Geotechnical Engineering II / Foundation Engineering

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Lecture – 23
Geotechnical Investigation

Good morning, today we are going to start a new chapter we can say. We have completed basically bearing capacity and settlement of footing. Now, while determining bearing capacity we have mentioned several assumptions like; there soil has to be homogeneous, isotropic then water table should be at this at a depth of B.

Of course, if there is a water table location varies then we can find out or you can incorporate the bearing capacity into it. Or you can incorporate the effect of the water table in the bearing capacity. Similarly if the instead of homogeneous if it is layer or something else then also can be done, but we have not discuss that we have used only homogeneous case.

Similarly, for settlement also we have shown that if the you require several parameters of like you need to find out if you want to find out immediate settlement then you need to find you need to know Poisson's ratio, you need to know the Young's modulus of the soil.

Again whether the soil is homogeneous or layered so that information is required. Similarly if you want to find out consolidation settlement you need to know the whether the soil is compressible one or not. And then the similarly if it is compressible then we need several parameters like CV, CC, void ratio many other things to calculate the consolidation settlement.

So, that means and also you know that consolidation is a phenomena for a saturated fine grain soil. So, water table location also another important aspect. So, we have so far done those problem, we handle those problem bearing capacity problem or settlement problem by a known situation.

That means, we have given the profile we have given the soil parameter we have given put in size and based on that how to find out the bearing capacity ok. So, that much we have done, but we have, but how to get those information; that means so, what below the

footing what type of soil is there what is it is pi value, what is it is C value, cohesion value, what is this Poisson's ratio, Young modulus or any other similar how is the grain soil distribution and how is the soil type. So, those information actually how to get. So that is the thing to get those information we need to do we carry out geotechnical investigation actually.

That means, geophysical exploration and or soil exploration and geotechnical investigation. So, soil exploration means up to certain depth actually you need to explore the soil type, we have to know the type of soil and for that we do something. So, those things actually there are geotechnical investigation under these we will discuss those aspects.

Basically what are those? Those are actually your initially you have to make more hole and then see the stratification and all those thing. So, may be four five lecture or module I will spend on this to address the geotechnical investigation.

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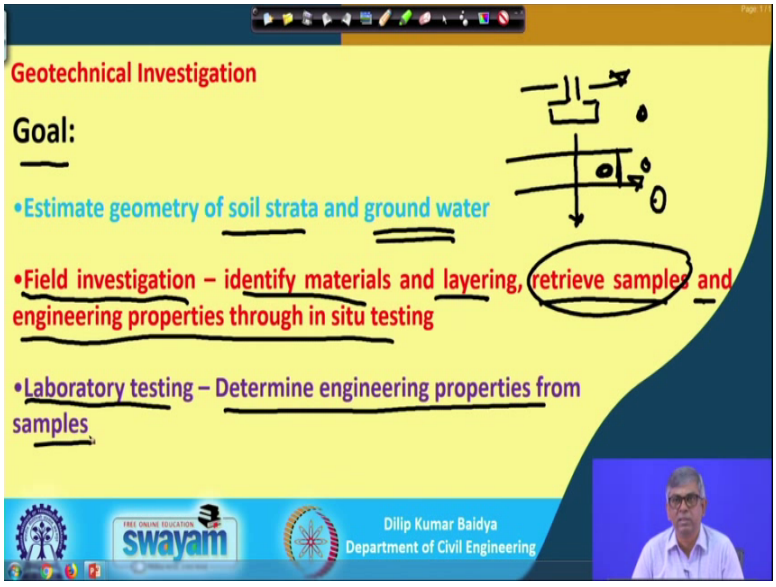

Let me go to the slide first slide of this geotechnical investigation. You can see that geotechnical investigation you know you need to know what is our goal or what is our objective ok. So, that objective is actually the estimate geometry of soil strata and ground water. As I have mentioned that if there is a footing here, here whether the soil is homogeneous infinitely.

Or whether it is layered number of layer, or the soil parameter bearing with some depth, all those things are those variation actually we have to show geometry of soil strata we have to know. And then another thing is that if the water table is here if the water table is here the whatever bearing capacity and if water table here bearing capacity will change that actually we have shown. So, because of that this ground water table also another import aspect that will first thing we have to find out.

So, estimate geometry of the soil strata and ground water this is two first thing. Second thing is the field investigation. Field investigation, that means; what is that actually? Identifying materials and layering. That means, we have to suppose this is a layer we have got what may this is a layer. Suppose this within these actually soil may be homogeneous what even that is sand whether it is clay or if that is shield or a sandy shield or sandy clay or clay shield like that this can be many thing you it is a gravel sand gravel.

So, like that so identify materials and layering. So, this two things, a retrieve sample. That means, when you carry out this investigation when you collect sample from different depths. So, the actually if I collect the sample from here this will be the representation of this some area actually. So, we will collect sample here from here from here sample from here those sample to be collected for what purpose actually?

To carry out test in the laboratory and to find out the engineering properties through retrieve sample for engineering properties of testing in the laboratory. And in addition to that during this process we can also carry out some field test by which directly we can find out the engineering properties of some engineering property like C5 and all.

So, they are actually directly it will not give based on experienced people correlated actually with certain things is field experiment they have correlated C5 and other parameters. So, we will discuss those things later on. So; that means, what? First of all this investigational, stratification and layering that identify materials and layering. So, first of all geometry of soil strata at ground water then identify materials layering.

Then retrieve sample and then carry out field test to find out engineering properties and then last part is what about sample we collect that sample actually ultimately laboratory testing. So, determine engineering properties from samples. That may whatever sample during investigation part we collect those soil sample will be tested in the laboratory to

find out engineering properties like sequential friction angle and similar other parameters ok.

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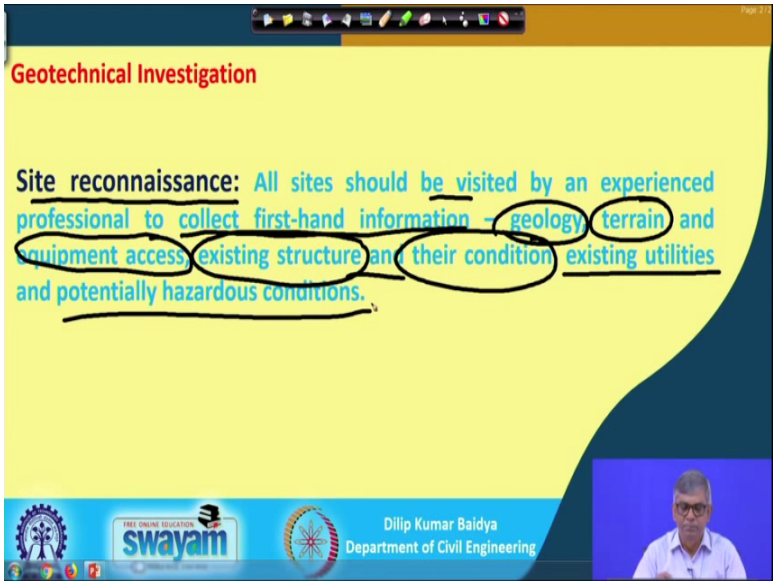

So, let me go to the next slide; I can see that site reconnaissance. Site reconnaissance this is this is nothing, but actually one sort of survey without any instruments. And the physical you visit the site and then see the surroundings and note make a note of it. What are those all sites should be visited many proposed project actually supposed you selected a place

and then to study the suitability.

So, first of all you have to visit the site and by and that has to be a not like ordinary person it should be by experience professional to collect first hand information. What is those first hand information? First of all you have to get the geology of the site, you have to know the terrain of the site you know the equipment access.

That means, if the it is a forest or a hill area or something else then you have to explore weather for a particular facility we need to move with different types of vehicles. So, whether that access is not there or whether it is there or not then existing structure. That means, that the nearby areas what are the different types of structures are available that has to be seen whether it is a tall structure, or it a small structure, or it is a some other type.

So, that has to be seen based on that actually we will get lot of information why they are not doing tall. Suppose if you know tall structure is there then may be some reason. So, that to be seen and then they are the tall existing structure and their condition. Suppose there are existing structure and you will find that most of the buildings is having cracks.

So, that means the what are the type of building and their condition both should be seen. And suppose example as I have mentioned that there may be start building everywhere that is cracks. Then what is that what is the reason for cracks? That has to be also investigated talking to nearby people and all.

For example suppose if there is a area with expansive soil. And if the small type of house building are there that small building on expansive soil expansive soil generally will have cracks. Mainly because of this expansive soil when come in contact with water it volume increase and when drying actually volume decrease.

And because of this seasonal variation of the volume of soil the building will generally goes up and down. And because of that mechanism sometime buildings will have some cracks. So, those thing; that means, existing structure should be seen and their condition also to be seen and existing utilities and potentially hazardous condition weather.

Put it like; if it is a close to sea shore then there will be some problem. If it is a somewhere else there may be industries are there also maybe some other problem like that those are the things to be noted in the in the in the beginning that is called site reconnaissance. by an by an experienced person site to be visited and these are the things to be noted.

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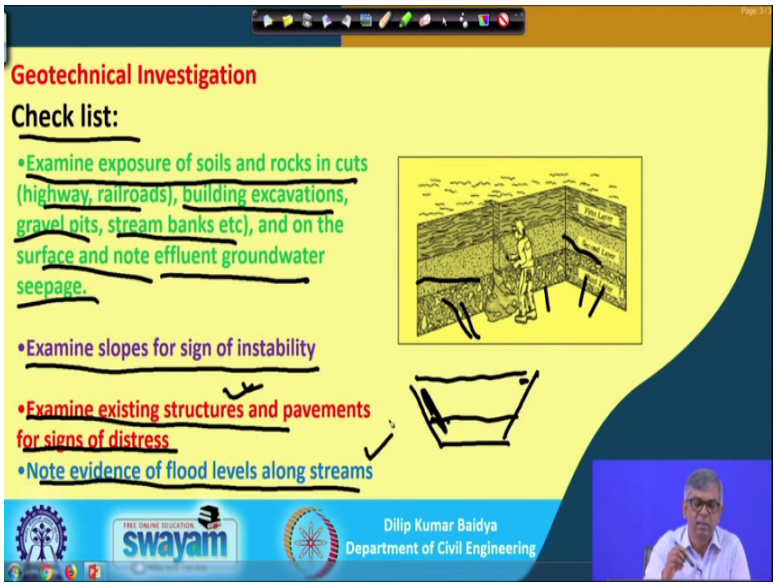

Next part is and then further there is checklist? Actually you can see on the checklist the examine exposure of soils and rocks in cuts like this. If you see the cuts and cuts and cuts. That means, this is the excavation and you can see it is actually hand drawn because of that. So, distinct, but it may be somewhere layering may be like this somewhere layering may be like this inclined.

So, it maybe there with lot of variation will be there, but if you if there is an excavation going on then or if it is there is no excavation also if you can make our self. And then you can see the distinct variation of the soil type with depth. So; that means, examine exposure of soils and rocks in cuts; that means, high way railways. Ten building excavations there also you can see gravel pits, then stream banks.

If the river etcetera there is a bank there also you can see. And on the surface and note effluent groundwater seepage if there is a cut. And again you may see that somewhere water is coming seeping. So, that is also to be noted at what depth water is there that has to be turn. So, this is the checklist that mean you have to examine these are the things. Then examine slopes for sign of instability. If you see some site there maybe some natural slope.

And you have to see by visually by seeing the slope angle and material you will be able to visualize whether the slope is stable or unstable. Then examine existing structure and pavement for sign of distress ok. So, as I have mentioned that the expansive soil on the

expansive soil if there is a road normal road then you may find cracks; because of this seasonal variation of moisture content in the soil the pavement will goes up and down and may result cracks.

So, that is examined existing structure and pavement for sign of this stress so these are the things to be noted. Note evidence of flood levels along streams sometime if the if the river or something if it is full sea. But if it is at bottom level also you may see that this water table sometime will goes up and down. So there will be some mark actually up to which maximum level water can rise that there will be some indication in the bank itself so that to be seen. So, these are the things to be noted.

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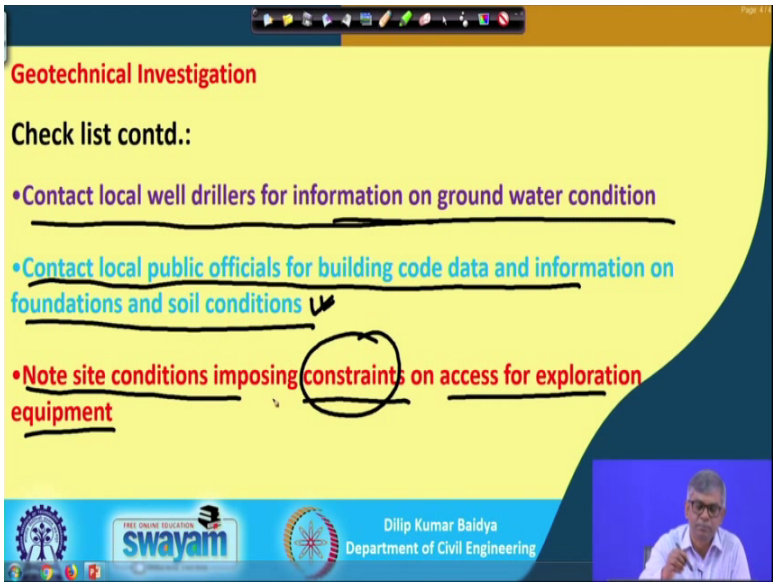

Next one checklist continued you can see some more points contact local well drillers for information groundwater condition. So, those people who the well drillers they will be having a locality on wise they know at what depth water is available. And also they know the soil type because while drilling for in search of water they also find difficulties. And based on that they know what level? What type of soil?

Or if there is any rock? And what level? There may be multiple layers of water, but which level of water is good. All those thing information is will be available from the well drillers. Similarly contact local public official for building code data and information on foundation and soil condition. So; that means, local officials the actually they finally, actually certify the building type and then the structure and all.

So, from there you can get some information what are the different types of foundations are used in that locality. And what is the reason all will be all information may be available from them. Similarly note site condition imposing constraints on access for exploration equipment. So, this is already I have mentioned that specific if want to detail soil exploration and construction. And that time what is the constraints that has to be also noted and then based on that feasibility studies of the project will be done.

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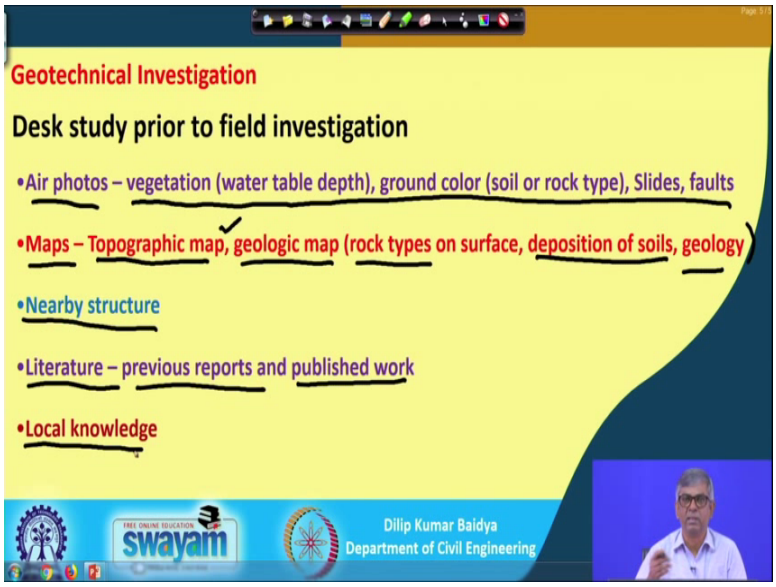

So, next let me go to this desk study prior to field investigation. What are these what are those actually? air photos; this is one thing that means vegetation, ground color, that slides falls, all those things from the air photo. That means, from the air photos these are the information will be available. Then maps you have to consult the maps. So, from the map what is the topographic, geologic.

And from the geologic map we will get rock type on surface, deposition of soils, geology etcetera we will get from the geology map. And topographic map means how the surface is and what are the features etcetera are there that can be obtained from this. And nearby structure actually you have to see that the close to the site of site what are the different structures are available and all those thing that has to be noted.

Literature; that means, previous reports and published work; that means, sometime people will carry out some investigation on failures and all. Sometime they will be available in the in the literature as the case history. And if you get this some time it will

helpful to take some decisions and like that there may be some difficulties because of the some or there will be some failure there may be some investigation team is formed.

They might have submitted report that may be available or sometime because of this academic nature publication like; suppose high rise building is constructed and then it is monitor for some several years. And then some data is published in the form of case studies. Then that also can be seen to get information what will be the difficulties. Or what is the advantage available in that particular site. Then local knowledge ok, so local knowledge means sometime you have to consult local people. They sometime may have lot of information about flood earthquake many other things. So, that to be also considered.

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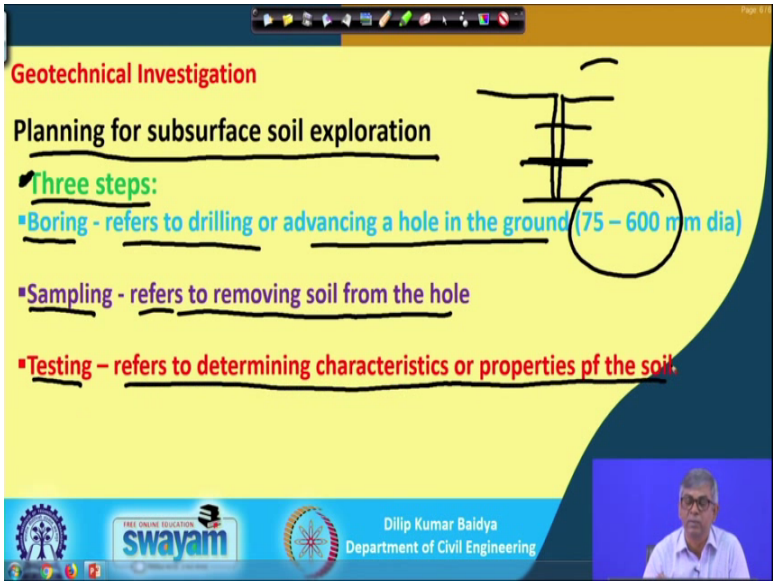

And then next part is a so all the after seeing all those thing and when the project suppose felt is feasible then you have to get the soft soil exploration you have to do. That means, as I have told that is the basic requirement you can design you can if you have soil data and all and you can design a foundation without any difficulty but how to provide the data where from it will come.

Because foundation will be there and foundation carry some load and that load will be transferred up to a great depth. That you have seen that the how the pressure distributed over depth and; that means, so you need to know that soil type up to some depth where actually because of the foundation pressure will go. So, that for that actually you need to

do some subsurface soil exploration. And that subsurface soil exploration will have three steps actually so this is not required.

So, three steps will be there; one will be the boring, another will be sampling, and third one will be testing; boring, sampling, and testing. So, boring refers to drilling or advancing a hole in the ground. So, that means, if there is a ground then you have to go deep and you have to make a borehole. And while making borehole the soil will come out and you have to absorb continuously.

So, suppose up to this depth one type of soil came then from here to here some when you cross this one some soil type change. And again up to reach it is constant then may be after reaching some depth again there is (Refer Time: 19:22). So, this observation will make finally, soil profile will be made. So, so you have to drill a hole and or advance a hole in the ground.

So, and the how depth etcetera that and what may be diameter etcetera will spacing all those thing I will discuss. But generally this drill hole will be from 75 millimeter to 600 millimeter. Actually most typically actually 3 inches to 4 inches I mean 75 to 100 is more common large number of boreholes will be there in the most of the sides all will be between 75 to 100 sometime 150 also, but common very common is for 100 millimeter.

So, those boreholes will be done that is steps in subsurface soil exploration is boring first that we have to advance a hole deep enough. That means, what are what are the depth etcetera required that I will come later on. And then sampling while doing this occasionally what we have to do refers to removing soil from the hole. That means, as I have mentioned when we are advancing the hole and that time whenever we will see there is a change of soil type then immediately we can collect a representative sample.

And that represent sample that is called sampling. And then how to sample it whether they disturbed undisturbed how to get disturb sample how to get undisturbed sample that also I will discuss later on. So, that means while making the advancing the borehole you have to collect the sample also for testing so that is second part. And third part is the testing; that means, when you get the sample from the borehole that has to be brought into the laboratory for characterization.

Characterization means what first of all some index properties like liquid limit, plastic limit, distribution unit weight and all those things so moisture field moisture content we have to find out. And then afterwards you have to find out the strength parameter. Parameters like C5 and then you have to find out compressibility parameter like CC CV and other things NB.

So that means, so first part is boring second part is sampling third part is testing and testing means determining or characteristics of properties of the soil.

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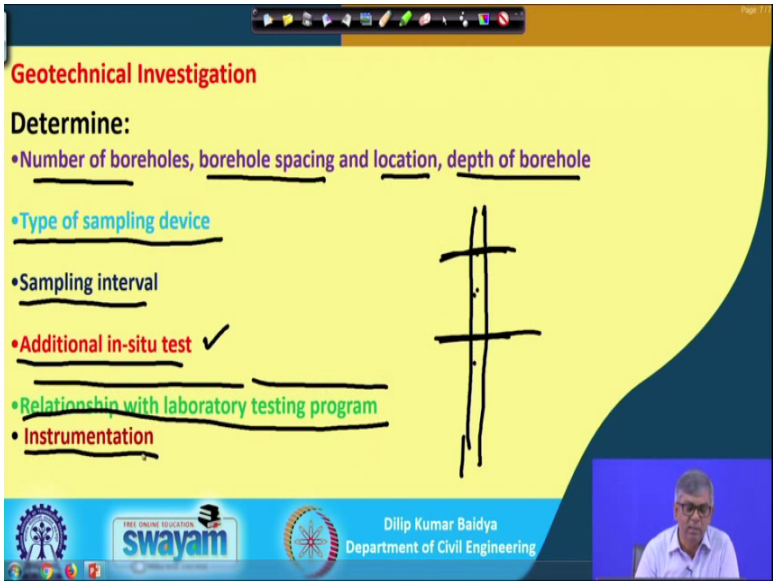

Then how to determine the number of boreholes? Boreholes are the so we have to determine those are the things I think this is wrongly written, but anyway number of boreholes and borehole spacing and location. so you have to yes we have to determine actually. I have mentioned that previous slide that you have to do borehole ok.

And you have to collect sample and you have to do testing. But that borehole again you have to find out how many in numbers required? What is the spacing? What should be the location? What should be the depth? So, these are the things to be determined or this has this has to be specified because this borehole will be done by a contractor.

You have to very clearly you have to give in the contract that you have to you have to you have to draw a map and you have to mark on that map what is the location. And then

you have to also mention what will be the depth. And then while finding out the location etcetera you have to know what should be the spacing required minimum spacing.

So, based on that only you have to you have to fix. And accordingly if there is a site then how many numbers are even small site may be one is required. So, if it is bigger than a it will be more numbers boreholes will be required. So, like that number, spacing, location, and depth these are all to be determined. Then type of sample device sampling device.

Then you have to fixed that how what sample device you used. If you want to find out undisturbed sample the sampling method is different. If you want to collect disturbed sample the sampling method of different and different sampling equipment may sampling device are there which can give you the undisturbed sample that also we will discuss later on.

Then sampling interval sampling interval means I am doing borehole like this and then at what depth actually I will collect simple. So, there are some guidelines actually there are I will discuss that one every some distance. Or otherwise where are there is a change in soil type we can have one. Suppose from this depth to this depth there is no change.

So, no there is no point of collecting several samples instead of that; I can collect one or two samples. Or similarly if there is a there is no change also sometime minimum spacing interval actually it is mentioned that accordingly you have to collect the sample. Then additional in situ test; so while doing this borehole and I will discuss that one later on.

Along with borehole one can conduct that SPT test and CPT test all those things. And so if it is possible that can be conducted because that SPT data can be correlated with many other soil parameters. And so you can do in the laboratory and the same time you are getting from the field both results can be compared.

And decision can be taken for the better project for the betterment of the analysis and design. Similarly relationship with laboratory testing program; that means how we will do laboratory testing that should be made. And then some instrumentation actually can be done. So, these are the things to be done.

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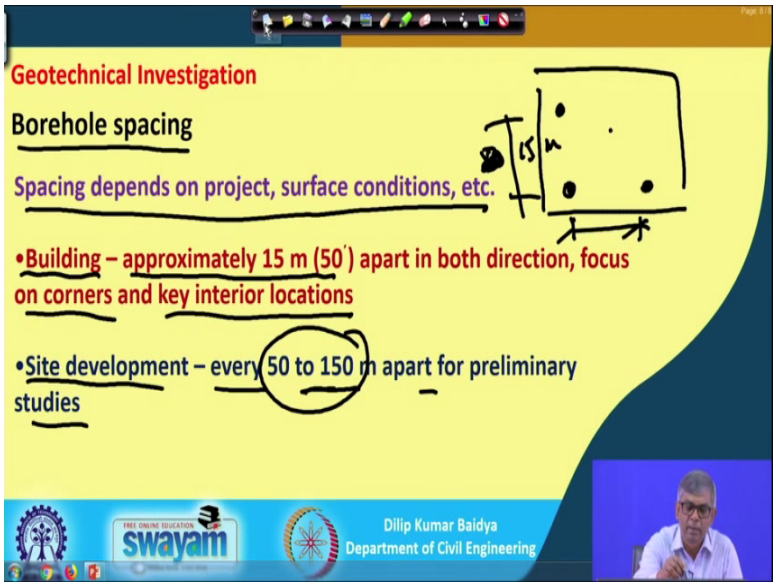

So, next thing is you can see borehole spacing. Now whatever I have mentioned in the previous slide borehole spacing is here mentioned. The spacing depends on project surface condition etcetera ok. So, you can see for a normal building and reasonably well level ground approximately 15 meters or 50 feet apart in both directions.

Suppose if this is the area so if I have a borehole here if a borehole here. Approximately this should be 50 meter. So, in both direction and similarly in this direction also 50 meters. And if this type of a small area there must be a middle also there maybe another borehole. So, both the focus on corners and key interior location.

So, normal this is the generally it is given in sorry not 50 meter it is building 15 meter interval and 15 meter; 15 meter intervals and same time at the corner location to be seen. Or if there is any the building plan you know the where actually heaviest load this likely to come those are the various critical areas to be selected as a borehole location additionally.

And site development; that means, every site development means there is a barren land nothing was there ok. So, in that case first of all site to be developed for project. So, for that every 50 meter 50 to 150 meter apart for preliminary studies. Initially first of all for preliminary studies one can do borehole in 50 to 150 meter apart. So, in between it can be 100 meter also it can be 125 meter it can be 50 meter it can be 75 meter so anything in between.

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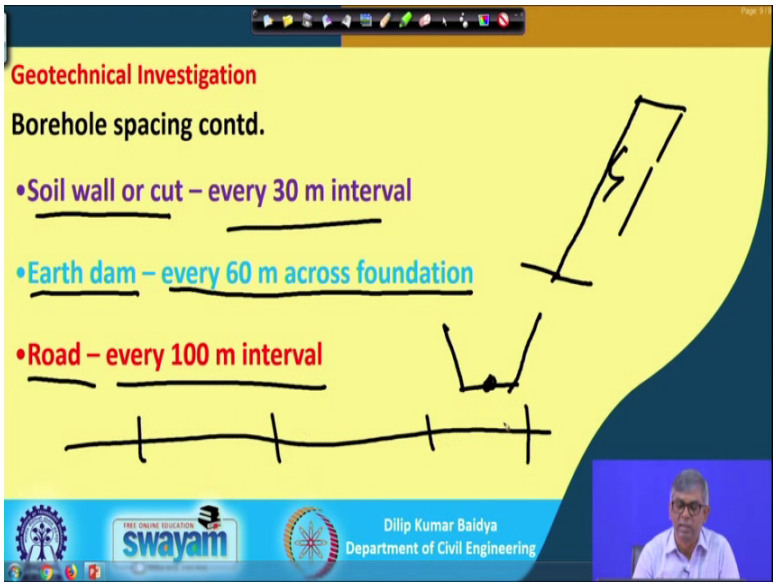

Similarly, borehole spacing in continued you can see soil wall or cut. If there is a excavation like some excavation will be there anyway I will not be able to draw here will leave it. So, if there is a excavation actually like this if the elevation if it is like this excavation work. Then you have to excavate suppose a canal so for a long distance then so or some other reason.

So, you have to do borehole in every 30 meter interval. Earth dam when you construct a earth dam and for that if you want to do the soil investigation every 60 meter across foundation you have to find out the you have to do the borehole and in the road actually every 100 meter interval. Suppose there is a road several kilometers so every 100 meter distance you have to find out the you have to make borehole to find out the soil characteristics.

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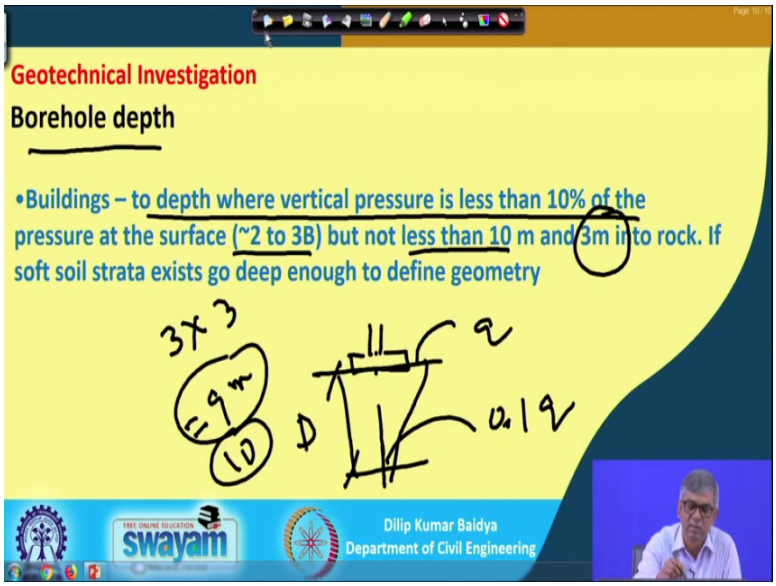

Similarly, for borehole depth you can see for buildings to a depth where vertical pressure is less than 10 percent. As I have told that footing when there is a footing and your vertical stress vertical stress will be distributed like this. So, at some depth whatever pressure here if it is q and here actually 0.1 q suppose.

So, this depth actually how much you have to find out this depth. So, so up to at least that much depth so generally this 10 percent happened at 2 to 3 B depth. So, because of that you have to investigate or you have to make the borehole at least this much depth 2 to 3 B. If the B is 3 meter then it will 3 into 3, 9 meter depth up to 9 meter depth you have to do the borehole. And in no case it should be less than 10 meter.

So, it came calculation 9 meter, but you have to go up to 10 meter and if it is rock then minimum is 3 meter to be done. If soft soil strata exists; that means, while doing this if you find there is a continuously very soft soil layer then you have to go some deeper to find out up to who that is existing because sometimes that will contribute lot of consolidation settlement. So, for that reason we have to go deeper enough.

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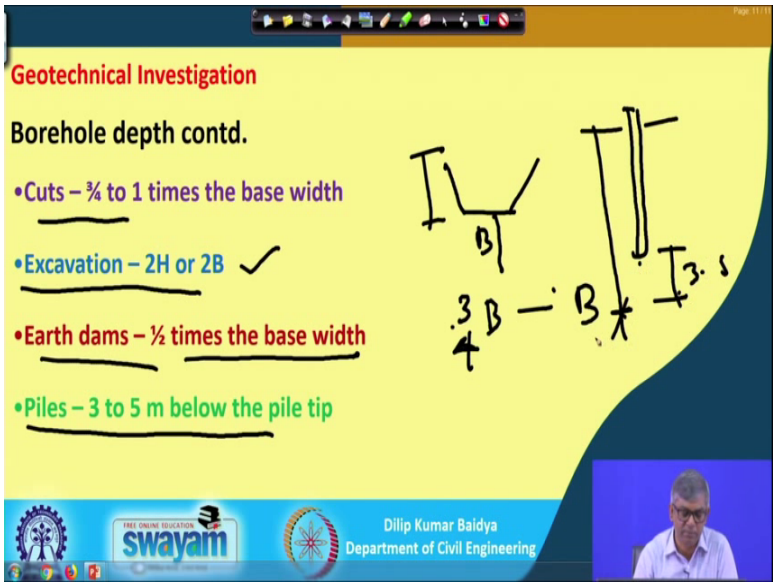

Similarly, borehole depth again for cut, the depth should be 3 to 4 to one times of the basement width. If there is cuts something like that base width is B then your 3 three fourth B to B that should be the depth of the borehole from here. Then if it is a excavation 2H or 2B this is this is this is also excavation similar so it is 2H or 2b.

Then earth dams half times the base width. And then if is a piles three to five meter below the pile tip; that means, if there is pile foundation we have not discussed yet this is a pile foundation suppose. And then from pile tip it should be 3 to 5 meter. So, if this distance should be 3 to 5 meter. So, that means you have to do borehole after this much depth.

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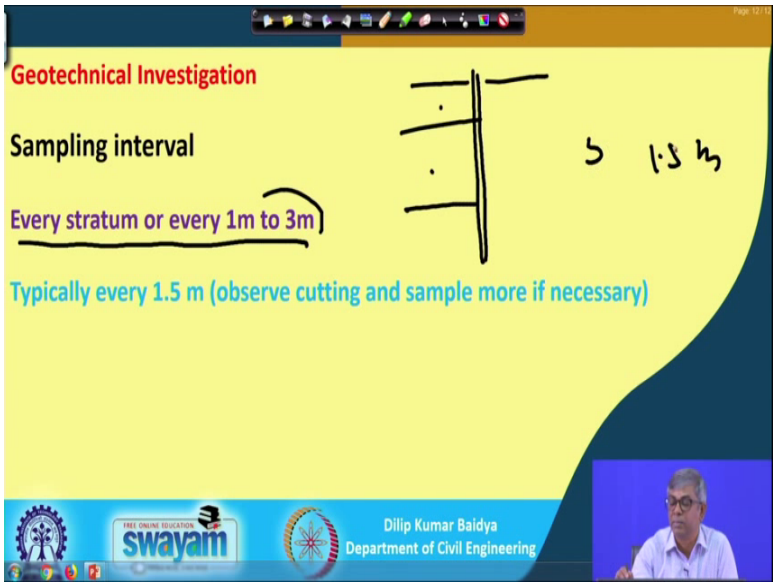

And sampling interval you can see that every stratum or every 1 to 3 meter. So, suppose if there is a borehole we are doing and there maybe stratum we are getting like this. So, either every stratum that is minimum or 1 to 3 meters. So, generally in SPT when you carry out SPT test then we carry out every 5 feet interval that mean 1.5 meter interval you collect the sample. So, that is one and typically every 1.5 meter ok.

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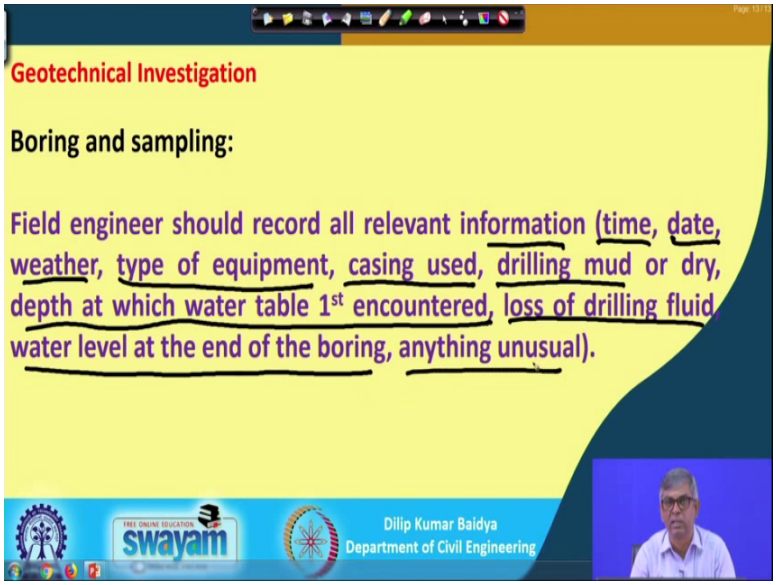

And boring and sampling that is actually you can see field engineer should record all relevant information. that means, what actually boring and sampling program when it

will take. Then first of all we have some sheet and on that sheet top of the sheet you have to keep these are the infinite time. What time you are carrying out test? What is the date that has to be done, weather winter or summer or rainy season?.

Type of equipment you are using different types of boring equipment is there we will discuss that. Casing used whether either uncased or cased the. When we do borehole some soil we have to use casing. Otherwise the site will collapse. Drilling mud or dry depth at which water table first encounter, that has to be noted. Loss of drilling fluid, if it is happening that has to be noted. Water table at the end of the boring.

At the end of the boring what is the final water table that has to be and anything unusual. That means, while doing this borehole sometime you may encounter some sort of difficulties; how we have handle from that we will get that whether is there is rock layer or steep layer all those thing information. So, in the top of the boring program you have to write these are the information for clarity. With this I will stop here.

Thank you, I will go to the next one.