Geotechnical Engineering II / Foundation Engineering
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Lecture -06
Foundation Engineering Introduction

Welcome again, to this Foundation Engineering. I will be starting I have in few lectures I have covered the just to review the soil mechanics. Now, I will start foundation engineering with Introduction of Foundation Engineering.

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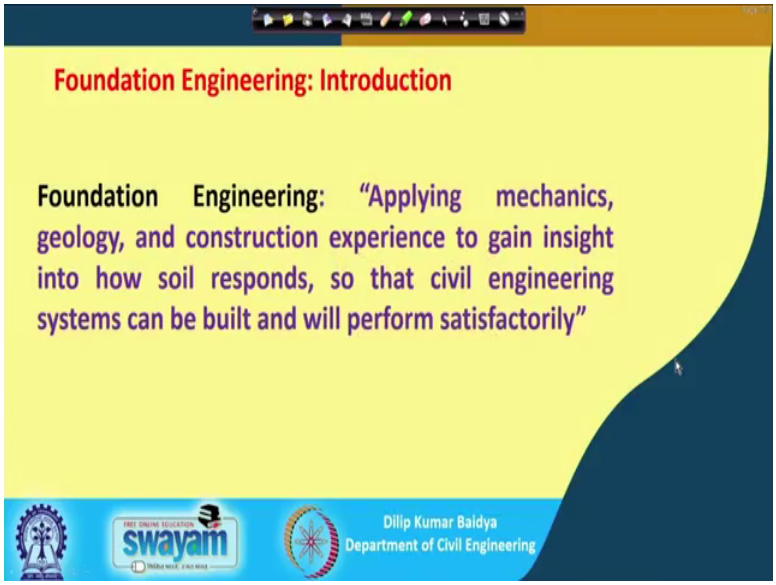

And you can see that the foundation engineering means what actually? This is the applying mechanics, then geology and construction experience to gain insight into how soil responds, so that soil engineering systems can be a, civil engineering system can be built and will perform satisfactorily. So, this is the foundation engineering key goal ok. So, you have to see applying mechanics, geology, and construction experience past experience somewhere so already done from there some difficulty or set or whatever happened based on that experience, we will learn something. And based on that we show that we can civil engineering system can be built and will perform satisfactory that is actually nothing but foundation engineering.

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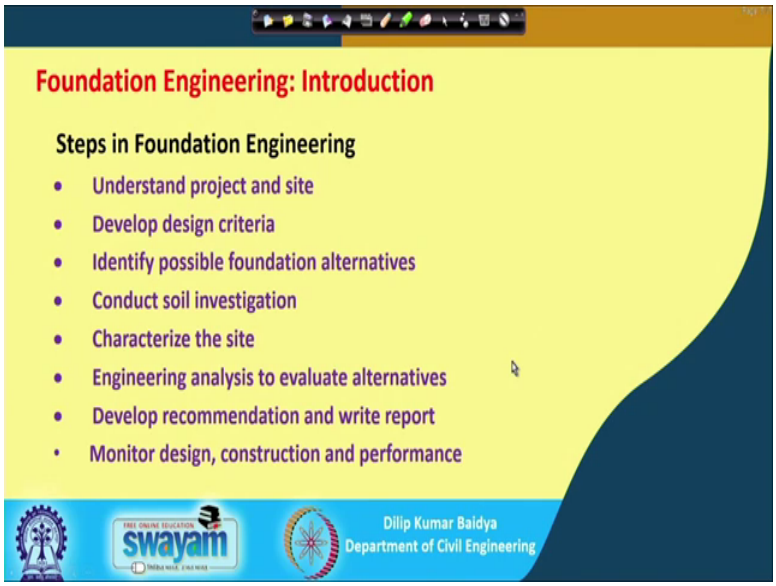

Now, under this foundation engineering as I have covered that this is foundation engineering will be covered in various steps. You can see the first step in the is understanding project and site, and then develop design. Understanding project in site means what for the project and the locations etcetera you have to understand first. And then develop design criteria, that mean, different design criteria that means, somewhere you have to restrict certain settlement or sometime some pressure, so those are all different design criteria that has to be used.

Identify possible foundation alternatives that means there may be the several options, but finally you have to pick up the suitable one. Then you have to soil investigation you have to carry out that means you have to know the detail about the soil. In fact, sometime soil investigation may be done before selecting the foundation time. Then you have to after soil investigation, you have to categorize the site that means, whether it is what type of site it is.

Then engineering analysis to evaluate alternatives, then real analysis has to be done to evaluate the alternatives. Then develop recommendation right before that means finally after doing that you have to give a report and recommend that this type of foundation is suitable this area or some similar type of things. And then finally, after doing that you have to monitor design, construction and performance, that means, while doing this, while designing you have to monitor, whether is there is something anything goes wrong,

and then during construction also you have to have monitor, and also after construction also you have to see how it is performing. So, all those things to be considered in foundation engineering.

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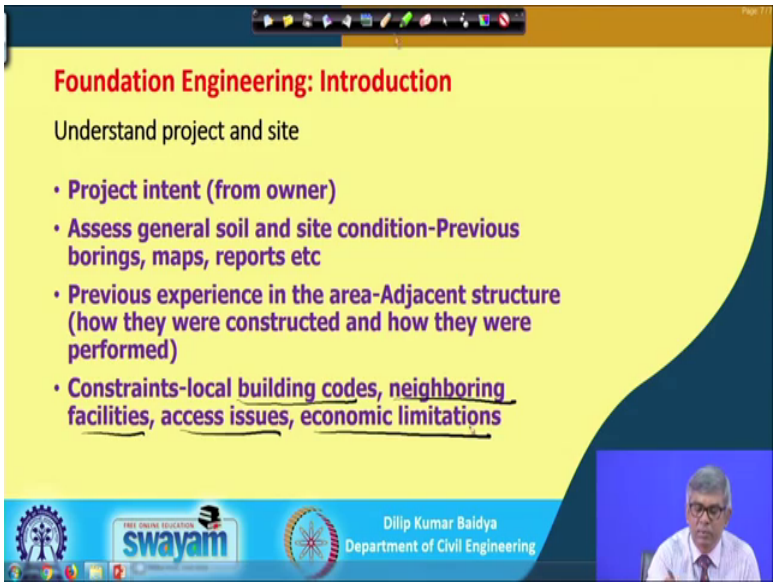

Then understanding the project and site under that what you should look for this is the one actually you can see that project intended. That means, if you cover, if I have, if you get a project, then you have to know what is the project, that is (Refer Time: 03:37) from the owner. Actually, that is a residential building, whether it is a commercial building and whether it is a something else that that project intent first to be learned. Then assess general soil and site condition, that means, how you will get that form the previous borings, maps, reports, nearby structure etcetera.

And then previous experience in the area that we adjacent structure, how it was constructed, how perform that has to be also investigated or it has to report. If there is any report, you have to see and evaluate them. From there, you can use your experience to the next project. And then constraints that means local building codes, sometime there are building codes will vary place to place. So, you have to see those codes, the neighboring facilities, access issues, economic limitation, all those things to be seen under understanding the project and site. So, these are the points you have to look for.

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Next part is developed design criteria, under these actually there are several things, what are those? First thing is allowable settlement. That means, when you construct a building or develop a facility that on the soil, then the building definitely will undergo settlement. I have already explained in the soil mechanics. And even in the review that if you build something on the soil, then because of the compressibility property of the soil the building will settle. And that settle you cannot allow any amount, so that there is a limit so that is one thing allowable settlement you have to see.

Then acceptable factor of safety, so factor of safety actually is a term that is the ratio of two things and different project, different factor of safety is demanding will be demanded. And so the accordingly you have to see what is the type of work and what value of factors can be used that has to be seen. Then identify constructability issues that means, in a particular area some method may not be able to apply, so that thing you have to see. Then obtain design loads that means, what are the different source of loads building loads allow is obviously will be there, there will be live load will be there.

In addition to that, there may wind load, there may be earthquake load, there may be some other loads that has to be seen. And then finally, you have to refer the building codes for designing. So, you cannot do just like that apply application of mechanics. In addition to that, must considering the material behavior and many other things people have given, some recommendation the form of codes that has to be used for the design.

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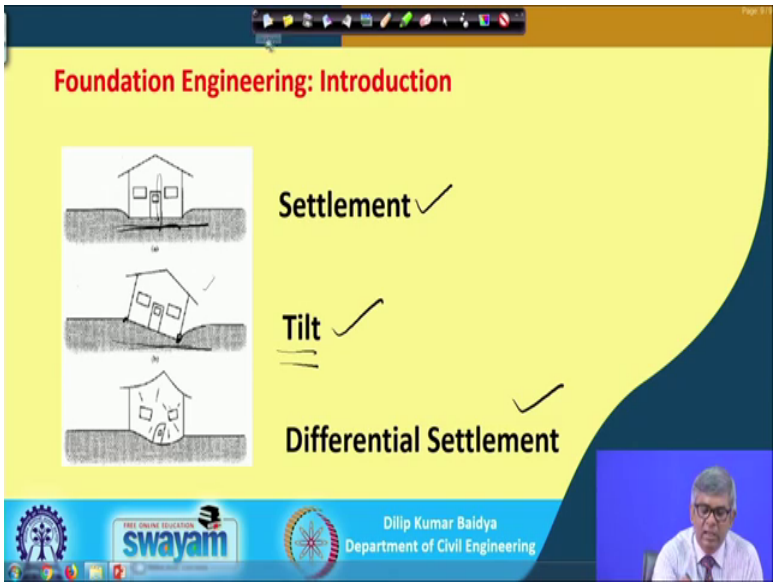

And next part is the under this settlement as I mentioned the settlement, settlement again can be of three different types you can see. This is settlement where they enter building is settling uniformly, it is not that much harmful. If it is little higher value, but still it is not harmful because building is this is settling uniformly. Whereas this settlement is called tilt that means one side is tilt is settled more than the other side, then that is called tilt. And this tilt actually sometime is a harmful that I will come later on. And this is another type of settlement you can see that this is actually tilt, actually what this can be different amount it can be this site no settlement this settlement because of that also tilt can happen.

And this is another situation where this is called differential settlement, because different places settlement is different, and because of that, building may develop cracks and all that is the thing is shown here also. So, these three types of settlement are there settlement, general settlement, then tilt, and then differential settlement. So, these different of settlement have different limiting value that has to be seen and considered during your design.

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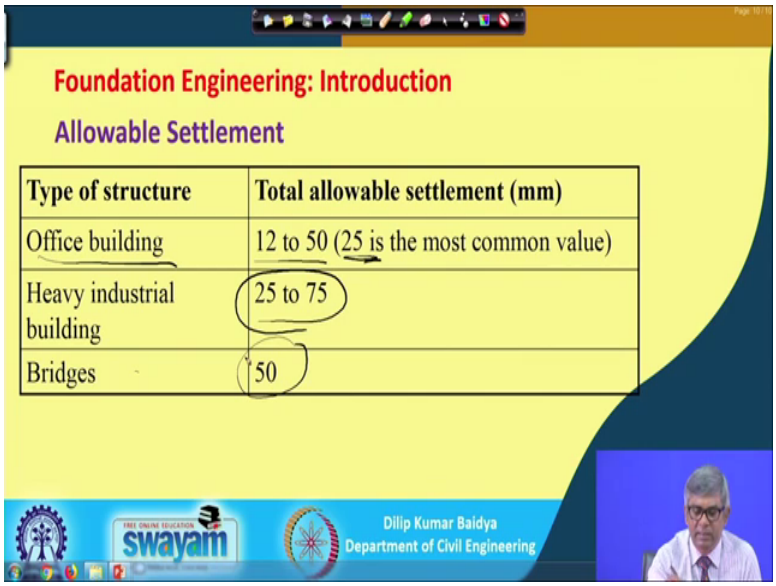

And you can see that allowable settlement for your office building. It will be sometime 12 to 50 millimeter in our code if you see value may be different. I am just referring a average value 25 millimeter may be the most of the time is common value. And heavy industrial building the settlement can be allowed little more; it is 25 to 75 millimeter and bridges generally settlement limit is 50 millimeter.

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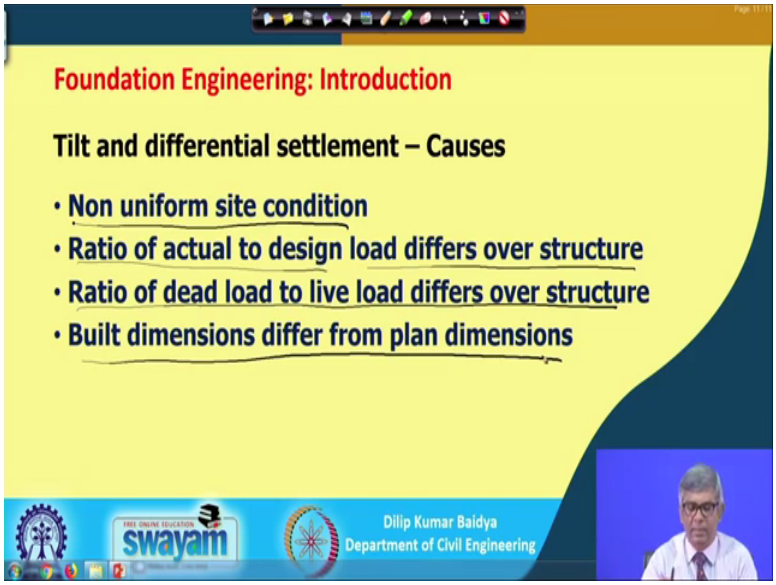

Similarly, tilt and differential settlement why it happens actually there are a number of issues you can see. Non-uniform site condition, that means, building is constructed over

a site, one site is better, other side is not that good. In that case, one site settled will be more, and other site will be settled will be less and that will cause non uniform settlement. Then ratio of actual design load differ over structure, that means, while designing you have consider certain amount load, but actual in the functioning time load is different, then it will have some differential settlement or tilt.

Ratio of dead load to live load, if differs from the structure that also cause some tilt and differential settlement. Building dimensions differ from plan dimension. Actually, you have designs certain dimension, but finally while construction it differs a lot in that case also these things can happen.

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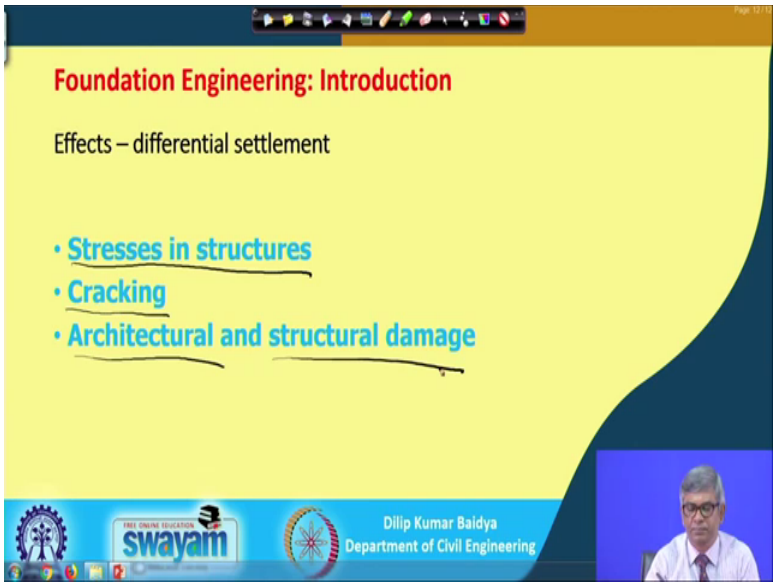

Similarly effects of the differential. What are the different effects of differential settlement? As I told you the differential settlement is the harmful the stress in the structure. So, if the if the building is there, if it is settled like that, if it settled this side, then automatically these will be extra stress on the building elements like beam, column or wall, and then automatically there can be cracks, and there can be architectural and structural damage.

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And then, what is the effect of tilt? Tilt also will have some effect. And you can see the first thing is uncomfortable feeling. If you see that the building is tiled like this, you will feel free uncomfortable. You will get scared to reach to close to that building. Anytime, you will be feeling that it may fall. It may not fall always, but if it exceeds certain values then only it will fall. But if there is any minor tilting is observed then automatically, you will have uncomfortable feeling. And then of course, this tilting is too much then there will be lack of stability and it may finally fall also, so that actually because of that this tilt differential settlement; and settlement all should be considered while designing. And this is the tilt example we have given.

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And then next is the develop design criteria. So, next step I have shown the number of steps and projects understanding project is one, and then design criteria develop design criteria under that then I have shown the settlement and next is the factor of safety. And this factor of safety what is the meaning of factor of safety is the capacity divided by demand. Capacity means what? The soil will have capacity to bear certain stress, so that is actually soil capacity.

And whatever demand means what, if I build a structure and then because of that soil will be stressed and that stress actually has to be resisted by the soil and that stress is because that become divide, so that stress says should be smaller than the capacity of the soil then only it will be stable. Otherwise if your demand is more than the capacity then it will collapse or failure will occur. So, that factor of safety will be another issue which has to be considered carefully and typically this factor of safety general 2 to 3 for foundation engineering, whereas for slopes and other wall generally 1.5. So, these are the value recommended values, we have we have to use during design step.

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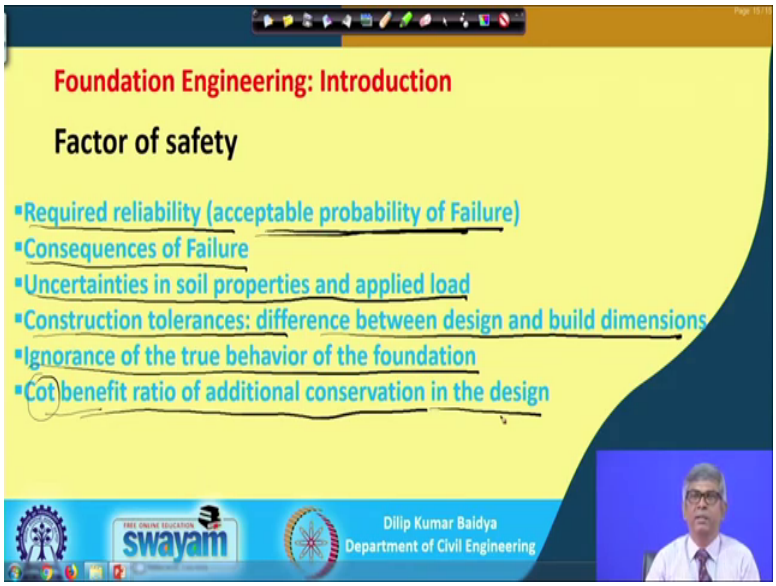

Next is a factor of safety. Again factor of safety depends on many things. You can see here the required reliability. So, the acceptable probability of failure, that means, the factor of safety you are, by calculation you are giving factor of safety 2, but in the mean time, in the soil parameters itself if you have some error, then you are not able to access the value properly so that mean how reliable that that is another issue to be seen. That when you will make the ratio of capacity by demand and while estimating the capacity, while estimating the demand if there is an error then that value learn know that number will have not any significance. So, because of that you have to have certain reliability; that means, how reliable your data, how reliable your calculation that has to be you have to make sure.

Similarly, consequences of failure then means you have to understand that if failure of occur what are the consequences, there is big loss that has to be kept in mind. And because of that if necessary you may have to adopt little higher value of factor of safety. Then uncertainties in soil properties and applied load that this is off course sometime as I have told you answered, and so you have to do is little bit of reliability to make sure what could be the value.

Then construction tolerance, so difference between design and build dimension. Sometime how much difference you can permit that has to be there. Ignorance of the true behavior of the foundation. Sometime you understand the soil may behave like this, but

that soil may content something else. So, you do not know the behavior, in that case also something may go wrong. So, you have to also take care of that.

And this is a spelling mistake, actually cost benefit ratio of additional conservation in the design, that means, if you always if you want to see that the economic, but if you add little cost what will be the benefit, so that should be seen. And you have to make as far as possible the structure safe and serviceable.

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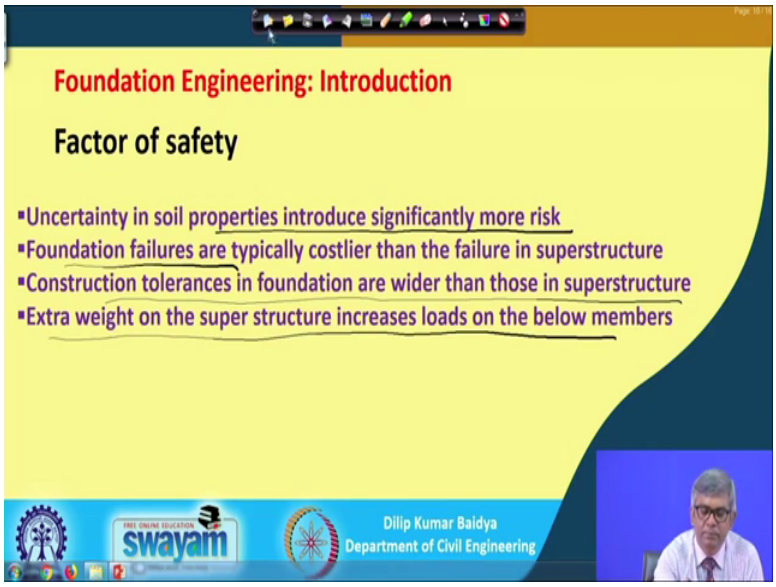

Similarly, factor of safety is will be uncertainty in soil property introduce significant seek to more risk. Then foundation failures are typically costlier than the failure in the superstructure. If the sub structure some portion is failed, sometime you can reviewed, but if the foundation failed, then the entire thing to be build, so that has to be kept in mind. So, because of that sometime you need to adopt little higher value of factor of safety while designing geotechnical structures.

Then construction tolerances in foundation are wider than those in superstructure that is also you have to make sure that you have to you can accept. And extra weight on the superstructure increase loads on the below members that is also sometime make little bit of unreliable. So, that also has to be considered while calculating factor of safety.

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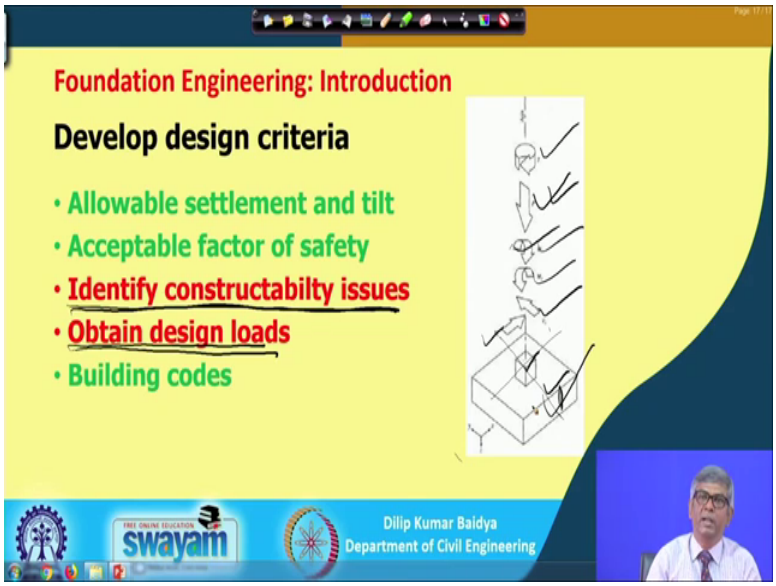

And next is developed design criteria and under this you can see there will be allowable settlement and tilt I have discussed. The acceptable factor of safety I have discussed. Now, identify constructability issues, that means what way you can identify those sometime the sites you saw that will not able to reach with heavy equipments that is one issue. Sometimes the soil type is something you have designed something, but the soil type is not permitting that then you have to reassess and try to find out a proper foundation types. So, these are the things under identify constructability issues. And finally, you decide that what are the things will not permit an accordingly you modify that and do the design.

And then finally, obtained design load you can see under this after design load you can see the building will have when you construct a facility, we will have the self-weight of the building first. You can see this is a foundation, then and this is a column, the self-weight of (Refer Time: 16:36) will be there.

In addition to that, this column will bring the load from different sources like being that there will be beam and then beam will support the slab. So, slab load will come to the beam, and beam loaded with the coming to the column. So, like that if there are several floors, so from each floors the alter dead load will bring to the foundation through this column.

In addition to this, there can be several other types of load. There can be horizontal load you can see, horizontal load in this direction, horizontal load in this direction. Two horizontal load can be there. And again there can be because of this loading is not through the centre of the footing, in that case you may have the moment. And this if there is two axis the moment can be in this with respect to this axis, again moment can be with respect to this axis. So, there will be moment these axis another moment is this both can be there.

And in addition to that which will be generally uncommon may not be there allows that is actually your torsional load, that means your sometime there is a building. And as I will explain the torque with respect to a rod, if I apply a load actually like this, then this will you have a torsional load. Similarly, building foundation can have also torsional load because of some reason because of some special situation, so all those things to be considered. And finally, you have to design for the foundation. And so that means, you need to know this is actually all vertical load through cell point of the building or live load from the building and then torque loan. Then there will be couple.

Actually, two types of couple that there will be respect this axis with other axis. And there can be horizontal load from this axis and this axis. Source of horizontal load said generally wind and both to be considered. Similarly, earthquake load also can be horizontal load this will come as a thrust and so that will be also will be sometime it will be vertical load and horizontal load both will be there, so all has to be considered while designing the foundation.

And these foundation is actually what you have to design finally, it will have a definite capacity soil will have definite pressure, resisting capacity. So, you have to find out the first area of the foundation in such a way such that the total load including all moment torque, the stress at different point below the foundation should not exceed the capacity of the soil, so that is one thing to be of is estimated.

And another thing to be estimated another thing or another two more things to be found out. Another is that what should be the thickness of the footing. This thickness of the footing means what actually see, if there is a column is there at the centre, and from the bottom there is a oblique pressure. And in that case what will happen with respect to if I

can assume that the footing just inverted one, if I just invert this one, I can ensure that it is supported like this and this cut leaver portion is loaded by the soil pressure.

In that case that it will bend like this, it bend like this. So, structural bend that to registered bending moment, you have to find out the reinforcement required and thickness to be required, so that to be designed as a geotechnical engineers. So, finally, you have to give the reinforcement, you have to decide what is the thickness, what should be a dimension. To make sure that it should not exceed the bearing capacity of the soil, and also it should not bend it fail because of the bending or shear. So, these are the total things to be done. This is of course a simplest job for geotechnical engineer that is a design of isolated footing. And more other type of work which are there that have more complication will be there. We will discuss one by one.

So, this is under your develop design criteria, there are number of things as I have told you that have to see. And then finally, while as I have told that you have to find out this dimension, and then you have to find out the thickness, we have to find out the reinforcement. And while doing this calculation, again you can apply mechanic is definitely, but only application of mechanics is not permitted, you have to refer the code. Why, what is the meaning of the code? Code actually will study on different materials and see the performance; and based on that, they have given some recommendation and you have to use those recommendation. Finally, you have to provide the dimensions.

Suppose based on your calculation if footing site came some of 0.75 millimeter, 0.75 meter by 0.75 meter, but such a small footing some time code may not permit. So, code sometime may be give the that minimum size of footing should be 1 meter by 1 meter, then you have to go for that. Though it is not required as per calculation, but as per codal provision you have to do that, so that is the code, that is the importance of the code actually.

So, based on various studies on material and soil material behavior and all those things that we have civil engineering particularly, all design has to be done as per code. And that codal provision has to be applied properly and finally, have to suppose you have to give the reinforcement. You have got certain amount of reinforcement, but code mentioned that for this you need minimum this much reinforcement, this many number, this is the minimum diameter. It may not be required as per calculation, but still you have

to give that is called a building code. So, all building codes as per building codes, finally, you to do all calculation, and finally you have to provide as per building codes.

So, that is all today. With this I will call, I will just introduction still there are several steps. I will discussed in the next lecture that what are the other steps, what is their importance as a part of introduction, I will cover in the next class ok.

Thank you.