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Lecture No – 09

Compaction

Welcome I am professor J. N. Mandal, department of Civil Engineering Indian Institute of Technology Bombay.

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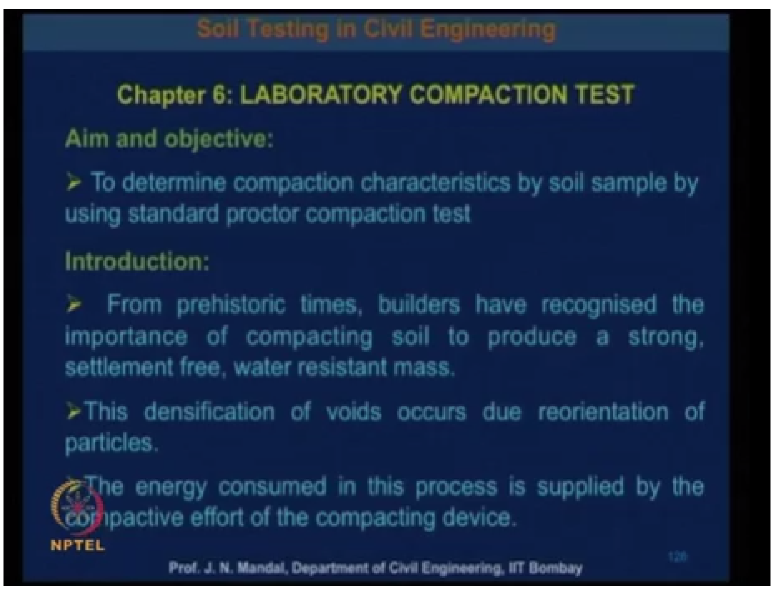

I talk about laboratory compaction test, from the compaction test, we are I will show you how you have to calculate the different parameters. For example, we want to do some calculation.

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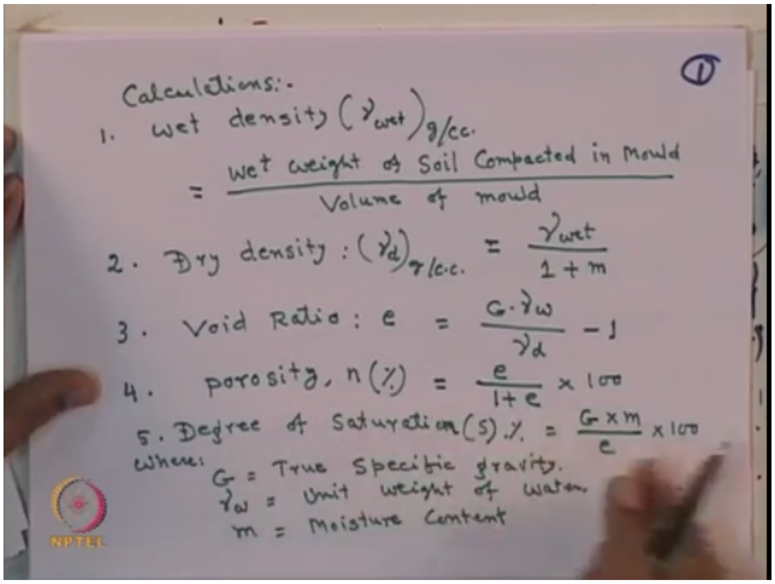

Number one is the weight density, so this is designated at γ weight in it is gram.cc. So this will be defined as weight of soil compacted in mode this / by volume of mode. Then second parameter is the dry density, and dry density is expressed as γd and this g/cc = γ of weight this / by 1 + M, where m = moisture content. And number three parameter a void ratio and this is designated at E this is equal to G into γw/γd-1 and number four is porosity, and this is designated at n and expressed in terms of the percentage that is n=e/1 + e this into 100.

And fifth parameter is degree of saturation, degree of saturation that express as S and that in terms of the percentage this is = to GM/E x 100, where G is true specific gravity γw is unit weight of water and M = moisture content. So these are the parameters are very important for the determination of dry density, void ratio, porosity, and the degree of saturation. Now I show you some specimen calculation for the standard proctor test.

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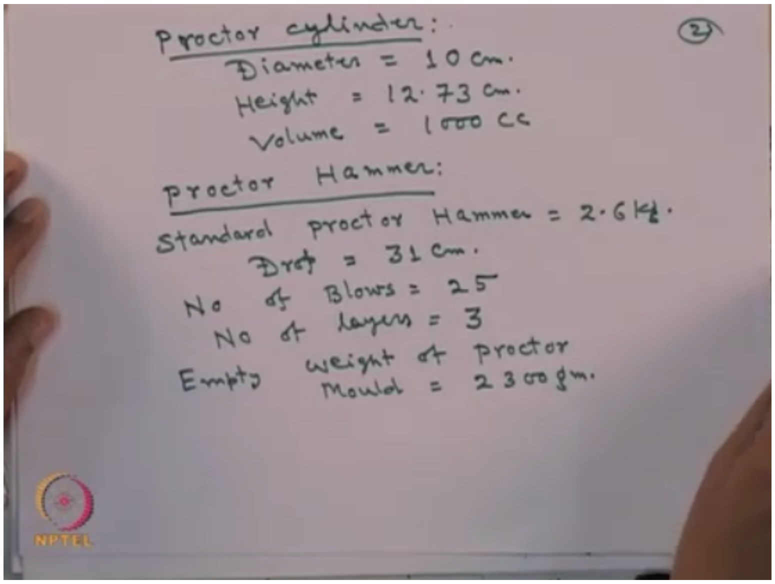

Now we use that proctor cylinder. Now this size of the proctor cylinder it has a diameter, this diameter is about 10cm treasure height is about 12.73cm and it has a volume = 1000 CC. Now we have also the proctor hammer in which we compact the soil sample this proctor hammer, this is proctor cylinder. So standard proctor hammer the weight is about 2.6 kg, and it can be dropped from a height of 31cm.

And you have to provide number of blows, number of blows that is about 25 and number of layer when you compact the soil you have to compact in three layer. And we have also empty weight, empty weight of the proctor mould is about 2300g. So with this we record for the, what will be the shape and size of the proctor cylinder and the proctor hammer and I am just showing you that this is a kind of the equipment.

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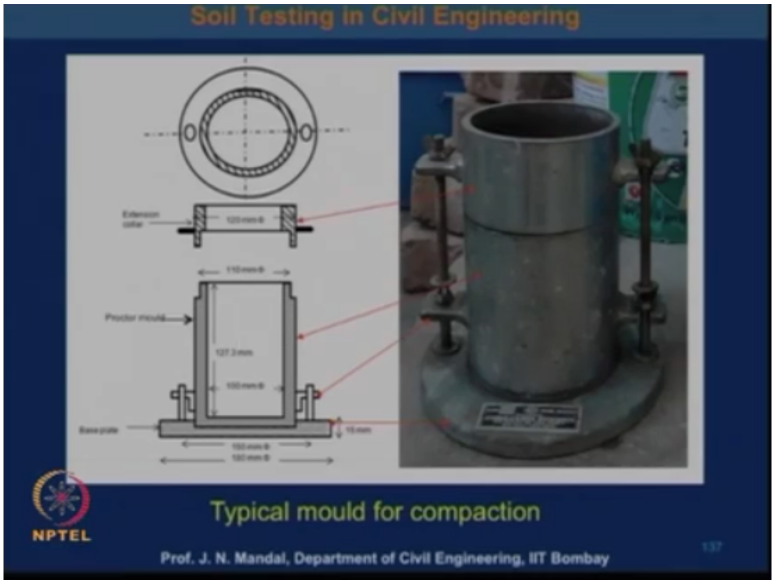

These are proctor, this is a proctor cylinder okay and this diameter is about 10cm and this height is about 12.73cm and this has a volume, that proctor cylinder as a volume of the about 1000CC. And we have some also the proctor hammer, so this is the sketch area it is the sole which you can see also here in detail this is one 80m, diameter this is 150mm, this is 15mm this is base plate this one is the base plate and this is proctor mould and this dimension is 110mm and this is 120mm this is extension collar here.

So you can see this is extension collar here, so this is a typical mould for compaction. And similarly you can see here this is the standard proctor hammer.

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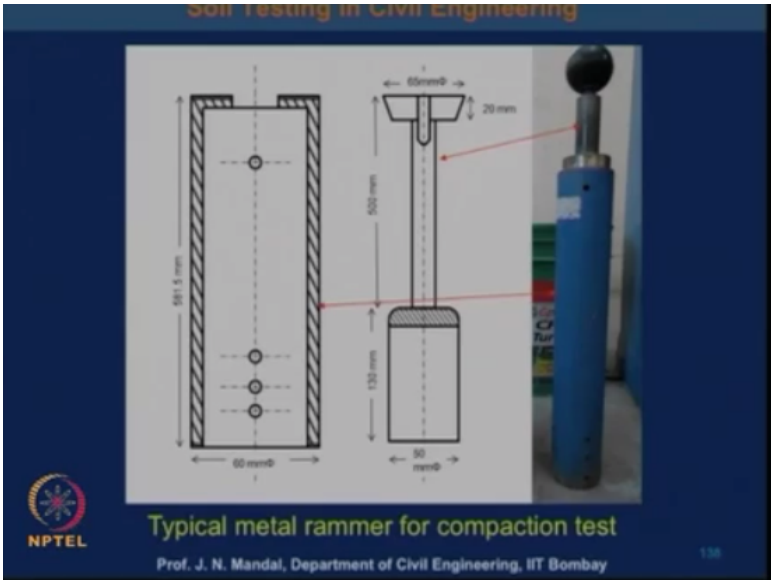

And its dropped from a height of about 31cm and you have to compact the soil number of blue 25, and number of layer is 3 and these details is given here, I am just explaining here this is the 60mm this is 581.5mm and this hammer is 130mm, this is 150mm, and this is 500mm, this is 65mm diameter and this is 20mm. So this is the typical metal rammer for compaction test. So we use this equipment for the compaction test, now I will show you some calculation.

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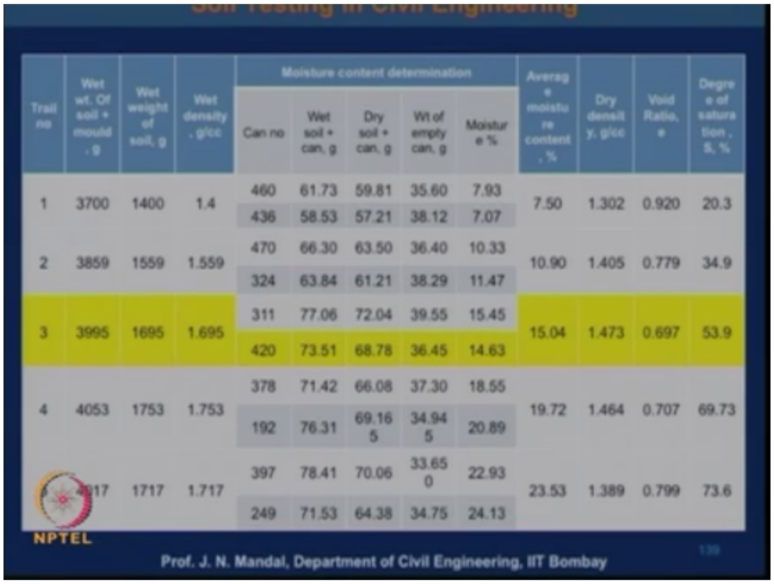

Trail no	Wet wt. Of soil + mould, g	Wet weight of soil, g	Wet density, g/cc	Moisture content determination					Average moisture content, %	Dry density, g/cc	Void Ratio, e	Degree of saturation, S, %
				Can no	Wet soil + can, g	Dry soil + can, g	Wt of empty can, g	Moisture %				
1	3700	1400	1.4	460	61.73	59.81	35.60	7.93	7.50	1.302	0.920	20.3
				436	58.53	57.21	38.12	7.07				
2	3859	1559	1.559	470	66.30	63.50	36.40	10.33	10.90	1.405	0.779	34.9
				324	63.84	61.21	38.29	11.47				
3	3995	1695	1.695	311	77.06	72.04	39.55	15.45	15.04	1.473	0.697	53.9
				420	73.51	68.78	36.45	14.63				
4	4053	1753	1.753	378	71.42	66.08	37.30	18.55	19.72	1.464	0.707	69.73
				192	76.31	69.165	34.945	20.89				
[illegible]	[illegible]17	1717	1.717	397	78.41	70.06	33.650	22.93	23.53	1.389	0.799	73.6
				249	71.53	64.38	34.75	24.13				

How you can determine this, the dry density and the moisture content of the soil. So here you can see that that weight of the soil mould is gram and particularly mentioning this row that weight of the soil mould is 3995 this gram and this is weight of the soil is 1695g then you can determine that weight density gram/cc 1.695g/cc and this is the moisture content determination what this is a can number this then you can, weight of the soil +can is 73.51g when dry soil plus can 868.78g then weight of empty can is 36.45g.

And then you can determine this moisture content that is about 14.63g. So for different toll number you can determine or this parameter, and then you have to calculate the average moisture content. So you take the average moisture content it may comes about 15.04% then you calculate the dry density that is 1.473 and the void ratio E is 0.697 and degree of saturation is 53.9% this is I am just showing you one of the typical calculation here. Now I can say one calculation that how we can determine this.

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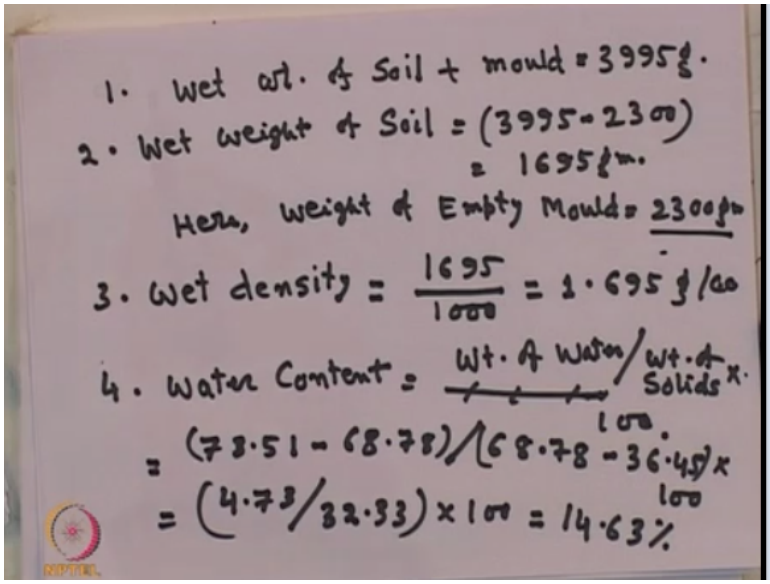

So first is that weight of soil plus mould say this is 3995gm second you take that what will be the weight of soil this is 3995 – 2300, so this will give about 1695g okay. Here weight of empty mould is equal to 2300g. So here weight of empty mould 2.300g, and that is why weight of the soil is 3995 – 2300g is 1.69g. Next weight density, now weight density is weight soil that is 1695 okay, and that divided by you know that volume I, so is earlier that is 1000 that means this will give you 1.695g/cc.

So you calculate that weight density. Now you have to calculate that water content, so water content is weight of water divided by weight of solid this divided by this into this into 100 okay. Then we weight water content weight of water give weight of solid in 100. So weight of water is given in the table this 73.51 – 68.78 this divided by weight of solid 68.78 – 36.45 this into 100.

So this if we calculate this will give 4.73/32.33 and this into 100 that is about 14.63%. So which I have shown you here that moisture content this is you can see here this is 73.51 weight of this water here and then 68.78 this is die soil and weight 68.78 this divided by minus weight of solid that is 68.78 - this is weight of mt is 36.45. So that this into 100 which will give you that what will be the moisture content and this is 40.63% so you are having that 40.63%, so you can calculate that much water content. Now next parameter is the dry density.

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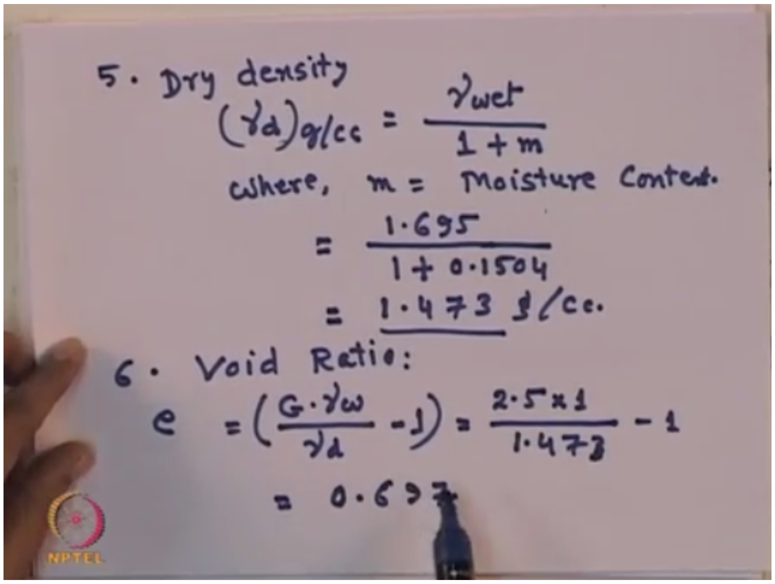

Dry density and that is expressed as γd this is g/cc that is γ of weight / by 1 + M, where M = moisture content. So γ weight we have calculated that is 1.695 here 1.695 γ weight density 1.695, so this is 1.695. So you can write 1.695 and this divided by 1 + moisture content. So moisture content we have also determined and that moisture content is about 0.1504.

So this will keep about 1.473 that is g/cc. So you can determine the dry density if you know the weight density and moisture content. Now another parameter which you call the void ratio and is designated at E = G γw/γd-1. So G is the specific gravity we know 2.5γw1/γd is you have determined 1.473 so this is 1.473 this minus 1 okay.

So this will give you that void ratio with 0.697 and G as the specific gravity which you have determined from the specific gravity test method. So earlier we have determine the specific gravity ity from this method what is the specific gravity of the soil and that is 2.5. So from this we can calculate that what will be the void ratio. So next term we have to calculate that 7, that is degree of saturation.

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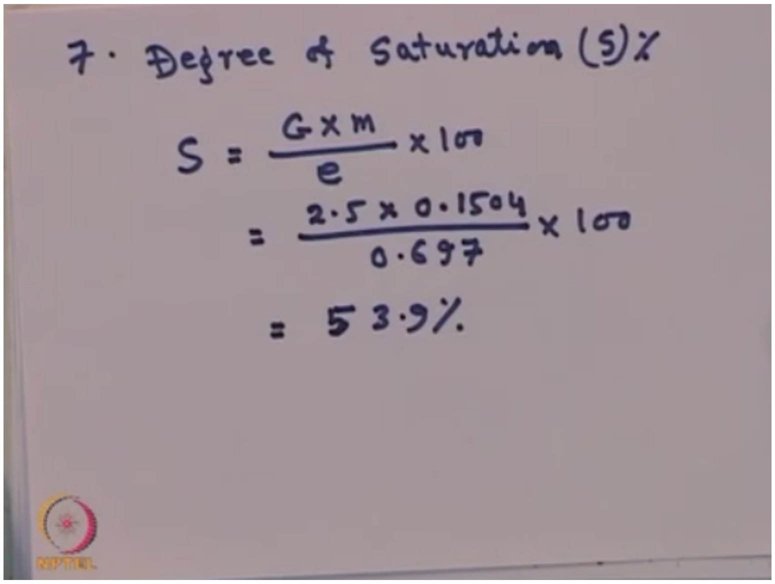

Degree of saturation that is designated at S and percentage that means S = GA/Ex100. So G you know specific gravity of the soil that is 2.5 and moisture content we have determined earlier that is 0.1504 and this divided by E that is void ratio okay. That is E void ratio you have calculated 0.697, so this is 0.697 x 100. So if you calculate this you can have the degree of saturation is about 53.9%. So you can calculate that the degree of saturation is 53.9.

So like this in this table for the different moisture content, so ultimately you are having that what should be the void ratio and what should be the dry density, and what should be the degree of saturation?

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Soil Testing in Civil Engineering

Trail no	Wet wt. Of soil + mould, g	Wet weight of soil, g	Wet density, g/cc	Moisture content determination					Average moisture content, %	Dry density, g/cc	Void Ratio, e	Degree of saturation, S, %
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				249	71.53	64.38	34.75	24.13				

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So from this data from this table you can draw a correlation between the dry density and the moisture content. So here I am showing you this relationship between the dry density and the moisture content for different values of dry density and the corresponding that moisture content and the void ratio from the with the standard proctor test.

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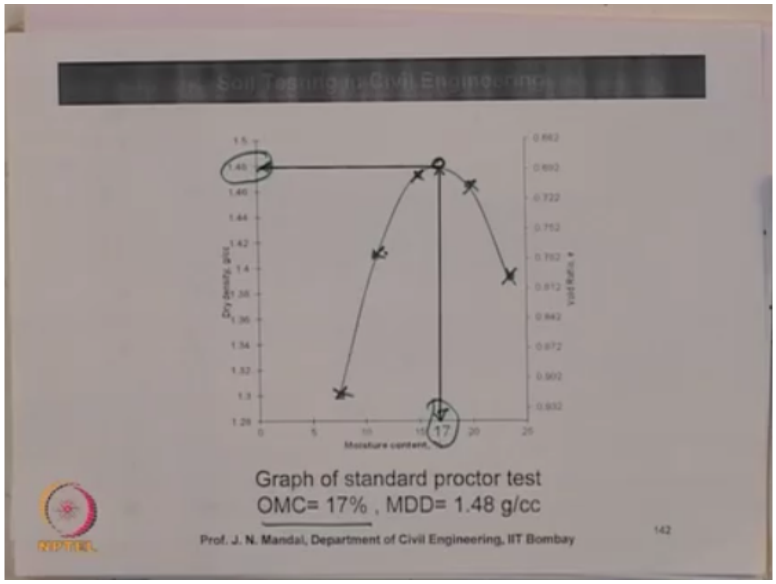

So this is from the standard proctor test this x-axis is the moisture content in percentage and Y axis is the dry density γ/CC. So for any moisture content value, so you know what is dry density. So you can fix some dry density similarly for another moisture content you can determine what will be the dry density so you can get a point like this you can get these at the point for the difference. After sudden moisture content then it is decreasing, so initially that moisture content is increasing, dry density is decreasing after reaching to the optimum value then the dry density decreasing and moisture content is increasing.

So from this curve you can determine that what should be the maximum dry density and corresponding what would be the maximum moisture content. This is a graph for standard proctor test and here you can see that optimum moisture content is 17% this is optimum 17% and maximum dry density is this that is 1.48g/cc. In the right hand side also you can have that void ratio value which I have shown in this table that here the void ratio value okay, void ratio moisture content by void ratio.

And from here also you can draw a different saturation line. So this is very important from the proctor compaction say how to draw the compaction curve and from the compaction curve one should know that what should be the maximum dry density and corresponding the optimum moisture content. These two parameters are very important in civil engineering. Then particularly for the soil mechanics for the design of any kind of the structure.

First of all you should know that the area what should be the optimum moisture content and the corresponding dry density. You can also draw the zero air void line and how you can draw the zero air void line for the zero air void line.

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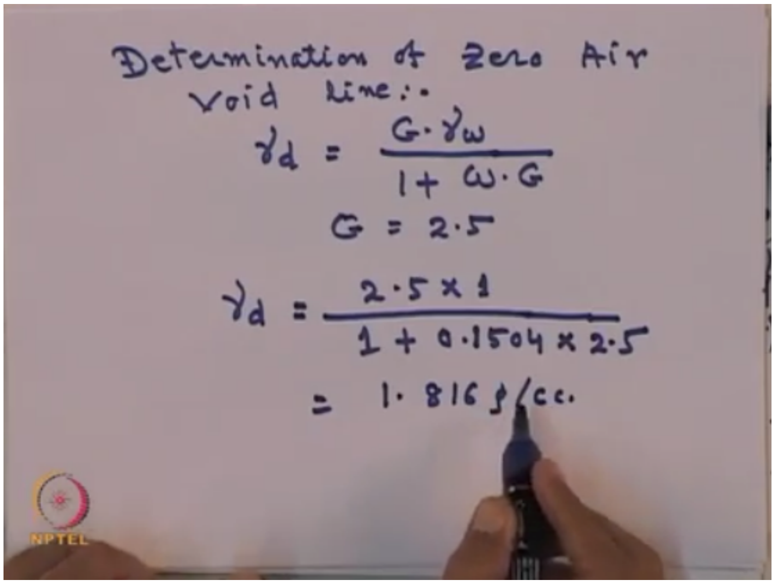

So now your determination of zero air void line So this zero air void line can be expressed as γd = G.γw/1 + wG, what is G, the specific gravity. So G is the specific gravity and this G value is about 2.5. So you have to determine what is γd, so γd = G is 2.5 γw is 1g/cc/1+ this is the W moisture content which we determined earlier 0.1504 okay.

This into that G that is 2.5, I showed you earlier that moisture content also that is 1.04 earlier, so from this you can calculate that what will be the dry density that is 1.816g/cc. So you know that what will be the γd and from here for a particular that moisture content and this dry density you can determine that what should be the zero air void line, so zero air void line will be like this okay, advert line will be like this.

You know that dry density γ dry density 1.0 air void line, 1.8 on 6 I mentioned that 1.816 and the corresponding moisture content is equal to 15. So you can have a point like that for different water container and density you can have a zero air void line where the degree of saturation is 100%. So this zero air void line also called the saturation line or zero air void line. So you can draw this zero air void line like this, here is 1.816. Similarly for the degree of saturation can be done for suppose 100%.

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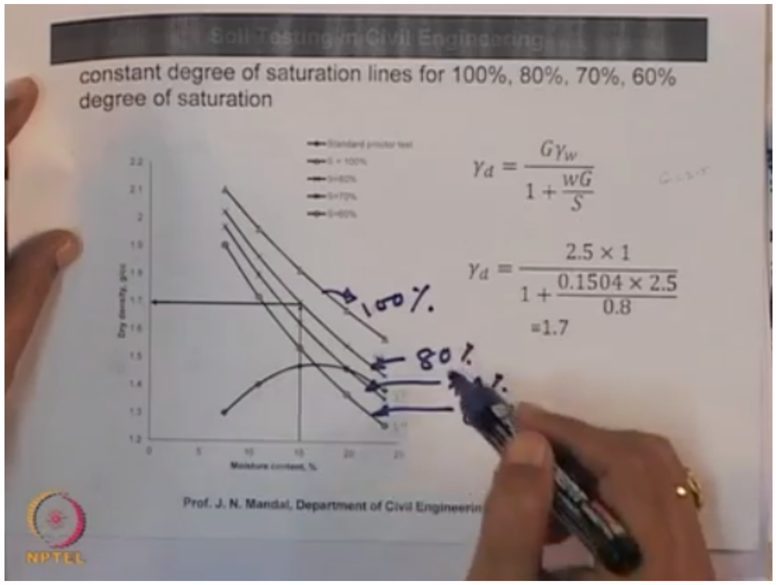

You can draw for the 80%, 70%, and also the 60% you can draw number of degree of saturation. Here I am showing for the constant degree of saturation you can see again this is the compaction, standard compaction curve and this is the degree of saturation and this is for 100%, this curve is for the 80%, and this curve is for the 70%, and this curve is the 60%, and this is 100%.

So you can draw the various degree of saturation curve by the 100, 80, 70 and 60%. So different types of the degree of saturation curve can be also drawn. So far we discuss about the compaction test and this is a standard compaction test, and from the standard compaction test how you can determine that maximum dry density and the corresponding moisture content.

In addition to the maximum dry density and the optimum moisture content you can also draw the different degree of saturation, degree of saturation may be 100, 90, 80, 70, 60, 50 so that it can be drawn. And these are the particularly these two parameter maximum dry density and the optimum moisture content is very important for any civil engineering infrastructure project. So these are standard proctor test and this also very useful for any kind of the project or the compaction is necessary.

For example, for reinforced soil retaining wall or for the root construction, or for the embankment construction you have to check up that whether you have achieved the 95% degree of compaction or not this is, as for this is same code specification, it should achieve at least the minimum 95% of the compaction effort.

And if sometimes that if you do not achieve or if you do not check it, so there may be certain kind of the problem in the construction. So one has to be very careful for the proper compaction. So now we ended up with the standard proctor compaction test and next we will discuss about the modified proctor test. And this modified proctor test is slightly different from the standard proctor test and that we can discuss in the next lecture thank you.

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