Foundation Engineering

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Lecture - 01
Introduction

Welcome all. So, today I will start the first lecture of this course, which is Foundation Engineering. So, as you know that in soil mechanics or in geotechnical engineering, we have two basic courses one is soil mechanics and another is foundation engineering. So, in the soil mechanics we generally describe the theories and in foundation engineering we apply those theories to design the different geotechnical structures.

So, here in this lecture I will discuss about, what are the criteria's to design the foundations for a structure and then what are the parameters required to design such structures and as I have already mentioned that, we need some soil mechanics background also to design our foundation engineering.

So, that is why the knowledge of soil mechanics is also important to design a foundation. So, in the introduction section, I will discuss the what are the parameters will be required to design our foundation and what are the values we will select and then I will also discuss, how we are getting those values what are the terms generally we use for our foundation design and these things I will discuss in the first introduction class.

And then we will proceed for our main object that is the foundation design and another thing I want to mention, that when we are talking about design in this course, we will not do the structural design of any foundation. We will do the design means basically we will do the dimension of that foundation, how I we will determine the dimension of a foundation based on the load that is coming from the superstructure and the properties of the soil on the particular site.

And how we will choose the depth, where I will place the foundation, what would be the dimension on the foundation. So, these things we will discuss. Similar to retaining wall also we design means the dimension of the retaining wall, how we will check the stability of the retaining walls; So, based on the earth pressure theories. So, all these things will be discussed in design part. So, before we start the design. So, we should know what are the things.

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We will cover in this total course. So, this is as you know, this is the 12 week course. So, in the first week we will discuss about the introduction and then the soil exploration. So, the soil exploration is also very important thing, because we should know how we can determine the properties of the foundation design, or the soil properties that will be required for foundation design.

So, in the soil exploration there is a two parts, one is the field exploration only in the lab test. So, basically in this soil exploration part I will discuss the field test, that are conducted to those are conducted to determine the soil properties; in the field and as well as I will also discuss about few laboratory testing methodology by which also we can determine the soil properties. So, in the week 2 we will discuss about the penetration test and geophysical exploration.

So, I will discuss all these things in detail, then the bearing capacity of shallow foundation, settlement of shallow foundation, design of shallow foundation.

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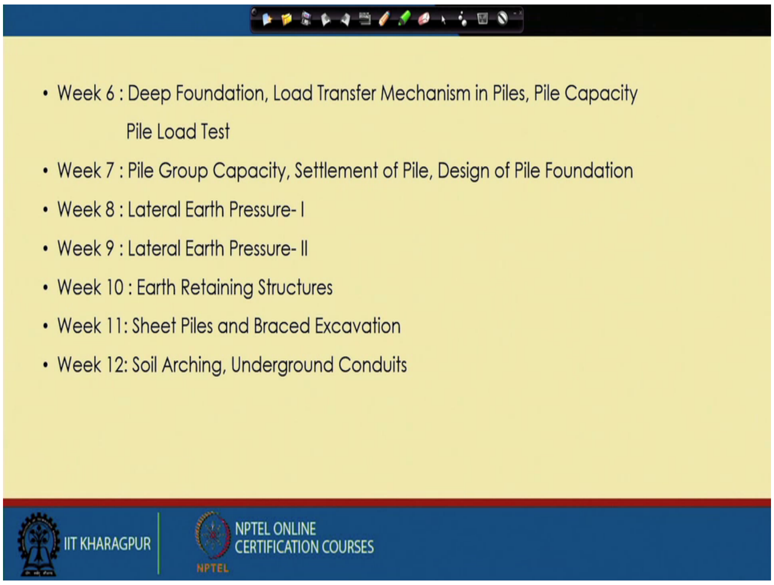

Then deep foundation, load transfer mechanism in piles, pile capacity and pile load test. In week 7, I will discuss about the pile group capacity, settlement of pile, design of pile foundation and week 8 and 9, I will discuss the lateral earth pressure theories, required to design a retaining structures. And week 10 we will discuss about the earth retaining structures and the design of those structures and week 11 we will discuss another earth retaining structure, that is a sheet pile and braced excavation.

So week 10 basically, we will design discuss about the rigid retaining structure and week 11 the sheet pile, which is a flexible retaining structures. So, those we will discuss in these 2 weeks and last week 12 we will discuss about the soil arching, you see which is a very important phenomena in soil mechanics, to understand or to design the underground conduit.

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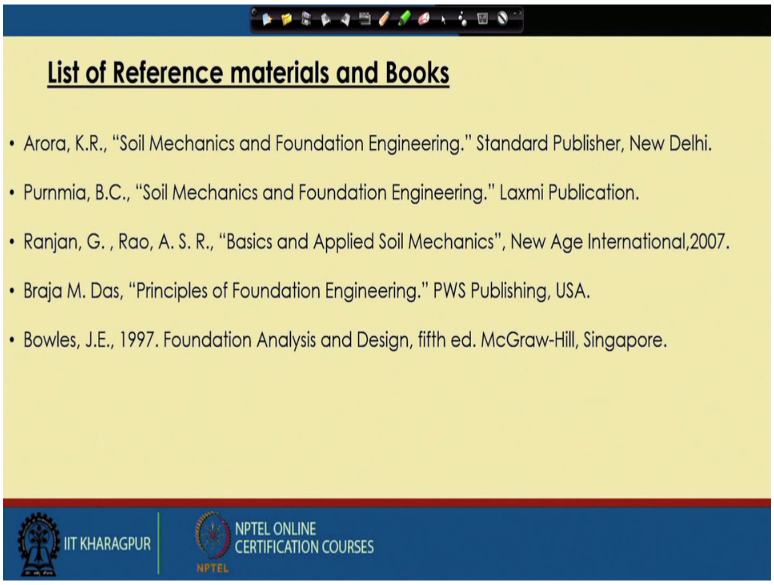

So, these are the books those we will follow that first three books, we will follow as the textbook and the next two we will we will follow as a reference book.

So, this books generally; I will refer I will refer in two of the courses.

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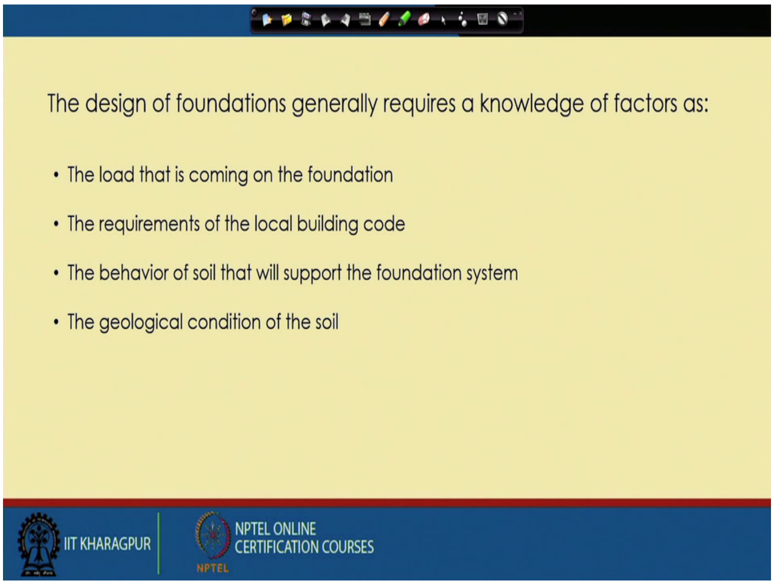

Now, the design of foundation generally requires a knowledge of the factors as that how much load is coming on a foundation from the superstructure. So, these load here, we will not do in this course we will not do any load calculation, we will assume that these loads are known to us and we will design our foundation based on the loads, that is coming on this foundation from the superstructure. So, that load we will assume for our design and the required requirement of the local building codes.

So, when we design a foundation, we should also know the code those are available for that particular area so, or particular country. So, basically in most of the lectures, I will follow the Indian standard or IS code.

In some cases, I will also discuss some foreign codes or mainly the American codes also, but as we are talking about all this foundation design in India. So, I will discuss mostly the IS code. Then the behavior of the soil, that will support the foundation system. So, that is also important we should know the properties of the soil, on which we have we are constructing the foundation.

So, these properties, how we will determine those properties and how we will use those properties? What are the theories required behind those you use up those properties. So, those things will be discussed in this course and then we should know the geological condition of the soil, or that mean if the site is very close to any fault or not.

So, these geological conditions also will be required. So, basically in this course, I will not concentrate on the geological part of this design, I will concentrate on the soil part of this design. So, I will discuss that we will load is coming from the superstructure and we know the properties of the soil and then how we will design the foundation.

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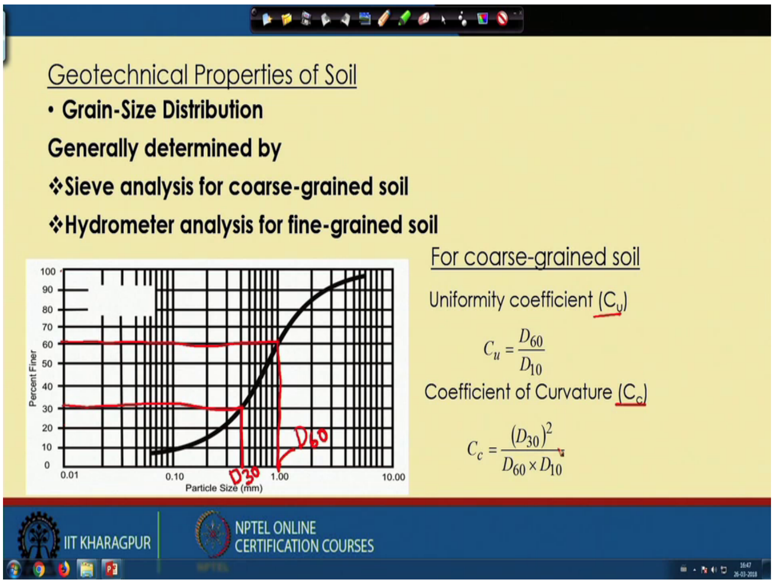

So, before I, go to directly foundation in design part. So, as I mentioned so, we should know different properties of the soil, before we design in foundation. As I mentioned, that the knowledge of soil mechanics is also required for the foundation design. But here I will discuss every I will discuss the terms those I will use for this design, before any new term I introduce I will discuss, that how the what is this term, from where we are getting this term. So, because of that I am discussing the few terms that we will use frequently in this course.

So, you should also know these terms, you should also familiar with these terms so, that when I use these terms later on so, you do not have any problem. So, the first thing is that you should know that what is the grain size distribution of soil?. So, this is the one of the one of the important parameters that we should know that which type of soil we will use for our design, what are the properties we will use for which type of soil, then how I will determine those properties.

So mainly, when in soil mechanics we have two types of soil one is the coarse grained soil, now it is the fine grained soil. So, signed is a example of coarse grained soil or sealed and clay is the example of fine grained soil. So, in grain size distribution, generally two types of test we are conducted for sieve analysis for coarse grain soil and hydrometer analysis for fine grained soil.

So, this is a typical percent finer and particle size garb. So, remember that particle size is written in millimeter and percent finer is the percentage and so in the x axis or the particle size axis in log scale and percent finer in x is in say centimeter square.

So, basically it is a semi lock graph. So, you can see that, this is the percent finer versus particle size graph and here, we have different percent finers 0, 10, 20, 30 up to 100 and from that we can determine a few coefficient. One is the uniformity coefficient C u, another is the coefficient of curvature C c. So, this C u and C c these are basically important parameters or required for coarse grained soil. So, the uniformity coefficient C u is defined as D 60 divided by D 10 and coefficient of curvature is D 30 square divided by D 60, into D10.

Now, what is D 60? What is D 10 and what is D 30? Now, if I say D 60, D 60 is the particle size, suppose this is the 60 and this is the particle size. So, here this is, term as the D 60. So, the particle size corresponding to 60 percent finer is known as D 60, similar to D 10 and D 30. So, 30 D 30 means, the particle size corresponding to 30 percent finer is known as D 30.

Now, what is D 60 means that so, this particle the particles are 60 percent finers, than this particle size. So, D 60 is meaning is that that, this particle say 1 millimeter. So, the particle that is present in the soil is 60 percent of those particles are finer, than the 1 millimeter.

So, that is termed as a D 60 similar to D 30, that mean D 30 percent particles are finer of that particular particle size. Similar, to you we will get the coefficient of curvature that is C c this is 30 square by D 60 into D 10. Now, when we are; when we have these C u and C c then we can divided the total soil in three greatest grades. So, one is the well graded soil, next one the poorly graded soil and third one is the gap graded soil

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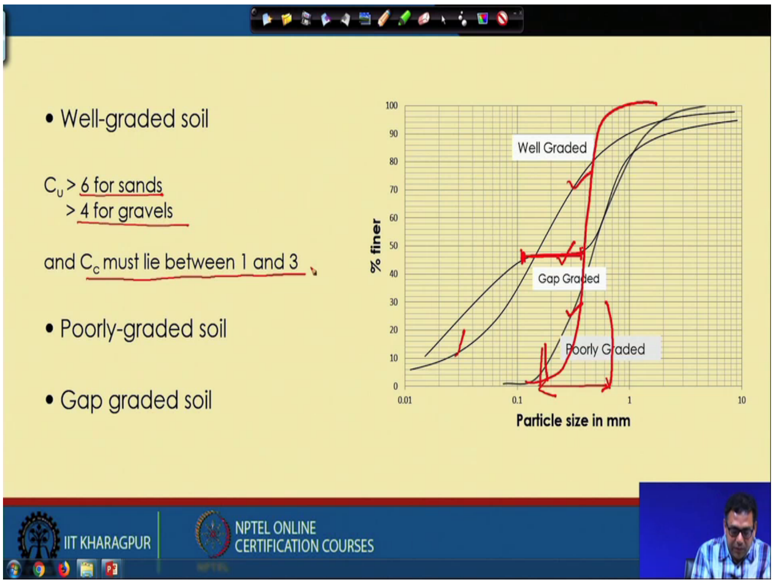

Now, the if you look at this graph. So, this is the poorly graded soil, this is the gap graded soil and this is the well graded soil. Now, if I define this three different gradation. So, poorly graded soil means, that one particular particle size or a range of particle size is excessively present in the soil.

So, if you look at this graph. So, this particle size of the soil, most of the particle size of this soil is present in the soil; that means say 80 to 70 to 80 percent of the soil, is within this particle range. So, that is all this graph can be like this also.

So that means, one particular particle size is excessively present in the soil. So, we can see this particular range of the soil is excessively present in this soil, particular range of the soil particles is excessively present in the soil. So, that is called the poorly graded soil.

Another one you can say, this particle distribution or this particle size curve, a grain size distribution curve, you can see that all particles are uniformly or it is present in the soil. It is not one particular, a particle or particle size is excessively present. It is more or less all the particles are present. So that is why it is called the well graded soil and gap graded soil, you can see one particular particle range is missing. So, that is why that mean this is a gap.

So, this particular range of the soil particle is not present in the soil. So, that is why this is a 3 particle size. So, these are very important for our coarse grained soil, that is the poorly graded, gap graded and well graded.

So a poorly graded soil, we can say that if C u value is greater than 6, then it is called as a well graded soil, if it is greater than 6 percent and it is greater than 4 for gravels and you can see that C c must lie in between 1 to 3. It is not that that one particle if one particular condition is satisfied, then we can say it is a well graded soil no both the condition have to be satisfied.

So one it is for sand, then C u should be greater than 6 and C c should be in between 1 and 3.

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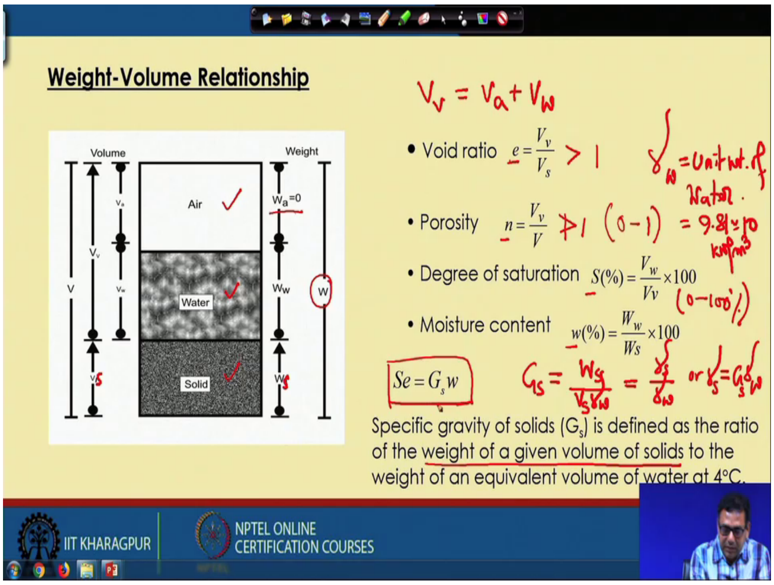

So, that is the definition of the well graded soil. Similarly the poorly graded soil and gap graded soil, I have already explained. So, next one that is very important is the weight volume relationship of the soil. So as we know that soil is a seep 3 phase system; that means, soil has soil particles and in between the soil particle, these are voids. So these voids can be fill with water or they can be filled with Air. So, that is why the soil has 3 3 phase that is solid, water or liquid and gas or air.

So that means, this is the a typical soil phase diagram, now if soil is the suppose these voids are fully saturated or fully filled with water, then soil is a two phase system, that is solid and water and if the soil is totally dry; that means, those voids are filled with air only, then also soil is a 2 phase system that is solid and air.

Now, if we have this soil diagram is a 3 phase diagram then this W a is the weight of air which is generally neglected this so, that is W a is equal to 0. Then weight of water W w, then weight of solid W s and total weight is W of the soil and then in terms of volume, the volume of air is the V a, then V w is the volume of water and V s is the volume of solid and the volume of water class volume of air is termed as volume of voids that is V v.

So, we can write that V v is equal to V a plus V w and this is the total volume is equal to volume of voids plus volume of solid. So now, based on that we can, we have different definition and these terms, we will frequently use during our a design or during our foundation course. So, first one is the void ratio, which is volume by volume of voids divided by volume of solid and then we have another one the porosity, which is volume of voids divided by total volume, then the degree of saturation which is volume of water divided by volume of voids and the moisture content, which is weight of water divided by weight of solid.

So now we can see, that that value void ratio is the volume of void divided by volume of solid. So, the volume of void can be greater than the volume of solid. So, this e value can be greater than 1 also, but if you look at the porosity, that volume of voids and this is the total volume.

So, volume of voids cannot be greater than total volume, so porosity cannot be greater than 1. So, generally the range of porosity is 0 to 1. So now, the degree of saturation you can see this is also the range is 0 percent to 100 percent and the moisture content that is the weight of water and weight of solid.

Now, these definitions are very important, you should remember these definitions because this definition or these terms, we will use in our course. So now, we have a number of relationships between these terms. So, one very important relationship is that S e equal to G s into w; where G s is the specific gravity of the solid. So, which is defined as the ratio of the weight of a given volume of solid to the weight of an equivalent volume of a water at 4 degree centigrade.

So, we can write that G s as per the definition it is the ratio of weight of a given volume of solid. So, that weight is a W s divided by to the weight of an equivalent volume of water.

So, the weight of a equivalent volume of water is Vs into gamma w. So, we can say weight of a given volume of solid to the weight of an equivalent volume of water. So, this is equivalent volume is V s and gamma w is the unit weight of water. So, we can write the equivalent volume of water is V s into gamma w. So I can write in another way, this is gamma s divided by gamma w. So or I can write gamma s is equal to G into gamma w.

So, where gamma s is the unit weight of the solid, so we can write that gamma s, is equal to specific gravity of solid into the unit weight of water. So, I can write that, gamma w is the unit weight of water. So, this unit weight of water value we are taken as a 9.81 or equal to 10 kilonewton per meter cube ok. So, at 4 degree centigrade, so in all the calculation purpose generally, I will use the unit weight of water is 10 kilonewton per meter cube. However, you can use 9.81 or 10 anything, but I will use 10 kilonewton per meter cube.

So, this is the G s. So, this relationship is also very important, that S e equal to G w. Now, the question is that how this relationship is coming. So, I am just writing few relationship that we will be directly used in, other in mixed classes.

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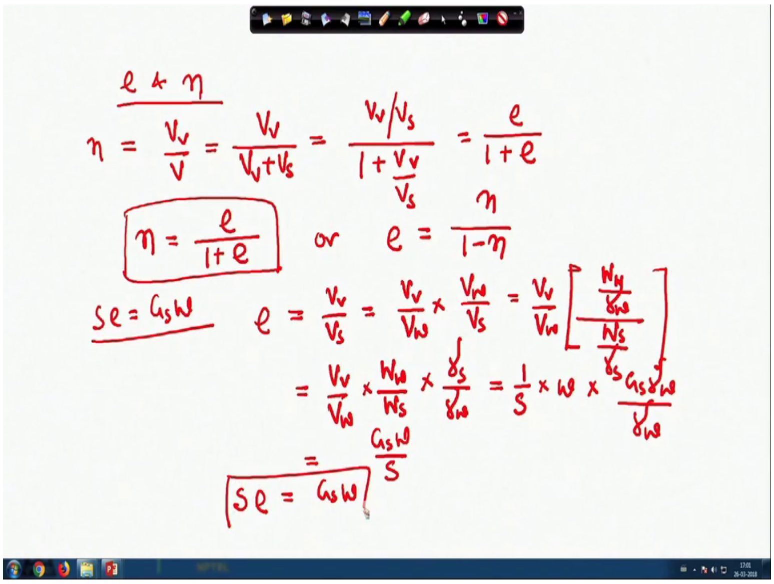

So, that is why I am just first relationship that I am writing is e and porosity; that means, void ratio and the porosity. So, you know that porosity is equal to volume of voids divided by total volume, so that is equal to the volume of voids divided by V v plus V s.

Now, I can write V v by V s is 1 plus V v by V s. So, V v by V s volume of voids divided by volume of solid is equal to void ratio. So, this is equal to 1 plus e. So, the first relationship is porosity is equal to volume of voids, divided by 1 plus, volume of porosity is equal to void ratio divided by 1 plus void ratio, or another way we can write is equal to n 1 minus n. So, that also we can write. Now, the next relationship that we are talking about that how S e equal to G s w is coming.

So we have, we know that e void ratio is equal to volume of voids, divided by volume of solid. So, that is we can write volume of voids, divided by volume of water into volume of water divided by volume of solids. So, I can write volume of void, divided by volume of water and volume of water I can write, weight of water divided by unit weight of a water, then the volume of solid I can write weight of solid, divided by unit weight of solid.

So, I can write that volume of void divided by volume of water and weight of water, divided by weight of solid, into unit weight of solid, into unit weight of water. I can write this is 1 by S and weight of water, divided by weight of solid, which is water content and then I can write, that as I know, that unit weight of solid is equal to G s into unit weight of water. So, this is unit weight of divided by unit weight of a water.

So, finally, I will get this is G s w, divided by S. Then S e is equal to G s by w. So the degree of saturation, into void ratio is equal to specific gravity of the soil and the water content.

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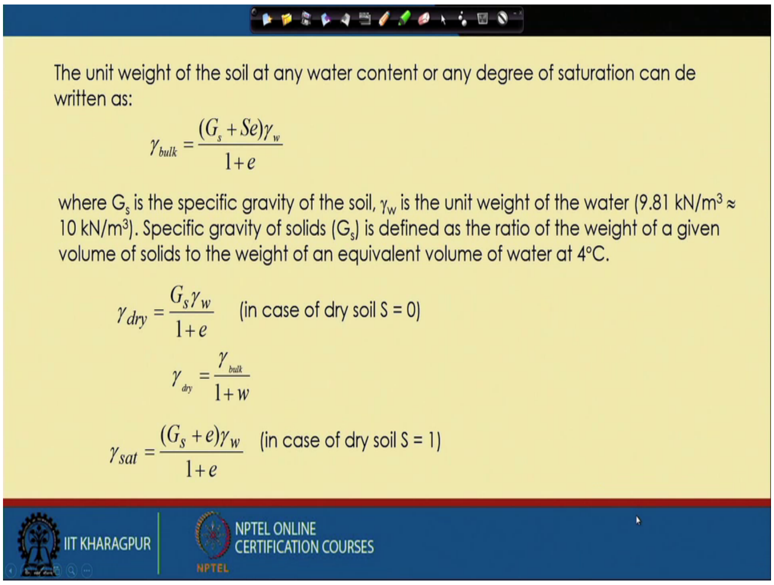

So, next one the unit weight of soil. So, these are the different unit weight that we will use for our calculation purpose. So, we have different types of unit weight depending upon the water table position. So, we have a bulk unit weight, we have a dry unit weight, we have a saturated unit weight, we have a submerged unit weight.

So, depending upon different condition, we will use our different unit weight. So, first is the bulk unit weight, is the unit weight of soil at any water content or any degree of saturation. So, the bulk unit weight expression is G s plus S e, into gamma w 1 plus e. So, how this expression is coming, which is also we can derive this expression.

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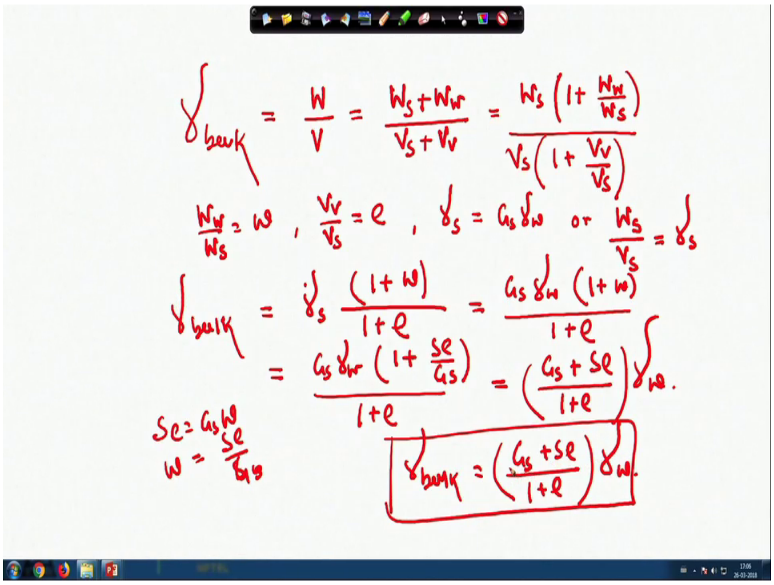

So, we have to derive that how the gamma bulk is coming. So, gamma bulk is equal to total weight of soil and divided by the total volume of soil.

Now, the total weight we can write weight of solid, divided by weight of water and divided by V s plus V v volume of voids plus volume of solid. So, I can write weight of solid 1 plus weight of water, divided by weight of solid and again V s 1 plus V v divided by V s.

Now, I know weight of water divided by weight of solid is equal to water content and V v by V s equal to void ratio and unit weight of solid is equal to G s into unit weight of water. So finally, I can write gamma bulk is equal to is equal to this is the weight of so, 1 plus w is the unit weight divided by 1 plus e and or I can write weight of solid divided by volume of solid. This is equal to unit weight of solid. So, I can write this is unit weight of solid or from this expression I can write G s into gamma w 1 plus gamma into 1 plus e.

So, another way I can write as, we know S e equal to G s w. So, I can write G s gamma w 1 plus so, this is S e divided by G s 1 plus e. So, we can write that this is G s plus S e 1 plus e into unit weight of water. So, finally, I can write gamma bulk is equal to G s plus S e 1 plus e into unit weight of water.

So, this expression is very important. So, we can use this expression to determine, the bulk unit weight of soil. So, next one I will discuss that how I can use this expression. For next one is that that if the soil is dry then our degree of saturation is 0. So, if I put s equal to 0, then equation become G s gamma w 1 plus e and we can write this gamma dry also in terms of gamma bulk divided by 1 plus water content and degree of saturation is equal to 1 or I can say 100 percent.

So, I am writing here it is 1; 1 means the 100 percent in percentage, but in terms of value it is 1, then I can write G s plus e divided by 1 plus e into gamma w. So, another unit weight is there. So, that unit weight is we can write that that unit weight. So, is equal to your gamma sat is the saturated unit weight; another one is the gamma sub, gamma sub is the submerged unit weight which is gamma sat minus unit weight of water.

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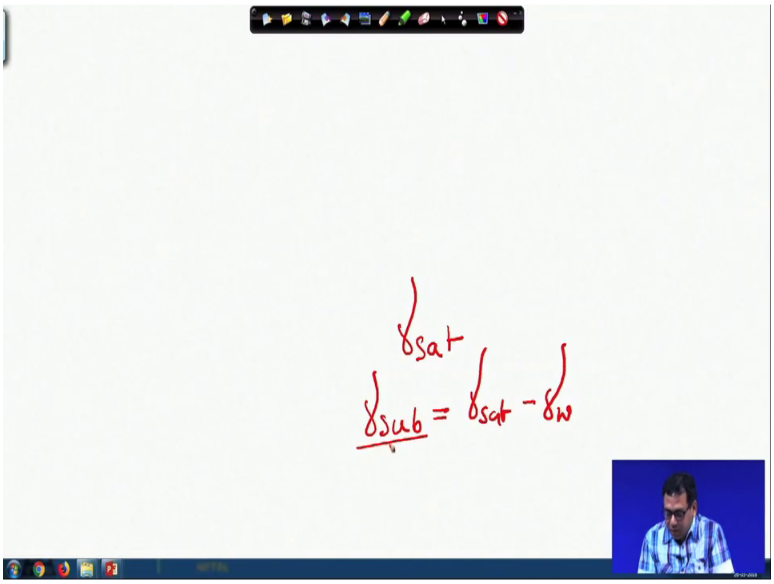

So, if the soil is below water though generally in that case we will use the gamma sub or the submerged unit weight. So, we have four different types of unit weight one is the gamma bulk. So, this is the unit weight at any water content and any degree of saturation then gamma dry if the soil is totally dry; in that case degree of saturation is 0.

The next one is gamma sat or gamma saturated, e degree of saturation is 1 and another is gamma sub which is gamma saturated minus unit weight of water. So, today I will I am finishing the first class or first lecture. In the next lecture, I will also discuss few terms that will be required for our foundation design.

Thank you.