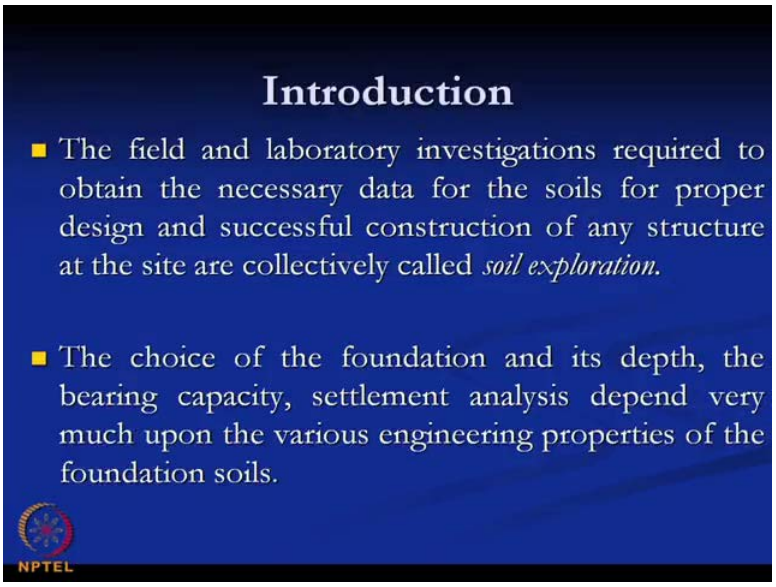
Advanced Foundation Engineering
Prof. Kousik Deb
Department of Civil Engineering
Indian Institute of Technology, Kharagpur

Lecture - 2
Soil Exploration

So, this is the second lecture of this course and this is the first lecture of module one that is soil exploration. So, before in first class as I mentioned that it is very difficult, very important to know the soil behavior of the soil or the properties of the soil for design of the foundation. So, you should know what the property of a particular site where this foundation has to be constructed, so in that way you have to go for the field test as well as the laboratory test. This collectively, all these test and methodology that will be discussed in this module one that is soil exploration.

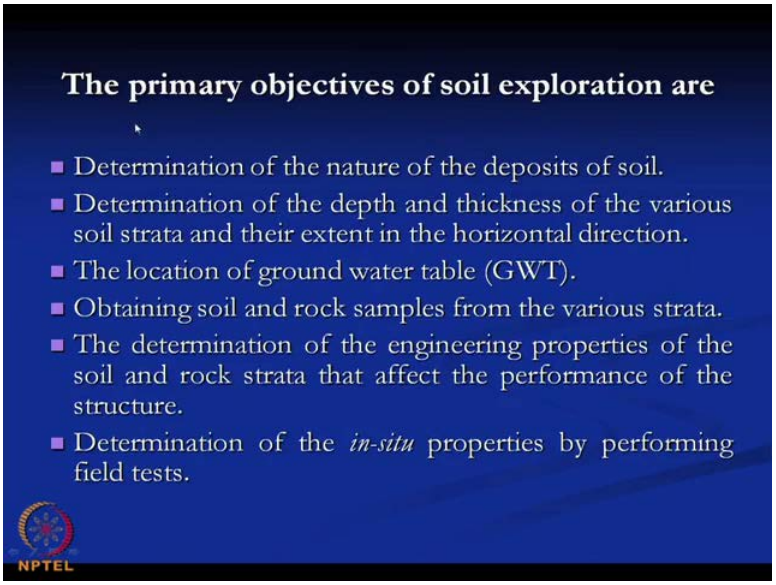
(Refer Slide Time: 01:11)



So, before we start what is soil exploration that should know the definition obviously of this soil exploration the field. Laboratory investigations required to obtain the necessary data for the site for proper design and successful construction of any structure is collectively called as soil exploration. The choice of the foundation and its depth the bearing capacity settlement analysis depend very much upon various engineering properties of the foundation soils.

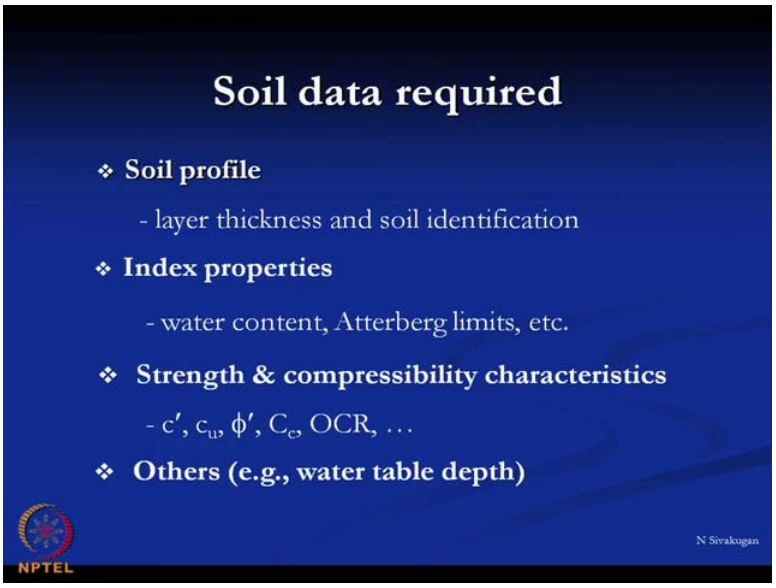
So, you should know the various engineering properties of the foundation soil before we start the design of the foundation soil. As I mentioned the strain property that means c 5 is a very important properties for the foundation design of important properties of the soil for foundation design. Similarly, for settlement calculation, that consolidation property of the soil is also a very important properties that you should know for the foundation design.

(Refer Slide Time: 02:16)



Now, the primary objectives of soil exploration are determination of the nature of the deposits of soil determination of the depth and thickness of the various soil strata and their extent in the horizontal direction. So, what is the depth and what is the thickness of the various soil strata, and that is very important for any foundation design. The location of ground water table because ground water table also play a very important role 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 and determination of the in situ properties by Performing field tests.

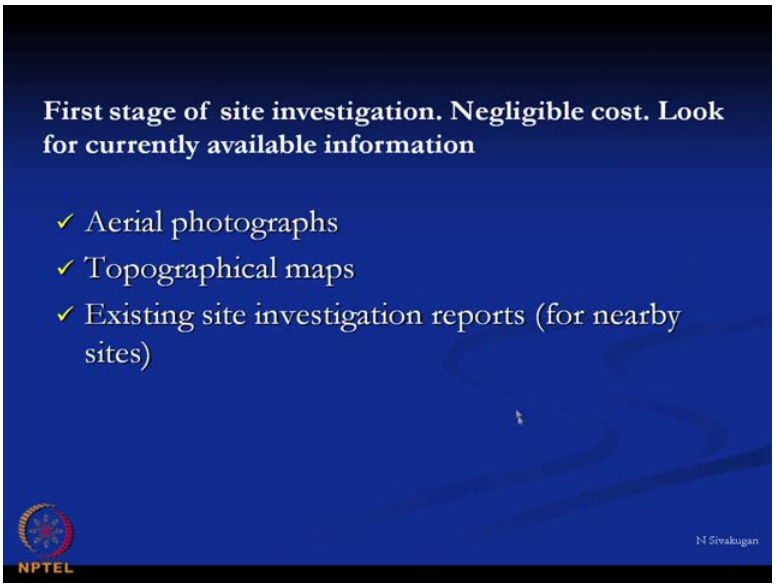
(Refer Slide Time: 03:05)



These are the objectives of a soil exploration, now before we go for the soil exploration you should know what soil data required are. So, data is required is mention the soil profile that means the thickness and soil identification that is important in the index properties index properties. The first lecture mentioned following property like water content and Atterberg limits extra in strength and compressibility characteristics are c dash collision. Then, collision, and collision of soil phi dash sectional angle or internal friction angle of the soil angle, then C c compression in this and OCR over consolidated ratio. These things you should know then other is a location of the water table depth that you know where it is located.

Then, first stage of site investigation, so for the look for the currently available information what are the reformation available before we start as a soil collision aerial photographs. If it is available, you collect that and topographical maps if it is available and existing site investigation reports for nearby sites. If any nearby site exists, site of investigation reports is available that also we collect all these things, collect all these things before you start a soil exploration.

(Refer Slide Time: 04:10)

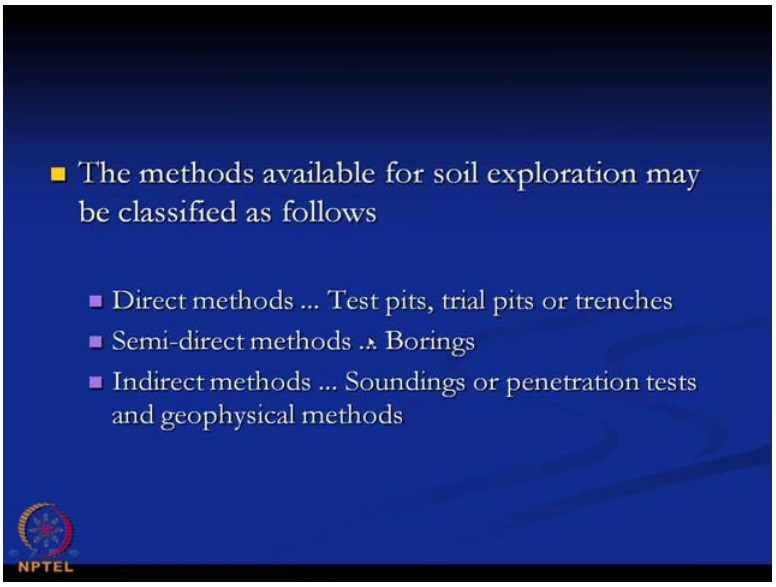


(Refer Slide Time: 04:46)

Then, first we will go for a site reconnaissance, so we will go for a preliminary survey of the land of site. However, look under the soil exploration and we look at over the site access, first you have to need the access of the site for from equipment used for soil exploration we look at the site access. Then, the topography of the site, site geology and condition of adjacent structures, so if structure is very close to the soil exploration site. Then, you have to take some precaution because during the soil exploration when noise will be there some disturbance will be there. So, if that affect that structure in have to get

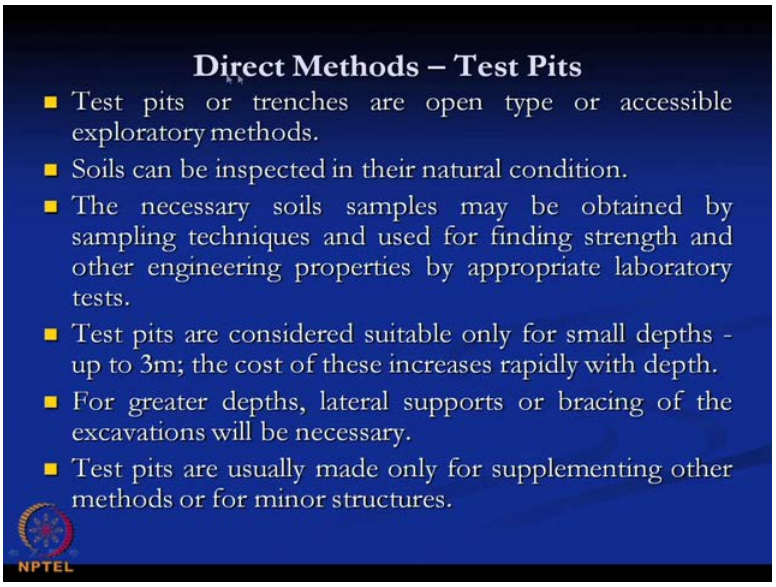
the equation for that structure, so that conditions of the structure that will be study nearby location of the site.

(Refer Slide Time: 05:51)



Then, the methods available for soil exploration may be classified as follows the direct methods, semi direct methods and indirect methods. Then the direct methods, which is a test pits, trail pits or trenches, then semi direct methods that is borings indirect methods soundings or penetration tests and geophysical methods, so one by one explain all the methods.

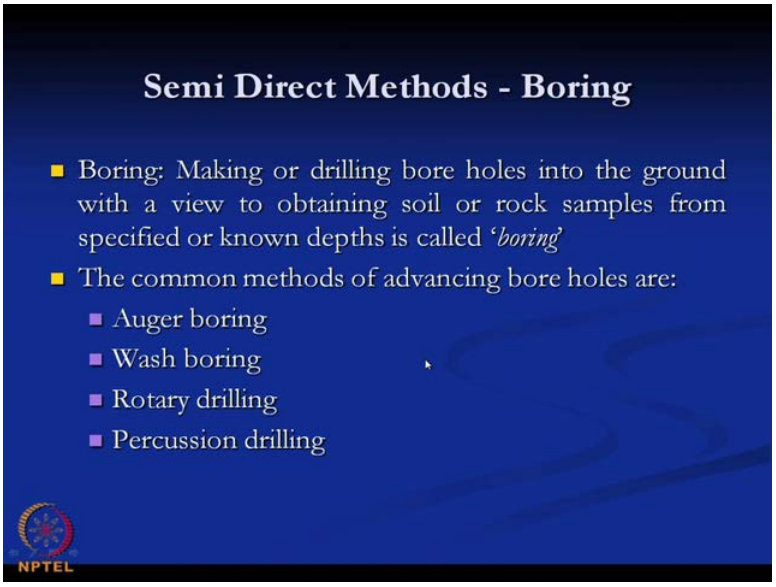
(Refer Slide Time: 06:21)



Then, the direct method of the test pits test pit or trenches are open type or accessible exploratory methods, which means open trenches or open pit cost of level of foundation from where you collect the soil sample. So, that means coil 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.

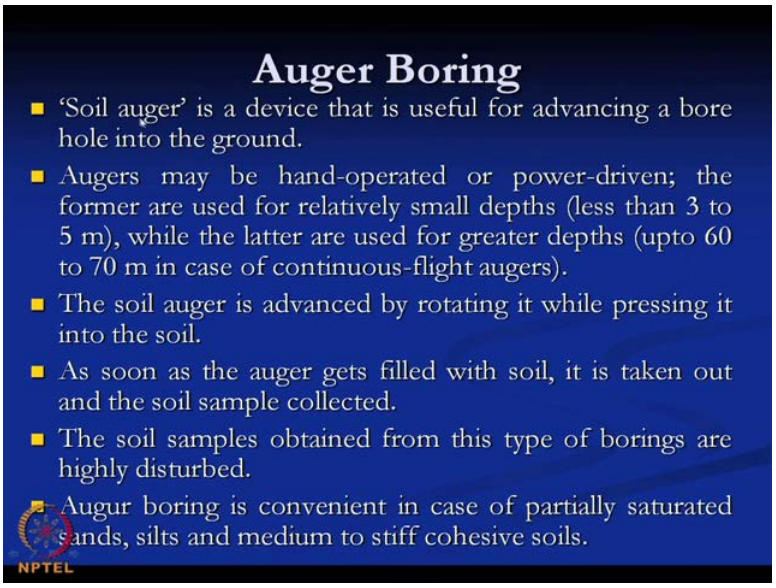
Test pits are considered suitable only for small depths up to 3 meter and cost of these increases rapidly with depth, so this type of direct methods by tests pit trenches. It is suitable for very small depth up to 3 meter, because you have to consolidate trenches up to lower vary place the foundation for greater depths, lateral supports or bracing of the excavations will be necessary. So, lateral support of bracing excavations necessary if its depth is high also cost will increase incase rapidly for a higher depth, so test pits are usually made only for supplementing other methods or some minor structures.

(Refer Slide Time: 07:56)



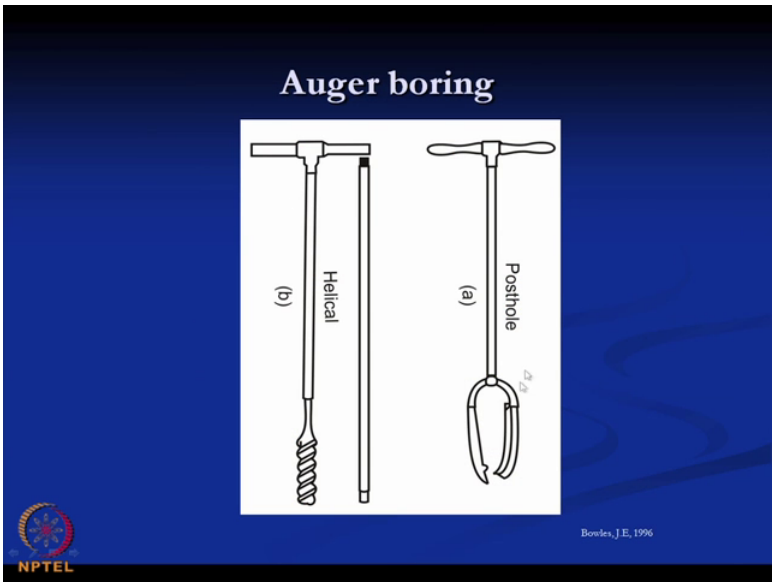
Now, semi direct methods or boring are making or drilling bore hole into the ground with a view to obtaining soil or rock samples from specified or known depths is called boring. Now, common method of advancing bore holes are auger boring wash boring rotary boring and percussion drilling.

(Refer Slide Time: 08:18)



Now, what is auger boring now the soil auger is a device that is useful for advancing a bore hole into the ground.

(Refer Slide Time: 08:29)

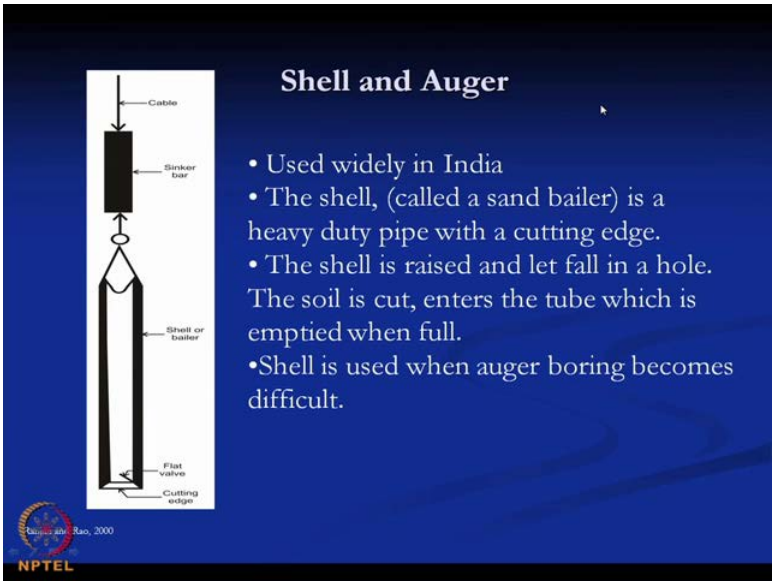


This is a technical figure of the anger boring augers, so this is a posthole of auger boring and this is a helical auger and this is a rod. It can be attached here to increase the we can reach up to the required depth, but length of a auger we can increase by putting this rod here. Then, auger may be hand operated or power design the hand operated augers are

used for relatively small depths less than 3 to 5 meters while the power driven are used for greater depths up to 60 to 70 meters.

In case of continuous fight augers the soil auger is advanced by rotating it while pressing it into the soil as soon as the auger gets filled with soil it is taken out and the soil sample collected, the soil sample obtained from this type of borings are highly disturbed sample. It is here the sample are greeting, which is very highly disturbed auger boring is convenient in case of partially saturated sands sits and medium to stiff cohesive soils a next type of soil exploration.

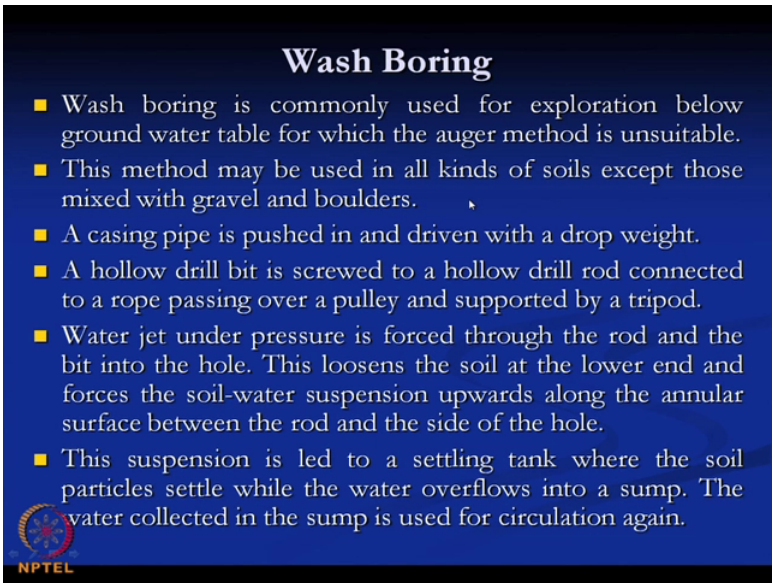
(Refer Slide Time: 10:01)



Next type of soil exploration boring technique is shell and auger, so this is the auger and this is typical shell and auger photograph so it is used widely in India the shell called as a sand bailer is a heavy duty pipe with a cutting edge. The shell is raised and let fall in to the hole, the soil is cut enter into the tube which is emptied when it is full that means which is the cutting edge and this is the heavy duty shell. So, that is shell is taken up and then which is falling into the ground, so this is a valve, I mean a valve open and the soil enter from here into shell.

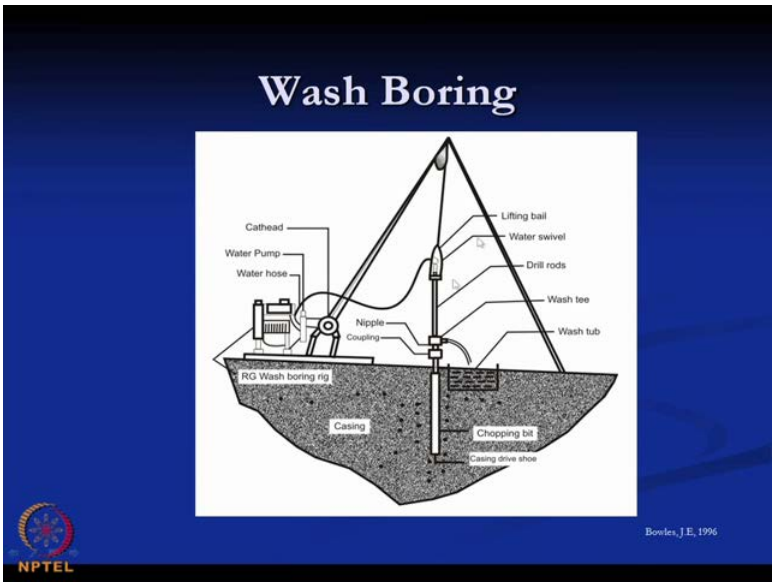
Once it is enter valve is close cannot go there, so in this shell is fill by the soil then it is taken out and then soil samples are collected. Then, again it is put into the bore the shell is used when auger boring becomes difficult while auger boring is difficult, then this technique is used.

(Refer Slide Time: 11:23)



Next one is the wash boring and a wash boring is commonly used for exploration below ground water table for which the auger method is unsuitable. So, that as mention that auger boring is suitable for partially saturated soil if the soil is completely saturated on below the water then auger boring is not a suitable method. So, in that case we will go for a wash boring this method is for all kind of soil except those mixed with gravel and boulders a casing pipe is pushed in to and driven with a drop. So, casing pipe pushed into a soil then it driven with drop, the hollow drill bit is screwed to a hollow drill rod connected to a rope passing over a pulley and supported by tripod.

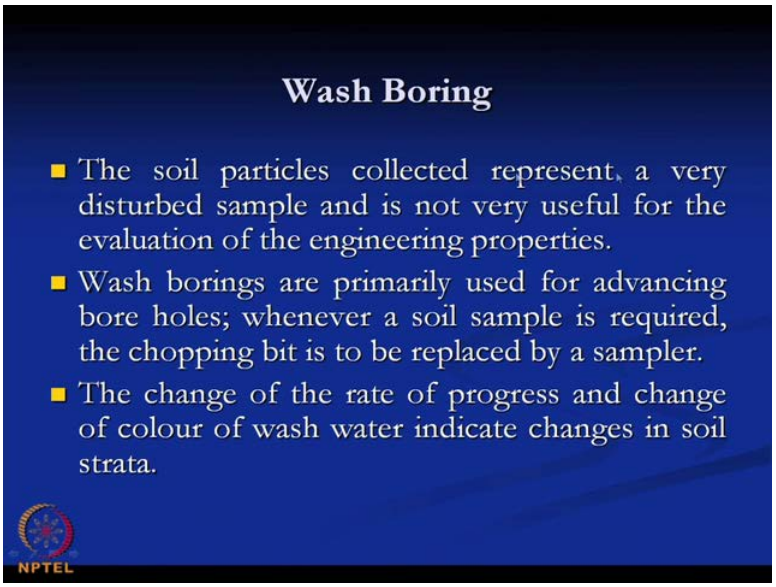
(Refer Slide Time: 12:19)



So, that means this is typical wash boring arrangement, so here this is the this casing is chopping bit into the soil and this is the pulley and this is the tripod and here the soil is collected on wash tub this is the drill rod and this is the pump. This is the typical system, so here it is pushed and design and into the soil and water jet under pressure is forced through the rod and bit into the hole. For this water jet loosens the soil at the lower end and force forces the soil water suspension upwards along the annular surface between the rod and side of the hole.

This suspension is led collected to setting tank where the soil particles settle while the water overflow on that sump and water collected in the sump is used for circulation again. So, that means the when the soil particles settle down then that soil particles soil is collected for the testing and water is allowed to flow for overflow so that this water can be circulated for this water can be used next for that feature boring purpose. Now, here as I mentioned that here the water sample is collective instead of soil and water, so that water sample is collected is highly disturbed.

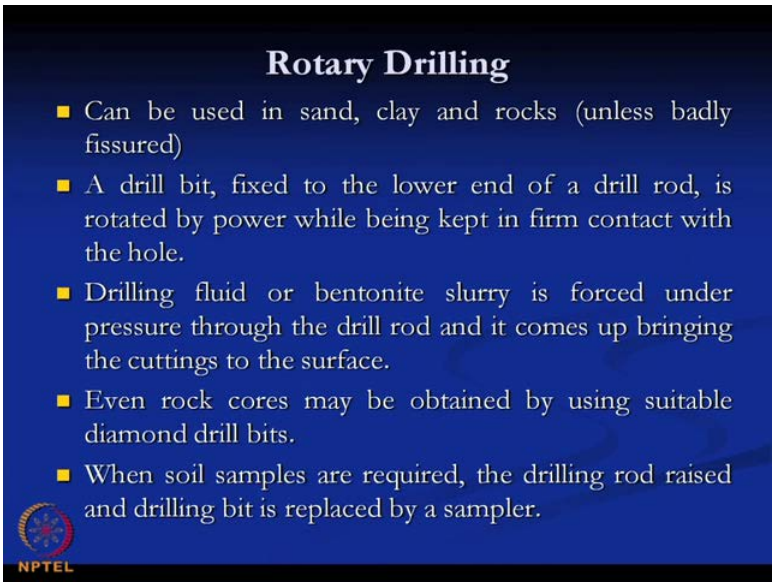
(Refer Slide Time: 14:10)



Now, the soil particles collected represent a very disturbed sample and is not very useful for the evaluation of the engineering properties, the 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 color of wash

water indicate changes in soil strata. That means that color of soil water mixed it give indication this is change in soil strata.

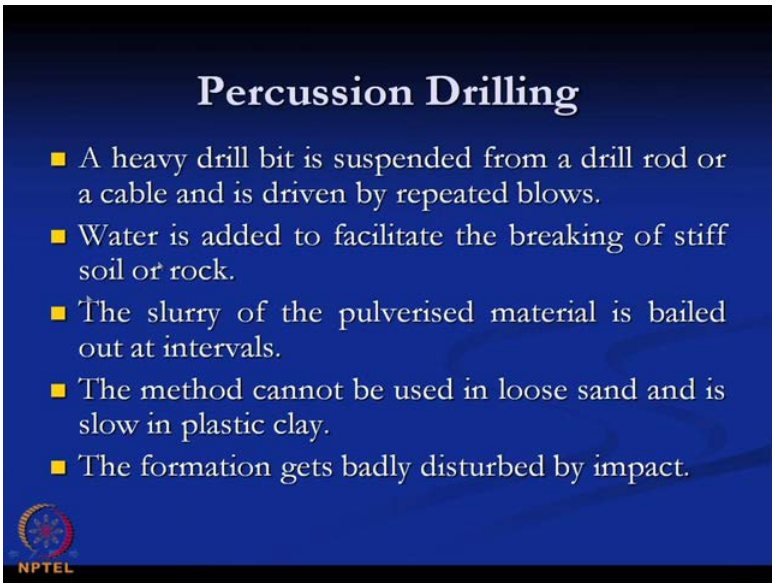
(Refer Slide Time: 14:53)



As I mentioned that wash boring is high disturbed sample, so it is not suitable for determine the Indian property of the soil. It is basically used for functioning a bore hole and whenever the soil sample is required, we can replace the bit of soil sample. Next one is rotary drilling that can be used for sand clay and rocks unless badly fissured a drilling bit fixed to the lower end of a drill rod.

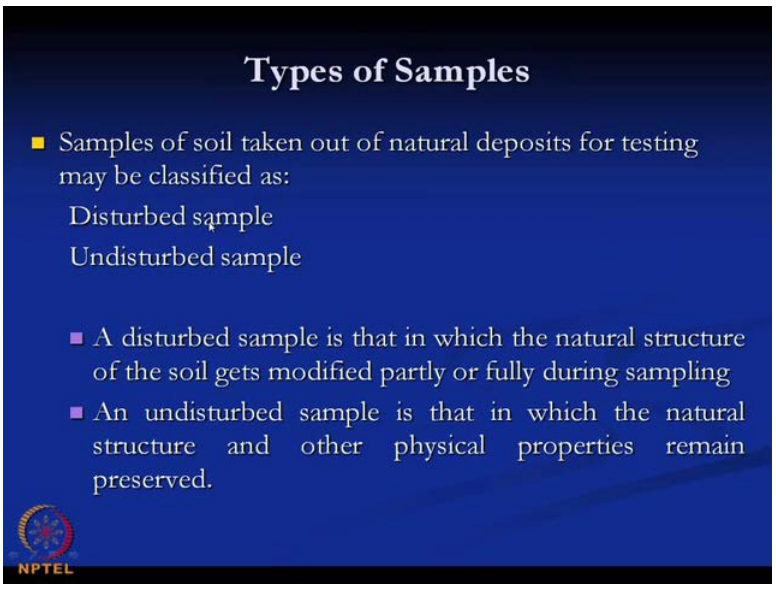
It is rotated by power while being kept in firm contact with the hole drilling fluid or bentonite slurry is used under pressure through the drill rodent it comes up bringing the cuttings of the surface. Even rock cores may be obtained by using suitable diamond drill rod, when soil sample are required the drilling rod raised and drilling bits is replaced by a sampler.

(Refer Slide Time: 15:54)



Next one is the percussion drilling a heavy drill bit is suspended from a drill rod or a cable and is driven by repeated blows, so water is added to facilitate the breaking of stiff soil or rock the slurry of the pulverized material is applied in out of certain intervals. The method cannot be used in loose sand and it is slow in plastic clay the formation gets badly disturbed by impact.

(Refer Slide Time: 17:04)

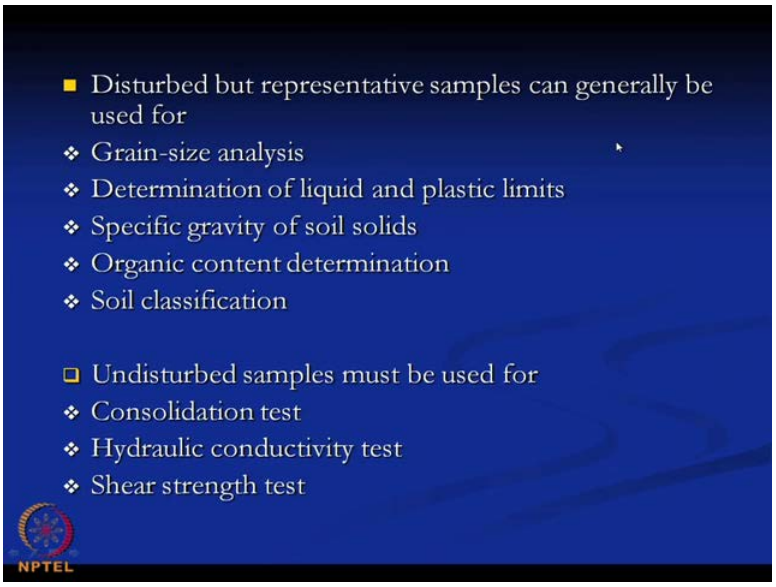


So, when talking out this type of boring if all the borings that except the auger borings drill rod is there and bit it attached in point of drill rod and this drill rod is pushed into

the soil and driven also. Then, the bit is help to advance this rod into the soil bore hole and why never the soil samples require the bit is replace by the sampler.

Now, the types of soil samples that mention we can get the soil sample in two types one is disturbed soil sample and another is undisturbed soil sample. A disturbed soil sample is that in which the natural structure of the soil gets modified partly or fully during sampling. Undisturbed sample is that in which the natural structure and other physical properties remain preserved.

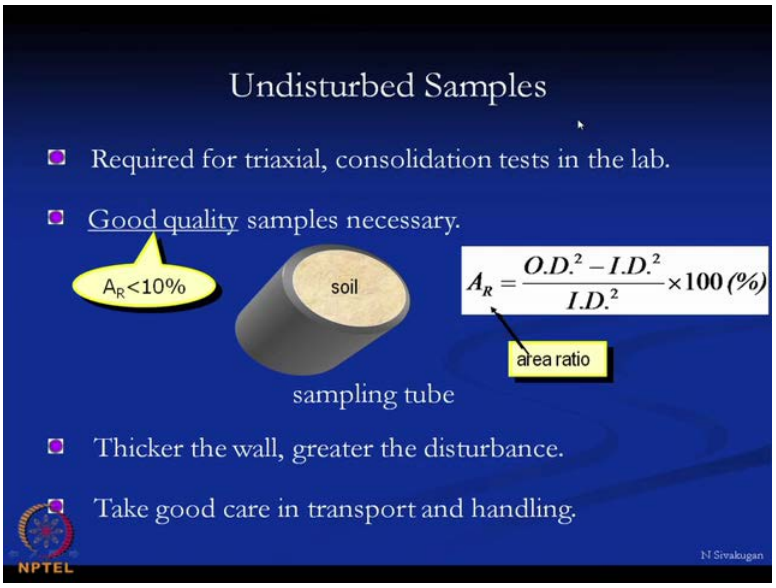
(Refer Slide Time: 17:33)



Now, the why the disturbed sample is used why the undisturbed sample to be used the disturbed sample is used for a grain size analysis determination of liquid and plastic. This limits the act of the limit of the soil specific gravity of soil solids organic content determination and soil classification soil classification.

Also, the disturbed sample will be used but for the stain property of the soil that in the shear strength test then consolidation test hydraulic conductivity test in this test, undisturbed sample soil must be used. That is mandatory because these unless we use the undisturbed soil sample in this properties will get form this consolidation test the hydraulic conductivity test or shear strength test that will be required for the foundation design. So, in that we should get the properties in is in soils natural conditions so that so I need the undisturbed soil sample for this test.

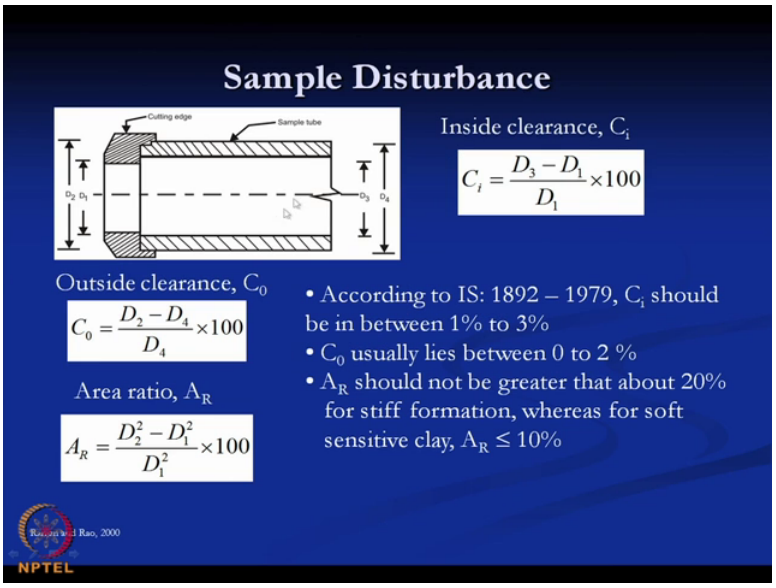
(Refer Slide Time: 18:43)



Now, for the undisturbed soil samples some conditions, we have to follow that if we get this is the undisturbed soil sample, then what is the requirement what is the condition will be there. So, required for tri axial consolidation test in lab and good quality samples and necessary is this is the sample. So, this is the hollow tube you it has inner diameter it is an outer diameter also and the area ratio we can determine from this way that is the outer diameter square minus inner diameter square divided by inner diameter square.

It is expressed in percentage, so here we can determine we can measure the inner diameter and outer diameter of a sampling tube. We can determine what would be the area ratio for a good quality soil sample, this area ratio should be less than 10 percentage, now thicker the wall of the sampler this thicker. The wall of the sampler tube greater the disturbance then take good care of the transport and handling of the soil sample wants to collect the soil sample. Let us take care for the transport and handling of the sample soils so that soil do not get disturbed.

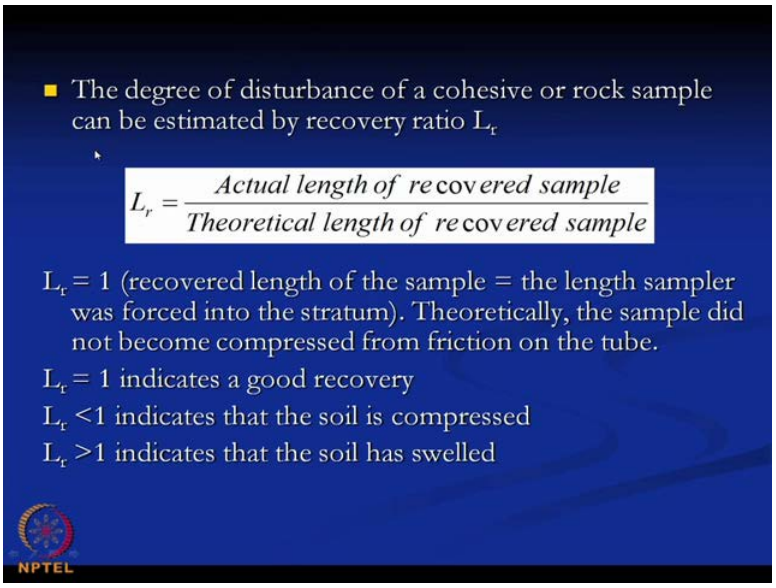
(Refer Slide Time: 20:10)



Now, the require mentation also, one is area ratio that should be less than 10 percentage and additional to that is code require mentation few other condition for the and the disturb samples. So, here this is typical sampler to figure here d 1 is the inner diameter of the cutting edge and d 2 is the outer diameter of the cutting edge and d 3 is the inner diameter of sample tube and d 4 is the inner outer diameter of this sample tube. Now, inside clearance c, I calculated when d 3 minus d 1 divided by d 1 percentage into 100.

Then, outside clearance C zero we can determined two minus d four divided by d four and the area ratio here we can determine for this type of sampler tube d 2 square minus d 1 square divided by d 1 square. So, according to i s 1, 8, 9, 2 ,1, 7, 7, 9 c 1 I should be in between 1 to 2 percentage for a good sample collection and C zero usually lies in between 0 to 2 percentage and area ratio should not be greater than about 20 percentage. For stiff formation whereas, for soft sensitive clay a r should be less than equal to 10 percentage, so these are the require mentation given by the I S code.

(Refer Slide Time: 21:55)



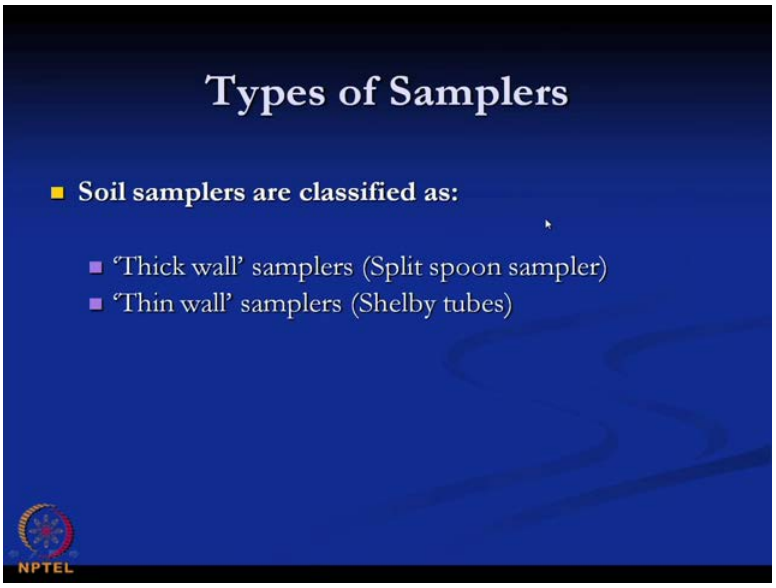
Now, the degree of disturbance of a cohesive or rock sample can be estimated by recovery ratio also, now once we enter in a soil sampler into the soil in the recovery ratio is defined as actual length of recovered sample. Theoretical length of recovered sample so that is how much soil sample we can what would be the length of soil sample we have collected to the sampler that length is the actual equal length of the sample.

Theoretical length is the total length of the soil sampler, so this is the ratio now for L r equal to L recovered length of the sample is equal to the length sampler was forced into the stratum. Now, theoretical length of recovered sample is equal to actual length of recovered sample when this is l r is equal to 1.

So, when the is the length of the soil sample we have collected that is equal to length of the soil sampler, that we have push into the soil sample sum pus into the soil sample to collect the sample into the soil. So, that length of the sampler is equal to the length of the length of the sample soil we have collected. Then, that L r ratio is 1 and L r is l r is equal to 1 that indicates a good recovery.

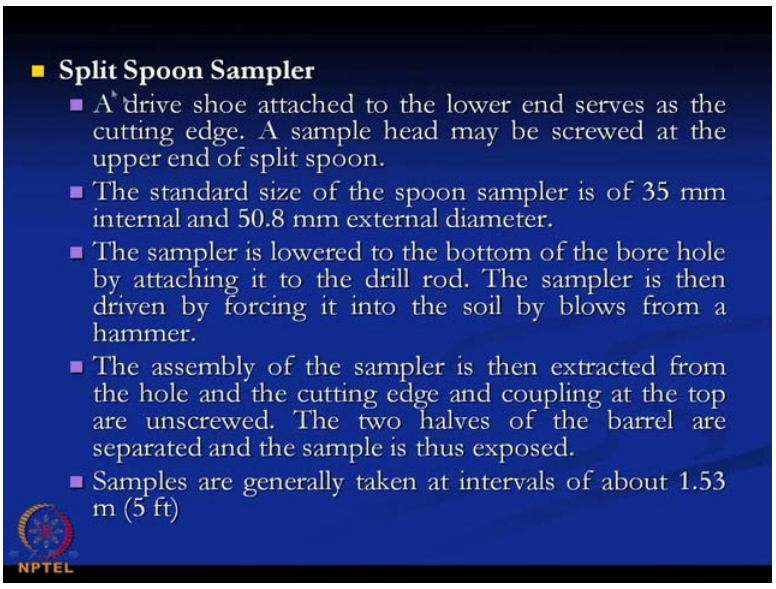
If L r is less than 1 indicates the soil is compressed and if L r is greater than 1 it indicates the soil has swelled. So, a good sample collection is sample will be that one where L r is equal to one otherwise either sample if compressed is l r is less than one or it is swelled if L r is greater than 1. So, both are disturbance is there in this two cases where if l r is equal to one which is less disturbance is there.

(Refer Slide Time: 24:11)



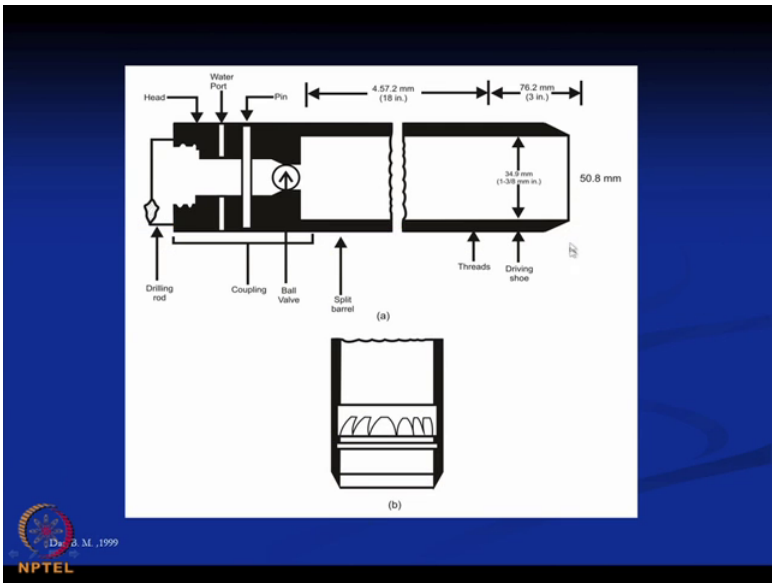
So, that is the what are the different types of soil samplers, so what are the different types of samplers so the two types of soil samplers, one is thick wall samplers that is the split spoon samplers and one is the thin wall samplers where is Shelby tubes.

(Refer Slide Time: 24:30)



Now, split spoon samplers is a drive shoe attached to the lower end serves as the cutting edge, so this is the typical sampler tube.

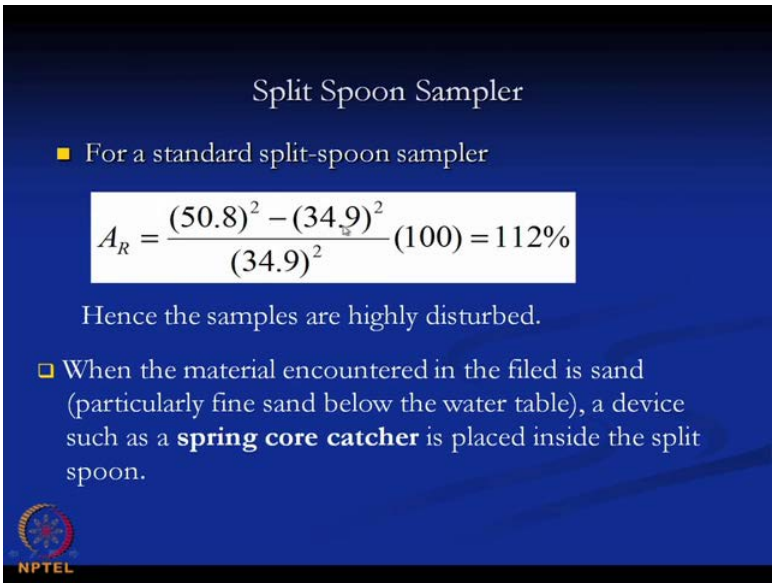
(Refer Slide Time: 24:42)



So, this is the cutting edge and this is for the split spoon sampler and a sample head may be screwed at the upper end of split spoon and the standard size of the spoon sampler is of thirty m internal diameter and fifty point eight m external diameter. So, this is 50.8 external diameter and 35 millimeter is the internal diameter, the sampler is lowered to the bottom of the bore hole by attaching it to the drill rod. The sampler is then driven by forcing it into the soil by blows from a hammer, so sampler is attached by drill rod and then drill rod is the sampler is placed at the required depth. Then, among is applied in the drill rod so that the sample sampler tube can be pushed into the soil, so once the sampler is pushed into the soil then the assembler sampler extracted from the holes.

Then, it is taken out from the hole and the cutting edge and coupling at the top are unscrewed the two halves of the barrel are separated and the sample is the collected the samples are generally taken at intervals of about 1,53 meter and 5, 5 feet. So, once he they soil sample is pushed into the sampler is pushed into the soil sample then after that it is taken out and soil is enter into the soil sampler. So, once it is taken out then it is half's hollow tube, so it is it is opened and then soil sample is collected inside the tube.

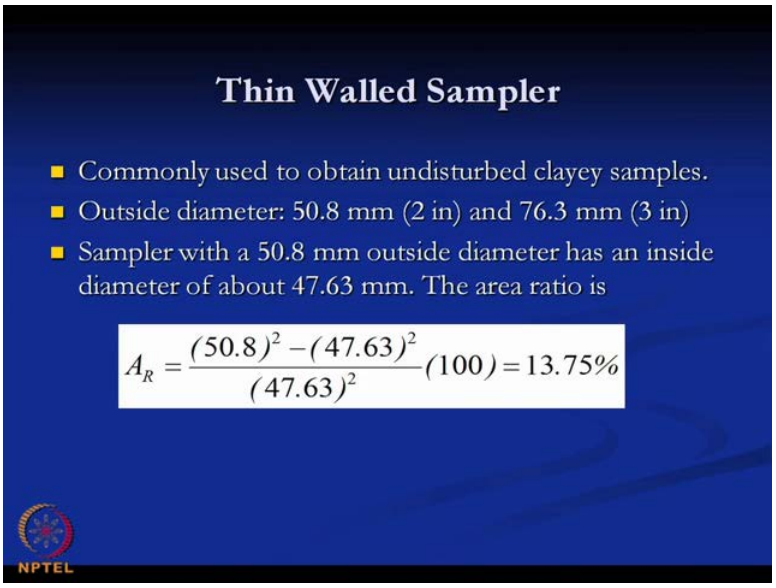
(Refer Slide Time: 26:51)



Now, as I mention the external diameter of the soil sample is a sampler split spoon sampler is 50.8 and internal diameter is 35 millimeter. So, what would be the area ratio that is 50.8 square minus 34 or close to 35 millimeter or it is close to 30 actual 34.9 millimeter. So, that is the area ratio 1, 2 percentages, whereas for the good sample area ratio should be equal to or less than 10 percent, but it is 112 percent. So, split spoon sampler is highly disturbed the sample is collecting by split spoon sampler is highly disturbed sample.

Now, when the material encountered in the field is sand, so that is a r we are talking about, we get the sample from the split spoon sampler is it is suitable for the standard one is suitable for the clay soil if you encountered for the sand soil then partially fine sand below the water table is a device. Such as a spring core catcher is placed inside the split spoon so that will receive the spring core catcher which is this is the normal split spoon sampler which is used for the clay soil. If it is sand soil below the water they will split spoon this is the spring core catcher this one is fixed in the split sampler split spoon sampler.

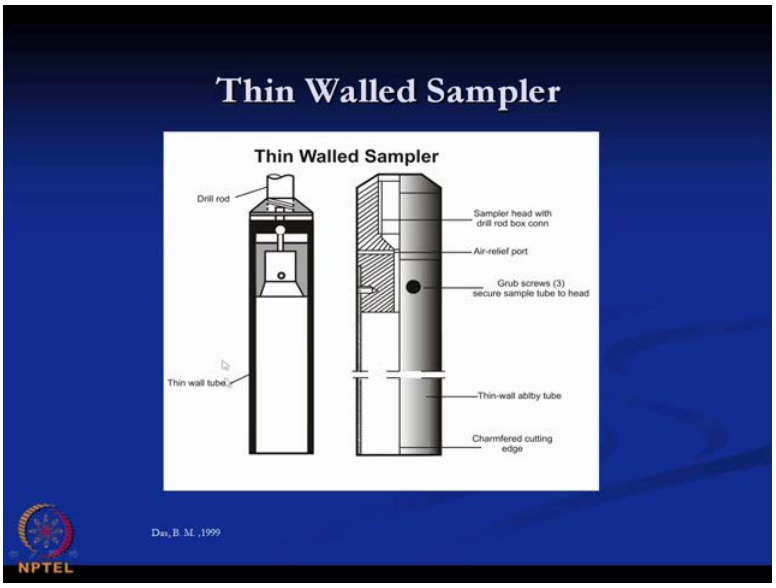
(Refer Slide Time: 00:48)



Now, the thin walled that is the previous one is the split spoon sampler or thick walled sampler, this is the thin walled sampler tube commonly used to obtain undisturbed clayey samples. So, previous one is obtained for disturbed sample because the area ratio is 112 percent, but here this is commonly used for undisturbed clayey sample the outside diameter is 50.8 millimeter and 76.3 millimeter.

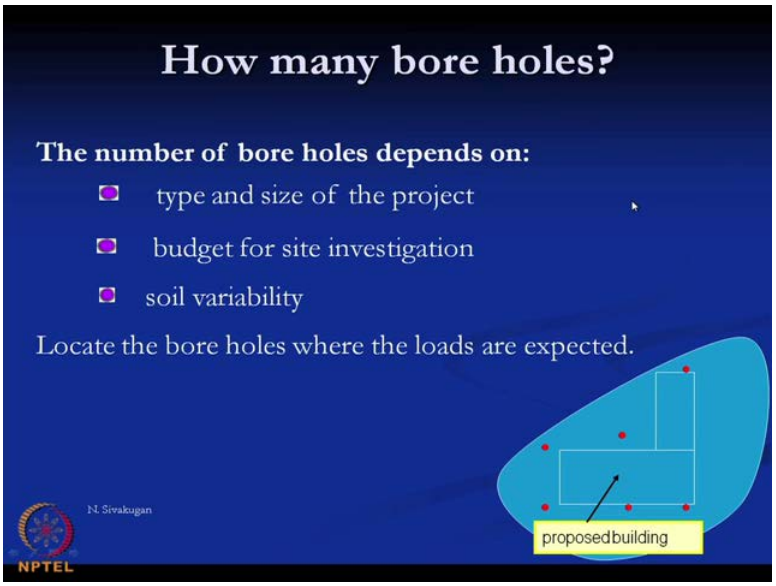
Two types of sample the sampler with a 50.8 millimeter outside diameter has an inside diameter of about 47.63 millimeter, so the area ratio is coming out to be 13.75 percentage which is very close to 10 percentage. So, that is the for the good undisturbed soil sample collection area ratio should be around 10 percent less than that. Here, it is around thirteen poi or 14 percentages which close to 10, so this generally used for collection of undisturbed clayey samples.

(Refer Slide Time: 29:42)



So, this is the typical thin walled sampler photograph which is used for the collecting undisturbed sample.

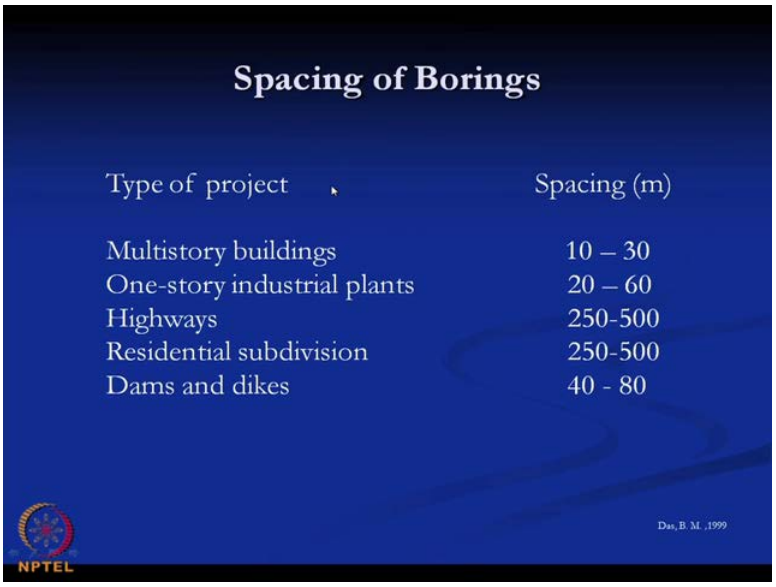
(Refer Slide Time: 29:52)



Now, how many bore holes will decide that for the particular site, how many bore holes will be there how decide, so the number of bore holes depends on the type and size of the project. Now, budget for site investigation and soil variability, if type and size of the project depending upon that decide how much what the number of the bore whole is.

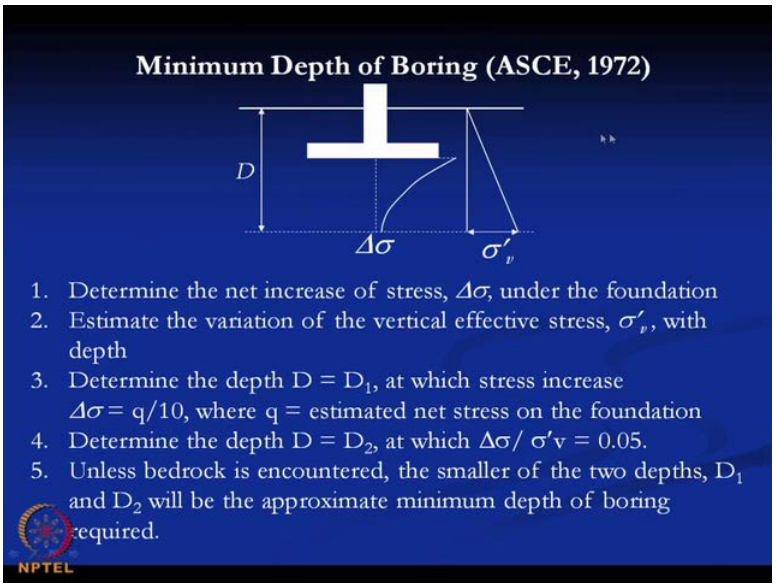
We take the soil sample if the site investigation budget is more, then we can definitely go for higher number of bore holes, and if the budget is less we need not to go for the less number of bore holes. If the soil variability if the soil variability differ in bore holes as is well very much to decide, then we should increase the number of bore holes for the particular site so locate the bore holes where the load loads are expected.

(Refer Slide Time: 31:02)



When spacing of borings, so initially the number of bore holes in the spacing of bore holes depending upon the type of project. So, what is the spacing the multistory buildings spacing should be 10 to 10 to 30 meter for the one story industrial plants 20 to 60 meter highways. It is 250 to 500 meter residential subdivision 250 to 500 meter and dams and dikes 40 to 80 meters, so this is the typical spacing can we used for find of structures.

(Refer Slide Time: 31:44)



Now, the depth of bores what would be the minimum depth of bores, so first we have discussed the number of bore holes then the spacing of bore holes. Now, the depth of the bore holes up to what depth we collect the soil sample that is very important. We should for generally of a foundation is foundation internally taken as the twice of the width of the foundation. So, that is the thump rule that the twice of the width of the foundation is generally taken as the initial zone, so in that there are sample quotation is there by which we can determine what would be the minimum depth of the boring.

So, first one is the given in 1972 here, the foundation and D is the depth of the bore hole from the ground and here first determine the net increase of stress. So, net increase is the increment of stress D 2 is applied load at the foundation, so at the foundation is applied load what would be the net increment of the stress at the front depth so that we can calculate. For this calculation, various equations are available, so in the lecture on we can calculate settlement on the show how to calculate this increment of the stress due to the applied load at the front level.

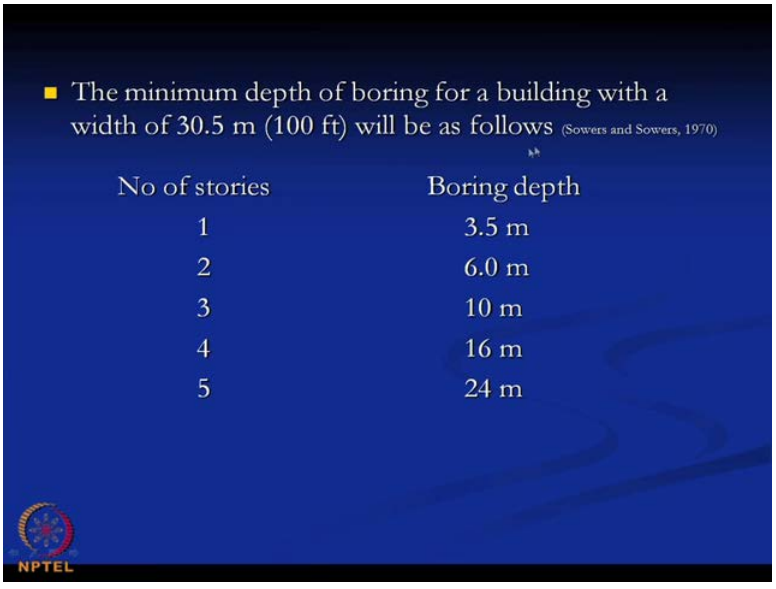
So, that is the net increasing the stress, then estimate the variation of the vertical effective stress with depth, so that means here we can see the vertical stress effective stress will increase axial goal in depth. So, that depth it is increasing and for the net increment stress is decreasing with depth, so this is the vertical effective stress that is

increasing and this is the net increment of the stress due to applied external load. That is decreasing with depth, now determine the depth d is equal to d 1 at which stress increase.

Delta sigma is equal to q by 10 where q is estimated net stress on the foundation and now here what is q is the net stress applied at foundation level that is q. Then, determine the depth d 1 at which the net increment of stress del sigma is one tenth of the net stress applied at foundation level. So, determine that depth as a d 1, then determine the depth d is equal to d 2 at which the ratio net increment of stress divided by effective vertical stress is equal to 0.05.

So, that is determine that depth also held we get this condition unless bed rock is encountered. The smaller of the two depths D 1 and D 2 will be the approximate minimum depth of the boring required, if be encountered bedrock in between the this state go to bed rock. Then, if the bedrock is not encountered the smaller of the two depths will give you this was the approximate minimum required depth of the boring.

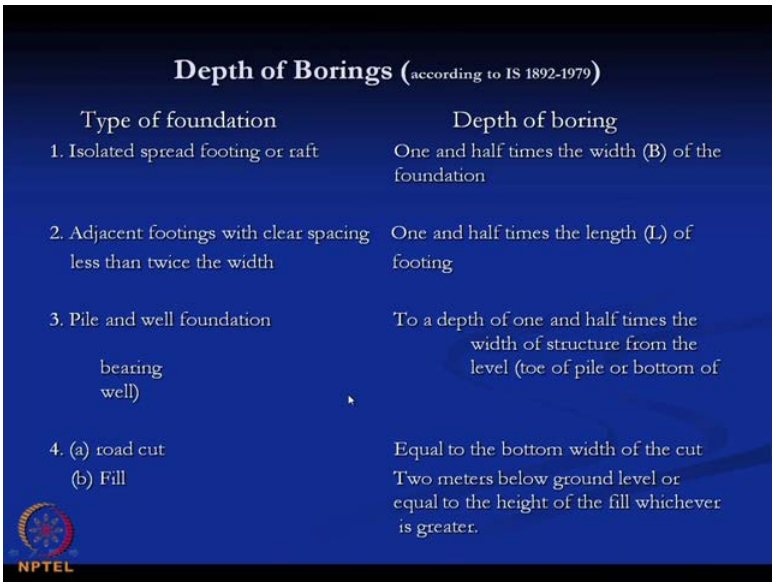
(Refer Slide Time: 35:32)



Now, another and that we can get this the depth of the boring by this requirement condition boring for a building with a width of 100 feet or 30.5 meter that for the this is the one particular case which is shown here that a number of stories if it is 1. Then, the boring depth is 3.5 meter and number of stories two, then the boring depth is 6 meter and number of stories is 3. Then, the boring depth 10 meter number of stories four the sixteen meter if the number of stories is three then boring depth is 10 meters. If number of

stories is 4, then is 16 meter, if it is 5, then is 24 meters, so these are the typical example is shown here.

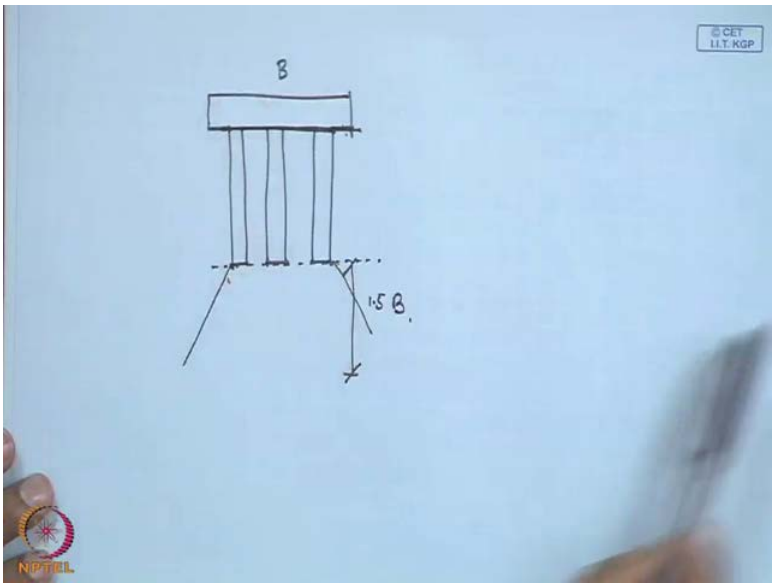
(Refer Slide Time: 36:28)



Now, depth of boring according to is scope, so according to is scope what would be the depth of boring, so that is 1, 8, 9, 2, 19, 79, 17, so according to that what would be the depth of boring. If the type of foundation, if it is the isolated spread footing or raft the depth of boring will one and half times the width of foundation.

This is the minimum required of the depth of boring for the isolated spread footing or raft foundation this is 1.5 times the width of the foundation. Now, if adjacent footing with clear spacing less than the twice of the width then also one and half times the length of the footing. Then, if it is the pile and well foundation then to a depth of and half times the width of the structure from the toe of the pile of bottom of well. So, that is the form the bearing level, so if it is a pile or well foundation to a depth of one and half times the width of structure from the bearing level or that is the toe of pile or bottom.

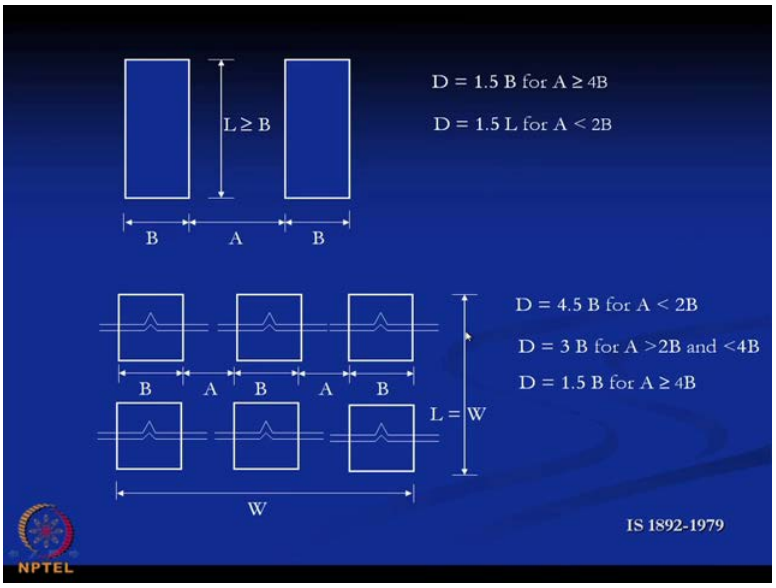
(Refer Slide Time: 38:07)



For example, if is it is the pile foundation this is the pile foundation and say this is pile gap, so generally these saying that this the width of the structural width of the pile gap. Then, form this bearing we can go 1.5 times if the width of the structure that is from the toe of the pile or bottom of we will go. So, there to the minimum required depth of the well these also have depending upon the type of the soil also this depth change.

Let the calculation of piles settlement C, then up to which will be there depending upon the differing type of soils will take up to which that will also change. So, the typical rule is that the width of the structure is then form the bottom of the pile is will go up to 1.5 times of the width. Then, for next one is the road cut that equal to the bottom cut, then sill if it is sill two meters below ground level or equal to the Height of the fill whichever is greater.

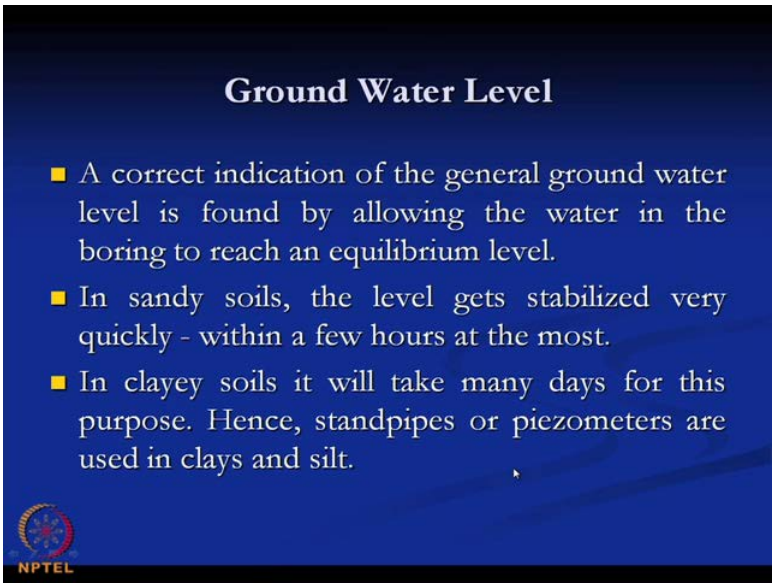
(Refer Slide Time: 40:04)



Then, we had some other conditions also that is the highest also require some other condition of the depth of boring this is to building structure for if this is of the one is B another one is B this is gap A if l is greater than equal to B. Then, the depth of the boring will be 1.5 times of that B for A equal to greater than equal to four B this is an another one depth of boring is 1.5 times L for A is less than twice of B, so this is one condition.

These are some billing dimension of billing blocks are there and this is the total width W this is A L equal to W, this width is B this space is A. Then, B A B and depth of boring will be 4.5 times of the B for a less than twice B. Depth of the boring will be 3 times of B for a greater than twice B and less than four B and depth of boring will be 1.5 times of B for a greater than or equal to 4 B.

(Refer Slide Time: 41:45)



The next one is, we should know the location of the water table also as I mention the location of water table also very important issue. We should know that what would be the location of a particular water table because as the position of the water table changes the loot gain capacity of foundation of soil. Then, the settlement of the soil that will also change, so before we design the foundation, we should know what would our location or what the location of the water table is. Now, to locate the water level the correct indication of ground water table level is found by allowing the water in a boring to reach an equilibrium level that will show how will get the location of the boring.

So, water table we can construct a borehole and then water into the borehole and allow this water to settle down so that in the correct indication. After sometime, we will get the water table to reach the equilibrium condition, so there water within the borehole to reach the equilibrium condition after that there is will change in the water table. So, that equilibrium condition equilibrium condition level will indicate that is the level of the water level.

Now, if sandy soil, if the soil is sandy soil the level gets stabilized very quickly within a few hours at most that are it is a clay soil for the sandy soil. This water will takes the equilibrium condition very quickly within an hour, but if it is a for clay soil, then it may take many days for this purpose. Hence the standpipe or piezo meters are used in clayey and slit so for the piezo meter that is suitable for the sandy soil because it takes very less

time say few hours, but if it is clayey soil or slit soils, then it take very long time. So, that is why that method is not suitable for the clay in that case the piezo meter or standpipes are used to determine the location of water table.

So, in this way we can determine the various engineering properties for that today's class I have discuss only, the discuss the direct method and semi direct method or not discuss about the indirect method or indirect method that with penetration test or geophysical explosions, those things will be explained in the next class.

So, today's class we are discuss about the direct methods and the semi direct methods then what are the different type of soil samples, so what are the different of soil sample that is the disturb soils samples and undisturbed soils. So, where use those soils that means it is that means it will get boring methods or semi direct methods you will get the whole disturb samples. So, where will use disturb samples that is the determination of sample properties or the soil classification we can use the disturb samples. If it is in case of strain properties or consultation properties or the highly conductivity properties in that case we cannot use the disturb samples in that case use of undisturbed samples.

It is compulsory you should use the undisturbed samples in that case because these properties are very important for foundation design. Next one is that how we will get the disturb sample and undisturbed samples; how we will collect the undisturbed sample what is the conditions of a collecting of good quality soil sample. So, for the good quality soil sample should use the sampler tube use area is as less than equal to 10 percent and highest also.

Commonly, some other conditions those things have already in next period or in next class, so in this lecture that means should use the soil sampler whose area is less than equal to 10 percent. Generally, for the sampler that is two types of sampler are used one is thick well sampler tube that is the split spoon sampler another one is that these things cell.

That is expected that if thickness of the sampler tube because sampler tube is a hollow sampler it will increase the thickness there will be no disturbance. So, in the split full sampler tube as seem that the area ratio is 112 percent, so if we use a split full sampler tube to collect the soil sample. Then, that is soil sample will be very highly disturbing sample because where the area ratio is 112 percent. So, here is if we use the thin oil

while the sampler tube or the shell by tube the area ratio is around 10 percent that is 13.75 percent for the particular case. So, that is that if we can use for collecting and disturb collecting undisturbed soil.

Quickly, now the question is that that once u collect the soils sample then what would be the number of bore holes that we have to also decide where will the first condition is where the maximum load is expected where to locate a bore hole. Again, what would be the number of bore hole that depends on the type of structure for which we are doing the soil explosion, then the budget of soil explosion? If budget is more we can we can provide this bore holes if budget is less then we can provide we have to go for the less amount of the number of bore hole. Another issue is the soil variability if the variations of the soils sample is more it will differ bore hole then it is equal to use more bore holes in the proposed area.

So, we can get the proper soil properties of that locations, so once you decide the number of boreholes next will decide the spacing of bore holes what would be the required spacing bore holes. They will also discuss some guidelines for different types of structure or different types of construction what will be the spacing between the bore holes. Next one is the very important issue is the depth of the bore holes up to what depth will go for our soil sampling. So, depending on the type of the structure we are constructing over there what would be width of the structure and the based on that width we can determine what would be the required minimum depth of the bore holes.

Again, for that purpose also we had explain I have explain one recommendation proposed by a c by which also determine which will be the minimum requirement of the depth of the bore hole and some typical example for particular 100 feet width of the building for different number of as number stories increases thus depth of the bore also increases, so that thing also explained there.

So, the next one contract on the highest score recommendation also given the typically for foundation. If it is a width is would b say the depth of bore hole if it’s a shallow foundation or raft foundation say if it is depth width of the foundation is b then typical minimum depth of bore holes is varies from 1.5 times to 2 times of the width.

So, that is the generally it is taken the two times of the width of the foundation soil is influence by the by the stress which is coming from the foundation, that is externally

loading and generally when you design a foundation will design for two criteria's. One is bearing capacity criteria, another one is settlement criteria for the bearing capacity of the criteria will take the soil properties up to the twice b's up to the b's sorry. For the bearing capacity of the calculation purpose, we take it is up to the b at the and up to the b of the soil foundation. So that mean here b is the width of the foundation then we take the soil properties the depth below the foundation level up to the width b so the depth is equal to B.

So, up to that portion, we take the soil properties for the bearing capacity calculation, but for the settlement calculation. Generally, we take the depth of the foundation soil depth up to the depth of the soil below the foundation base is equal to twice of the width of the foundation. So in that way we can, so that mean at least up to twice of the width of the foundation we have to go for the depth of the boring and for that is for the shallow foundation for the dept. foundation deep foundation of pile or for the well foundation.

Again, we have to go for the 1.5 times to 2 times of the width of the structure, but that is from the base of the pile or from the tip of the pile or the below the well up to 1.5 or twice the width of the structure ((51:47 to 53:08_added)

So that while we can determine and also I S code high score has recommended some guidelines those thing also be explained this lecture, that what would be minimum of the depth of the boring. And then the next one is location of water table what type that is also important. So, we should also know what would be the location of the water solu…soil explanation this are the things is very important for the soil exploration, so we should known should known this things before start the foundation design.

So, next class I will explain in lecture two what is the indirect method that mean the penetration test and then the geophysical explanation.