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Lecture - 06
Standard Penetration Test & Cone Penetration Test

So, in this lecture 4 I will discuss the corrections factors whose are recommended by the ASTM and then I will go for the next test which is the Cone Penetration Test.

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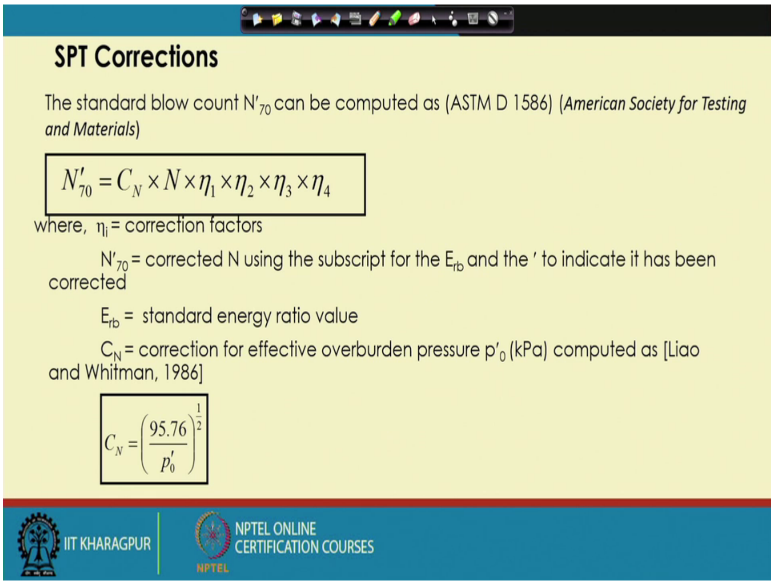

So, first as in the last class I have discussed the as per IS code there are two corrections one is corrections due to overburden pressure another is a collect correction dilatancy correction.

But as per ASTM or American Society for Testing and Materials we are recommending five corrections; one is the corrections due to overburden pressure, then your hammer efficiency correction, then the drill rod corrections, sampler correction and borehole corrections.

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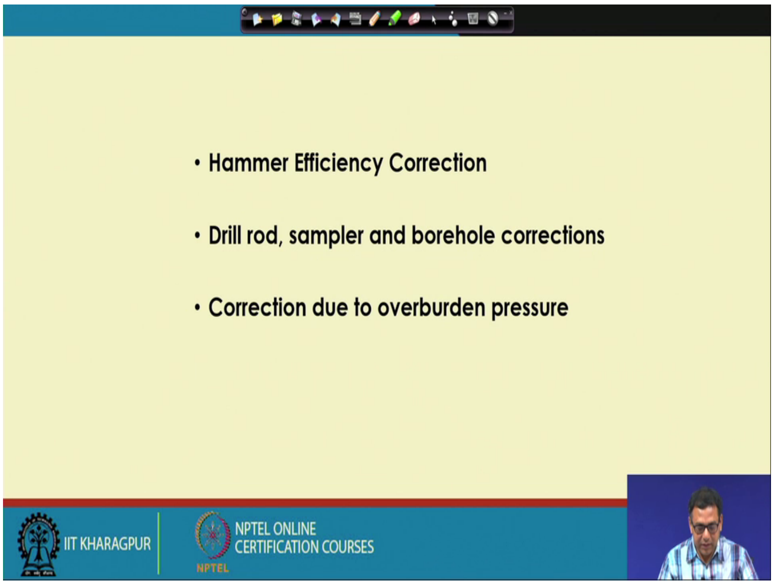

So, the hammer this is the corrections due to effective overburden pressure we can get with this expression. So, where p 0 bar is the effective overburden pressure and which is in kPa.

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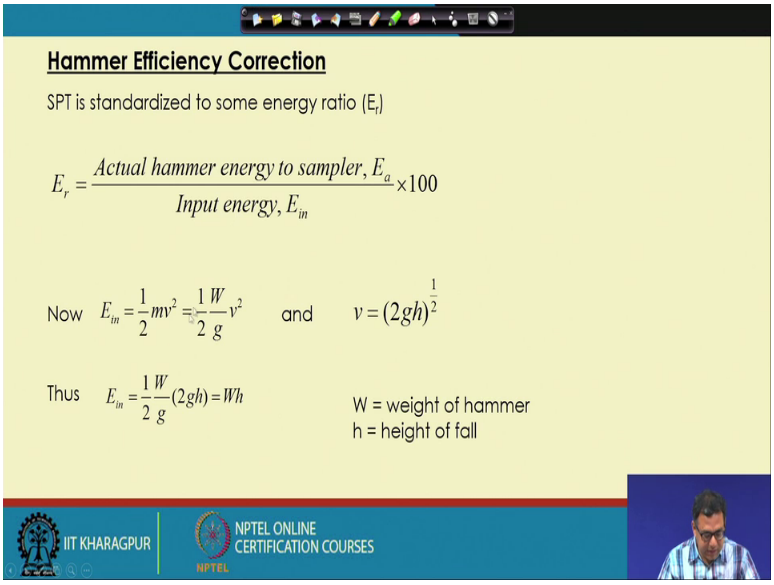

So, now next one is the hammer efficiency correction. So, as I mentioned that the our theoretical input energy is weight of the hammer into the height of free fall, but our hammer efficiency is not same for different hammer. So, that is why our actual hammer energy that we are applying in the field is different. So, that is why we will get an ratio that is the some is energy ratio E r. So, this is the actual hammer energy by the input energy.

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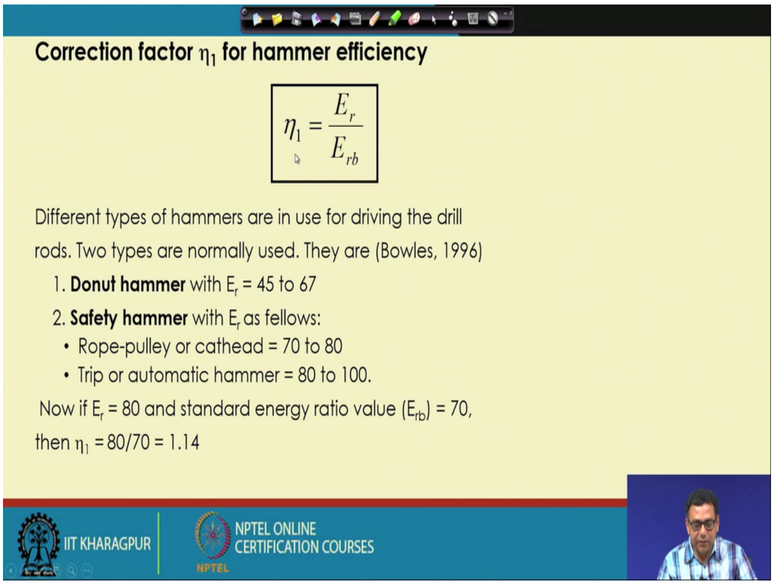

And the correction factor is that E r divided by E rb. Now E rb is the energy by which we are converting all the hammers to a standard energy. So, this is the energy by which we can represent into the soil. So, that is why in this figure it is 70; this 70 means the 70 is the E rb. So that means, the I mean all the hammers N value we have to convert to 70 percent energy.

So that means, E rb is the 70. So here so, we can see this is E rb is the hammer efficiency. So, this is the hammer efficiency correction so, standard energy. So, that is why standard energy ratio. So, you all the standard energy ratio will come back our N value.

So, that is why the if for different hammer this E r value is different. So, this is for different hammer as I mentioned in the last class this is the different values and you will take the if the E r values 80, if we use the automatic hammer then the and the standard energy ratio is E r b 70; that means, you have to convert it we are this E r is 80, but we will represent them in 70.

So, basically we are applied more energy now we are we are representing in a lower energy. So, our N value should be increase. So, that is why it is the 80 by 70. Now if our applied energy is less and we want to represent it in an higher energy ratio then our N value will reduce. So, but here our standard energy representing energy 70 which is less than the applied, so the N value will increase. So, this is 80 by 70; 1.14.

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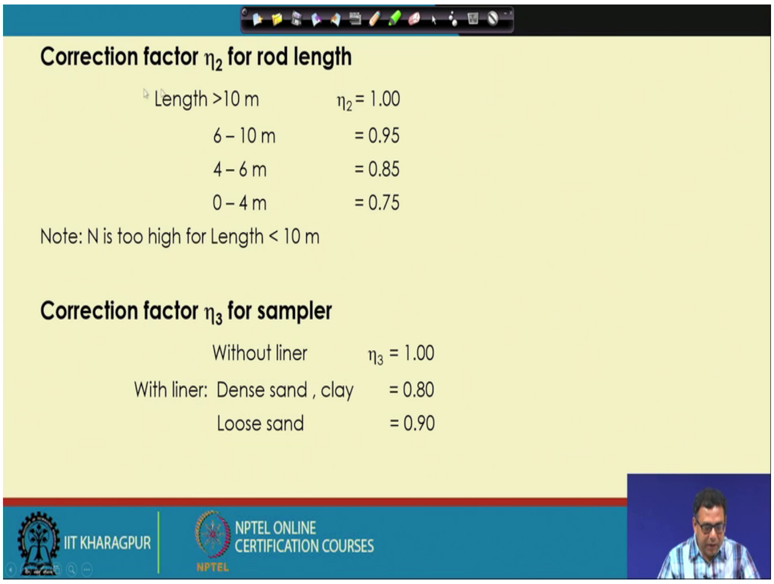

Similarly, some correction factors for rod lengths are given. So, these are the tables we can we can use this table for different rod length what would be the correction factor. This is the rod length and this is the correction factor.

So, this table is can be used for the rod length correction then this table can be used for the sampler corrections, when the different sampler tube because we are using different sampler tube and if the sampler tube is different and depending upon there our N value will also be will also influence.

So, that is why it is without liner if there is a liner and if there is not liner. So, there will be different correction factor, if without liner the correction factor is 1 and with liner dense sand is 08, loose sand is 0.9.

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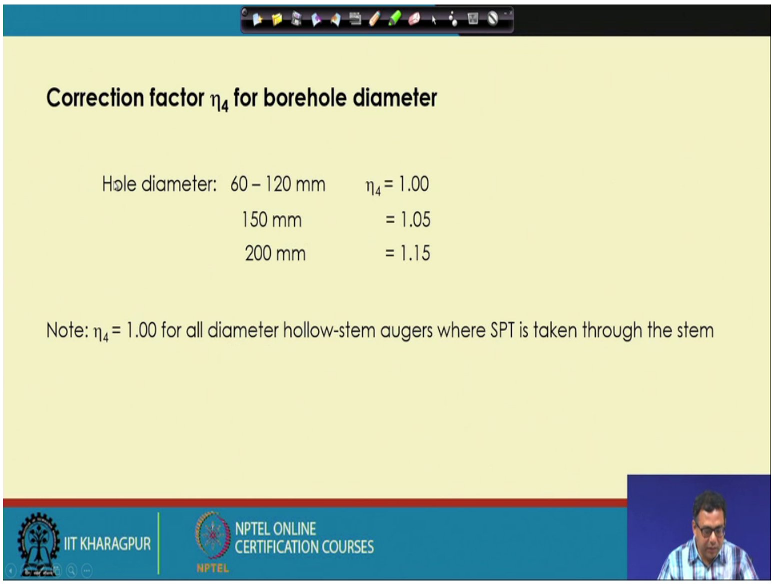

So, similarly for the boreholes diameter depending upon the borehole diameters we have to apply the corrections. So, borehole diameters if it is 60 to 120 millimeter this is the correction factor is 0; otherwise 150 is 1.05; 200 is 1.15.

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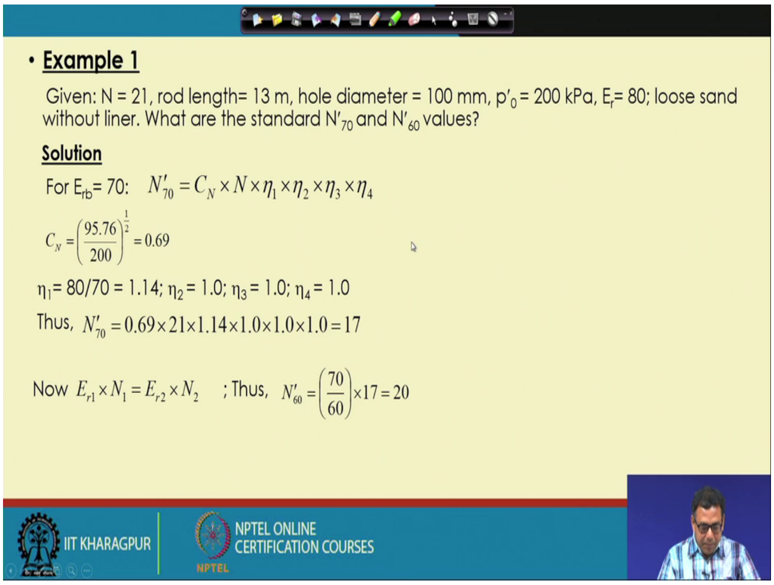

So, now this is a example problem. So, if the your measured value is 21, rod length is 13 meter, borehole diameter 100 millimeter and p 0 bar is 200 kPa, E r is 80, loose sand without liner. What are the standard N dash in 70 percent standard energy ratio and the corrected N value in 60 standard energy ratio?

Now, the your solution that E r b is this is the standard is given first past first case E r b 70. So, the this will be N dash 70 because our standard energy ratio is 70. So, these are the expression. So, C N I will get from because your 200 p 0 bar is already given in 200 kPa. So, we can put directly here; it is kPa, remember that p 0 is always kPa if we put it in this expression. So, it is 0.69.

So, our in a our correction factor for the overburden pressure is point 0.69, then correction factor for the because E correction factor for hammer efficiency is E r divided by E r b; here E r b is 70 and E r is given 80. So, this is 1.14 and it is given your rod length is 13. So, it is in between greater than 10. So, it is 1. So, it is rod length correction is 1, saying them when it is your loose sand without liner. So, it is without liner again the correction factor is 1. So, it is without liner correction factor is 1.

Similarly, it is borehole diameter is 100 millimeter. So, it is in between 60 to 120 millimeter. So, it is again 1. So, it is again 1. So, finally, the N dash 70 will be 17. Initially towards 21, now it is become 17. Now if I want to convert these things for N dash 60. Then we can write this expression this is E r 1 into N 1 plus E r 2 into N 2. So, your N dash 60 will be 70 divided by 60 to 17.

So because this is the standard energy ratio 1 into the N 1, so, N 1 is here your for the standard energy ratio 17; 70 N 1 is 17. For standard ratio 60 what will be the N 1? So, that is the case. So, it will further it will increase because now we are reducing this energy ratio. So, it is ultimately 20.

So, this is the one particular example in terms of the corrections are required for ASTM. Now, I will show you the, I will show you one example which is which I am using in terms of the IS code. So, in terms of is code the problem is given that we have soil layer which is saturated.

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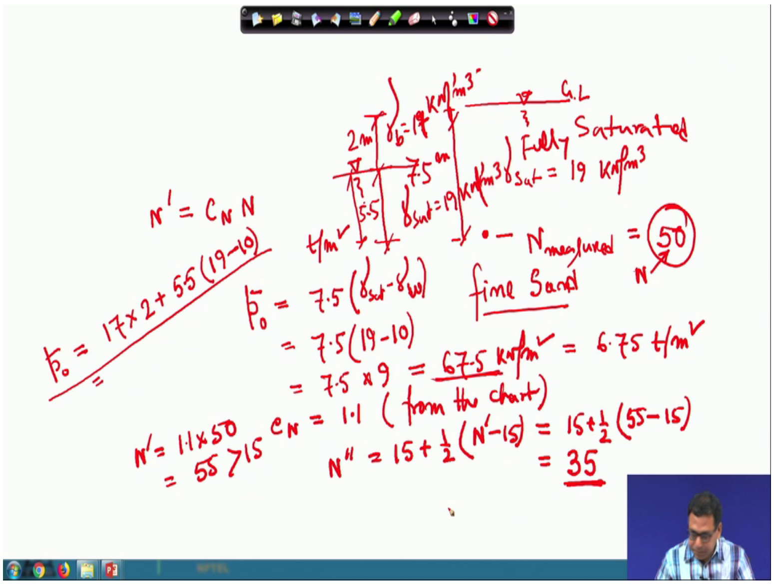

So, water table is at the ground level and the gamma saturated gamma sat is 19 kilo Newton meter cube and we have to determine the N value which is this depth is 7.5 meter from the ground level.

So, our N measured is equal to 50 and the soil type it is a fine sand fine sand. So, soil type is a fine sand measured N value is 50. Now we have to apply the corrections and we have to determined what will be the corrected N value.

So, first correction is for the N dash overburden pressure which is C N and N so or N measured here this is the N. So, now, C N we need to know the as per IS code we use this chart that I have shown you in previous class, so, you use that chart and in this chart it is given ton per meter square.

So, but the p 0 bar p 0 bar or p 0 dash here is it is fully saturated. So, here it will be 7.5 into as I mention this will be the gamma sat minus gamma W; unit weight of water 7.5 is the height. So, 7.5 minus 90 19 minus 10; the unit weight of water we are assuming 10; you can consider 9.81 also, but most of the cases in this course I will consider it is 10.

So, this will be 7.5 in to 9, so, this value is 67.5 kilo Newton per meter square because this is 19 kilo Newton per meter cube. So, this is 10 kilo Newton per meters cubed, this is kilo meter per meter square, so, in terms of ton. So, this will be 6.75 ton per meter square.

Now, if you look at that chart so, corresponding C N value corresponding 6.75 ton because as I mentioned if it is 10 then you see it if it is 10 ton per meter squared your C N value is exactly 1, but if it is less than 10 tons per meter square so, your C N value is greater than 1; if it is less than if it is greater than the 10 ton per meter square plus C N value is less than 1.

So, yeah definitely C N value will be greater than 1. So, from the chart the C N value is coming out to be 1.1. So, this is from the chart. So, we will get the N dash value is equal to 1.1 into 50. So, it will be 55 which is greater than 15 and it is saturated as well as it is fine sand, it is fine sand and it is saturated also or fully saturated.

So, we have to apply the dilatancy correction this is greater than 15. So, that the dilatancy correction you know this is N double dash which is equal to 15 plus half into N dash minus 15. So, this is 15 plus half N dash is 55 minus 15. So, this is coming out to be 35. So, my final corrected value after applying both overburden correction and dilatancy correction the N dash value is N double dash value is 35, whereas, measured value was 50.

Now, this problem will be slightly different if the water table is not at the ground level, suppose this is just if the water table is suppose this is it is say 2 meter below the ground level. So, the if this is the water table location is here and this gamma bulk is say 19 kilo Newton meter or gamma bulk is slightly less is 17 kilo Newton per meter and gamma sat is 19 kilo Newton per meter.

So, in that case your p 0 bar value will change. So, p 0 bar value will be in that case 17 into 2 plus 5.5 into 19 minus N. So, this is the only difference after that. So, based on that you calculate the p 0 bar and then from the chart you calculate corresponding C N if it is greater than 15 you apply the dilatancy correction.

So, that is why the position on water table and based on that. So, here the total soil is fully saturated; first case we have consider the two cases the first case the total soil is fully saturated so, I am saturate it unit weight is 19 kilo Newton per meter cube. So, we calculate this value. So, this is coming out to be 67.5 kilo Newton per meter square.

Now, if the total 7.5 meter is fully saturated. Now if the water table is 2 meter below the ground level then first 2 meter is not fully saturated whereas, the unit weight is or bulk unit weight is 17 kilo Newton per meter cube and the saturated unit weight as it is 19 kilo Newton per meter cube.

So, in that case p 0 bar will be 17 into 2 plus this is the 5.5 because totally 7.5, so, 5.5 into 17 minus 10. So, you calculate this p 0 bar and then do these things again so as it is. So, this is the two example problems that we are doing for two cases, first one is for as per ASTM and the second one is as per IS code.

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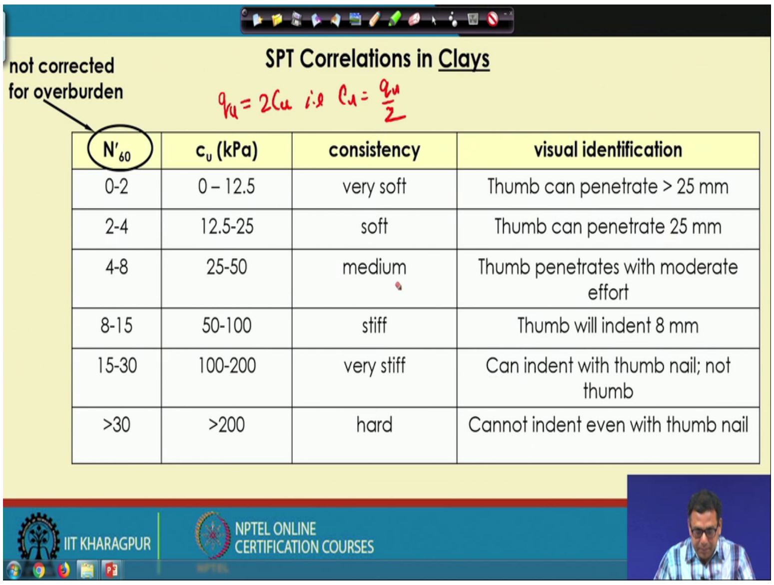

N'_{60}	c_u (kPa)	consistency	visual identification
0-2	0 – 12.5	very soft	Thumb can penetrate > 25 mm
2-4	12.5-25	soft	Thumb can penetrate 25 mm
4-8	25-50	medium	Thumb penetrates with moderate effort
8-15	50-100	stiff	Thumb will indent 8 mm
15-30	100-200	very stiff	Can indent with thumb nail; not thumb
>30	>200	hard	Cannot indent even with thumb nail

So, as I mentioned that here based on the calculated N value or the corrected N value we have some correlations. So, based on that we can determine what type of soil it is. So, for example, there are in table is given if N value is for the clay if N value is 0 to 2 then the cu value is 12.5 and that means, cu value is 12.5 means your undrained shear strength is to cu that is cu is qu by 2 this things I have already mentioned.

So, this is we can so, the consistency is very soft if your cohesion value is 0 to 12.5 kPa the soil is termed as very soft; if these 12.5 to 25 it is soft, 25 to 50 medium 50 to 100 kPa stiff, 100 200 kPa very stiff, then greater than 200 kPa it is hard and these are the video visual identification you can get this information. So, these are the correlation N corresponding cu and the type of soil.

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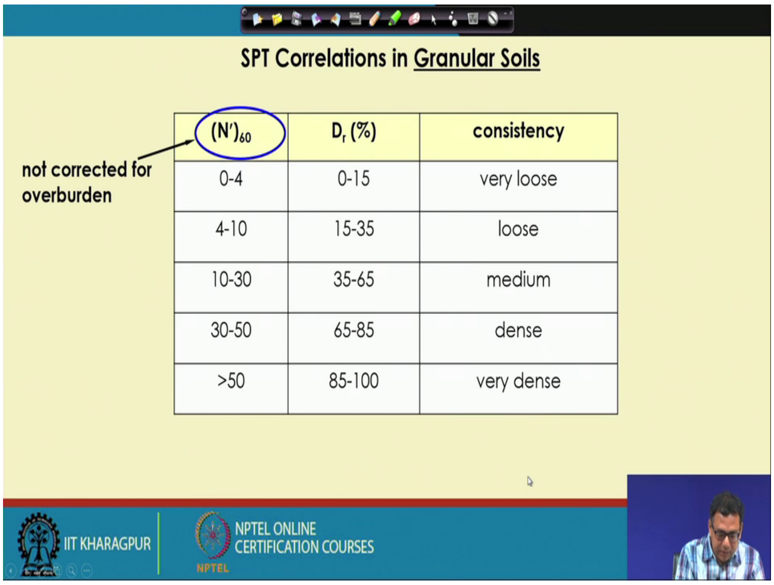

Similarly, we have similarly we have this is the corrected here. These both case these are correlation was not corrected for overburden remember that here overburden correction is not applied. So, as I mentioned these correlations are given for different conditions sometimes it is with the only measured valued with the corrected values applying all the corrections with the corrected value applying some correction not applying other correction.

So, this is the so, we have to a careful which correlation you are using. So, and these conditions you have to satisfy. So, this is the correlation not corrected for overburden.

Similarly, for the for the sandy soil this is the N value corresponding relative density and the type of soil because this is the consistency because in the consistency in the sandy soil or the granular soil we represent it in terms of relative density and for the clay soil in terms of the cohesion or the undrained cohesion.

So, this is the N value corresponding relative density and the type of soil. So, this is the 0 to 15 is what a very loose and 85 to 100 is very dense or greater than 85 is very dense. So, and this is the corresponding N dash 60 60. As I mentioned 60 is the that standard energy ratio.

And then once we get these; so, there are other correlations available. So, I am not representing all the correlations for so, any here I am not giving you if you the have any standard text books or the book reference that I have giving in one in those books you will get other correlations also. So, you can use those correlations. So, I am giving one or two correlations or one or two standard a table that we are generally using.

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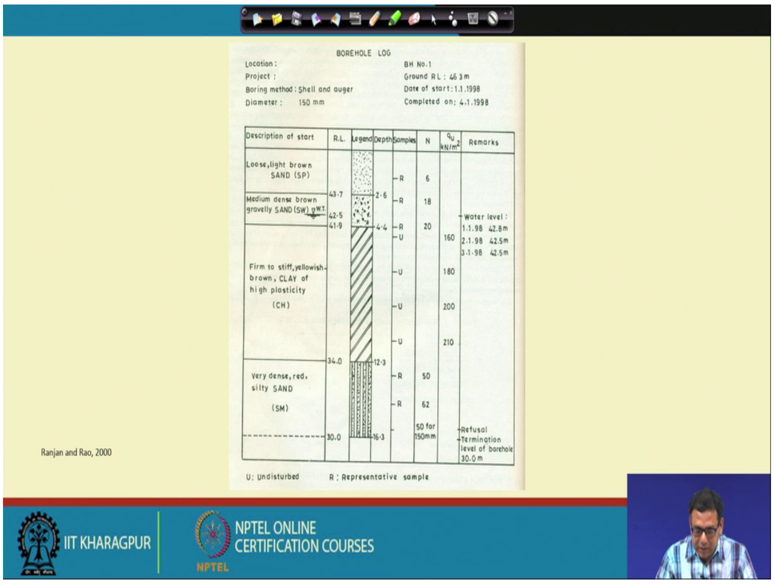

So, next one is the once we conduct these SPTTA. So, this is the final borehole logs. So, these borehole logs this side the description of soil this is the R.L. or the depth where we are conducting the SPT and this is the legend we are for different soil type like showing them in different way and this is the depth this the R.L. this is the depth and this is sample.

Now sample here it is mentioned R and U; R mean the representative soil u in the undisturbed soil so; that means, here you can see its the clay soil this portion is clay where we can collect the undisturbed soil sample, but these are all sand where the collection of undisturbed soil sample is very difficult. So, that is why we are collecting the disturbed sample or the representative sample and then so, in the sandy soil we are getting the N value because as we are not able to collect the undisturbed soil sample.

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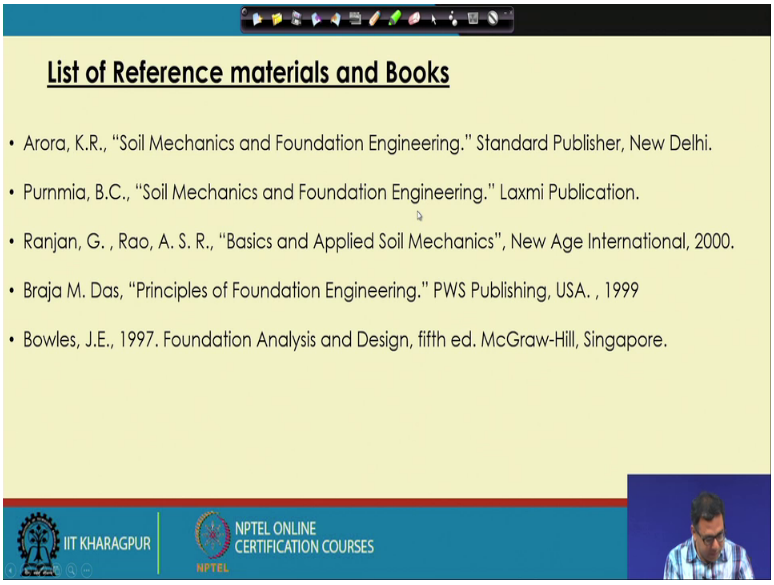

If you collect the undisturbed soil sample then we can use them to determine the strain properties of the soil. So, we are get the qu value; qu means the unconfined compressive strength of the soil. So, cu you will get cu is equal to qu by 2. So, here as it is the undisturbed soil sample we can use determine the C value, but here it is not the undisturbed soil sample it is the disturbed soil sample. So, here we will get the N value. So, finally, this is the 6 18 20 50 62 50. So, these are the N value. So, and here the refusal is given at 30 meter depth and what are the condition for refuel refusal I have already mentioned.

So, here this is the measured N value, now after that you have to apply the corrections and you will get the corrected N value. So, this is the end of our standard penetration test part. Now these are the references so, that we are those these are the common references I am using for all the all the classes.

So, next one that I will go is for the is our the penetration test that is. So, so, next one is the penetration test which is another indirect method. So, we have go for the standard penetration test previous class and this class now will go for the cone penetration test.

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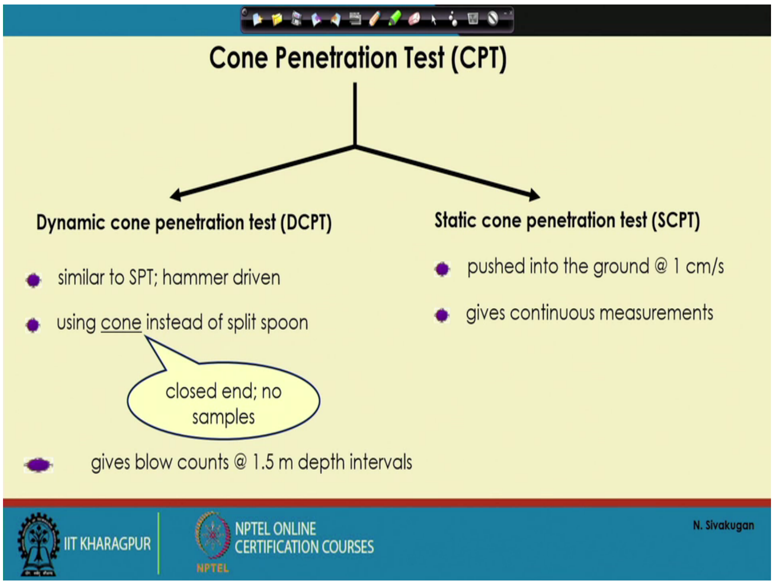

So, this is also another indirect method. So, the cone penetration test, it is two types one is the dynamic cone penetration test or DCPT another is the static cone penetration test or SCPT. So, the difference between these two is the dynamic cone penetration test is similar to the SPT that means, we have to apply the hammer blow to drive the cone and what static cone penetration test we are not applied any hammer blow.

So, we are pushing it into the soil it a particular rate, so, here 1 centimeter per second. So, with a 1 centimeter per second rate we are pushing this cone into the soil. So, and the another difference is that in DCPT we are using the cone instead of split spoon sampler.

So, in the SPT we are using the split spoon sampler, but as DCPT is similar to the SPT. So, but the difference between DCPT and SPT is there in the SPT we are using the split spoon sampler. So, we can collect the soil sample, but in the DCPT we cannot collect the soil sample. So, it is the solid cone, but in case of SPT issuer it was a hollow tube.

So, so, here also we can conduct the test at the rate of 1.5 meter interval. So, and another similarity between SPT DCPT is that here borehole is required. So, in the SPT also we required borehole. So, at a particular depth we conduct the SPT, CPT also borehole is required. So, we cannot get the continuous data through these tests. So, we get the data with certain interval with certain depth interval where we are conducting the test. So, if that interval is 1.5 meter not more than 1.5 meter; So, interval, but in SCPT as we are pushing these things into the soil and we are continuously measuring the data. So, you will get the continuous measurement in case of SCPT.

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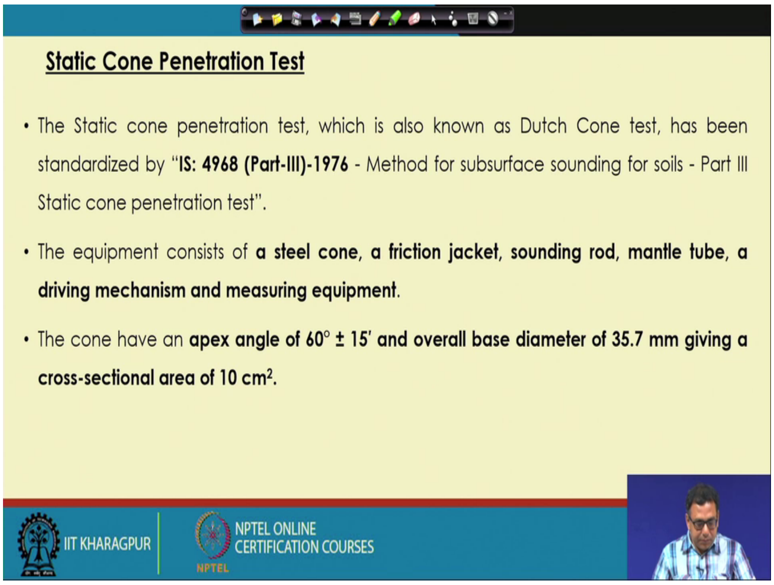

So, the first I will discuss about the SCPT then I will go for the DCPT. So, the this is the some description that so, this as per 4968 IS code, but III 1976. So, this is the static cone this equipment consists of a cone friction jacket sounding rod mental tube and a driving mechanism and measuring equipment.

So, this is the SCPT the cone have a apex angle is 60 degree plus minus 15; second overall base diameter is 35.7 millimeter and the cross section area of the cone is 6 10 centimeters square.

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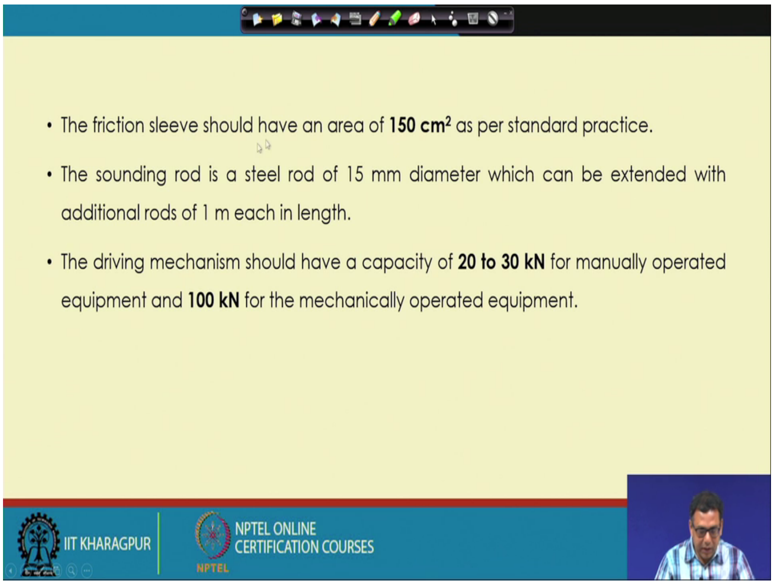

So, the there is a friction sleeve we can area of 150 centimeter square and this is the sounding rod 150 millimeter diameter which can be extended with the addition rod of 1 meter for each length. So, which is common for any test whether it is SPT or DCPT or a CPT so; that means, you have you can add the drawl a rod and you can increase the required depth of there of the test. So, that mean you can increase the rod length by adding one after another and you can do the conduct the test for up to the required depth.

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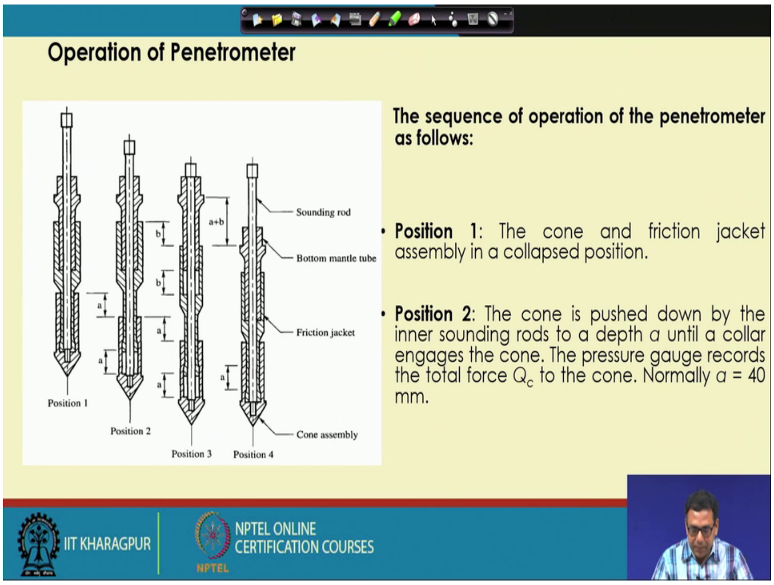

So, here the driving mechanism should have a capacity of 20 to 30 kilo Newton and it is for manually operated equipment and 100 kilonewton for mechanically operated equipment. So, these are some informations. So, here the some this is the procedure which is explained here, but you cannot read this procedures that how it is been explained, but I will show you with the help of animation. So, that will be I think that will help you to understand these things in better way how these equipments are actually works.

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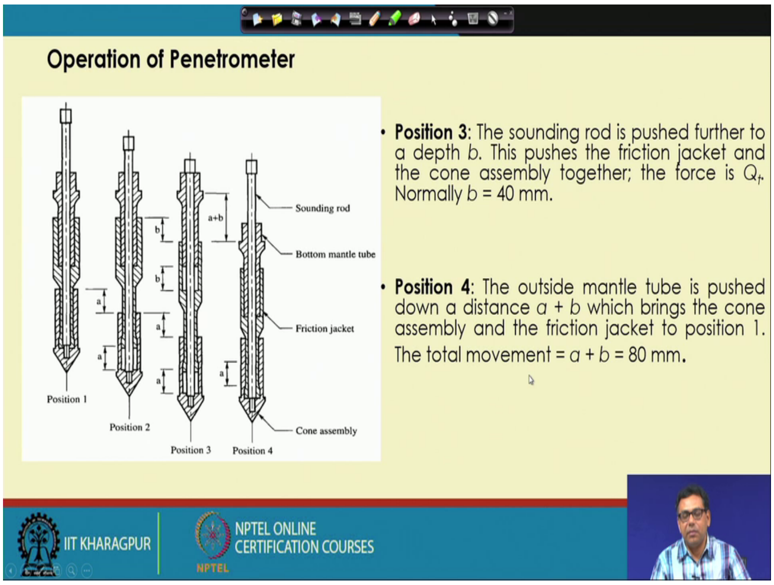

So, this is the there are basically the four steps or four position by which we can conduct this test.

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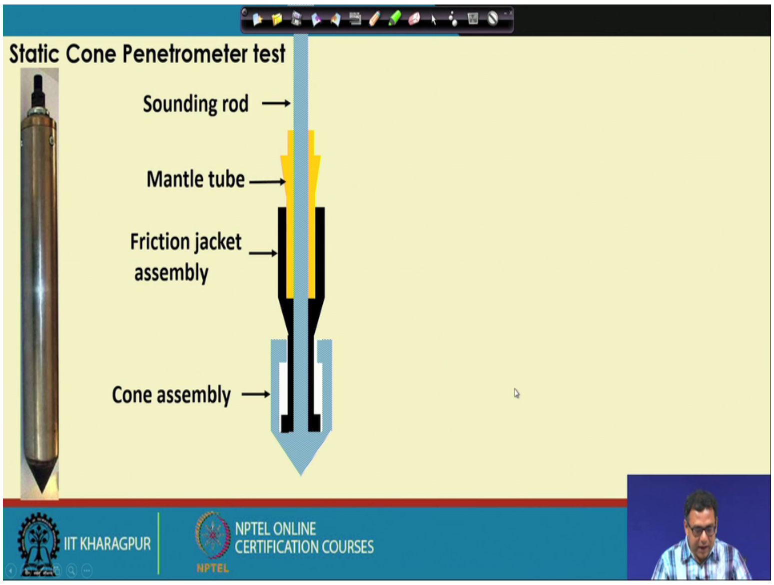

So, first position is that so, as I mentioned there is the four components one is the sounding rod, one is the mental tube, friction jacket assembly and cone assembly. This is the sounding rod, this is yellow one is the mental tube, this black one is a friction jacket assembly and this one is the cone assembly. So, this is the and this is the overall picture of the of the cone.

So, now the this is the first stage. So, what we will do I will push the this total sounding rod along with cone assembly is pushed by 40 millimeters. So, this is 40 millimeters it is not visible here. So, I can write for you. So, this is 40 millimeter. So, so, this is 40 millimeter. So, first stage sounding rod along with the cone assembly is pushed by 40 millimeter. So, we will get a resistance which is given by the soil.

So, that resistance is measured. So, that will give you the cone resistance. So, that is the it is the advantage of the cone static cone penetration test is that here the cone resistance and the frictional resistance we can calculate separately. So, that will be helpful for our pile load carrying capacity design because we know that pile it has the cone resistance and it has the friction resistance.

So, here first stage the when the sounding rod along with the cone assembly is pushed into the ground by 40 millimeter will measure the resistance that will give you the cone resistance which is the q c. So, you will get the q c which is the cone resistance. In the next stage in the this is the same stage in the next stage your sounding rod, cone resist cone assembly and the friction jacket all three are pushed into the ground it further 40 millimeter.   .

So, here the friction jacket and cone resistance both are pushed into the ground the resistance that I will get it is the total resistance. So, I will get initial stage I will get the cone resistance next I will get the total resistance. So, if I subtract the cone resistance from the total resistance so, I will get the frictional resistance.

So, and in the third stage what I will do what it is done that this is the second stage you know third stage the mental tube is pushed by 40 millimeter and in the fourth stage final stage your mental tube and the friction jacket both are pushed by 40 millimeters. So, total 80 millimeter penetration is there 40 plus 40 and this fourth stage is the original stage when we started the test.

So, these are the four stages first stage we penetrate the sounding rod and the cone assembly will you get the cone resistance in the second stage we will push the sounding rod friction jacket and cone res a cone assembly. So, you will get that total resistance. So, if I subtract the cone resistance from the total resistance I will get the friction resistance and in the third stage the mental tube is pushed by 40 millimeter and fourth stage metal tube and the friction jacket assembly is pushed by 40 millimeters.

So, total 0 millimeter penetration we will get the friction resistance as well as the cone resistance separately.

So, here I will finish this class and in the next class I will discuss that what are the correlations. How I will correlate these static cone penetration values with the soil parameters and then I will discuss the dynamic cone penetration test also.

Thank you.