Geology and Soil Mechanics
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Lecture - 13
Soil Compaction- C

Welcome back. So, in the last lecture we just talked about the different procedures by which you can measure the unit weight in the field. So, what are those procedures, what are those methods?

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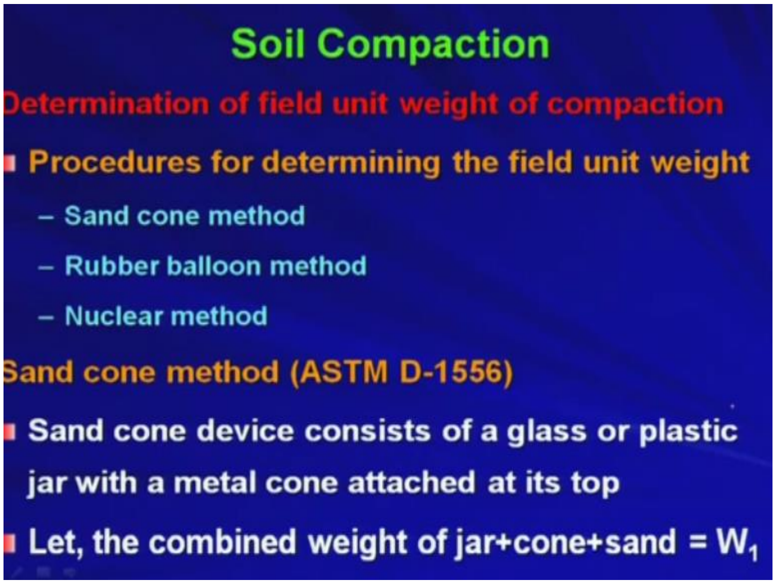

First one was the sand cone method, then rubber balloon method, and nuclear method. So, among these 3 we will be talking about the sand cone method which is as per (ASTM D-1556). So, basically in the sand cone device consists of a glass or plastic jar with a metal cone attached at tips right. So, you will be having one jar which will be made of glass or plastic and on top of that you will be having some metal cone.

So, I will show you the figure how it will look like. So, now let the combined weight of jar plus cone plus sand. So, you will be filling some sand inside the jar. Now the combined weight of the jar, jar itself plus cone which will be attached at the top and the sand whatever you have put inside the jar, the combined weight is a W1, capital W1 okay.

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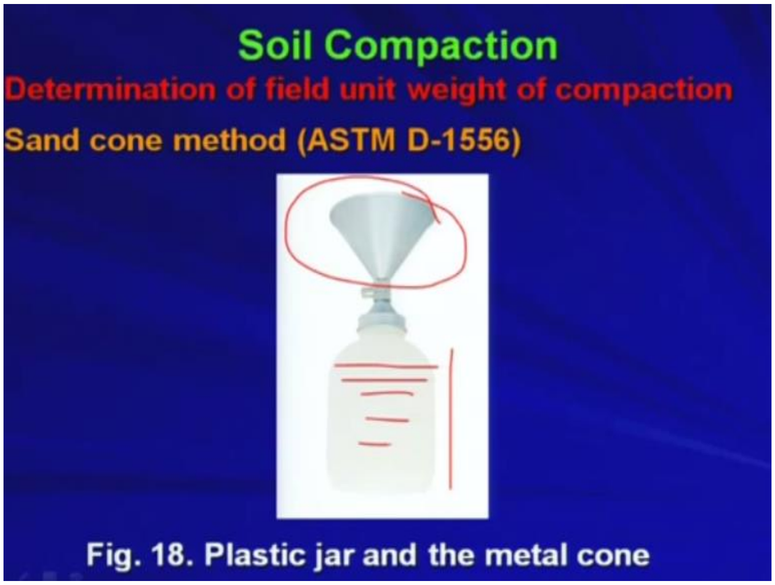

The plastic jar or and the metal cone will look like this so this is the sand cone method device. So, as you can see so basically this is the jar which can be made of glass or say plastic and this is the metal cone okay which will be attached on top of the jar. Now you can put sand in inside the jar okay and then the combined weight of the jar plus cone plus the sand whatever you have filled inside the jar so that say that is W1 whatever we have decided now and now in the field what exactly we are doing with this sand cone device.

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Now in the field where you have compacted the soil and where actually you need to find out the unit weight, so basically in the field you excavate a small hole okay that is I mean comparatively reasonably small hole you just excavate okay and say the weight of moist soil excavated from hole is W2. So, whatever soil you have excavated from the hole, say the weight of that moist soil is W2 because you have compacted so the soil will be moist.

So, now if the water content of excavated soil is known which is possible right so you are excavating the soil from the hole whatever you have excavated in the in the site and then you are collecting the soil and then you can find out the water content from the laboratory experiment. Then the dry weight of the soil is given by this expression where W3 is equal to W2 whatever is already explained.

So, as you can see here so the weight W2 is the weight of the moist soil divided by the 1 plus small w where small w is the water content which you have determined from the laboratory experiment by 100. So, if you express the water content in percentage so it will be coming as w in percentage by 100. So, that will give me the dry weight of the soil, so that is W3.

Now after excavation, the cone with the sand filled jar is inverted and placed over the hole; sand is allowed to flow out to fill the hole and the cone. So, now what you do, so you have excavated the soil, you have taken out the soil, and you have done whatever experiments are required to find out the water content and other things. So, that you have done. So, in the I mean you take the jar which is filled with sand.

Now you invert the jar on top of the hole okay, excavated hole and then you allow the sand to fill in the hole itself. So, now the what will happen? The sand will come out from the jar. It will fill the cone as well as the hole. Now based on that you will be getting some jar some sand will be remaining in the jar itself and some sand will be remaining in the cone as well as the it will be filling the excavated hole.

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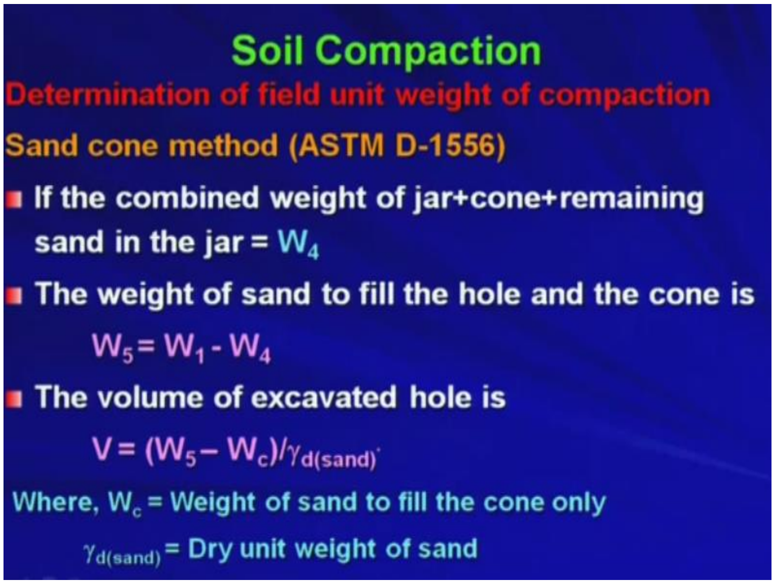

Now if the combined weight of jar plus cone plus remaining sand, now whatever sand has gone out from the jar, so whatever is remained okay. So, jar plus cone plus remaining sand in the jar if it is W4 then the weight of sand to fill the hole and the cone is W5 which is nothing but W1 what was W1 that is the combined weight of jar plus cone plus the total sand which was filled in the jar. Now the W4 is nothing but the weight of jar plus cone plus the remaining sand. So, whatever sand has gone out from the jar and which has filled basically the hole as well as the cone that is nothing but W5 which is equal to W1 - W4 as simple as that.

The volume of excavated hole is the V is given by W5, W5 is the weight of sand which has filled the hole as well as the cone minus W c by the gamma d sand. But W c is the weight of sand to fill the cone only because W5 was the weight of sand which was filled in the cone as well as the hole. Now if you want to find out the weight of sand which is filled only in the hole then W c must be deducted or must be subtracted from W5.

So, W5 -W c will give you the sand which is filling the hole divided by gamma d sand if you talk about or if you that is nothing but your dry unit weight of sand if you divide the W5 - W c by gamma d sand you will be getting the volume of excavated hole. So, whatever hole you have excavated, the volume of excavated hole can be obtained by this expression.

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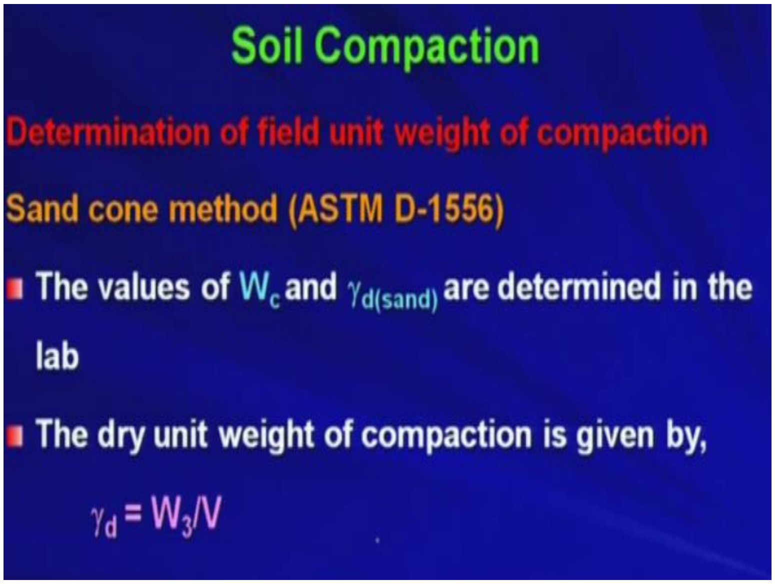

Then the values of W c and gamma d sand are determined in the laboratory okay. So, there is no issue gamma d sand that is the dry unit weight of the sand. It can be obtained from the laboratory experiment and W c also you can find out from the laboratory. Now the dry unit weight of compaction is given by gamma d which is equal to W 3 by V okay.

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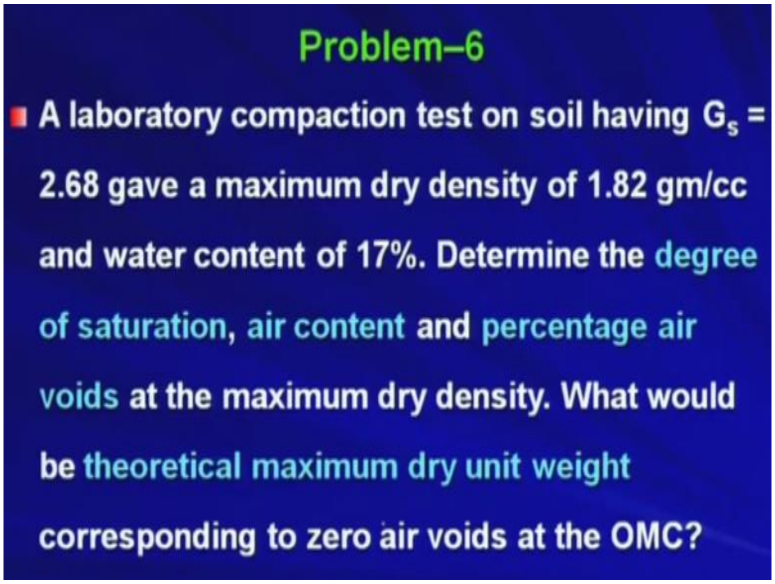

Now we will take one example. Now we will be taking a few examples on compaction topic. So, this is the problem 6. The problem says a laboratory compaction test on soil having G s equal to 2.68 gave a maximum dry density of 1.82 gm/cc and water content of 17%. Determine the degree of saturation, air content, and percentage air voids, so these all terms are known to you from the basic definition when we discussed in very earlier classes, at the maximum dry density.

What would be theoretical maximum dry unit weight corresponding to zero air voids at the OMC okay. So, these things we need to find out. So, we have few parameters and we are going to obtain those other things whatever has been asked in the problem. Okay let us start this problem.

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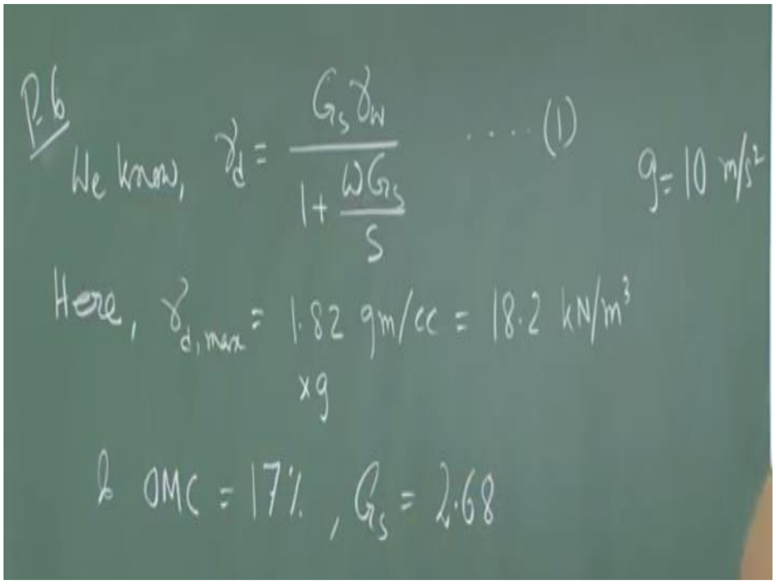

Okay, so we have seen the problem. Now we are going to solve this problem. So, problem 6. We know from our basic definition and we can establish these relations that is gamma d is equal to G s into gamma w, already we have seen this expression earlier for several times, W that is your water content G s by S that is degree of saturation right. This equation is or this expression is known to me or else you can establish this relation, there is no issue.

So, here what are the things are known to me, gamma d max which is equal to 1.82 gm/cc which is nothing but 18.2 kilo newton per meter cube, so this multiplied by g right. So, I am considering g as for this problem I am considering g 10 meter per s square okay. So, in some problems we can g basically is 9.8, so anyway so for some simplification we are considering g equal to 10. So, there is no issue.

So, gamma d max equal to 18.2 that is given in the problem and that is happening at the water content 17% so gamma d max will always occur at OMC right. So, the whatever water content is given so that is nothing but your OMC which is 17% and your specific gravity of soil solid is given as 2.68. So, these are the parameters are given in the problem.

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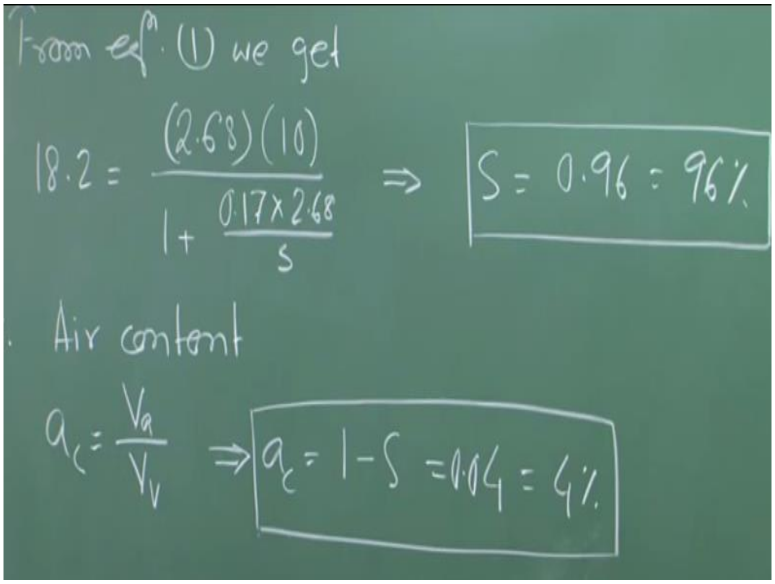

Now from equation 1 we get so from 18.2 is equal to 2.68 multiplied by 10 that is the unit weight of water divided by 1 + 0.17 into 2.68 by s. From this I can get the degree of saturation is equal to 0.96 that means 96% okay. So, by knowing gamma d max so if you if you plot the compaction curve okay and then basically if you find out gamma d max and OMC you can observe from the compaction curve from this expression you can find out the degree of saturation okay.

Now therefore air content which is given by a c if you recall we have covered these simple definitions which was given by V a by V v right where V a was the volume of air and V v was the volume of voids right. So, now a c if you recall from the definition it is nothing but 1 - S that is 1 minus degree of saturation which is coming as 0.04 which is nothing but 4% okay. So, your air content is 4% okay. Now we will be talking about the percentage air void.

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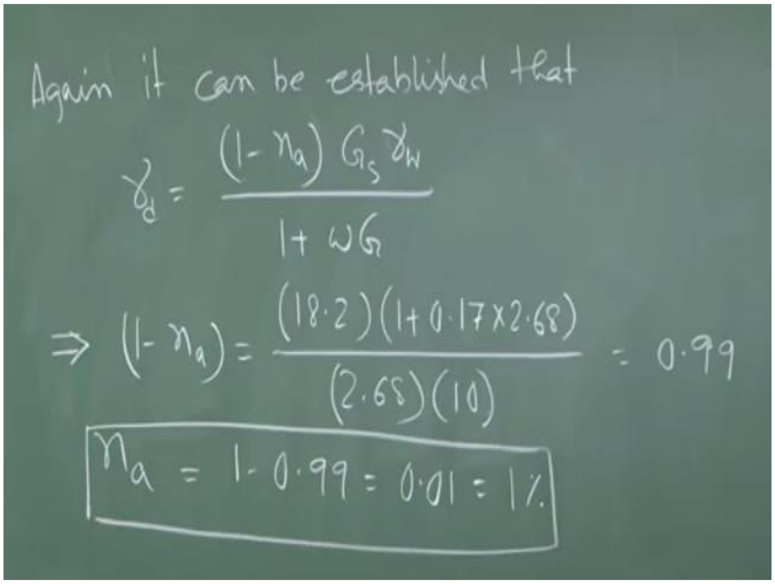

Now again it can be established that your gamma d that is the dry unit weight of soil is equal to 1 – n a. What is n a percentage of air voids right into G s into gamma w by 1 + wG right. So, this expression can be established from the simple definition whatever you have seen so far. So, gamma d is equal to 1 – n a where n a is the percentage of voids into G s into gamma w divided by 1 + wG where w is the water content.

Now from this expression we can write 1 - n a is equal to 18.2 multiplied by 1 + 0.17 that is your water content multiplied by 2.68 by 2.68 into gamma w that is 10 which is giving me 0.99. So, therefore n a is equal to 1 - 0.99 which is equal to 0.01 which is equal to 1%. So, percentage air void is 1% okay. So, now basically when your percentage air void is say zero that means your degree of saturation is 1. So, at that time you will be considering that zero air void condition is occurring.

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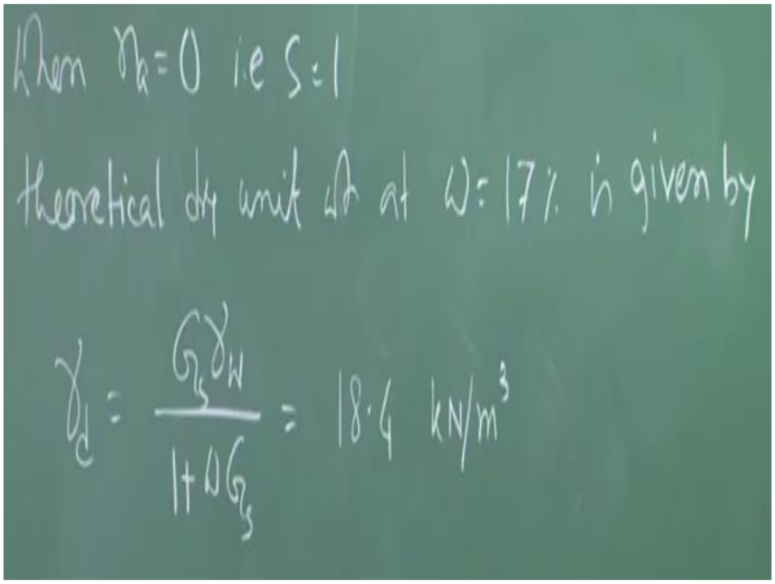

So, when n a is 0 that is your S equal to 1 that means degree of saturation is 1 at that time your theoretical dry unit weight at water content 17% is given by that means at zero air void condition what is your gamma d that means dry unit weight. So, that we are going to find out. So, at zero air void condition your percentage air void is zero and that means your degree of saturation is 1 okay so is given by gamma d which is equal to G gamma w 1 + w into G s.

From this we can find out gamma d is equal to 18.4 kilo newton per meter cube because we know all the values here. So, at the water content 17% that is your OMC your gamma d max that is the practical or the actually observed gamma d max in the laboratory was 18.2 whereas the theoretical maximum is 18.4 which you cannot achieve but this is the theoretical maximum which is happening at zero air void condition. So, now we will take the next problem, again on compaction. So, let us see the problem first.

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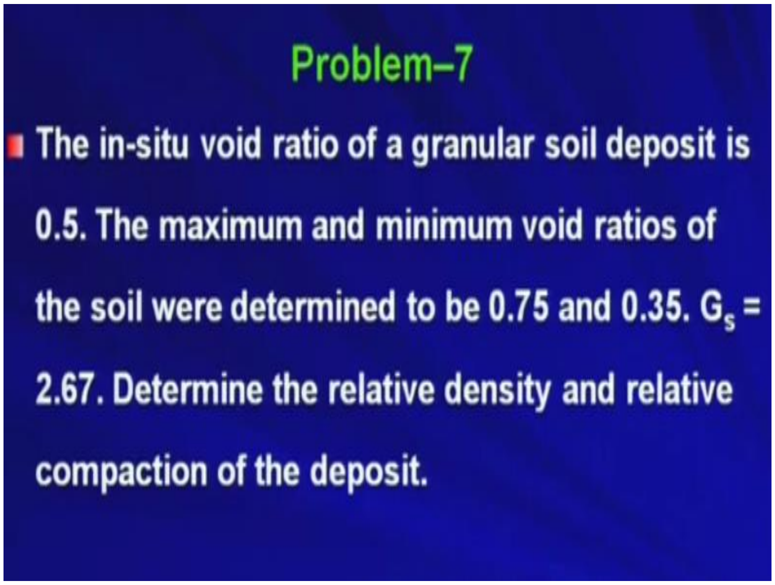

Okay, so the next problem says the in-situ void ratio of a granular soil deposit is 0.5 okay. The maximum and minimum void ratios of the soil were determined to be 0.75 and 0.35. Now G s is equal to 2.67. Determine the relative density and relative compaction of the deposit. So, basically, we are going to find out the relative density and as well as the relative compaction of this particular soil.

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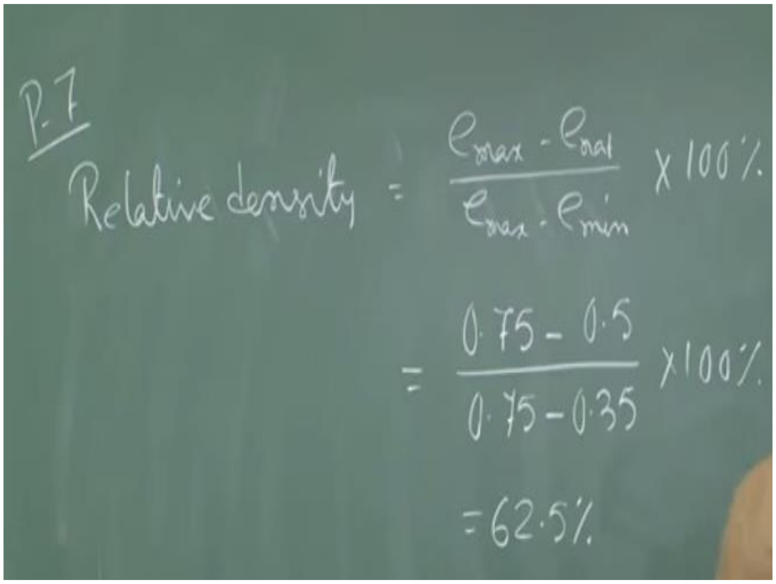

So, now basically your relative density, this is your problem 7. Your relative density from the definition you know e max - e natural by e max - e mean into 100%. So, that is your, that is the expression for your relative density and already we have established this relation and we have seen and we have solved a couple of problems on that. So, what is your e max in the problem? So, that is your maximum void ratio which is 0.75, it is given in the problem.

Now what is e natural? What magnitude of e natural is given in the problem? Now in-situ void ratio that means the natural void ratio of the granular soil is 0.5, so that is given, divided by e max is 0.75 again and what is e minimum, that is your minimum void ratio which is given in the problem as 0.35. So, if you solve this calculation you will be getting your relative density is 62.5%.

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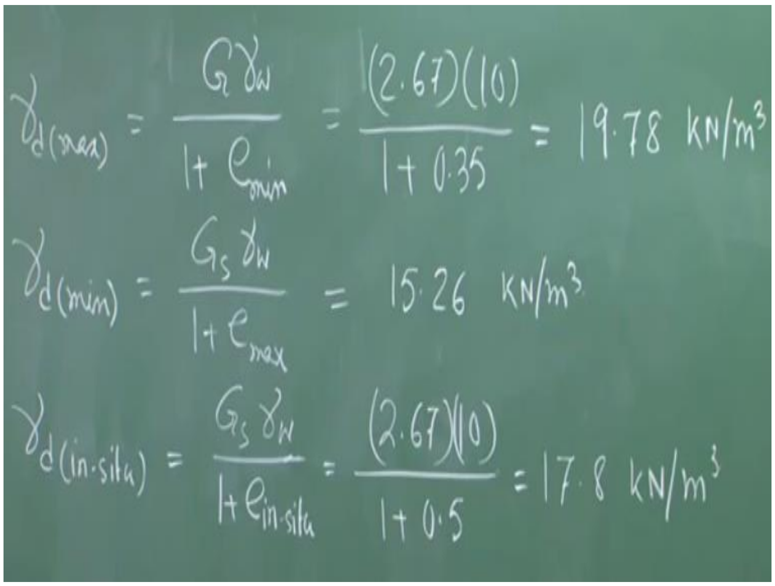

So, your gamma d max will be G gamma w by so at what situation you will be getting maximum dry unit weight? So, could you please I mean could you please tell me that what should be the maximum unit weight at what void ratio when the soil will be densely packed. So, when the soil will be densely packed, at that time what should be the void ratio, e minimum. So, gamma d max will occur at e minimum, so from this expression, this expression is already known to me or else you can establish that relation, there is no issue.

So, in that relation, you e value that is the void ratio value should be minimum which will be giving me the gamma d max. So, if you put all the values 2.67 into 10 divided by 1 + 0.35. So, that is giving me 19.78 kilo newton per meter cube. Similarly, if you can find out gamma d minimum that is the minimum dry unit weight. At what situation gamma d minimum will occur when your void ratio will be becoming maximum that means loosest packing will be giving you the gamma d minimum.

So, that is given by 1 + e max. So, if you put the values you will be getting 15.26 kilo newton per meter cube. Now what is the value of gamma d in-situ that means in the field condition. That is G s gamma w by 1 + e in-situ which is nothing but e natural right. So, if you put all the values divided by 1 + 0.5 which will give me 17.8 kilo newton per meter cube. So, you have got the relative density as well as you have got the different unit weight at different condition.

That means when your soil is densely packed at that time you have got gamma d max which is equal to 19.78 corresponding to e minimum. Then you have got gamma d min that means when the soil is loosely packed or the loosest state that means your void ratio was e max and at that time you have got gamma d min equal to 15.26. Whereas at the in-situ condition, at the natural condition, your gamma d in-situ is coming as 17.8 okay. So, now with that we can calculate the relative compaction.

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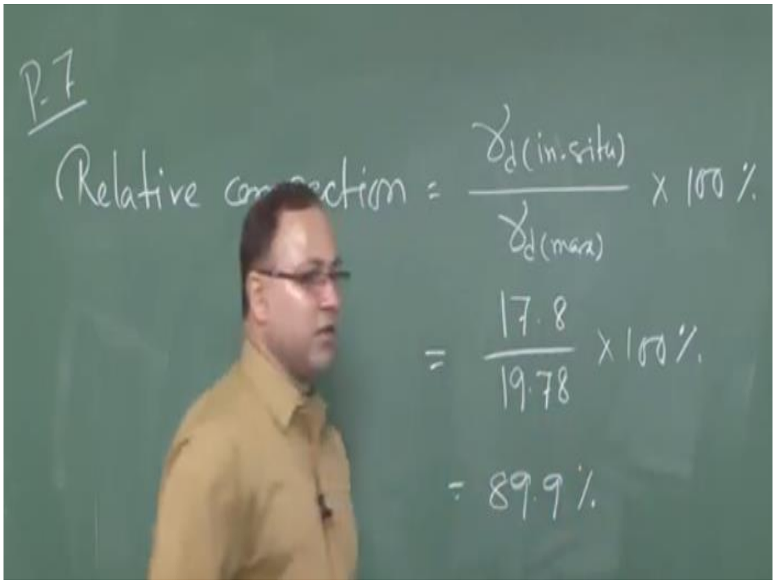

So, we can write down the relative compaction. What will be the expression for relative compaction? From the definition, itself we can you can see that that whatever you have achieved and whatever was there, based on that you can calculate the relative compaction. So, that is nothing but gamma d in-situ by gamma d max, or by if you want to express that thing in percentage multiply by 100.

So, gamma d in-situ that means you have achieved that much of compaction. Whereas gamma d max that is the densest packing available in the laboratory. So, in the laboratory basically gamma d max you can achieve okay, but in the field, you have achieved gamma d in-situ. So, the ratio of these 2 will give you the relative compaction and if you put the values 17.8 by 19.78 into 100, so which will be coming as 89.9%. So, you have achieved 89.9% compaction in the field as compared to the gamma d max available in the laboratory.

So, I will stop here today. So, in the next lecture we will solve another problem which will be very important and I mean there are several aspects and that problem is basically talking about some practical problem or practical situation. Based on some practical situation we have developed that problem and in the next class we will see that problem. So, today I will stop here.

Thank you very much.

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