various strata.
- The determination of the engineering properties of the soil and rock strata that affect the performance of the structure.
- Determination of the *in-situ* properties by performing field tests.

So, first the primary objective of a soil exploration are, the determination of the nature of the deposit of the soil, then depth and the thickness of the each soil layer as we know that soil is a layered material. So, what is the thickness of each layer and at what depth is starts and end. So, those the informations are required to design a foundation.

So, the location of groundwater table is also very important to know so, that we can design a foundation based on that. So, location of ground water table also determination of ground water location of ground water table also is one of the objective of this soil exploration.

Now, the in the soil exploration, we collect the soil or rock sample from the site and then we bring the sample in the lab, and test in the lab to determine the soil properties. In addition to that, we can determine the in situ properties of the soil by performing field test.

(Refer Slide Time: 03:30)

Soil data required

- ❖ **Soil profile**
 - layer thickness and soil identification
- ❖ **Index properties**
 - water content, Atterberg limits, etc.
- ❖ **Strength & compressibility characteristics**
 - c' , ϕ' , C_c , OCR, ...
- ❖ **Others (e.g., water table depth)**

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

So, what are the things we determine or what are the data required. So, in terms of soil profile as I mentioned, the layer thickness and the soil identification and the starting and the end date of the each layer is also important then the index properties. So, that is the water contained, atterberg limit. So, these are very important. then the strength and compressibility characteristics. So, this strength material is this equation, friction angle then compression index C_c OCR Over Consolidated Ratio. So, this over consolidated ratio as I mentioned, I have mentioned about the normally consolidated soil and the over consolidated soil.

So, for the over normally consolidated soil this OCR value is taken as 1. Because in the normally consolidated soil. So, you have the present stress which is greater than the maximum past stress, which is soil is experience. So, here we assume that this for the normally consolidated soil, this OCR value is 1, but for the over consolidated soil where the present stress is less than the stress, than the stress which the soil is already experienced.

So, here this ratio is the past maximums experience stress of the soil divided by the present stress that we are applying. So, I have already discussed that how we can determine the maximum past effective overburden stress or maximum past stress, that soil is experienced by casagrandes method. So, I have already discussed.

So, we can get that value from $e \log p$ curve, and applying the casagrandes method we can determine what is PC. So, that PC is the past maximum effective overburden stress that this soil is experience. The ratio between the maximum past stress the soil is experience and the present test present stress. And then others things the water table, which is also you have to determine what this data are also required for our design purpose.

(Refer Slide Time: 06:13)

Direct Methods - Test Pits

- Test pits or trenches are open type or accessible exploratory methods.
- Soils can be inspected in their natural condition.
- The necessary soils samples may be obtained by sampling techniques and used for finding strength and other engineering properties by appropriate laboratory tests.

URL: <http://www.bblresearch.com/2010/07/20/>

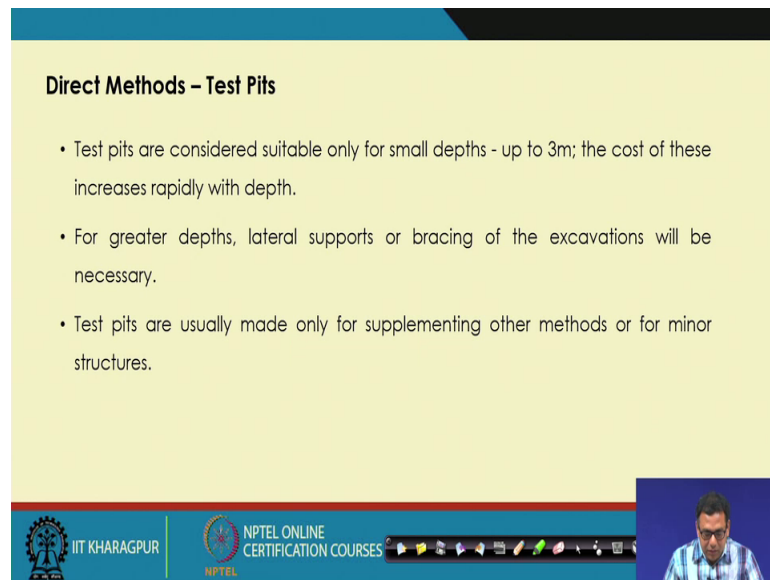
The slide features a photograph of a rectangular test pit dug into the ground. A red and white measuring tape is placed horizontally across the width of the pit to provide a scale. The soil inside the pit appears dark and moist. The slide also includes logos for IIT KHARAGPUR and NPTEL ONLINE CERTIFICATION COURSES, along with a small video inset of a presenter in the bottom right corner.

Now, there are the methods. So, first method that is the direct method or the test speed. So, if you look at the figure, this is the photographs of a test pit. So, this hm. So, this is the test pits or trench are often type of a is a open type of exploration mission method, where soil can be inspected in their natural condition and the necessary soil sample may be collected add the sampling techniques.

Sampling techniques and use for fire and use for finding strength and other engine properties by the and laboratory test. So, we can collect the soil sample from the site itself and those samples we can use to determine the soil properties in the laboratory.

So, and the another advantage is that, these trench pit we have to the depth of the trench pit should be the equal to the depth of the foundation, that mean at what depth you are placing your foundation. So, that depth will be equal to the depth of the trench. From where on that depth we can collect the soil sample, and we can bring the soil sample in the laboratory for the determination of the soil properties.

(Refer Slide Time: 07:36)



Direct Methods - Test Pits

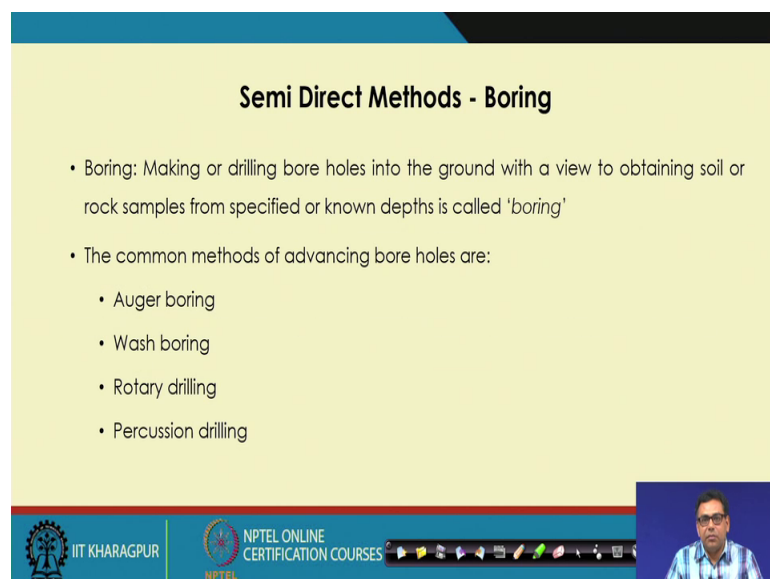
- Test pits are considered suitable only for small depths - up to 3m; the cost of these increases rapidly with depth.
- For greater depths, lateral supports or bracing of the excavations will be necessary.
- Test pits are usually made only for supplementing other methods or for minor structures.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

The slide features a yellow background with a blue header and footer. A small video inset in the bottom right corner shows a man in a blue shirt speaking. The footer contains the IIT Khharagpur logo and the NPTEL Online Certification Courses logo.

So, that is why this method is suitable for very small depth up to 3 meter and the cost of the this cost increases rapidly with depth. And when increase the depth of this strange so, we have to provide the lateral support and that is why. So, this the cost requirement will increase if we increase the depth. So, that is why this method is suitable for sample small depth up to 3 meter, and test pit are usually made only for supplementing other method or for minor structures.

(Refer Slide Time: 08:22)



Semi Direct Methods - Boring

- Boring: Making or drilling bore holes into the ground with a view to obtaining soil or rock samples from specified or known depths is called 'boring'
- The common methods of advancing bore holes are:
 - Auger boring
 - Wash boring
 - Rotary drilling
 - Percussion drilling

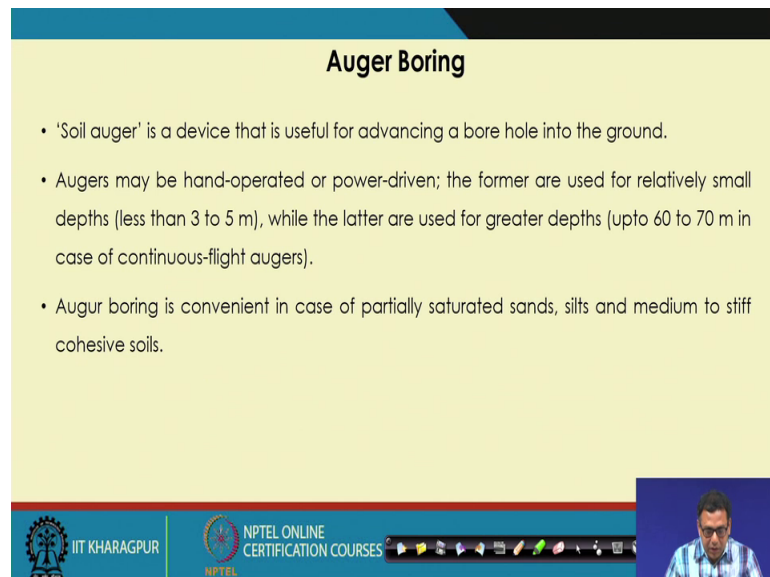
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

The slide features a yellow background with a blue header and footer. A small video inset in the bottom right corner shows a man in a blue shirt speaking. The footer contains the IIT Khharagpur logo and the NPTEL Online Certification Courses logo.

So, next method is the semi direct methods or the borings. So, here. So, borings that is the making or drilling bore holes into the ground, with a view of obtaining soil or the rock sample from specific a known depth is called the boring. So, boring we have to do, to collect the soil sample for a particular specific depth and those soil sample we use for our laboratory test to determine the determine the soil properties. Sometimes these borings are also required to conduct the field test for a particular depth.

So, the common methods of borings are the other boring, wash boring, rotary drilling and percussion drilling. So, one by one I will explain what is these methods are.

(Refer Slide Time: 09:19)



The slide is titled "Auger Boring" and contains three bullet points. At the bottom, there are logos for IIT KHARAGPUR and NPTEL ONLINE CERTIFICATION COURSES, along with a small video feed of a presenter.

Auger Boring

- 'Soil auger' is a device that is useful for advancing a bore hole into the ground.
- Augers may be hand-operated or power-driven; the former are used for relatively small depths (less than 3 to 5 m), while the latter are used for greater depths (upto 60 to 70 m in case of continuous-flight augers).
- Augur boring is convenient in case of partially saturated sands, silts and medium to stiff cohesive soils.

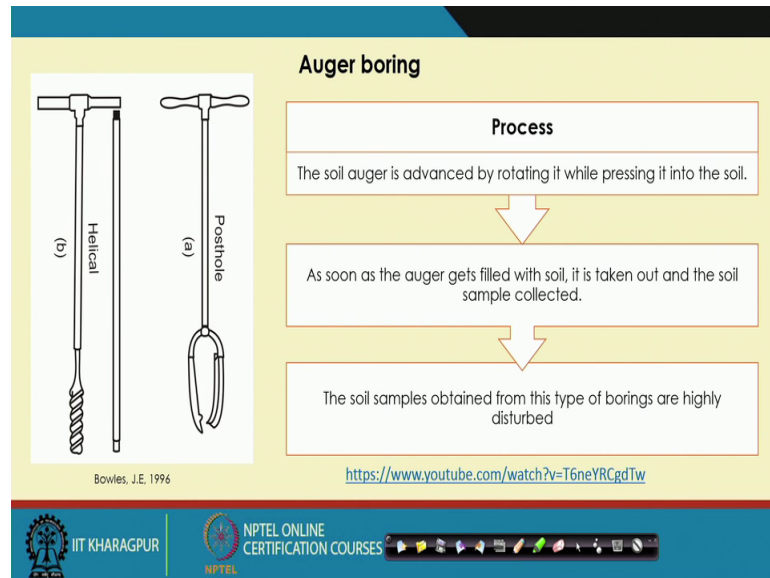
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

So, first petal is the auger boring. So, the soil auger is a device, that is useful for advancing a borehole into the ground. So, this soil auger we use for the advancing of a borehole a construction of a bore hole in the ground, it will also use to collect the soil sample and those soil samples we use for the in the laboratory test.

So, auger may be hand operated or powered even. If it is the hand operated then we can use it for relatively small dip up to 3 to 5 meter. If it is a power driven, then we can use this method up to a greater depth up to 60 to 70 meter in case of continuous light auger. So, you can go up to 60 to 70 meters is it is a power driven.

So, auger boring is convenient in case of partially saturated sand silts and medium to steep cohesive soil. Now, the process by which we can conduct this auger boring; So, this figure you can see these are different types of or sub augers.

(Refer Slide Time: 10:32)



So, this is the one type of auger and this is the another type of auger and this is the rod. Suppose if I want to increase the this drill rod height. So, we can attach another rod and we can increase it. So, a by attaching the number of rods, we can increase this height. So, that we can collect the soil sample or we can advance the borehole of to the required depth.

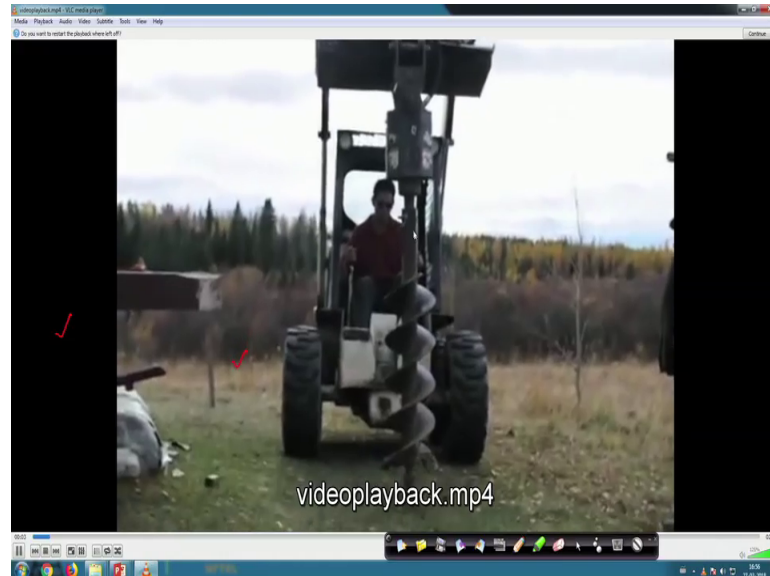
So, first is the soil auger is advanced by rotating it, while pressing it into the ground. So that means, first we have to place the auger onto the ground and then you have to press it and then as well as we rotate it so, that these auger; So, this portion of this auger.

So, this will this will be pushed into the ground or by placing it as well as rotating it. As soon as the auger gets filled with the soil, we it is taken out and the soil sample is corrected. So, once you I mean push it this auger into the ground. So, it will be filled with soil sample. So, when it is filled with soil sample, we take it this auger out from the soil and then collect the soil sample.

The soil sample obtained from this type of boring highly disturbed. So, it is it is expected. So, you can see we are just pressing it then rotating it and collecting the soil

sample. So, it is obvious that soil sample, which we are collecting by this method is disturbed.

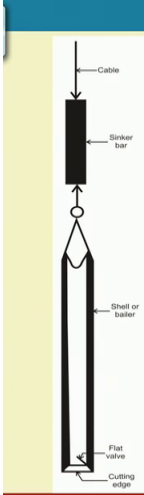
(Refer Slide Time: 12:38)



So, I have one YouTube video link. So, this link is given in the in the screen. So, you can see this is the typical this auger drilling. So, this is one type of auger. So, this is the power driven. So, it is rotated into the ground, and then it will insert into the ground. So, and the soil sample you can see it is inserted into the ground and then the soil sample is also.

So, on it is inserted into the ground. So, you can see that the soil sample is also collected and this is the soil sample which is collected and then we can make this soil sample and we can a collect the soil sample for our a laboratory test purpose. So, this is one typical example of the auger drilling.

(Refer Slide Time: 13:52)



Shell and Auger

- Used widely in India
- The shell, (called a sand bailer) is a heavy duty pipe with a cutting edge.
- The shell is raised and let fall in a hole. The soil is cut, enters the tube which is emptied when full.
- Shell is used when auger boring becomes difficult.

Ranjan and Rao, 2000

IIT KHARAGPUR NPTEL ONLINE CERTIFICATION COURSES

So, next one is the shell and auger, which is widely used in India. In a this there is a this is heavy duty shell or a heavy duty pipe. Basically this is a heavy duty pipe, on which a cutting edge is attached. So, and there is a one way valve; that means, in this valve will open only in this direction. So, this valve will open in this direction only. So, once it is fill, this valve the soil is entered into this pipe or the shell it will not come back again; So, because it is the one way valve.



So, what is the process? Here the shell is raised because this is the shell is raised, because this shell is attached with a cable and this shell is raised and let fall in a hole and the soil is cut as there is a cutting edge there, and the soil is cut and enters into the tube and then when this tube is full, then we a remove it is we take this shell or the tube from the bore hole and we collect the soil sample, and this shell is used when the auger boring is very difficult.

So, that is why when by this method, we can collect the soil sample when the auger boring is very difficult, in that case we have to adopt a different methodology electron I will discuss. So, methodology with two construct the borehole.

(Refer Slide Time: 15:52)

Wash Boring

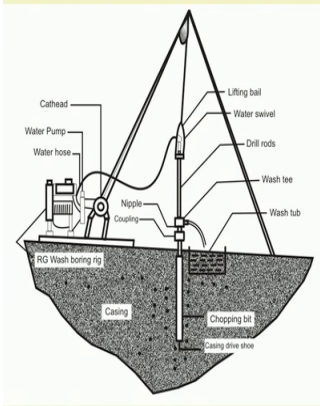
- Wash boring is commonly used for exploration below ground water table for which the auger method is unsuitable.
- This method may be used in all kinds of soils except those mixed with gravel and boulders.
- A casing pipe is pushed in and driven with a drop weight.



So, next one is the is the wash boring. So, wash boring is commonly used for exploration below ground water table for which auger method is not suitable. So, as I mentioned the auger methods which is if it is not suitable, then you have to go for the wash boring when it is below ground water table. This method is may be used for all kind of soil except those mixed with gravel and boulder.

So, a casing pipe is pushed and driven into the soil with the help of drop weight.


(Refer Slide Time: 16:33)



Process

- A casing pipe is pushed in and driven with a drop weight.
- hollow drill bit is screwed to a hollow drill rod connected to a rope passing over a pulley and supported by a tripod.
- Water jet under pressure is forced through the rod and the bit into the hole which loosens the soil.
- The soil-water suspension forced upward is led to a settling tank where the soil particles settle while the water overflows into a sump.

<https://www.youtube.com/watch?v=8PpbBnstrgs>



So, I have the this process. So, this is a casing pipe, which is pushed into the soil and driven with a hill pop drop weight; So, our drop weight. So, this is a tripod by which our drop weight a weight is applied or by which a casing pipe is pushed and driven into the soil, and the hollow drill bit.

So, this is a hollow drill bit is screwed with a hollow drill rod. So, in this is the bead which is attached with a rod, and connected to a rope passing over a pulley. So, these things is connected with a rope which is passing over a pulley and such supported by a tripod. And water jet under pressure is forced through the rod, and the beat into the hole which basically allow the soil become loose.

So, here we apply a water jet through the rod to the bit on the soil so, that soil become loose. So, this well this water is applied water jet is apply the soil become loose. So, we have a soil water suspension. So, this suspension is forced upward and allowed to settle in a tank, where the soil particle settle, while the water over flow into a sum.

So that means, this water and soil suspension is forced to move upward and then this suspension is allowed to settle in a tank where this soil particle settle down and the water is overflows into a sump. So, those soil particles we use for our testing purpose.

(Refer Slide Time: 18:37)

Wash Boring

- The soil particles collected represent a very disturbed sample and is not very useful for the evaluation of the engineering properties.
- Wash borings are primarily used for advancing bore holes; whenever a soil sample is required, the chopping bit is to be replaced by a sampler.
- The change of the rate of progress and change of colour of wash water indicate changes in soil strata.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

So, obvious the material or the soil particles or that are collected or soil that is collect is very disturbed sample, and not very useful for evolution of engineering property

basically the stream properties later on, I will discuss that when what are the cases where we will use the disturb soil sample and when we will use the undisturbed soil sample.

So, these method that till now I have discussed we are all the methods we will collect the disturb soil sample only. So, and the primary use of this wash boring is the advancing bore holes, and whenever a soil sample is required, then the this chopping beat is replaced by a sampler.

So, and then we can collect the soil to the sampler also. So that means, here there is a two things I am talking about, when the we are collecting the soil sample in terms of soil, water suspension that is one process, and another process we can collect the soil sample by sampler tube also. So, this what is the sampler tube I will explain later on that, what are the different kinds of sampler tubes and when we use these tubes to collect the soil sample, whether it is disturb or undisturbed.

So, now this is the one process we can collect it by sampler tube by replacing the bait or we can collect the soil suspension, and we settled with the soil particle settle down and we can use that soil sample for the testing purpose also. The change of the rate of progress or the change of the color of water or wash water indicate that there is a change in the soil strata. So, that is also will help us to identify whether there is a change in soil strata or not, by changing progress rate of progress or the change in color of the wash water.

And there is also one YouTube link. So, this is the this water jet is applied into this drill rod to the soil to become the should have soil become the loose.

(Refer Slide Time: 21:07)



And then this suspension are forced to move upward direction, and this is the tripod and the pulley and those suspensions are basically collected and then it allow to settle the soil sample soil particles and water is over flow.


So, this is the wash boring methods that typical things and rocking among.

(Refer Slide Time: 21:52)

Rotary Drilling

- Can be used in sand, clay and rocks (unless badly fissured)
- This is a very fast method.
- Even rock cores may be obtained by using suitable diamond drill bits.

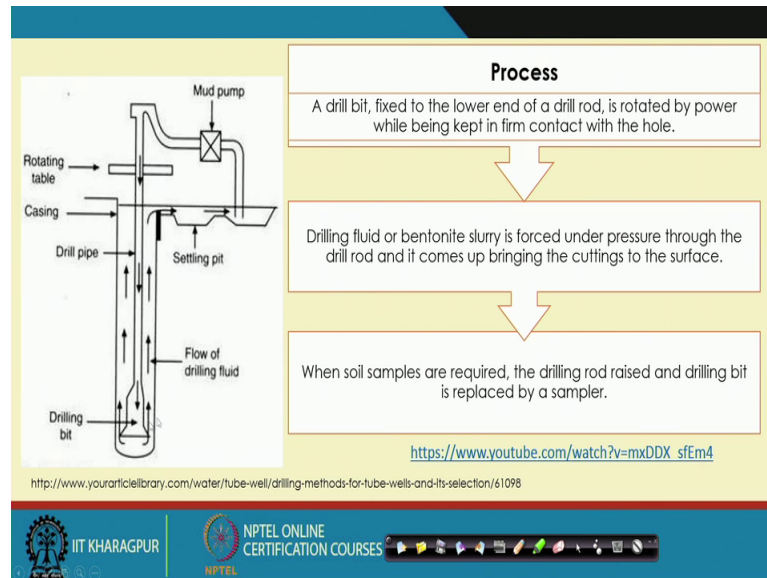
IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES



So, next one is rotary drilling. So, this is can be used for sand clay and rock, unless this is badly fissured. So, this rock part I am not talking about. So, in this course, I will discuss about the soil only. So, I will concentrate only the soil part. So, this is very fast method

and even rock course may be obtained by using a suitable diamond drill bits. So, we can obtain the rock sample also by using this method.

(Refer Slide Time: 22:31)



So, the process. So, a drill bit fixed at the lower end of a drill rod and it is rotated by power, while being kept in firm contact with the hole. So, here also you can see there is a drill rod. So, this drill rod there is a drill bit is attached with this drill rod and which is rotated by a power, and of drilling fluid or bentonites are bentonite slurry is forced under pressure through the drill rod and it comes up, bringing the cutting to the surface.

So; that means, we apply a bentonite slurry or drilling fluid through this rod so, that are under pressure. So, that when there is a we are rotating this drilling bit into the soil. So, the material which is cutted through this method, we can bring this material to the surface with this slurry under pressure.

So, when the soils again when the soil samples are required the drilling rod is raised and drilling bit is replaced by a sampler. So, again like the wash boring, we can collect the soil sample by either sampler tube or we can collect as a this bent slurry form. So, that is both way we can collect.

So, there is one YouTube video this link is also given. So, you can see there is a slurry, which is allow this cutted material to move up wide and through this drilling rod and this is this is the drilling beat.

(Refer Slide Time: 24:22)



So, that is an when the sample we want to collect the soil sample, we remove this drilling bit. So, this is the one method.

(Refer Slide Time: 24:46)

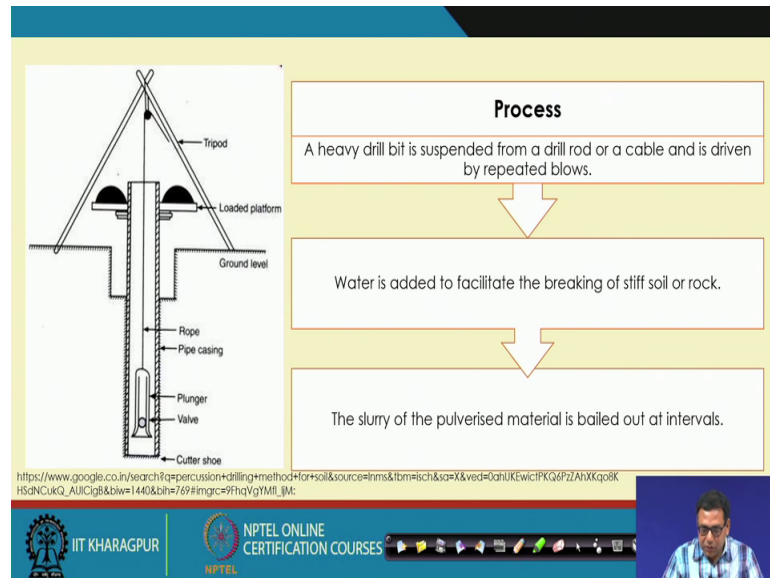
Percussion Drilling

- The method cannot be used in loose sand and is slow in plastic clay.
- The formation gets badly disturbed by impact.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

Then the fourth one it part is the percussion drilling. So, this method cannot be used for loose sand and is slow if this process is low in plastic clay, the formation gets badly disturbed by impact.

(Refer Slide Time: 25:09)

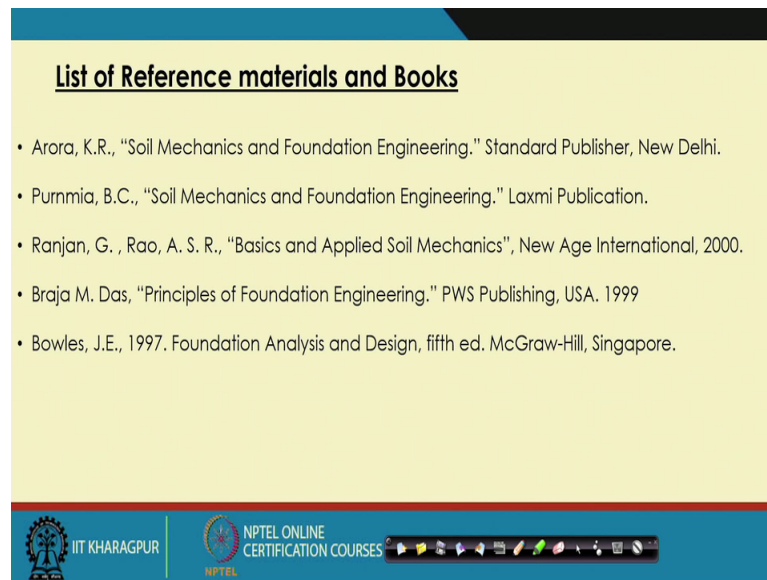


So, the process is. So, this is a typical figure. So, the this is a tripod the process is the heavy drill bit is suspended from a drill rod or a cable and it is driven by repeated blows.

So, here we are applying the blows to drive this drill bit. So, and the water is also added to facilitate the breaking of stiff soil or rock; if the soil is rock or a stiff. So, we applied the blows to drive this rod with the heavy duty bit by repeated into the soil , but you also add the water to facilitate or breaking the steep or the rock.

The slurry because as we are adding the water. So, the slurry of the pulverized material is build out at interval or it is released at intervals and so that in this way we can collect the soil samples. So, these are the methods by which we can so, we have these are the different references.

(Refer Slide Time: 26:30)



List of Reference materials and Books

- Arora, K.R., "Soil Mechanics and Foundation Engineering." Standard Publisher, New Delhi.
- Purnmia, B.C., "Soil Mechanics and Foundation Engineering." Laxmi Publication.
- Ranjan, G. , Rao, A. S. R., "Basics and Applied Soil Mechanics", New Age International, 2000.
- Braja M. Das, "Principles of Foundation Engineering." PWS Publishing, USA. 1999
- Bowles, J.E., 1997. Foundation Analysis and Design, fifth ed. McGraw-Hill, Singapore.

IIT KHARAGPUR | NPTEL ONLINE CERTIFICATION COURSES

So, these are the methods by which we can collect the soil sample as I am mentioned. So, these soil samples are highly disturbed.

So, that means, these soil samples we are not by this method we are not able to collect the undisturbed soil sample. So, now, this is the differ two way some in some methods we are two way we can collect the soil sample one is this undisturbed soil sample by collecting this material from the side, another we can collect the soil sample why sampler tube.

So, in the sampler tube you will later on in the next classes, I will discuss that what is the sampler tube, what would be the thickness of sampler tube so, that we can collect the disturb all undisturbed soil sample by using this sampler tube. So, if I used particular type of sampler tube we can collect disturb sample as well as we can collect undisturbed sample.

So, those things and again now we are collecting the disturb samples. So, when we use this disturb sample, and when you use the undisturbed soil sample, those things I will also discussed in the next classes.

Thank you.