INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

NPTEL

NPTEL ONLINE CERTIFICATION COURSE
An initiative of MHRD

Subsurface Exploration: Importance And Techniques Involved

By
Dr. Abhishek Kumar
Department of Civil Engineering
IIT Guwahati

Lecture 3
Geotechnical
Investigations

Dr. Abhishek Kumar
Assistant Professor
Department of Civil Engineering
Indian Institute of Technology, Guwahati
Webpage: http://www.iitg.ac.in/abhiak/

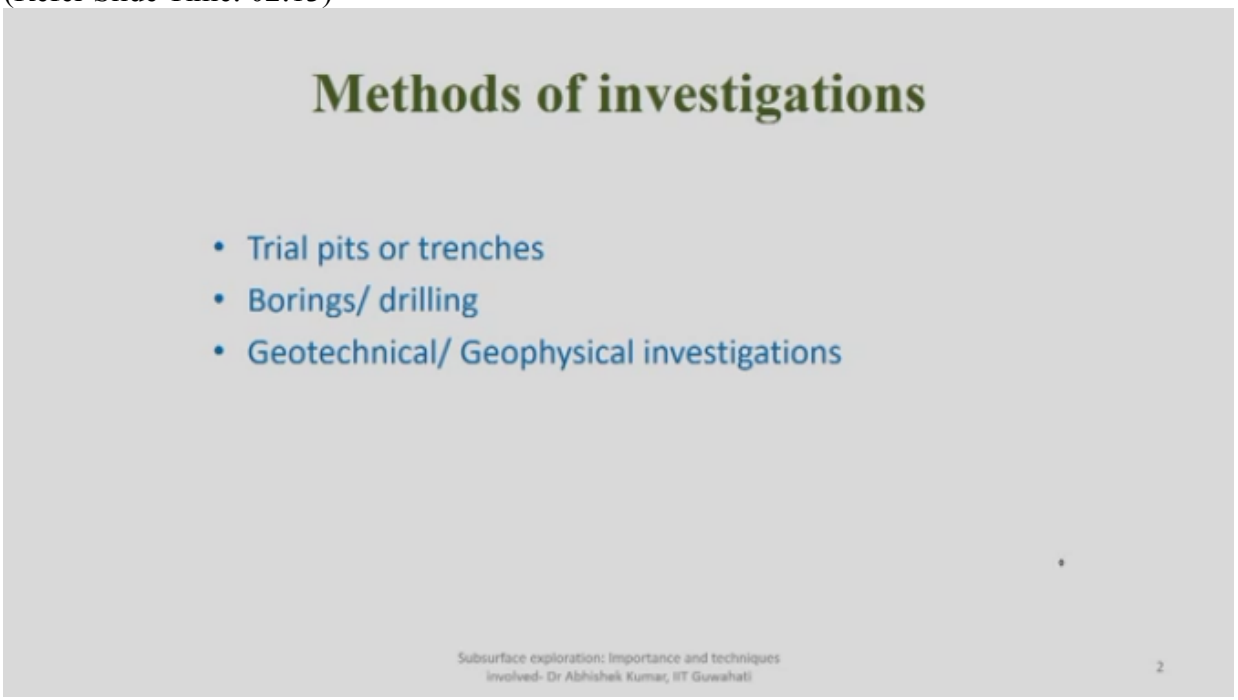
Welcome all to lecture 3 of subsurface exploration, investigation and technique involves. My self Dr. Abhishek Kumar, so in today's lecture we will be discussing about geotechnical investigation, we'll start like so far we were discussing what are the requirement, what are the needs for subsurface exploration, then we discussed once we go for subsurface exploration, what are the object is, what are the challenge is, which primarily arise at the site of interest.

Then again once we plan for investigation what are the different phases of investigation we go for reconnaissance survey, we go for study of maps, aerial photographs so on and so forth to collect the information. Informs of already existing resource is to know more about the site before you go for detail investigation.

Then we discussed about if you go for detail investigation what are the different level of investigation or types of investigation, whether you are doing investigation for existing structure, whether you are going for finding out the reasons for distress or failure of any existing structure or new structure, and third one to ensure the safety of adjoining structure, the fourth one was to find out the suitable material for constructions, what kind of investigation is required, what will be the objective of those investigations all those things we have discussed in the last two classes.

So today's lecture we will be talking about once we go for investigation, how we proceed whether, what are the different kinds of investigation, what are the different physically, what will be the different kind of investigation we can do at the site of interest, that's what we started with geotechnical investigation that is the today's topic.

(Refer Slide Time: 02:13)

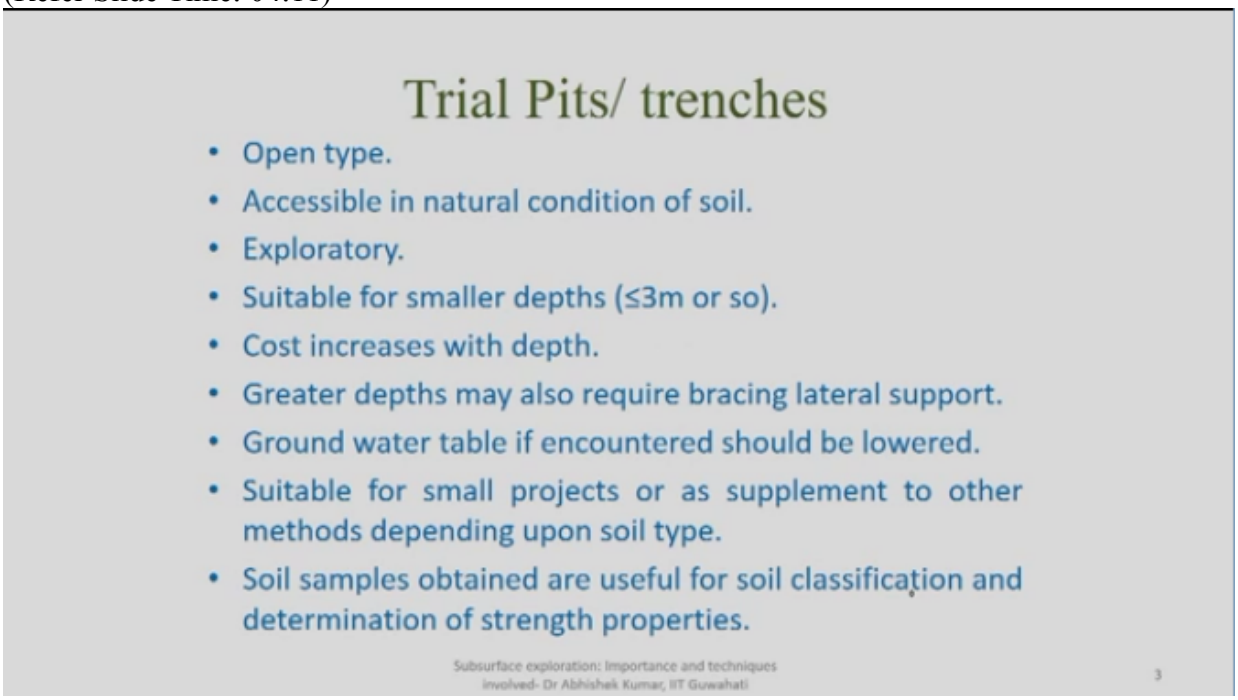


So there are different methods of investigation, though we call investigation for new structure, adjoining structure, structure under stress, but how we go for collecting the sample, how we go in understanding the soil, subsoil properties then water table and so on and so forth, so there are different ways to approach at the site for investigation, so basically we go for trial pits or trenches to know about the site, this is very preliminary way of investigating at the site, you go to the site, collect some samples, that will give you idea represented what kind of soil sample is there.

And then we go for detail investigation by means of drilling or boring at the site depending upon whether you are going for drilling in soil or boring, or whether you are going for drilling in rock, so what are different kinds of drilling and borings available then different geotechnical and geophysical methods, because you have to involve, majority of the location in addition to drilling and getting a different, different depths you have to also collect some physical properties of the soil parameters, some strength properties of the soil, so that those property you can use in whether you are going for design a foundation, whether you are going for design of any kind of support, whether you are going for a certain stability of adjoining structure, so you have to have different kind of, different properties of subsurface soil, whether it is at 4 meter, 6 meter, 8 meter depending upon what kind of soil is there, what kind of foundation is there, what kind of zone of influence is there, so you've detail of depth of investigation will vary.

So once you collect the soil sample at different, different depth, I mean how you collect the soil sample and how you can assess different soil properties that we will be discussing.

So in today's class we will be focusing on trial pits as well as trenches, and boring and drilling methods, so as we mentioned earlier,
(Refer Slide Time: 04:11)



so trial pits are basically these are the open trenches or open pits which you dug at the site of interest, you go to the site then try to find out reference, distance from nearby structure, and nearby any permanent structure it can be, building it can be, tree it can be, electric poll with reference to which you were able to actually locate the site, where you are actually going to dig and collect the soil, so these are basically open type, it's not like we need not go for any kind of small bore hole or kind of deep excavation, it's like open type you can go maximum up to 3 meter depth or so, accessible, so in this you will try to access or you will try to collect the soil sample which is existing in natural condition, because you go to the site you start excavating and then you collect whatever soil we're excavated, we try to retained in its natural condition.

Then these are exploratory method you will get to know what are the, how the soil variation because when you collect the soil sample, once you remove the soil from different depth you will be able to see what kind of certification is there, what is the depth of vegetation, visually by seeing what is the different colours even by touch you can get an idea about whether the soil is clay, equation less and so on and so forth, so it's like exploratory method, even without going for detail investigation by means of NC2 or by means of laboratory test you will get an fairly good amount of idea about the site soil, soil condition, soil depth and if possible water table if you encounter because as I mentioned earlier also this kind of investigation are more suitable for 3 meters or so depth, so if you have water table in depth which is very likely to occur in many of the locations you can even deport that part.

So you have a site which you have, you have given the chain age with reference to some nearby points, then you start digging you collect samples from different different depth by means of measuring type, every time you dig you will also represent like at this particular depth this kind

of soil, this kind of vegetation, this rock walls, gravels, cobbles and boulders all things whatever you encounter at the site you keep on making a log of that.

Have I mentioned this is more suitable for smaller depths, if you go for deeper depth the cost will increase because you have to make more arrangements in order to ensure that the soil should not collapse into the trench pits, so greater depth may also require bracing because not every time you will have cohesive soil, at times you have to retain the soil which is surrounding or which is lying on the vertical or close to vertical phases you have to retain the soil is in, in its intact position, otherwise the soil will fall and you will not be able to collect the soil sample from deeper depth, so you have to apply some kind of bracing that will be kind of lateral support, it can be in terms of shell, it can be in terms of anchors or different ways are there, if you are going for very deep trial pits.

Then ground water table if you encounter you have to report it and then you have to make arrangement which you can, you should be able to lower the groundwater table temporarily I mean as far as your investigation is going on, then it is particularly useful for smaller projects where the depth of foundations maybe 1 meter, 2 meter, 3 meter below the ground surface, so you can get an idea, okay, at that particular level where you are going to rest your foundation, you're actually getting sufficiently stable soil, sufficient stiffness of the soil is there, and then you can lay the foundation, it can also be used as supplement to other methods, so whatever soil type you are getting here that will give you an idea, that will give you some kind of indication whether same kind of soil you are getting from other test also.

So suitable for smaller project as well as supplement to other method depending upon what kind of soil is there, so that will give you, this method will give you what kind of soil is actually existing at the site, then depending upon what kind of soil you are encountering you can, and what is the strength of the soil in terms of stiffness you can collect, you can get an idea what kind of exploratory method you can go for and what, whether the resources available for detail investigation or sufficient to go for this kind of investigation at the particular site of interest.

Then soil sample which, because I mentioned earlier also because you go to the site, you actually try to dug, so every time you are digging the soil you will get a big chunk, so those sample can also be used for soil classification at that particular depth what kind of soil is there in terms of green soil distribution, in terms of hydrometer test and so on, and then determination of soil strength properties, so basically whatever soil type we are getting from trial pits or trenches you can use it for classifying the soil, you can also use it for determination of shear strength properties, because the soil whatever you are getting it is more or less in the same intact condition as it was there in actual site of interest, you are actually bringing some chunk of it, so it's like significant mass.

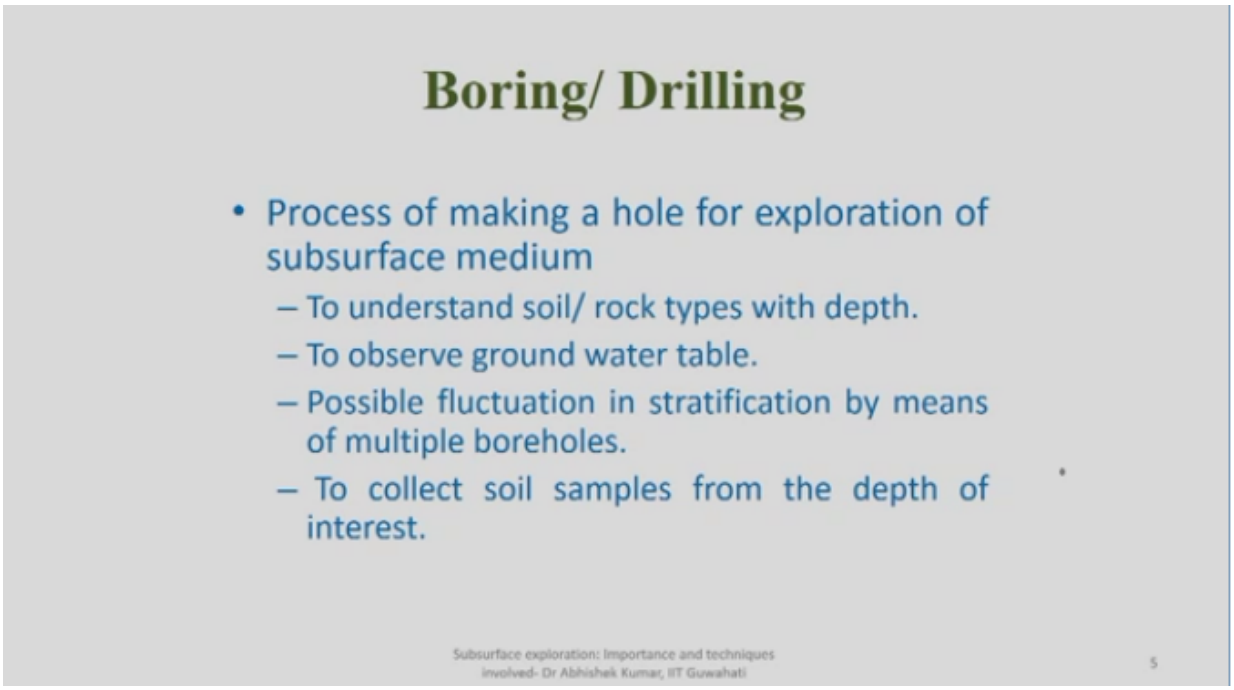
If it's in the mass you take some smaller samples, so moisture content and other parameter will remain intact as it was during natural condition, so you can use it for detail, only disadvantage here is so it's kind of investigation are selected for shallow or depth 3 meter or so, because you are actually not doing any test at the site, you are basically collecting the sample, so even you go for soil classification or strength determination you have to have detailed investigation or

detail test to be conducted in the laboratory, so this is one typical photo which has been, the reference is also given here,
(Refer Slide Time: 09:55)

Ref: http://www.archeolog-home.com/pages/content/east-sussex-g-b-iron-industry-revered-by-romans-discovered.html

so you can get an idea once you start digging what kind of soil is there at different, different layer you can see on the vertical phase, you can see some in the top layer there is vegetation and then you can see with respect to depth there is different kind of soil deposits available in terms of colours also, and whatever sample you have collected every depth you will report it like this is a particular depth from where the sample has been collected and based on inspection of the sample you can also classify whether the sample is cohesive, cohesion less, what is the strength characteristic of the soil, so on and so forth once you know the soil type, once you know the stiffness of the soil you can go for detail investigation.

(Refer Slide Time: 10:40)



Then you go for boring and drilling methods, so boring means whether you go for boring, boring we'll precisely use in case of soil sample, drilling is more commonly used when you are going for sampling in case of rocks, so both represent the process of making a hole, because once you start, you are objective of subsurface exploration is to collect the sample or to know about the soil which is available at different depth, it can be direct method, it can be indirect method, so when you go for direct method you actually try to collect the soil samples, you make a hole, the diameter of the hole can vary from side to side and depending upon what is the designers recommendation or field engineer recommendation.

General practice is to go for 150mm diameter borehole, so this is for traditional boring, of course you go for drilling you collect small diameter samples, so boring is a process by which, boring or drilling is a process by which you are actually drilling a hole or making a hole from the ground surface at different, different depths, so once the hole reaches a particular depth either by means of sampler or by means of drill bits, once it process through certain layer it will collect the soil sample, you withdraw your sampler you will be able to get the soil sample that is available at that particular site of interest, so 5 meter, 10 meter, 20 meter whatever is the depth you are doing the boring at the end you will get soil sample.

Depending upon what method of boring you are using you may have sample which is very disturbed, you may have sample which is represented, you may have sample which is you can call it as undisturbed, we will be discussing or what kind of samples are available depending upon different kinds of method to be chosen and how you decide whether a particular sample can be classified into any of the three categories, so it is particularly useful the boring and drilling it is particularly useful to understand what kind of soil, because as I mentioned earlier once you do the test you will be able to collect the soil samples, so once you collect the soil sample you will get to know what kind of soil it is there, similarly in case of rock what is the kind of rock available at different depth, it may not be possible, it may or may not be possible that at a particular depth you will have only soil sample or only rock sample, it can be

combination of those two, so depending upon what kind of medium encounter at a particular depths, you go for drilling or you go for boring, it may be possible you are going for boring and suddenly you realize your boring investigation is not sufficient to pass particular layer because it is significantly stiff, so you will replace your boring arrangement with the drilling arrangement and try to collect the sample from drilling mechanism.

And then if it again encounter soil layer at deeper depths you will go for boring otherwise you will continue with the drilling exercise, this way you can also encounter what is the ground water table, as I mentioned earlier also, majority of the location when you are going for 10 meter, 15 meter, there are 10 and 15 meter depth of exploration, majority of the location you will encounter ground water table.

Ground water table depending upon the soil type depending upon its depth, it can sometime compromise the safety of the foundation, sometime it can add additional advantage to the stability of the foundation, so depending upon which role the groundwater table is following, but it's always mandatory to represent and to indicate what is the depth of groundwater table.

Then possible fluctuation and stratification, whatever borehole you are doing and that is giving you at a particular point what is the soil type available at different different depth, of course if you do more number of borehole in the surrounding area you will be able to get an idea about how a particular soil layer is varying in lateral direction, it may not be a possible, majority of the location you will find at my sight of interest if I'm getting 2 meter, 3 meter, 4 meter, 2.5 meter, this kind of soil layers if I go away from my sight of interest maybe hardly 2 meter, 3 meter, at times you may find some soil layer or thicker in I mean the thickness is more while other soil layers are completely absent, so that will give you an idea because whenever we go for foundation we generally lay foundation on a larger area, not on 150mm diameter borehole.

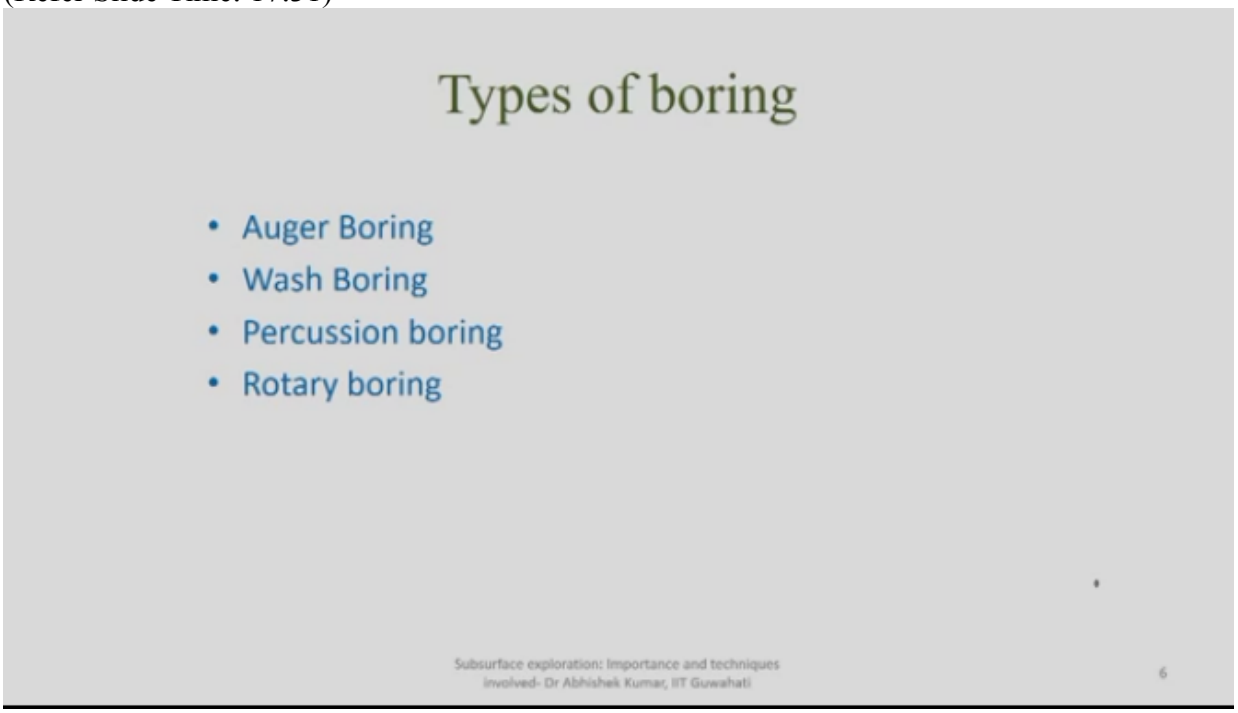
So you have to have an idea about what is the soil type at my site of interest and how it's literally varying because, because once you construct a layer foundation the load mechanism, the load has to be distributed throughout the area of the foundation plus the zone of influence, so borehole, one borehole will give you information available at that particular point of interest, but if you are doing multiple number of borehole that will give you on an average what kind of soil is available beneath the site, beneath groundwater, beneath ground level at my sight of interest and that will also give you on an average depending upon what is the cross-sectional area of the foundation, what will be the soil and how the overall soil will behave, because that's the soil which is going to take the load of super structure.

So possible fluctuation that means possible fluctuation means between two adjacent boreholes how the soil, how different soil layers are varying whether the thickness is increasing if you go from one borehole to other, whether it is decreasing, whether one soil layer is there in one borehole which is absent in second borehole and so on and so forth, so possible fluctuation and stratification by means of number of borehole.

So when we go for borehole again depending upon what kind of structure is there, what is its importance, there are guidelines which will tell you what should be the spacing of adjacent boreholes and what will be the depth of the borehole.

And the last and foremost important thing is this way you will be able to collect soil sample even rock sample also from the different depth of interest, you can collect the soil sample take those to the laboratory, you will be able to identify in terms of classification, moisture content, density, atterberg limit, strength, characteristics, even consolidation behavior of the soil you can understand if you are getting, as I mentioned earlier if you are getting relatively intact soil sample you can determine all those things if you are getting highly disturb sample you will be able to only identify classify the soil, because it depends upon what kind of, what is the extent of, what is the level of disturbance you are imparting or you are transferring to the soil sample while collection, so if it is more disturbed definitely you will not be able to use it for shear strength characteristics, because that is not to indication of whatever state the soil is existing at the site of interest.

(Refer Slide Time: 17:31)

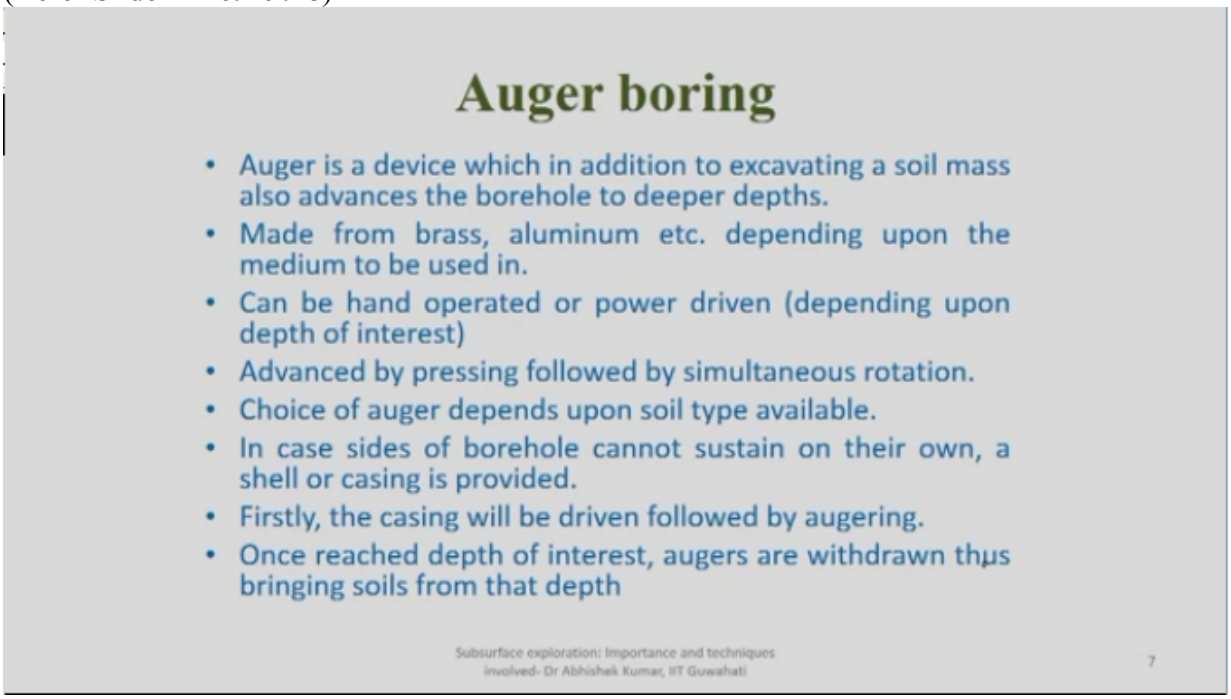


So different methods of boring are there, one is auger boring, second one is wash boring, third one is percussion boring, and the fourth one is rotary boring, there are you know four different methods, and once we go for boring because it will not be able to collect the soil sample I mean continuously throughout your depth of interest, so whenever you require some sampling to be done there are ways you can do the sampling, but on an average you have to proceed like, if you have to go for 20 meter depths you will not be able to, you will not be collecting soil samples throughout 20 meter depths, so in between every interval of soil sample collection you have to proceed with the boring, so these are the different method by which depending upon the soil, depending upon groundwater table, depending upon depth of exploration and depending upon whether sample are required you can go for different methods of boring, so that's how each of those method can be different from each other by means of the requirement of the method, by means of the soil type which will be likely to be encountered in the means of

groundwater table if it is available at the site of interest and so on and so forth, so this four are the methods.

So as you know the first method we call it as auger boring, so what is auger? Auger is actually a device which in addition to excavation of the soil mass also advances the borehole to deeper depth, so this is a device which you actually push into the ground that means you are advancing a borehole into the ground because the lower end of the hour is capable of actually excavating or scratching a soil medium, so when I scratch the medium simultaneous we are rotating so it's scratching and then considering its shape, it's also pushing into the ground, so you are doing two things, you are collecting the soil, you're also advancing the borehole, so that particular device is called as auger.

(Refer Slide Time: 19:28)



I'll show you some photograph also the augers in the next slides, so it's a device with two application, one is collecting sample and second is for advancing to deeper depth, generally again depending upon what kind of medium, medium can be very stiff, medium can be very soft it can be rock medium also, so depending upon what kind of medium you are going for detail investigation of boring, the medium, the material by which the auger is made of can vary, generally brass and aluminum augers are more commonly used, but it again depends upon which is the medium, because the toughness and the hardness of the auger should be see, the strength of the auger should be more than the medium in which you are collecting the soil sample, otherwise your auger will destroy.

It can be hand operated again depending upon what is the depth in which you are interested to collect the soil or because as you go deeper and deeper your overburden pressure your consignment will increase, so you will not be able to actually make any even indentation or impression on the soil sample, so depending upon the depth of interest, shallow depth you can go even by hand operated auger, so you keep on rotating their handles also, you keep on

rotating so it will push into the ground and concede and depending upon whether what is the arrangement for collecting the soil sample every time you rotate it, some amount of soil will be collected in the auger, so it can be hand operated as you go deeper and deeper because of overburden pressure you have to have some external source of energy which will be able to, some external source of power which will be able to actually scratch or chain out the material from deeper depth, so it can be hand operated, it can be power driven over.

So if one is interested and there are, there can be lot of videos also available with which you can get an idea about what kind of auger and how a particular hand operated a power driven auger works, and how you collect the soil sample, how you remove the soil sample, how you proceed for deeper depth, so this is like boring, once you go for sampling you remove this and then lower your sampler or the arrangement for sampling, so this is, please remember this is only for advancing the borehole work, because whatever kind of soil in majority of the boring methods you will be encountering it, it's mostly minimal to high disturbed soil, so you cannot actually use it for strength characteristics, but it is to proceed for deeper depth.

If you are going for 20 meter borehole and if you start collecting soil sample continuously it will take lot of time and it may be possible the soil layers are not varying that much significantly or that much frequently, so even one sample will be able to solve your purpose rather than going for continuous sampling in, multiple sampling in each soil layer, so that's why we go for sampling, we go for boring, so these two are separate thing but we practice it together, so we have, sample is required we'll remove the boring arrangement, will lower the sampler if boring is to be advanced to deeper depth you will remove the sampling arrangement, you will use appropriate boring method and then it will proceed to deeper depths, so it can be hand operated and power driven as I told you.

Advanced by pressing followed by simultaneous rotation, so it's like some kind of torque we are applying here, and at the lower end because it is having some mechanism which can scratch it or screw kind of arrangement, so that is actually pushing it into the ground, so when you are pushing it into the ground it will be having some kind of leaf arrangement which will collect the soil sample, so that is by default the part of the auger.

The choice of the auger also depends upon as I mentioned earlier, the choice of the material of the auger depends upon what kind of medium you are targeting for, the choice of auger depends upon what kind of soil is available, like some augers are there which are able to collect the soil sample, which are able to retain the soil sample particularly when you bring it on to the surface, because the soil is maybe vegetative soil, some soil maybe rocky soil but if you go for cohesion less soil if you bring it on to the surface many of the augers will not bring any soil sample, so those kinds of auger cannot be used for those cohesion less soil, so depending upon what kind of soil type is available at the site of interest which you can get an idea again based on the sample or once you advansive borehole from the ground surface to deeper depth, so you go for one meter depending upon what kind of soil you encounter from borehole, you will decide what the choice of auger will be required at deeper depth.

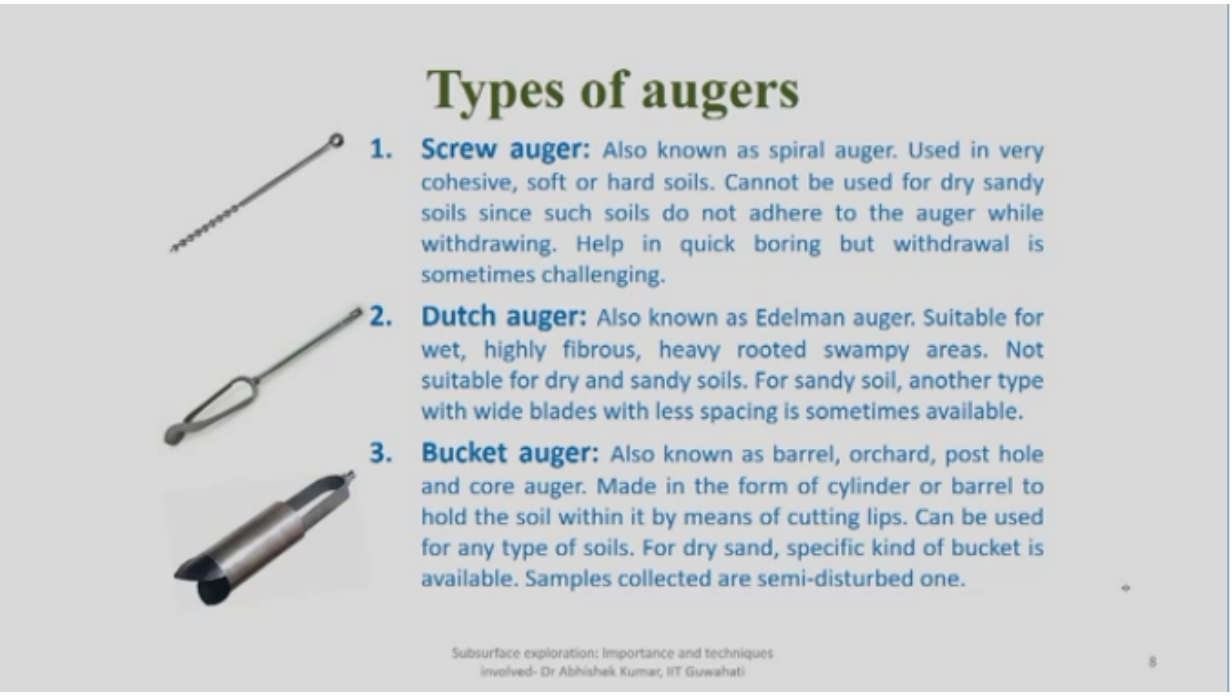
And that's how you will proceed, so every time you do some kind of sampling or boring you will get an idea on an average what kind of soil is there, there are very less chance that sudden

change in soil type like sandy soil to organic soil or some other combination, very unlikely to occur at the site of interest, so whatever soil type you are sketching at the shallow depth that will give you an indication what will be the soil, may be in the adjacent layer thickness, so that will give you again an idea what kind of soil, what kind of auger you can use it for boring purpose.

Again if at the site of interest you have cohesive soil you can very well proceed to deeper depth, but in case you are having cohesion less soil, once you reach the particular depth all the soil which is available at the site, we'll start following into the borehole, so in that case you have to have, you have to provide some kind of shell or casing which will be some kind of cylindrical casing available at near the surface maybe 2 meter, 3 meter that is the range of depth in which you put the casing that will ensure, that will provide some kind of lateral support to the soil which is available in the surrounding region and prevented from falling into the borehole, then you can proceed for boring to deeper depth, so firstly the casing will be driven, because if you don't drive the casing whatever boring you are doing it will every time will fill up with the soil surrounding it.

Once the casing is lower then you start boring exercise you remove the soil from within the casing and then you proceed for deeper depth, because then chances of soil to fall into the borehole will be almost, I mean it will be very minimal, once you reach depth of interest like 2 meter you have to, once you reach 2 meter depth and that is a target of your depth of investigation, you withdraw the auger, so each time you withdraw borehole auger soil sample will be retain on that, you bring it on to the surface soil will be there, you collect the soil that will possibly indicate what kind of soil is there and then proceed it for different depths, so that's why once you reach desired depth of interest augers are withdrawn, thus bringing the soil, so actually once you withdraw it, once you bring it, once you bring the auger on to the surface it will also bring the soil which was available at that particular interest, but as I mentioned because it is collecting or it is containing the soil by means of scratching so every time whatever soil was there you were actually disturbing the soil before it is getting contained in the auger, so though it is giving you what kind of soil is there it's not giving you any strength property, it's not giving consolidation property, it's not giving you index properties also.

And even moisture content also majority of that time changes, so it's only giving you indication about on an average what kind of soil is there.
(Refer Slide Time: 26:59)



Just to give you an example there can be different kinds of augers, to name a few we have screw auger which is also known as spiral auger, as you can see from the shape also, it's very much similar to the nail, so it does not contain any separate sampler, whatever sample will be collected, it will be collected on the phases of this spirals, so it is known as spiral auger you use in very cohesive soil or soft soil or hard soil, it does not, it cannot be used for dry sand because once you withdraw it whatever soil was content on the phases of this spirals or a lips, it will actually fall it into the borehole, so you will not, once you bring it on to the surface you will not have I mean any kind of sample, so it's particularly use for soft and hard soils and cohesive in nature, because those kind of soil can actually stick to the sides of this lips.

Cohesion less soil you cannot use it well we're drawing, this will help in quick boring because this is very quick you keep on rotating it will push into the ground, you bring it on to the surface and consider the diameter is also very small, so it will be easy for hand operator to operate it and proceed to deeper depth, but at times as you go deeper and deeper particularly for cohesive soil below groundwater table it will be very difficult to pull it on to the ground surface because of negative confection also, because you pull it and because of section which is developing at that particular depth, below groundwater table particularly in cohesive soils it will not be able to come so easily on to the surface, so this is about screw auger, so depending upon the soil, depending upon groundwater table you may or may not go for screw auger, this is particularly use for hand operations.

Second one you are having Dutch auger, so you can see here also it's the lower end you are having some assembly which is like partly twisted one, so it is particularly, it is also known as Edelman auger suitable for wet, highly fibrous, so highly fibrous is more important here because at the end you can see some arrangement which can actually hold the fibres and once you rotate it actually you're going to tear the fibres, that's how you will be able to collect the soil sample away from the parent position, so it is more suitable for wet location, highly fibrous, heavy rooted swampy areas, the previous one though you are able to penetrate you will

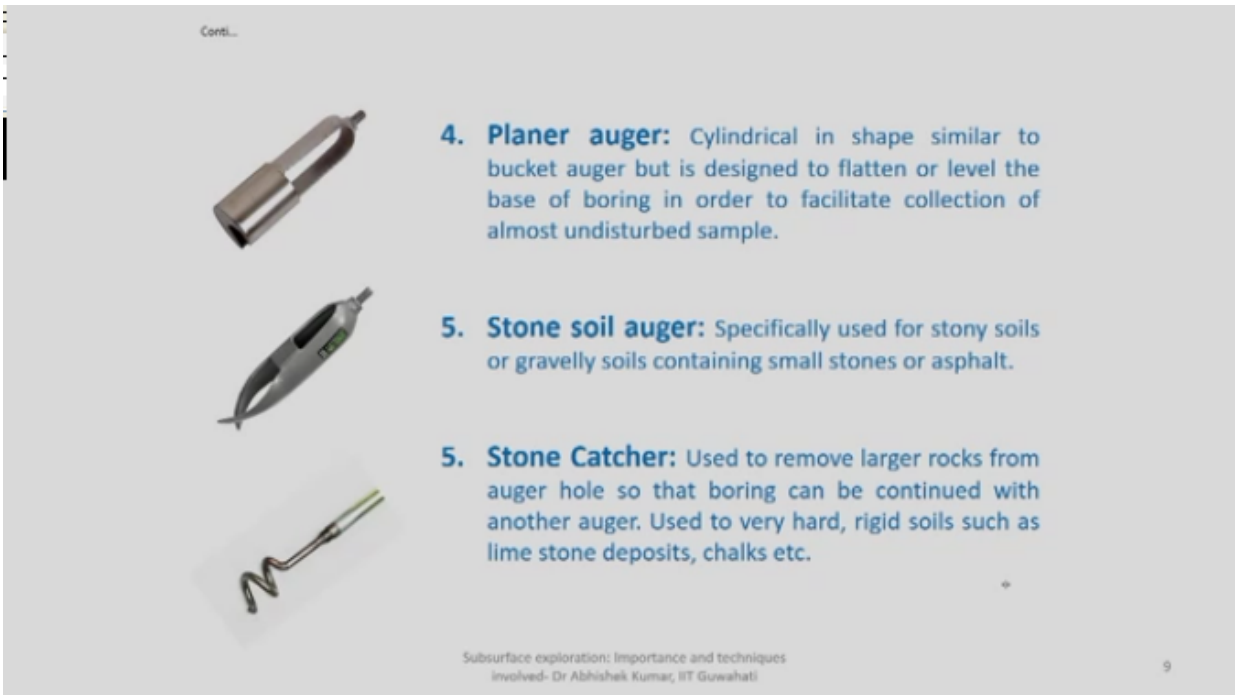
not be able to get any sample on to the surface, because once you start pulling here because of a roots it will actually retain the soil sample, but in Dutch auger as the sampler indicates, once you start rotating it will actually tear all the fibres or roots and then whatever soil sample we are collecting in this, with the inside that gap you can usually bring it on to the surface, this is particularly for heavy rooted soil.

For sandy soil another kind of auger with white blades but with layer spacing is more suitable or it sometime available, so this one again you can use it for cohesive soil particularly when it is highly fibrous or heavy rooted.

Then the third one is bucket auger, you can see here at the lower end it is having two lips, those two lips are adjacent to each other but the alignment is completely different, so whatever material one it is collecting and the second one is doing the same exercise, so once you keep on rotating every time, whatever material you are collecting the lip arrangement, and the lip assembly it actually pushing the scratch soil within the bucket which is there our weight, so this bucket auger also known as barrel occurred or post hole or core auger, because you are having a very well defined position here which can actually contain the soil, which were actually scratching, made in the form of cylinder, so cylinder or barrel is actually containing the sample whatever you are collecting or the core.

So made in the form of cylinder or barrel to hold the soil within by means of cutting lips, so at the end you can see the cutting lips which are actually scratching the material and whatever material it is scratching it will push it into the cylinder or in the barrel, it can be used for any kind of soil or dry soil specific kind of bucket is available, of course there the opening size will be significantly lesser, so that the chances of retaining the soil will be significantly higher, the soil sample which are collected from bucket auger or semi-disturbed ones, so you can use it for soil classification.

(Refer Slide Time: 31:38)



Then you are having plane auger which are cylindrical in shape similar to bucket auger you can see at the lower end here, but it is designed to flatten, this kind of auger is particularly useful, so at the end you can see actually once you rotate the opening, it's not symmetrical, so once you rotate the opening will start moving and it will scratch the material, it will give you a particular finish or level surface at the bottom ones your augering is done, so you collect the soil sample again it is also having some cylindrical space or barrel which will contain the soil sample and once whatever soil sample you are collecting at the end it will actually level it, so later on you can go for sampling, you can even collect the undisturbed, you can collect undisturbed sample because the kind of disturbance, the level of disturbance it is creating at that particular site of interest, at particular depth of interest it will be very minimal, so once you remove this auger you lower your sampler you will get it almost undisturbed soil sample, so that's how you can go ahead in coordination with sampling and boring simultaneously, you remove it then do the sampling, once your sampling is done you have to go for deeper depth, you lower this kind of auger it keeps on scratching the material, collecting the material then it will bring it on to the surface you lower the sampler.

Repeat the same exercise, so whenever there is, in order to understand or in order to get better idea about how the sampler and boring works, it's always useful to refer to some kind of bore log because it will give you disturbed sample, it will give you undisturbed sample, it will give you other properties of the soil, so disturbed and undisturbed sample when you are doing any kind of boring it will give you disturbed sample once you are collecting the soil sample it will give you undisturbed soil sample, you can take undisturbed soil sample, so index properties, moisture content, density, all those you determine laboratory based on the sampler which will give you undisturbed soil sample, this will give you soil classification again based on what kind of sample whether it is completely disturbed maybe, may not be appropriate for soil classification also, but it will help every time you do augering it will help in proceeding for deeper depths.

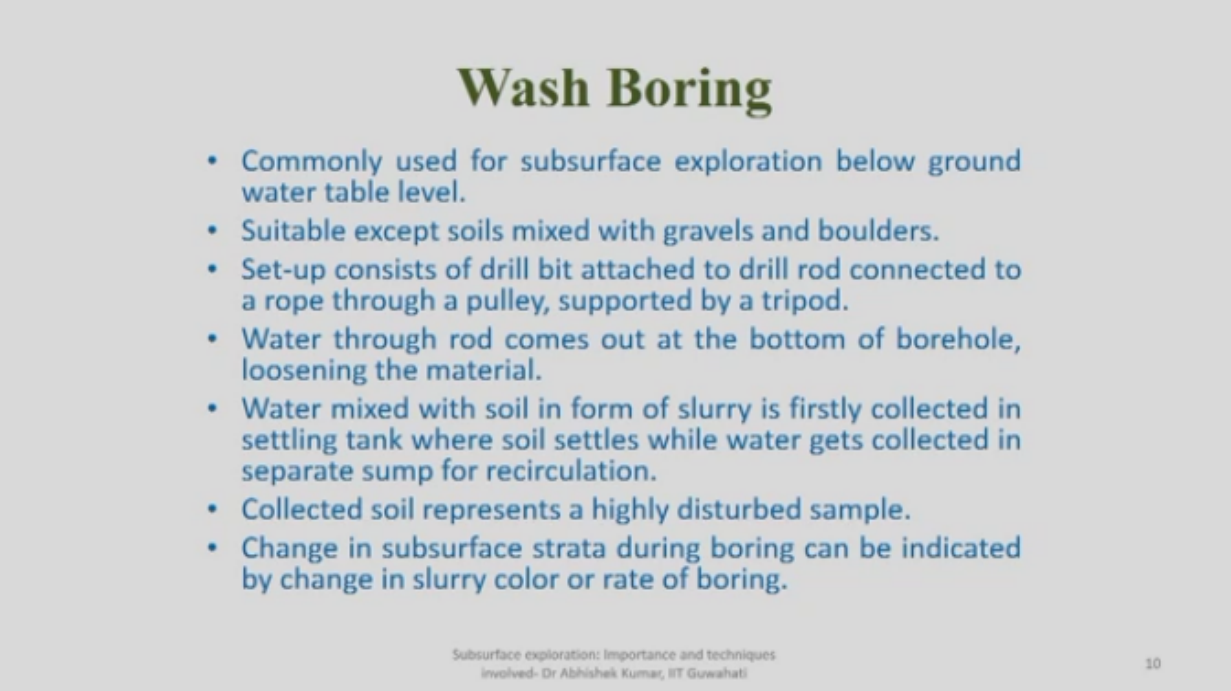
Then the fifth one is stone or soil auger, so it is particularly used when you are going for soil, but the soil is also contain of a small stones or asphalt or gravers mixed with the soil, so this as you can see the pointed ends it will actually scratch or loosen the soil, the stone material which is contain in the sample, mixed with the soil and it will help in gathering the soil sample, every time you break it on to the surface or soil mix with the stone will come on to the surface, you can bring it, you can remove it then proceed to deeper depth, again lower it and then starts scratching you proceed to deeper depth, so this is known as stone soil auger particularly use for when the soil is mixed with the gravel.

The last one is stone catcher, as a name suggest it is particularly useful to remove larger rocks from auger hole so that boring can be continued with another auger, so suppose you are doing some kind of boring maybe, since stone soil or auger or maybe the planer auger and suddenly encountered some boulder, how you proceed for other for boring, so you can use stone catcher, it will particularly scratch the material, the local boulders which is, which probably be encountering between two soil layers, scratch the material once you reach to soil layer beneath the boulder you can again replace this auger with any other augers depending upon soil type, proceed again for boring, so this is particularly useful as a name suggest, it is appropriate for whenever you encounter some larger rocks, boulders in between and you have to proceed even for boring a deeper depths.

Use to very high and rigid soil can also be used it, and such an example given is limestone deposit and chalks, so whenever you encounter these kind of deposit you can go, of course depending upon the boulder characteristics also, it may or may not be applicable to every kind of boulder and encounter at the borehole, so particularly when you are having limestone or chalk deposits you can scratch the material out from that particular borehole boulder and then once you again encounter soil type you remove it, put another sampler bore auger and then post it for boring that way, in between also wherever you require sample as I mentioned earlier also you replace you boring assembly with your sampling assembly and collect the soil sample, maybe next time I'll show you some typical bore log also, so that will give you clear indication like this is what do you mean by sample, what do you mean by different properties obtained from soil type or index properties or density and other properties, and then what is the meaning of other test, collect like bore log will basically gives you a summary of what kind of test you had done and what are the tentative, what are the possible outputs.

As I mentioned in last class also as for Terzaghi it was mentioned like whatever method you were using it is more suitable for the particular site of interest, and second thing whatever test you are doing you try to get more and more information about site and each component you are collecting at the site of interest should definitely help you in understanding about the site and have some contribution in design the foundation and other things.

So we'll get to get more clear view about the information we are getting from any kind of augering, sampling, boring, maybe once I show you some bore log, so this was about, once you go for auger boring, in addition to auger boring this was one among many types of borings that is called as auger boring,
(Refer Slide Time: 37:28)



at times you also practice for auger and shell boring, as I mentioned earlier if you have some cohesive less soil available at the ground surface you lower for some casing, and then you start doing boring by means of any of those augers.

In the second one method of boring is wash boring, it is commonly used for subsurface exploration below groundwater table, so if you have groundwater table the previous method you cannot use it because once you bring the sample, once you bring the auger on to the surface you are actually not getting any kind of soil sample, because it will be washed away by the ground water, typically it will be quite disturbed sample.

So this method you can use it suitable except for soil mix with gravels and boulders, you cannot use it with gravels and boulders because the arrangement which is defining or controlling the sampling here may not be applicable if the soil is mixed with boulders or gravel, so in this method what you do, you actually set up at the site of interest where you are going to do some borehole you put a tripod, from the tripod you actually lower some drilled rods, hollow drilled rods within those drilled rods at the lower end you will be having some kind of drill bit or yeah drill rod or any kind of arrangement which can actually scratch the material, and within that there will be a pipe which is connected to a pump, so the pump is actually forcing water through the drill rod at the bottom of the borehole, because of this water coming out from the drilled rod it is actually loosening the soil which is available at that particular depth, that's why I told you this method can only be used for soil, but it cannot be used for gravels and boulder because they are required pressure significantly higher than whatever pressure the water coming out from the drilled rod is exerting.

So this way you will be able to actually scratch the material and whatever material is scratch or loosening at the bottom of the borehole, it get mixed up with the water, so slowly this material will come on to the surface and then you collect it separately by means of some collecting thing, you collect the slurry which is water, which you had pumped through the drilled rod and

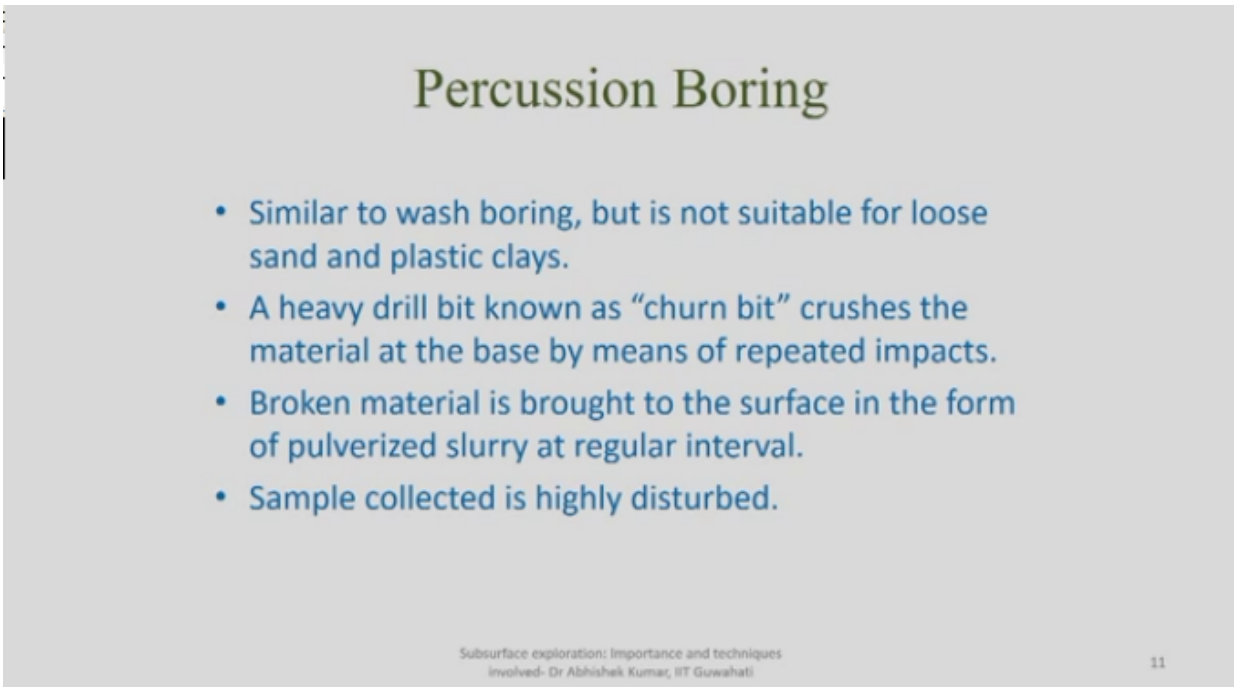
then the soil which was available at that particular depth, both are mixed you bring it on to the surface, collect it in the settling tank which will allow the soil available at that part, which was actually available at that particular depth of borehole into the settling tank and whatever water was there you send that water to some sump from which again the pump can use it and recirculate it, so water will be re-circulated but every time the slurry which comes out on to the surface is actually getting settled at particular site, at a separate location, that is called settling tank, so the beauty here is like because of the pressure exerted by the water which is coming out of the drilled rod, it is actually losing the material, the material what he actually loosen it mix with water comes up on to the surface, because water is coming out on pressure so other material will be easy to come on to the surface, collect it, so water mixed with the soil will come in form of slurry, it's first collecting in the settling tank where the soil settles while the water gets collected in separate tank for recirculation, you keep on recirculating the water, whereas the name suggest because the water, because the soil which was available at that particular depth you have now mixed with water, so this soil is highly disturbed, that's what is written in second last one, the collected soil samples are highly disturbed soil sample.

But as I mentioned earlier boring or particularly use for advancing borehole or advancing here boring exercise, so that you can very precisely and quickly reach to deeper depth and then collect the soil sample, but whatever slurry you are getting here it is possibly indicating what kind of soil is there, but in order to understand if there is change in strata, and change in soil type, and change in soil stiffness also you can understand, if there is, if you get slurry of one colour and suddenly you start getting slurry of different colour that means at that particular depth of borehole you are encountering a change in strata.

Earlier you were getting some clay soil, now you are getting sandy soil or maybe soil mixed with some organic material or soil, I mean dark material light kind of visual inspection, if you are getting, so any kind of change in strata or slurry that will indicate like your boring has penetrated some deeper depth, now a different soil strata.

And secondly as I mentioned here though the water pressure which is actually loosening the material is constant, it may be possible at certain location you are able to penetrate deeper depths quickly, while in certain location even for the pressure, water pressure remains constant, your rate at which borehole is progressing will reduce or will increase, which is also an indication of maybe you're encountering stiff material, you're encountering soft material, so two things are there whenever there is a change in slurry of the colour and whenever there is a change in the rate of progress of boring, so these two will indicate that you are encountering some different kind of soil strata which was not there previous to this, so this is about wash boring.

(Refer Slide Time: 42:44)

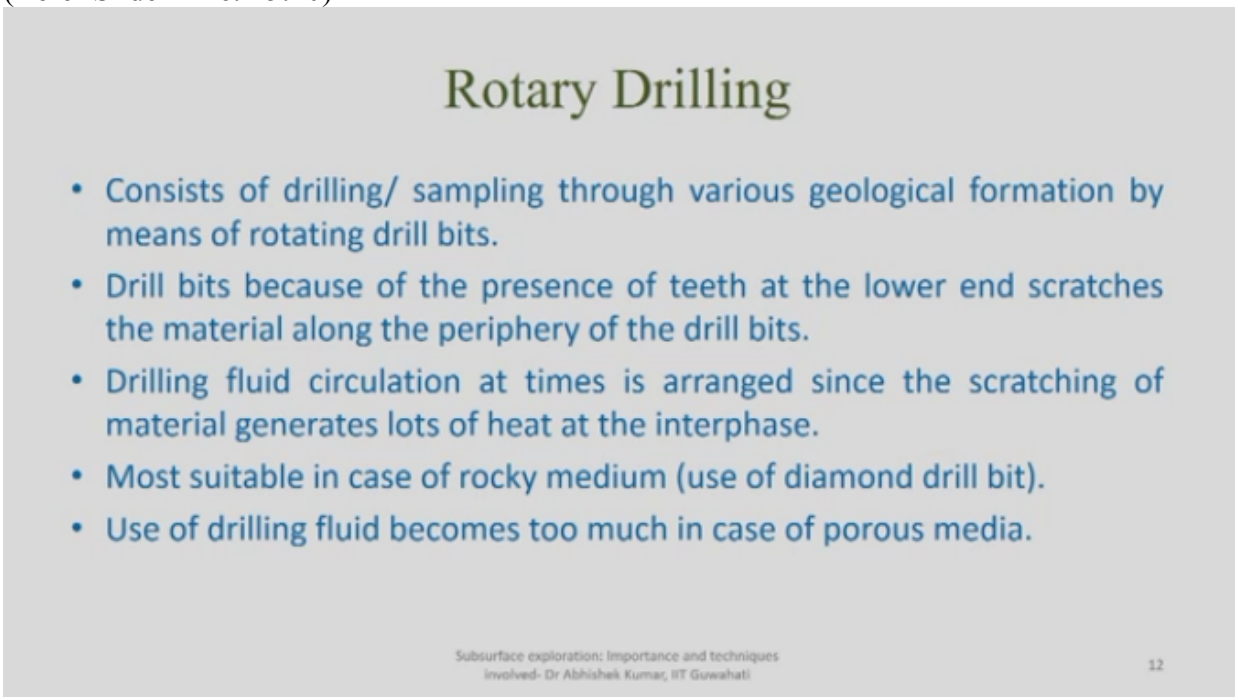


Then you have percussion boring, as I had mentioned earlier also, so wash boring particularly you can use it in case of soil where the water exerted by the pump, it's efficient enough to lose the soil and it will mix and bring it on to the surface, but it may not be applicable for any kind of medium particularly for gravels, particularly for rocks, so in that particular case you have to go for percussion boring which will actually, the way of bringing the material on to the surface will remain same like here also in percussion boring also you will mix up the material with water and then you will collect at regular interval you will collect by means of some bucket or some kind of barrel from the depth of the bore on to the surface, so there is similar to wash boring but it is not suitable for loose and plastic material, so what you do here actually a heavy drill bit called a churn bit, you can, I show some photos also maybe next time, so you can actually dropping those churn bit from particular depth what it will do? It will actually crashed the material which is available at the bottom of the borehole, once the material is getting crushed lower, there is water also, so the material will mix with water and make some kind of pulverized slurry, that pulverized slurry because otherwise if you don't put water, whatever material you are breaking it will remain or it will stick to the bottom, it will be difficult to bring it on to the surface, so that's why you are also putting some kind of slurry, it will bring the material on to the surface at regular interval.

So first because of impact load by the churn bit you are actually crushing the material, then the material during this exercise also mixed up with the water, then you lower some barrel which will or kind of bucket which will actually fill up with this pulverized slurry, it will bring on to the surface, so more material will get on to the surface, and the arrangement itself that's once the bucket is filled up most of the material will be there, but water will be drained out, so that later on once you go for deeper depth you need not put more and more water again and again at that frequent interval, so water is getting recirculated here because you are not bringing it on to the surface but the material which is actually getting crushed or the material which was actually broken because of the impact load by churn is actually bring it out on to the surface, so that's

how if you are encountering stiff material, when you are encountering rock medium, gravel medium you can proceed for deeper depth.

Again as you can observe here, the soil sample where you were collecting based is I mean it's based on actually impact load, so it's consider as highly disturbed soil sample, so this is about percussion boring.
(Refer Slide Time: 45:20)



Then rotary drilling, it consists of drilling, so drilling means you will be having some kind of drill bits which will be like diamond bits or titanium bits also available depending upon which medium you were drilling it, so at the end of these bits there will be some kind of tools or material which is, which can actually scratch the material, so this is particular use when you were collecting the soil sample or rock sample through different geological formation by means of rotary drill bits.

Drill bits because of the presence of teeth at the lower end, so you will be having some kind of drill rod, a smaller in diameter but some kind of pointed arrangement will be there like teeth which are actually once you rotate your drilled rod, those teeth will actually scratch the material, same thing doing at very faster rate, it will actually scratch the material from the periphery and whatever material was there inside the periphery it will be contained in the drilled rod or the drill bit and then you can bring it on to the surface, so that will be kind of sample. So drill bit because of the presence of teeth at the lower end, it scratches the material along the periphery.

Now you can see like because once the drill bit start rotating there will be access amount of heat generated along the periphery, so you have to have some kind of fluid circulation at times, otherwise the temperature will be significantly high and it can cause other problem.
.

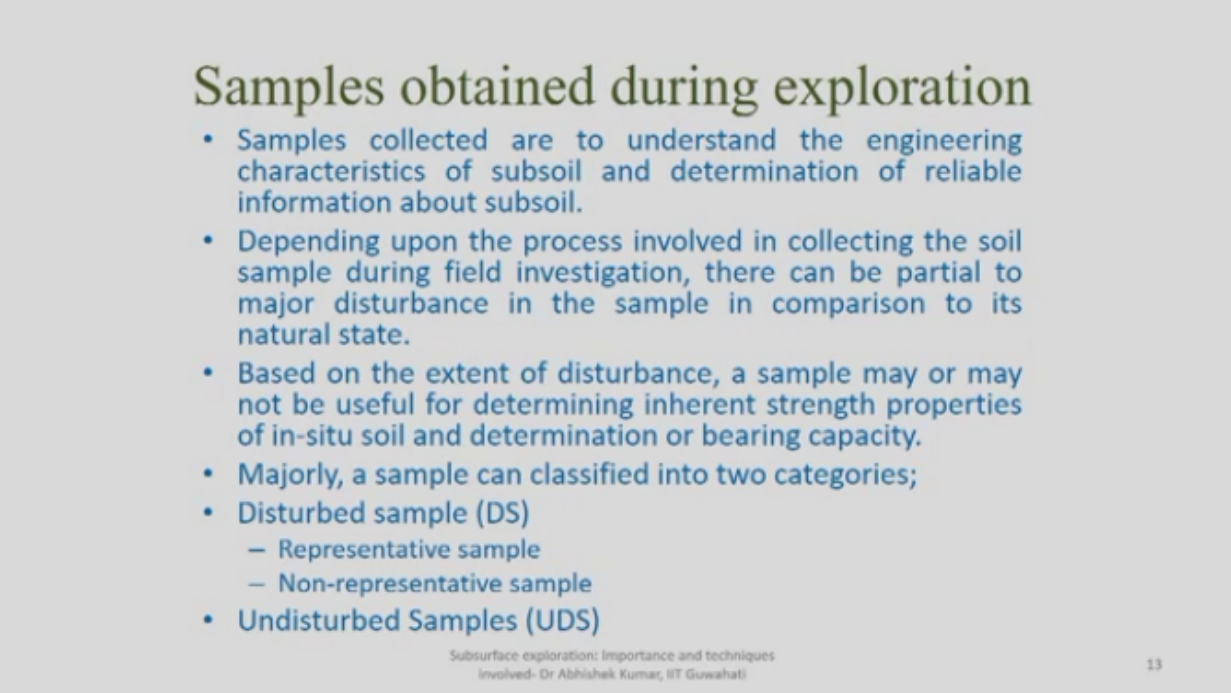
So drilling fluid circulation at times is arranged, since the scratching of the material generates lot of heat at the interface, interface means between the drill bit and the surrounding medium, there will be lot of heat, so in order to minimize it, in order to avoid any complication at later stage there will be some circulation of drilling fluid, it is particularly used for rocky medium where you cannot, the traditional method of sampling you cannot use it because of the mechanism may not work because medium is comparatively stiffer, the method which you are using for sampling in case of soil may not be applicable here, so this is more useful for rocky medium, particularly more common is use of diamond drill bits, if anyone is interested you can actually again look into different bits, they also come with some numbers also.

.

Use of drilling fluid becomes too much in case of porous media, so if you have some porous media lot of drilling fluid will go waste, it will actually flow into those cracks or openings which are available in the porous media, so you have to be little bit careful once you are drilling, once you are doing this drilling exercise in porous media, okay.

Now so far we were discussing about different kinds of method by which you can actually proceed,

(Refer Slide Time: 47:58)



by which you can actually lower or by which you can actually advance your boring exercise, depending upon whether you are talking for soil where you can actually post or logger into the soil and collect the soil sample, other end as you go deeper and deeper because of overburden confining pressure it may not be applicable, similarly if water table is shallow or it may not be able to collect the soil sample from auger boring for a soil which is available below ground water table, so you go for wash boring, then the material available is of rocky medium or gravelly medium, or wash boring, the pressure induced by water to the rock may not be sufficient to breaking it or to disturbed it, to bring it on to the surface, so you go for percussion boring, percussion boring gives you high disturbed soil sample, so you go for rotary drilling, so all those are different methods by which actually you are closing or you're advancing a

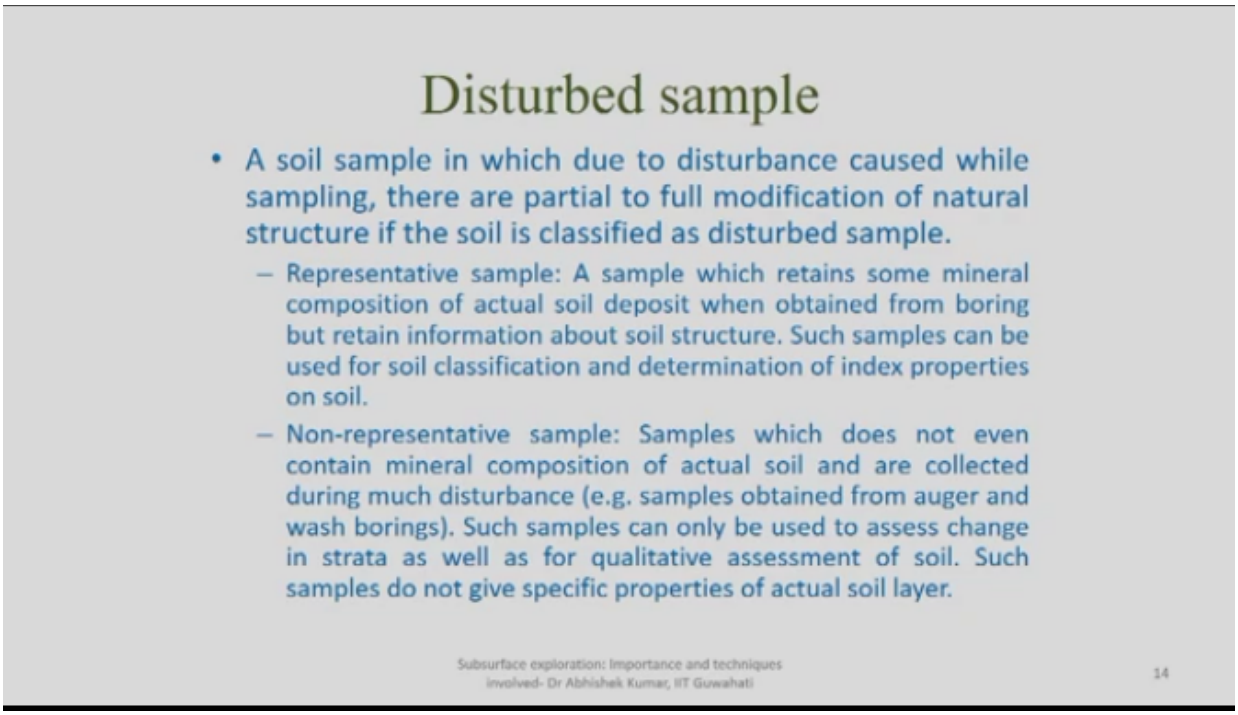
borewell at different different depths, so that at each time you find change in strata, or change in stiffness of medium you collect the soil sample generally practice, otherwise it's specified by the designer, it's like every 1.5 meter interval you collect a soil sample, whether the soil medium remain same, whether the soil medium changes also, but in order to reach that 1.5 meter interval you have to have some arrangement which can actually advance your borehole quickly, you can go there you can collect the soil sample then again do the boring exercise, same thing which I have been discussing earlier also.

So overall whether you are going for auger boring, whether you are going for wash boring, whether you are going for percussion boring, whether you are going for any kind of sampling also, each time you are getting some kind of soil at the site, so that is like you are collecting the sample whether the sample can be called as disturbed sample, whether the sample can be used to determine the index property, site classification, strength properties, physical properties, consolidation behavior, whether can you categorize or whether can you quantify each of this parameter from every soil sample, you are getting from sampler also, rotary drilling also and wash boring also or not, so in order to understand that you have to understand the soil sample whatever you are collecting, whether the soil sample can actually be used or it cannot be used for determination of this properties, so that's why this slide is about the samples obtained during exploration.

The soil sample collected are to be understood, to understand the engineering properties of the sub soil and determination of reliable information about the soil, depending upon the process involved in collecting the soil sample during field investigation there can be partial or major disturbance like in case of our, like in case of trial pits whatever disturbance you were doing it is minimal disturbance because within the chunk you might find some representative or minimal disturbance soil, you can use it for determination of engineering property, but if you go for wash boring, the kind of disturbance you are doing at the site of interest or at the borehole, depth of the borehole it is too much, so you cannot call that sample which is bringing on to the surface by means of slurry to be used for determination of engineering properties, so that's why I'm telling depending upon whether there are partial or major disturbance, the sample it will be decided whether sample can be used or cannot be used for determination of different properties of soil which is available at that particular depth.

So based on the extent of disturbance this sample may or may not be useful for determining the inherent strength properties of in-situ soil and determination of bearing capacity. Majorly a sample can be classified into two categories, one is disturbed sample we call it as DS particularly when we refer to bore log, again in disturbed sample you are having representative sample and non-representative samples.

(Refer Slide Time: 51:55)



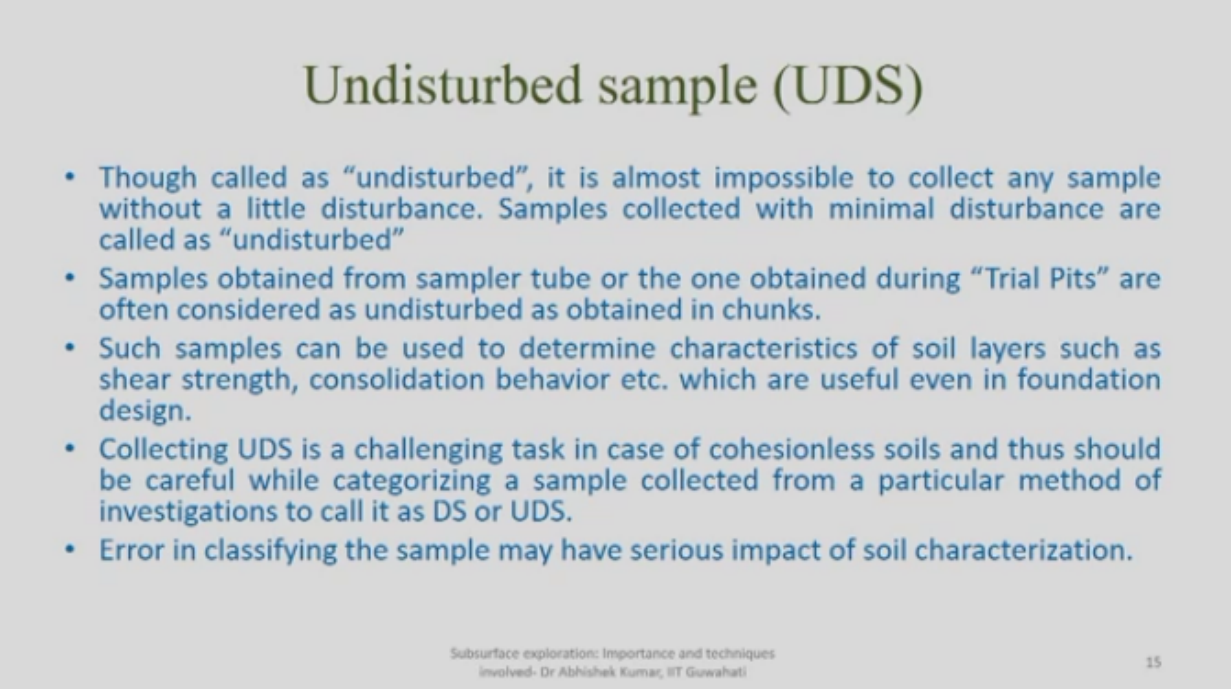
And the next one is undisturbed sample or UDS, so when we go for disturbed sample, soil sample in which due to disturbance caused by sampling there are partial to full modification of natural structures, if the soil is classified as disturbed sample, so if the soil is during the way of collection the soil has undergone disturbance so that even the soil structure is not remain same as it was there in natural condition you call it as disturbed sample, again you call it as representative sample when a sample which retains some mineral composition of actual soil deposit when obtained from boring, but retain information about sub soil structure, so some composition about mineral, some composition about soil structure both are contained in the soil sample as it was there in the natural condition, the soil will be called as representative soil sample, so such sample you can use it for soil classification, gain side distribution, hydrometer analysis you can do it and see on analysis, so you can do soil classification determination of index properties also you can do it on representative soil sample, makes sure the mineral composition and soil structure remain same as it was there in natural condition.

If it is not then you call it as non-representative soil sample which is like sample which does not even contain mineral composition of actual soil and or collected during much disturbance as collected during auger and wash boring, so you call it as non-representative because those are completely mixed with water, and bring you on to the surface you will not be able to get any idea about what kind of soil classification it is, what is the index property of the soil, because it is mixed and it is coming after lot of disturbance, it might be possible it will mix with, it may contains some soil sample even from shallow or depth while bringing on to the surface, because finally the soil is coming in mixed with water, so it may be possible it mix with some composition of soil from shallow or depth, so that kind of soil sample you can use it, you call it as non-representative soil sample.

Such kind of soil sample can only be used to understand change in strata as we discussed earlier also, as well as for qualitative assessment of the soil, qualitative assessment means the soil is

stiffer, the soil is lose, soil is partially stiff, the soil is intact, you can get an idea about that qualitative assessment, but you will not get any idea about quantity, what is the classification, what is the bearing capacity, what is this consolidation behavior, such sample do not give specific information about the soil, because but it will be useful when you want to quickly progress the borehole to deeper depth, so these are called as, so one way you have advantage, you can quickly proceed for deeper depth, other side you have disadvantage because the sample you are getting it is highly disturbed, you cannot actually quantify the information you are getting from there, then you are having undisturbed soil sample.

(Refer Slide Time: 54:43)



So though called as undisturbed, it is almost impossible to collect any soil sample without any disturbance, because you are collecting so you have to impart some kind of disturbance into the site, this is particularly useful when you are going for any kind of sampling, so sample collective is minimal disturbance are often called as undisturbed, so there are ways you can call like what level of disturbance can be called as undisturbed what level of disturbance can be called as undisturbed particularly it is refer to what kind of strength you are generating in the soil.

So sample obtained from sampler tube and the one obtained from trial pits, so sampler tube like every time you collect the soil sample you remove your boring assembly, you lower your sampler, those kind of sample will be called as representative undisturbed sample or the sample with minimal disturbance, and the second one the chunks you are getting from trial pits, you can call it, you can call those also as undisturbed samples.

So such samples which are known as undisturbed soil sample or UDS even you refer to a borehole, you will be able to understand from bore log also at which particular depth you had collected undisturbed sample it maybe because of sampler, or it may be because of some other arrangement, and what depth you have collected disturbed soil sample, so disturbed soil sample

will actually not give you any kind of index property, but undisturbed soil sample will give you all those property which are also listed out in the bore log in front of each depth and soil type, so such sample, the undisturbed soil sample it can be used for determination of strength properties of the soil to understand the consolidation behavior of the soil, and further those can be used in settlement assessment for foundation design for bearing capacity assessment even for, so there will also be, and that will also perturb very important role when you are going for investigation for existing structure which are going any kind of distress.

So collecting undisturbed soil sample is a challenging task in case of cohesion less soil, and thus one should be careful when categorizing a sample collected from a particular method, there might be a method which may not give you undisturbed sample and gives of sand but as per the agency which is responsible for collecting the soil sample, if the agency is saying it is undisturbed soil sample, but the method used is not representing, is not capable of collecting undisturbed soil sample so you have to be little bit, you have to be very careful whether the agency reporting method is able to collect the undisturbed soil sample for the kind of soil we are targeting for, because if you underestimate, if you commit mistake in indiscriminating whether it is actually undisturbed sample or represent disturbed sample that will help in or that will cause error in classifying the sample and we have serious impact on soil characterization bearing capacity, dimension and settlement analysis, so we have to be very careful first of all what kind of methods.

So overall in today's class we discussed about once you know that particular site based on preliminary investigation you found that site is suitable for kind of project, you go for detailed investigation, detailed investigation means you go for trial pits if it is shallow or you have to get an idea about what kind of soil is generally available at shallow or depth, so that depending upon the soil type you can select which kind of method to be used for detailed investigation, so if it is test pits and more over it will give you some kind of undisturbed soil sample at the site of interest.

Then you go for boring, so depending upon what kind of soil, what is the condition of ground water table and whether it is, whether you have to collect soil sample you can go for different methods of boring even if you are going for auger boring, depend upon whether the soil is cohesive, cohesion less, whether it is mixed with roots, whether it is the soil mixed with gravel you can go for different kinds of augers, once different then you have wash boring, percussion boring, rotary boring, so every time you are collecting the soil sample so depending upon the method used you can get an idea what will be the level of disturbance created in the soil, and depending upon that disturbance you can classify whether the soil will be disturbed or undisturbed, so that the properties you are getting, the qualitative or quantitative assessment whether those can be used for understanding the soil and its characteristics, so this is about that today's class. Thank you all and in a coming slide we'll be discussing more about detailed investigation and sampling. Thank you very much.

CENTRE FOR EDUCATIONAL TECHNOLOGY
IIT GUWAHATI
PRODUCTION

HEAD CET
Prof. Sunil k. Khijwania

Officer-in-Charge, CET

Dr. Subhajit Choudhary
CET Production Team
Alphul Gogoi
Bikash Jyoti Nath
CS Bhaskar Bora
Dibyajyoti Lahkar
Kallal Barua
Kaushik Kr. Sarma
Mriganka Borah
Queen Barman
Rekha Hazarika
Rajib Mahapatra
Sanjib Phukan

CET Administrative staff

Arabinda Dewry
Swapan Debnath