Geotechnical Engineering II / Foundation Engineering
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Lecture – 07
Foundation Engineering Introduction (Contd.)

Good morning, we will continue on Foundation Engineering 6th session or 7th session. Basically, I was discussing about the steps in foundation engineering and few of the steps I have already discussed rest of the steps I will discuss briefly. And, then slowly I will proceed to bearing capacity of shallow foundation. So, let me proceed to the next slide.

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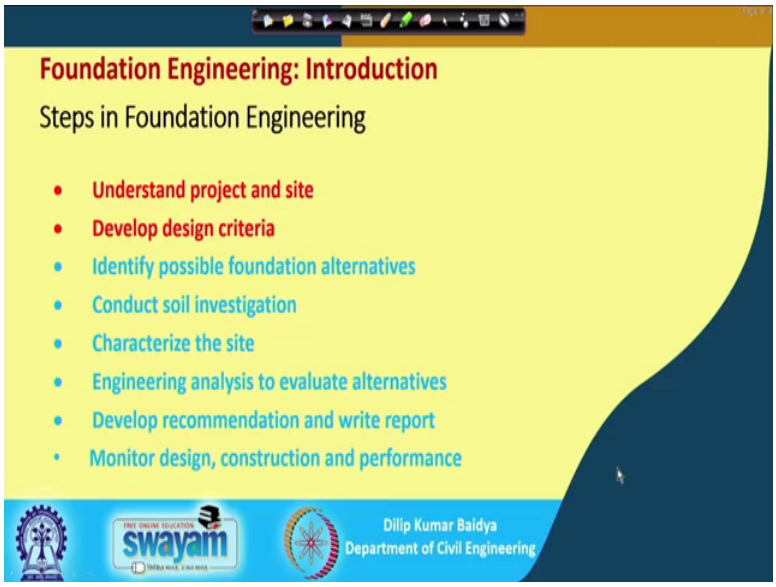

These are the things I have discussed perhaps understand project and site. And develop design criteria these two things I have discussed elaborately. And, now we need to discuss that identify possible foundation alternatives. These are actually depending upon loading condition and the site condition sometime we have several options like, shallow foundation deep foundation.

Again under shallow foundation and we may have isolated footing, combined footing, strap footing, wrap footing, like that several of them. And, sometime wall footing also will be there strip footing or wall footing and they will be assessed whether for a particular loading condition for the foundation they are suitable or not.

Initial objective or target will be to manage or to adopt shallow foundation. And, if you find that shallow foundation is not suitable then; obviously, we have to look for other type of foundation. What is the other alternative? That is actually deep foundation? And, deep foundation means what that close to the ground surface up to certain depth, the soil condition may not be good and that means, if you apply the load then there may be significant amount of substance or even failure.

So, because of that we have to transfer the foundation load or building load to a greater depth. And, we do these by adopting deep foundation. And, deep foundation under that pile foundation is one of the deep foundation then OL foundation pier foundation all are there. And, they are generally expensive also construction also takes longer time even lot of involvement will be there.

So, until unless it is essential we do not go for deep foundation. And, another requirement of deep foundation when the load is heavy shallow foundation may not solve the problem. So, in that case also you have to adopt deep foundation. And, now this regarding this let us whatever I have told let me see some of the thing.

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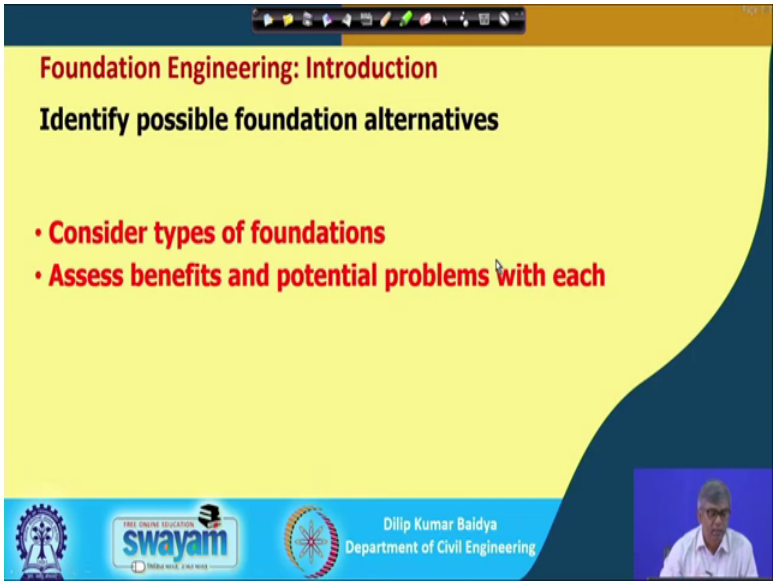

So, how actually this as I have mentioned considered types of foundation; that means, whatever there in my hand different types I will select initially.

And, assess benefits and potential problem with each; that means, what I may adopt as I have told you as I have told you that shallow foundation is economical easy to construct. So, I may adopt first adopt means I will choose the shallow foundation first and I will do different analysis assess, benefits and potential problems. Benefits means it will be cheaper, quicker, easy to construct all those things are benefits and what would be the problems? Suppose if I for a particular area and for a particular loading if we chose shallow foundation you may find that that foundation will go under go huge amount of settlement and that may result failure also. So, all those things to be finally, assessed and finally, we have to choose the best alternative.

So, if you choose the shallow foundation suppose for example and in that case what are the different types of shallow foundation are there?

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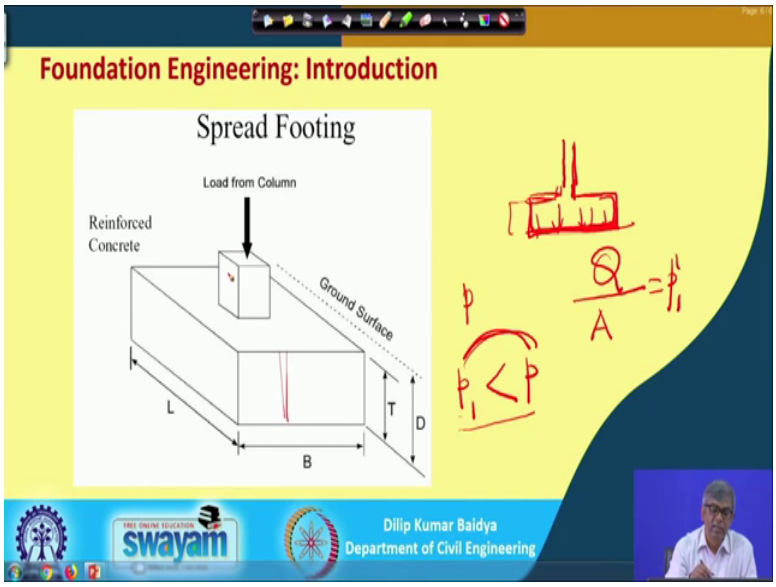

So, I just shown here few of them there can be many. So, this will be for example, isolated footing or sometime it is called spread footing, why it is called spread footing just column is coming here sorry there is a column here. And, then I will be spreading this load over the larger area by enlarging the base. And, how I will enlarge this base how I will select the size? As, I have previously also mentioned that ultimately because of this, this foundation will impose some pressure on the soil. And, how much pressure we can give that if the soil will have their limiting capacity.

So, we have to select the size in such a way that the pressure given by the foundation should be less than the capacity of the particular soil. And, this capacity actually depends on soil type and foundation type also and that can be analyzed later on.

For the time being loosely I am saying that capacity of the soil. What capacity I have not do not want to speak now, because I will do it later on. So, this capacity of the soil I have to make the size in such a way so; that means, if there is a capacity of the soil is suppose p and foundation load is Q, I will adopt area of foundation suppose A and that gives you suppose another p 1, this is the foundation because of the foundation where.

So, p 1 should be less than p. And, of course, I have talked about I will talk about factor of safety. So, how much this and this, how much less or how much more it should be and that has to be decided by a now that is another thing that is factor of safety in foundation engineering that we have to keep enough merging. So, if you keep the ratio is 1; that means, factor safety one that just verge of reaching the capacity, but the that is why to keep sufficient margin we have to go higher than 1.

So, it can be 1.5 2 2.5 3. And, I will show you later on that in foundation problem most of the time this margin will be 2.5 to 3 times; that means, factor of safety to be used 2 to 3 times. So, that is the one; that means, base of the column we are enlarging to spreading over a larger area, because the concrete and other things strong material, but when it will go to the soil it will has a very less capacity..

So, to reduce that stress intensity on the soil we are just enlarging the base and that is why it will be called as spread footing. And, also it is called isolated footing why, because the individual column a connected by a enlarge base or foundation. So, that is why it is called also isolated footing pad footing spread footing they are a different names by which we can tell this footing type. And, here actually main thing is that you have to give area in such way that pressure given by the foundation should be less than the capacity.

That is one aspect and of course, as a geotechnical engineer later on you have to do other things like what should be the thickness and then that should be what should be the reinforcement all those thing that is the design aspect that I will come later on. So, for the time being so, this is the example of spread footing.

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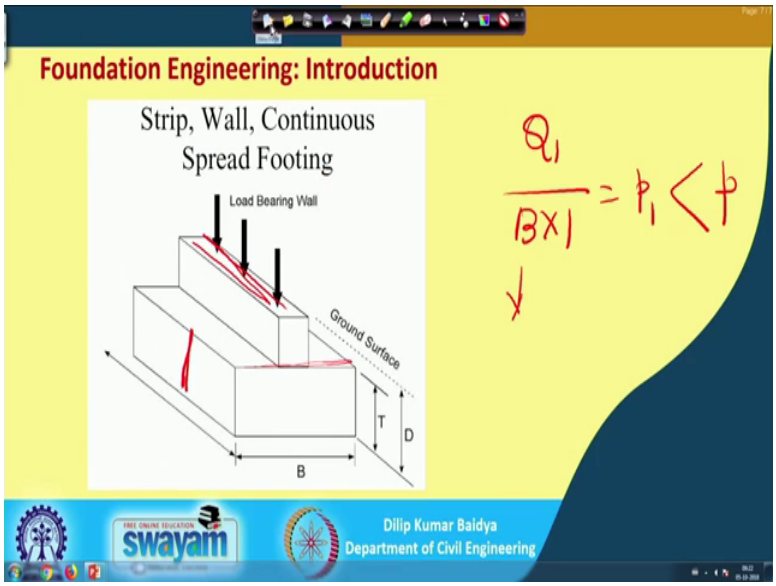

Next, I will show you one more type of foot this is actually another type of footing that is called strip footing, sometime it call wall footing, sometime it is called continuous spread footing. So, this was the thickness of the wall suppose and again whatever intensity there below the column or this wall, if I put that one in the soil again it will not be able to sustain or it will exceed the capacity of the soil.

So, because of that this base of the wall to be enlarge like this so, which will be widen. And, this direction can be any length wall can be of any length so, perpendicular to this that this direction can be of any length. So, I will I can take a unit; I can take a unit length and I can take this is the width so; that means, ultimately here also over a unit length how much load is there suppose Q 1 over a unit length then area is B multiplied by 1, that gives you a pressure p 1 and that should be less than the p of the soil.

So, this way so; that means, here actually you have to find out what should be the width that is the desired thing we have to find out. So, that the pressure applied to the soil by the footing will be less than the capacity of the soil. So, this is the spread footing, the different kind of spread footing that is sometime called strip footing that is like a strip continuous sometime it is called wall footing that below the wall most of the time we use this type of footing and sometime it is called continuous footing.

Sometime instead of wall there can be of number of columns that can be connected by a strip that also can be also called as a strip footing. So, this way different names are given.

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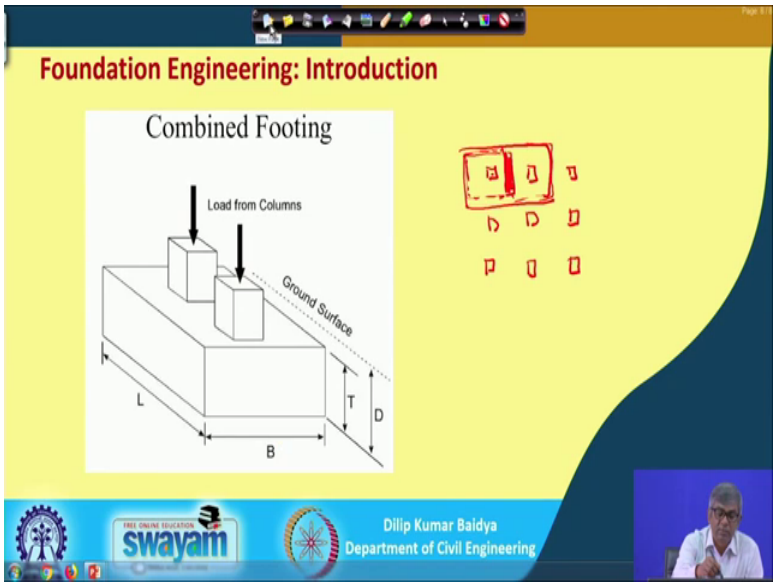

Then this is actually another type of footing that is actually a combined footing. You can see that 2 columns will have a common foundation ok. And, there are several areas where actually you need to do this one important reason why we do, when actually you can stability will be increased you 2 to 3 columns are put together, that stability will be increased settlement may reduce or chance are different settlement also will be reduced

. Another thing while construction of the constructing this foundation, suppose this is a column location, this is a another column location, this is a another column location, this is a column location, this is a another column location, this is a another column location, this is a another column location, this is a another column location like that is a building suppose there are several columns like this they are located like this. And, the compare to the dimension of the column your dimension of the footing will be quite large.

As a result means for construction time, you have to first excavate. Equal to slightly more than the size of the footing you have to excavate like this. Similarly for this footing also you have to excavate. So, like that; that means, if there area of footing required is such when you excavate then there you may find there will be over lapping ok; that means, this footing is reaching to this footing that is that may happen or sometime the excavation is so, much that little strip of wall or soil is left; that means, you are excavating almost entire area. Keeping a small portion on excavated sometime will difficult and not equal (Refer Time: 13:07).

So, because of that instead of keeping this small amount of soil here, if you can excavate totally and then 2 columns are given a common footing sometime it will be better many ways. So, we will discuss that also in the later on. So, that is these are the various reason why we use combined footing; that means, combined footing means some of this footing and this footing together I will put a common foundation. And, reasons are mainly if the excavation is too much for individual footing then I can at a together I can excavate. And, then finally, construct the single footing and then that footing 2 columns can be started.

So, these are the this is also called combined footing because 2 or more footing when there will be have a common foundation that is called combined footing. And, again combine when you will combine footing will design there are again other aspect like you have to first you have to find out area. And, most of the time it can be rectangular, but if the unequal load or spacing is different or some other constraints are there sometime the area can be also of trapezoidal shape. So, that aspect also we will discuss later on. So, this is another type of isolated footing.

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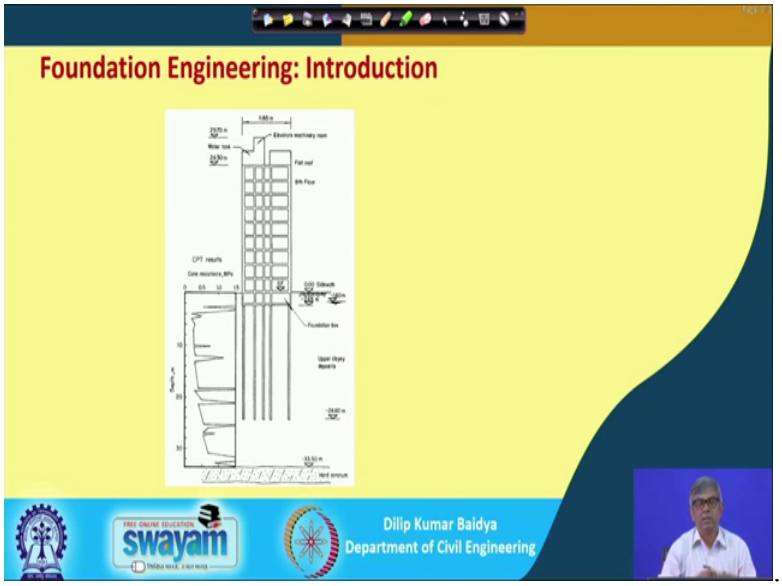

And, suppose those are there are many other like mat foundation also another thing that will be entire number of suppose whatever number of column 9 number column I have shown, instead of doing combined or isolated. If the entire base is first constructed like a mat and then from that mat respective position the column is erected; that means, all

columns we will have a common foundation, that is also called mat foundation. And, mat foundation is also god shallow foundation it is stable settlement also will be less.

But, problem if it is not, but it will be expensive compare to other type of footing. So, because of that sometime we will not easily select at the beginning. So, those are all different types of shallow foundation and those shallow foundation when you find that because of some situation it is not adoptable, then you have to go for deep foundation. And, deep foundation means actually what? The foundation will be at deeper depth, that is one thing and when you consider this deep foundation. Generally, if the building is very tall like this is heavy building this is tall building means automatically you will have more load.

Secondly, when tall building there will be stability problem also, if this a this is a tall building and if you make a this much depth of the foundation then there may be stability issues ok.

So, suppose if the foundation is stopped here for a (Refer Time: 15:59) tall building, then there is a chance of toppling; that means, stability problem. So, two things; that means, one is when the building is very tall, then stability aspect to consider stability address that stability issue we have to go for deep foundation or because of the heavy load you need to go deep foundation or when the soil surrounding this zone is weak; that means, shallow foundation will now work. In that case you have to go for deep foundation and deep foundation actually finally, how deep will go. Most of the time if possible you try to find out a stiff or hard stratum up to that you have to go or if it is not available suppose in the long pile can be made and whatever friction force available along this that will be enough to support the building load.

So, I will discuss all details later on that what is friction pile and all. So, as far as possible that pile should penetrate up to a depth of the up to a depth where at which good soil is there rock is there that will be most preferred it is not dense and if it is not there also it is possible.

But, as far as possible we try to reach to a better standard. And, so, this is another or foundation alternative that deep foundation. And, until unless it is essential we generally do not adapt this and we adapt only for important structure, heavy structure, tall structure, like that.

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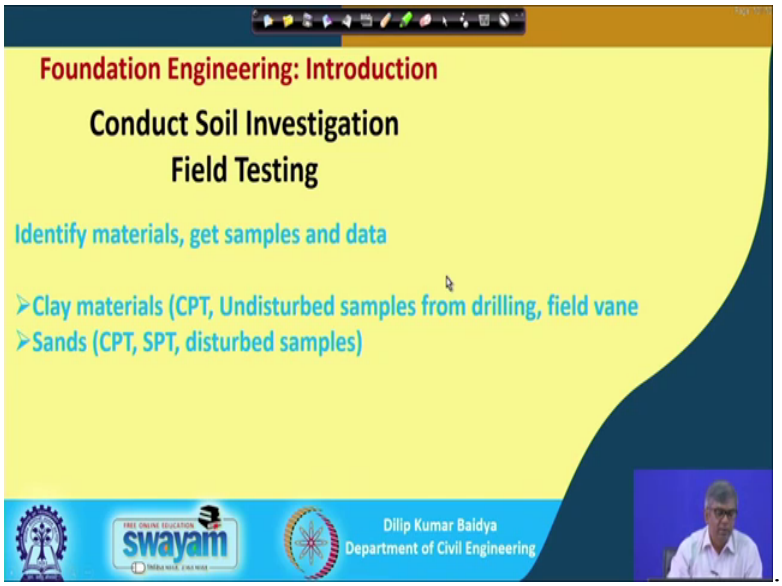

And, next part is identifying materials and get samples so, next part was the alter select the different alternatives and chose the best one suitable one. And, next part actually conduct soil investigation and field testing. So, in fact, sometime the soil testing etcetera can be done before foundation design, but sometime the reverse can be done. So, conduct soil investigation and field testing. So, in under that already I have discussed in soil in the quick review that identify materials and get samples and data.

That means if the site actually first we have to visit when the project site and you have to guess initially, what are the types of soil available there for just visual inspection. And, then afterwards we may have to carry out the number of field test. And, then some of the things cannot be determine the field in that case you have to collect sample. And bring it to the laboratory for carry out some test and get the other parameters, like that in combination of field and laboratory you have to characterize the soil ok.

So, characterize the soil; that means, finally; that means, what type of soil, present in the soil, at a particular soil, what is the thickness all those things are to be determined. So, typically if there is a clay materials they I leave clay type of soil is there then we conduct typically CPT, then undisturbed samples from drilling and field vane shear test we carry out. So; that means, if the clay materials clay type of soil if you see then generally carry out CPT test.

And, we try to collect undisturbed sample ok. If, I want to test in the laboratory you need undisturbed sample. Undisturbed means what that while getting sample you should not minimum disturbance will be created on the soil ok. There are some procedure we will discuss that later on. And, otherwise if it is too soft soil there is another field test method available that is a beam shear stress that also I will discuss later on what it is that can be carried out in the field.

And, if it is sand type of soil then we can carry out CPT sometime we can do SPT additionally that we can be do and disturb sample. So, sand actually the particles are not bounded properly. So, it is very difficult to collect undisturbed samples. So, because of that we just get the disturb sample generally to characterize like grain size and other properties to determine we get a disturbed sample in the laboratory.

And then on that disturbed sample in a particular field condition we can simulate and get the actual properties of the soil. So, these are actually two things; that means, depending upon the types of soil what type of field test can be adopted, that can be given guidance.

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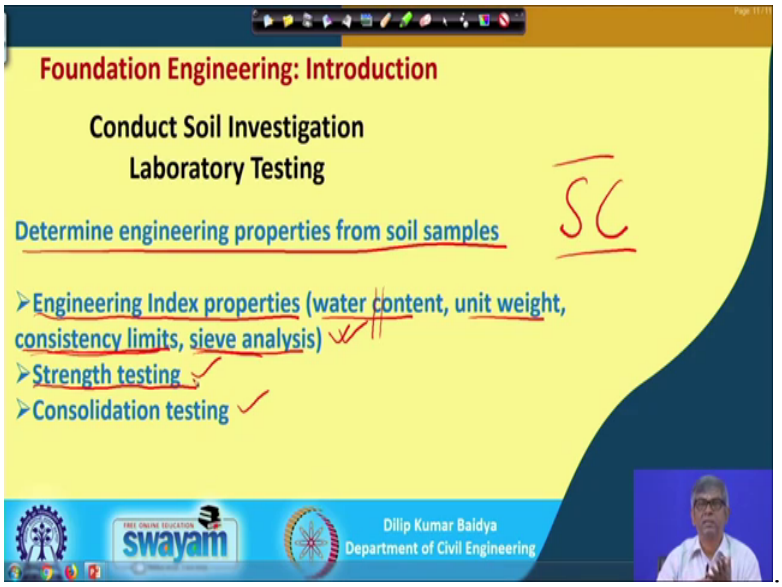

Next is the determination of the engineering properties from soil sample; that means, whatever we have we are doing the field we get some data. And other than that whatever sample you are collecting from there also you need to find out the engineering properties of very other varies other property type of properties of the soil.

So, engineering under that engineering index properties, this is that engineering index properties this we have discussed under soil mechanics quite elaborately. Even in the review of soil mechanics I have mentioned that water content unit weight these are the basic things to be first noted.

And, then if it is a soft soil or fine grain soil contents, then you have to need to find out consistency limit. And, if it is granular soil you need to do some sieve analysis sometime the soil is mixed type then sieve analysis and consistency limit to both to be done. And, after doing that what is the purpose of this again using either grain size distribution or combination of or plasticity charge or combination of grain size and plasticity charge together, we can classify the file ok.

You can name the soil and that is also how to do the classification step by step everything I have discussed also in the review that first of all you have to see the soil. If the soil is organic type how to identify organic soil, color is black, there will a smell, distinct smell, then treatment is different. And, if it is not if it is a inorganic type again you have to see whether it is granular or it is fine grain.

If, it is granular then the straight go for a sieve analysis and if it is a fine grain then you have to do the plasticity analysis. And, based on that you have to classify the soil and to later system you have to use suppose like S C. Finally, classification of classify the soil as this, it means what it is actually clay sand ok. So, like that that is finally, you have to name the soil based on this investigation.

Next part these are actually index properties to qualitatively know the soil characteristics, but actual characteristics will be known by some advanced states like strength test and consolidation test through the consolidation test. Actually soil compressibility will be known and strength test actually know the capacity of the soil how much load it can take. And, for strength test actually we have the several options, I have also mentioned discuss elaborately in the soil mechanics class also in the review class I have mentioned that, we have direct shear test, we have triaxial test, we have UCC test, unconfined compression test, we have beam shear test like the several test are there.

And, again if the triaxial test is the most suitable test only mainly because why it is most suitable, because we can simulate the different field condition that mean triaxial means

all 3 direction will be stressed, that suppose if I consider a point inside the soil a ground then you will be that that point will be subjected to pressure from all direction.

So, similar thing can be simulated in the triaxial test that you have to give a confining pressure and then you have to apply pressure from the top to reach failure of the sample. And, best on that we can determine various strength parameter of the soil and again this triaxial test again there are several types there can be unconsolidated undrained test, but very quickly we want to find out undrained strength of the soil we can do that, but actually if you want to find out the drained test drained strength of the soil, then you need to carry out the other type of test; that means, consolidated undrained or consolidated drain.

So, those details I have discuss I will not able to again repeat in elaborately so; that means, there should be a strength test you have to carry out and after carrying out strength test you have to find out the compressibility consolidation test and through this consolidation test what we will get the compressibility properties of the soil.

Now, what is mean actually; that means, if I the apply load certain amount of load to the soil, then how much it will settle that mean how much compression will take place and you know that every foundation will have some limiting settlement. So, until unless you know the compressibility property then you learn be able to estimate what will be the amount of total settlement?

So, this for that consolidation test to be conducted and consolidation test means actually you will have to pressure versus; pressure versus void ratio change to be obtained and from there we can find out C C M B A V there are many parameters and based on which you can find out the consolidation property. And, then in addition to that that you know you need to know that how long the soil will take to consolidate for that actually another parameter that is coefficient of consolidation. There are again various test available so, which we have discussed also in the soil mechanics. So, I will not do that here.

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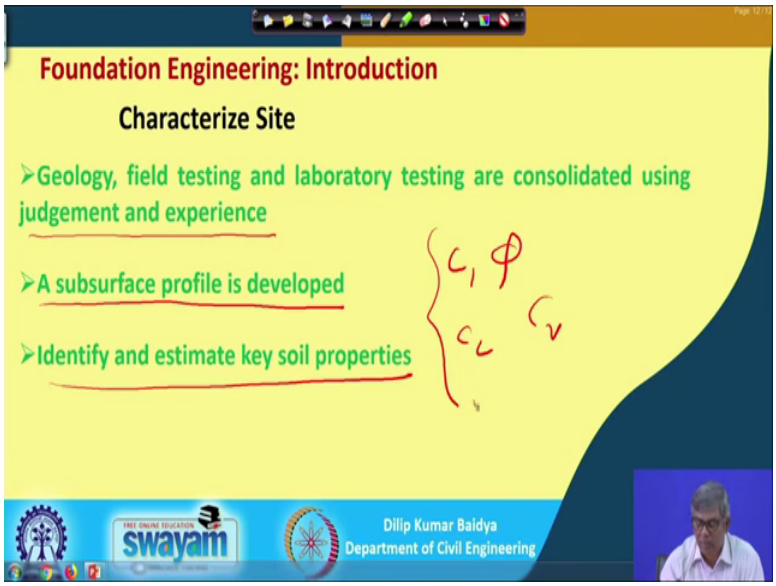

And, then characterized the site means actually what that means, ultimately after doing filters then after knowing the geology of the site knowing the laboratory test. Finally, you have to characterize the site geology field testing laboratory testing are consolidated are consolidated using judgement and experience. That means, using judgement and experience in soil mechanics or foundation engineering judgement is very very important.

Why it is know? That if you collect a sample and carry out test similar condition almost everything is identical, but you test in a 5 different places you will never get same results. Because of many reason because soil will not be identical same there maybe some variation then there are equipment there will be issue, then there will be a operator issue, there are various reason because of which you will get a 5 different results if I test from 5 test.

So, ultimately you have to adopt a value which may not be out any of them. So, that is actually the judgement; that means, with experience the geotechnical engineer has to develop that judgement judging capacity. That after knowing all those things you have to finally, characterize the site with certain values those values may not be exactly of any test. So, you have to in between some value to be taken. And so, that your ultimate building which will be constructed will be safe and sound serviceable.

Then finally, you have to give a subsurface profile to be developed and identify and estimate key soil parameter; that means, what is the value of C, what is the value of phi, what is the value of C c, what is the value of C v like that several other properties are there, which has to be listed. And, from there what should be the bearing capacity and all those thing which can be estimated again from there so, those to be identified.

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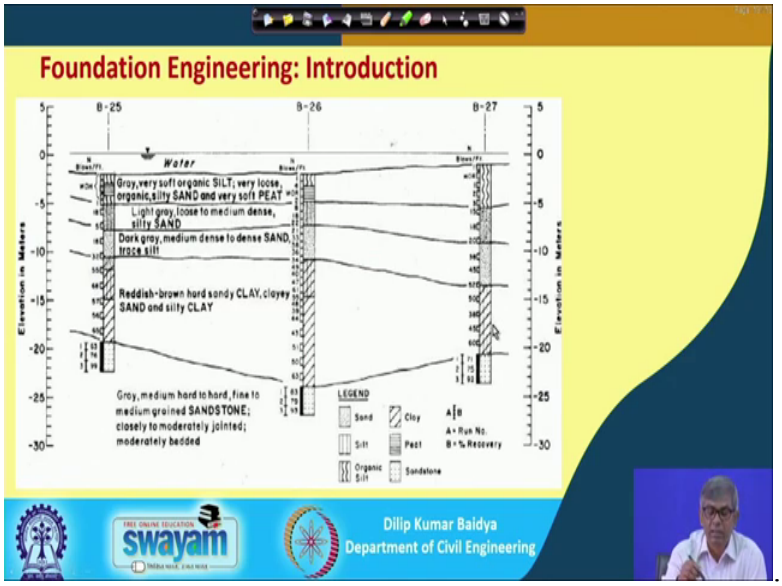

This is the typical soil profile actually can see that different depth how it is varying? So, you have to make a borehole and over the borehole you when sample is coming out from that you and what suppose I am advancing the borehole some 2 meter to 4 meter and then you have got throughout same type of soil.

Somehow in the as a fluid on soil mix with water as a form of fluid is coming out we can continuously monitor and from there you will see that 2 to 4 meter is coming uniform. Suddenly when it cross 4 meter you may get a different types of fluid, then from there actually you; that means, you have to understand that there is a news data.

So, immediately you have to collect sample and you have to mark accordingly and finally, you have to represent in the paper that profiling over depth. And, if there is a if there is a borehole here another borehole is here and if you see similar type of things in same depth; that means, layering is horizontal if it is a some depth and if it is some lower depth that mean may be there is a layering with slope this. So, accordingly finally, you have to give the profile of the site; with thickness of different soil layers.

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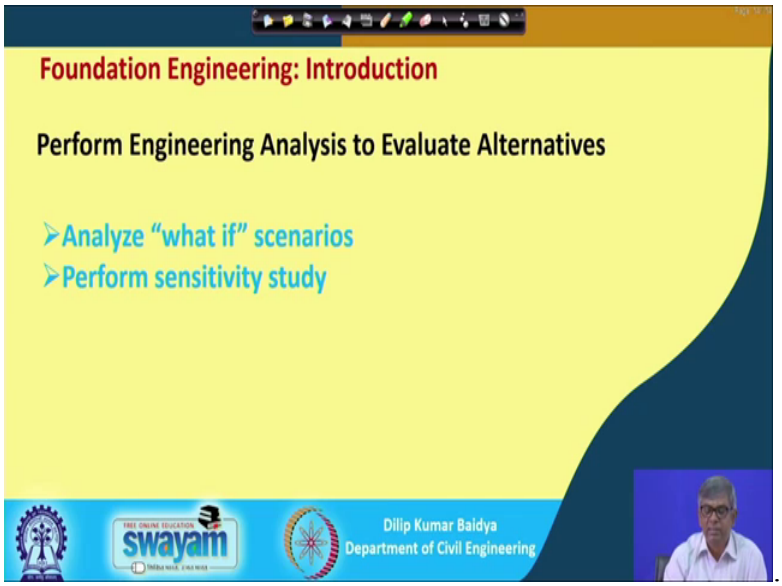

And, then perform engineering analysis to evaluate alternatives again once again after test results and all, you have to once again reassess and see that whatever you have adopted whether it is correct or wrong. And, analyze what if scenario; that means, if I do this what the happen, if I do this what will happen or if I do this what is the benefit if I do this, what is the harmful effect? All those thing if, but scenarios to be examine and finally, you have to make sure that whatever you have chosen that is the right one. And perform sensitivity study; that means, if I change this one how it is effective if I change this one? How it is effective this one? The, what which parameter is more sensitive all those thing to be again identified at this level.

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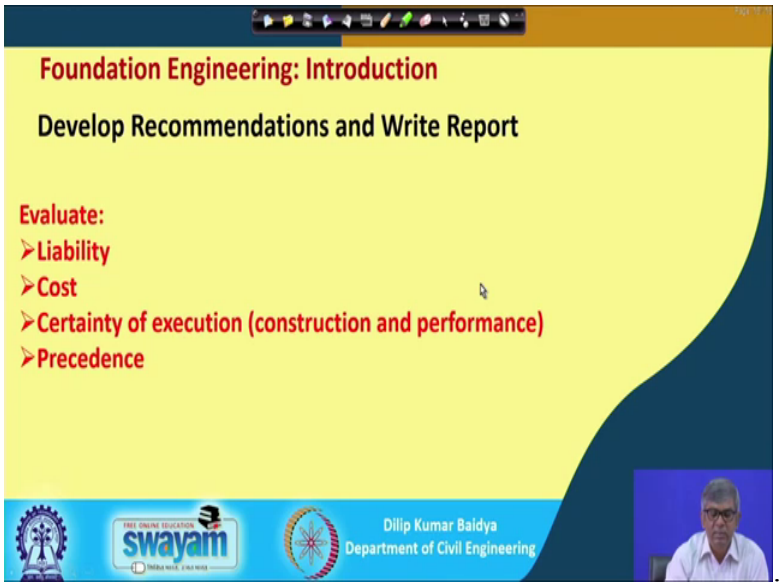

And, then foundation then again develop recommendation and write report. They are actually finally, after doing all those things whatever the steps we have examine and based on that finally, we have to write report and give a recommendation that, you should not do this you should do this or you have to do with this condition satisfying this condition or should some restriction. All those thing in the form of report to be given.

And, you can see here that liability what should be the liability what if you adopt this what should be the cost expected whether it is the economic or non-economic, or creativity or certainty of execution; that means, you have adopted you have suggested something which is difficult to execute that also we have to make sure by examining various parameters. And, presidents; that means, that nearby area what type of constructions are there and based on that sometime you can adopt easily.

So, that also has to within or suppose in the similar area something is constructed, but it did not perform properly that point also has to be considered for actually reexamining your whatever design you have done. So, these are the different aspect to be looked into.

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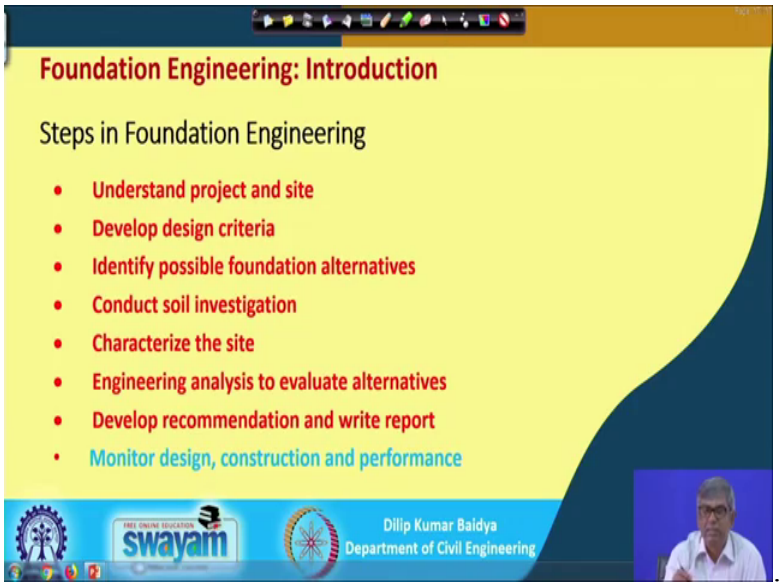

And finally, last step we have reached actually this I will not be going to discuss under this I will may I may go to the next lecture that finally, monitor design then construction and performance. The finally, after you construct actual recommend that design and then it will be constructed. After construction also you have to monitor for sometime because what we are expecting whether it is behaving as per that or not that to be seen. So, that part in detail I will discuss in the next slide. Now, with this I will close here.

Thank you, thank you.