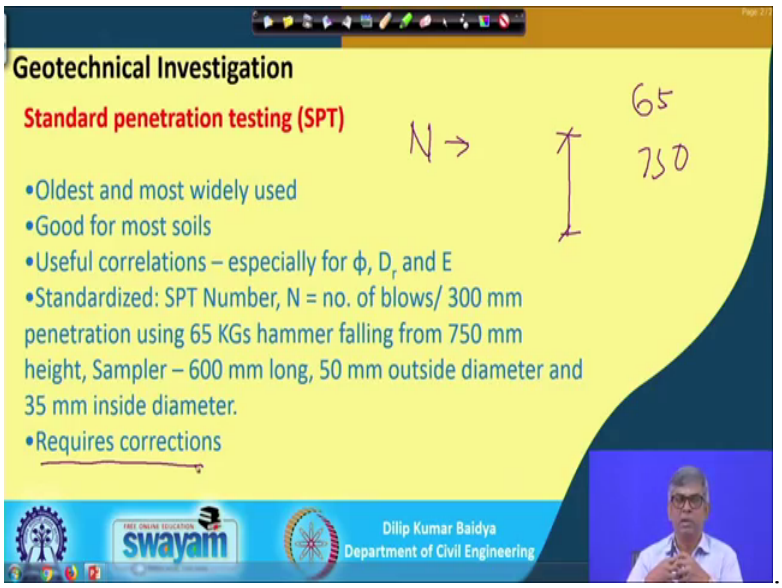
**Geotechnical Engineering II / Foundation Engineering**
**Prof. Dilip Kumar Baidya**
**Department of Civil Engineering**
**Indian Institute of Technology, Kharagpur**

**Lecture – 25**
**Geotechnical Investigation (Contd.)**

Good morning. We will discuss some more field investigation in the under Geotechnical Investigation. And, in this I have already mentioned that geotechnical field investigation has several advantages and also several disadvantages. And mainly is that main advantage is that you get the field itself the soil properties in the real condition, and also it is quick maybe economic and there are some disadvantages I have mentioned. So, I have also discussed about some method.

Now, I will discuss about most widely used field test which is used for characterizing the site that is SPT that is standard penetration test.

(Refer Slide Time: 01:25)




And, this standard penetration test is a apt test we generally call SPT means standard penetration test or testing. And, this is quite this is perhaps oldest method and soil investigation is used and is it easy to carry out and not much skills are required. And, it is suitable for most of the soils good most soils, and most in advantage is that initially SPT based on SPT is actually you are pushing certain member by some energy and the

amount of energy required to push certain depth from there actually we get a feeling about the quality of the soil.

And over the time actually people investigated this with different soil and they have got different energy level or that is penetration number that blow counts and they could. Finally, they could finally, correlate with that SPT number with those important soil parameters like internal angle of friction, then your relative density, then Young's modulus they are all very important parameters, for you know we have discussed bearing capacity, we have discussed settlement, and you know that in bearing (Refer Time: 03:03) phi is important, because the N C N Q N gamma are related to phi and in settlement actually E is important.

And, D r actually related to of course, classification purpose and say if you know the; if you know the classification and indirectly you get the phi value and C value it is phi value. So, these are the things, that is at most advantage is that it has several correlation. So, with the N value SPT number whatever we get with that there are several correlations available. So, if you can conduct the test in the field and you get that data then immediately you will be able to correlate the soil parameters with without much difficulty.

And, it is very much standardized and; that means, we have SPT number that is what we record that is actually denote by N and that is number of blows per 30 milli 300 millimeter penetration and using 65 kilogram hammer falling from 3 750 millimeter heights. That means, you have a SPT in a no count N and that actually blow corresponding to what there will be 300 millimeter penetration, 300 millimeter penetration, and under the application of weight of 65 kilogram which will fall from a height 750 millimetre.

So; that means, you for a for a particular SPT test there will be a sampler, on that sampler there will be arrangement collar will be there on that 165 kilogram weight will fall. And, we observe how many number of blows required to penetrate 300 millimeter of the sample a sampler. And, actually not exactly 300 millimeter because of several reason, we initially do not take any count for first 150 millimetre and 150 to 450 millimeter; that means, there is 300 millimeter for that distance what is the number required that number is correct is recorded and that is actually treated as your N value.

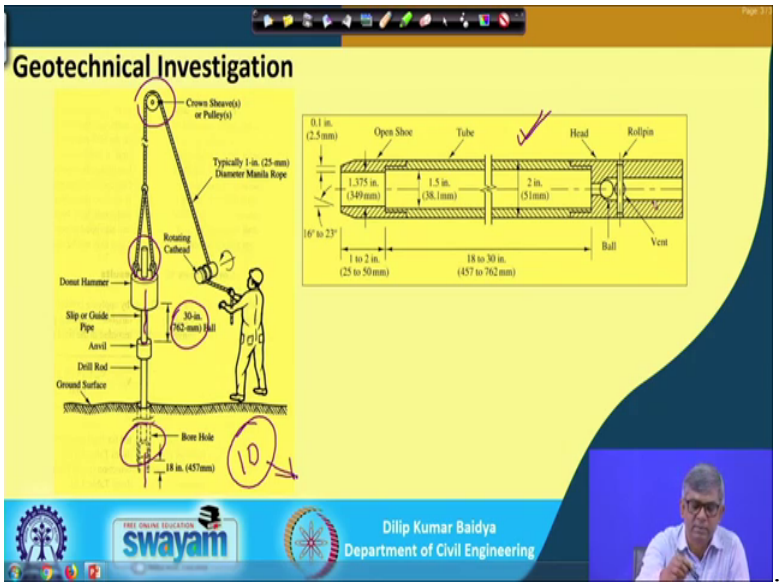
So; that means, it is very much standardised that is how we denote N it is across the globe is same, the number of blows required to penetrate the sampler by 300 millimeter with a weight of fall with a weight of 65 kilogram or at a with a fall of 750 millimetre. That is very much standardised and sampler also has a standard dimension 600 millimetre long and 50 millimetre outside diameter and 35 millimetre inside diameter. And of course, these sampler actually will have a dimension and it will have in it is hollow.

And so, while penetrating by the falling wait when it will go in it will collect sample also and that soil sample some time will be used for different classification purpose like (Refer Time: 06:18) size unit weight moisture content many, then your consistency limits all those thing can be done. So, because of that advantage the N value or SPT test is very very popular. Now, the SPT test also has some of course, some it requires some corrections, that I will discuss in the later on that whatever blow count we get in the field, that is for 300 millimetre penetration; suppose I require 12 blows, then N value field N value that is called field N value is 12.

And, then later on you have to adjust or you have to correct possible things, because though it is standardized. But while lifting the weight how you are lifting and how you are falling you are allowed to fall, that also depends and how many rod length you have connected that is also required, that is also that also affect, then what is the of bore well diameter that also affect the results, like that sampler thickness length all those things actually affect the result.

So, because of that later on we have to apply different corrections then after correcting the value of N value is called your corrected N value N corrected. So, N corrected will have relation with field N value with number of correction factors. And, those correction factors I will just mention one by one.

(Refer Slide Time: 07:53)




You can see that as I have already described that SPT test, this is this is actually is the initially the bore well will be made. And, particularly at a particular depth of bore well where actually we required to conduct the SPT test you have to first lower there actually and sampler. And, then you have to if it is too deep then you have to connect by your drill rod and then finally, you have to keep a anvil at the top.

And, then where actually on that actually your weight will fall. And, this weight actually supposed to fall actually I have mentioned 750, because these are all conversion of unit it was you know 30 inch. So, we have approximately made 750. So, it is actually if you inch if you if you convert it becomes 762, but otherwise 750 also will do. So, 750 millimetre height actually you have do so; that means, there will be some mechanism will be there actually by that mechanism it has to be lifted and then this weight will fall on this column on this anvil.

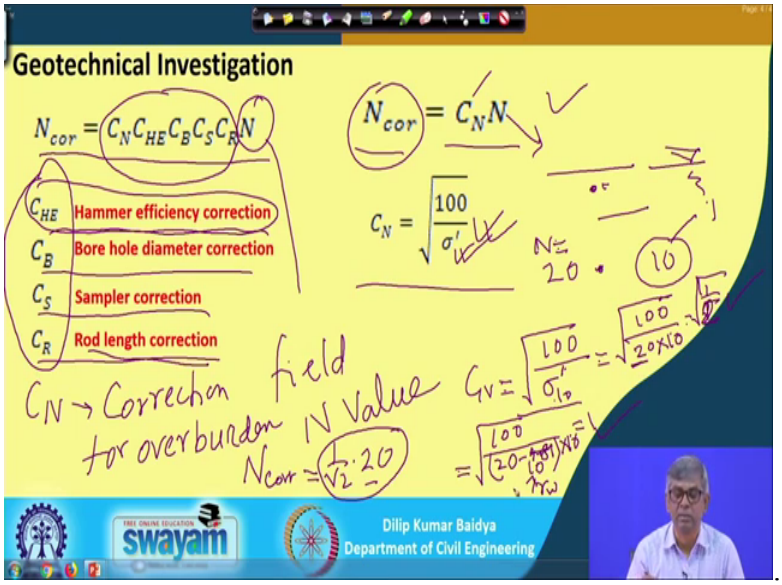
And, when this weight will fall with so, much of energy then automatically this will pushed downward like this. So, like this so, this arrangement there are different types of arrangement of these are the how to lift and how to fall, then what will be the diameter of the drill and all those things drill hole all those things actually are there variables.

And so, this is one way of carrying our test actually this is by pulley arrangement there are several other arrangement. So, because of that we need suppose for particular test we required some 10 blows, but this 10 blows not absolute and SPT value, you need to apply

correction depending upon the field condition and the method of application of the of load.

And, you can see here also approximately a sketch of the sampler is given or different dimension at different places. So, this is already I have shown some time back and once again it is related to that. So, this is actually the sampler. So, when it will come out then we can split it also split sampler, you can divide it to one part 2 parts can be separated and then we can see that soil inside. And from the there we can collect the soil for different testing purpose.

(Refer Slide Time: 10:33)




So, as I have mentioned that there are several corrections and I have seen you can see here. I have mentioned here this is the field N value field N value and these are actually several corrections ok. So, those correction you can see C N is not written C N actually correction for or overburden. That means what actually if I carry out test at this depth and if a test is carried out at this depth these 2 places actually overburden will be different and that will influence the N value actually.

So, here actually because of the less over burden we require less if the everything is identical, then actually you require less number of blows to penetrate 300 millimeter. Whereas, if I carry out test here for the identical soil, but because of the high confinement, I require more number of blows to penetrate they are same depth of the penetration. So, because; that means, this N value is has some influence of overburden.

So, that is what you have to correct that that is one most important correction. And, other correction like hammer efficiency correction; that means, when you are lifting and falling whether it is free fall or whether there is some friction there is a correction.

So, there will be hammer energy correction; that means, whatever energy 65 into 750 that is the energy actually that energy may not be fully transferred there. So, because of that energy correction will be there, then bore hole diameter correction that is another there are different size of bore holes can be there. So, because of that there will also some corrections, sampler corrections how we are using sample then rod length correction. If it is too deep then you have to connect by the rod number of rods and it has to come to the surface.

So, if they are 2 long rod then there will be some correction. So, these are the corrections in literature that is given in the form of same numbers actually and you can find out and what suppose I am not discussing about that they are all you have to remember actually, you have to know that they are there are some corrections. But how to correct this one there are some recommended values based on their experience.

So, I am not listing that what is important actually that overburden correction which we can calculate actually anytime. So, I will try to discuss these are frequently we at least we correct overburden correction.

So, because of that I will discuss in length about the overburden correction C N. So, if I simply ignore other part and if I consider N corrected equal to C N into N; that means, the field N value corrected by overburden correction, then this is the when corrected. So, of course, if I know other value we can apply other number other characters, but suppose ignore that and I correct for only one.

So, this C N actually correction factor over the time many people gave many correlations, but finally, at the most convenient one which is widely used that is actually 100 by under root 100 by sigma dash; that means, effective stress.

So, what is the meaning of it suppose I have conducted a test at that a depth 10 meter depth and I have got a SPT number is 20. So, my C N correction factor will be correction factor will be will be under root 100 divided by sigma dash at 10 meter. So; that means, if I have the soil properties of the soil at this zone is having unit weight of suppose 20,

then it will have 100 divided by 20 multiplied by 10 ok. So, it become one by under root 1 by 2 and here actually 20 into 10 20 I have taken; that means, I have consider is a fully dry there is no water table etcetera. So, the effective stress become like this.

Now, the same one suppose the water table is here at this surface, then your equation will change will be equal to will be equal to under root 100 divided by your the unit weight was 20. Now it is since in a summer condition to calculate effective unit rate we have to we have to subtract 9.81, then multiplied by 10. Approximately one can use this one as a 10 also. So, it become then 10 20 minus 10 is 10 multiplied by 10 100, this become ultimately become 1, but this value will be under root 1 by sorry under root 1 by 2.

So; that means, that meaning of C N is under root 100 by sigma dash I have tried to show here the application, suppose there is a deposit of soil and I have conducted test at a depth of 10 m. So, depth actually H is 10 meter and N is 20. And at that depth you have got the N value as 20. Now so, C N will be equal to hundred by sigma sigma 10 dash; that means, at depth 10 meter. So, if it is a dry soil it will be hundred divided by 200 multiplied by 10. So, it become under root 1 by 2.

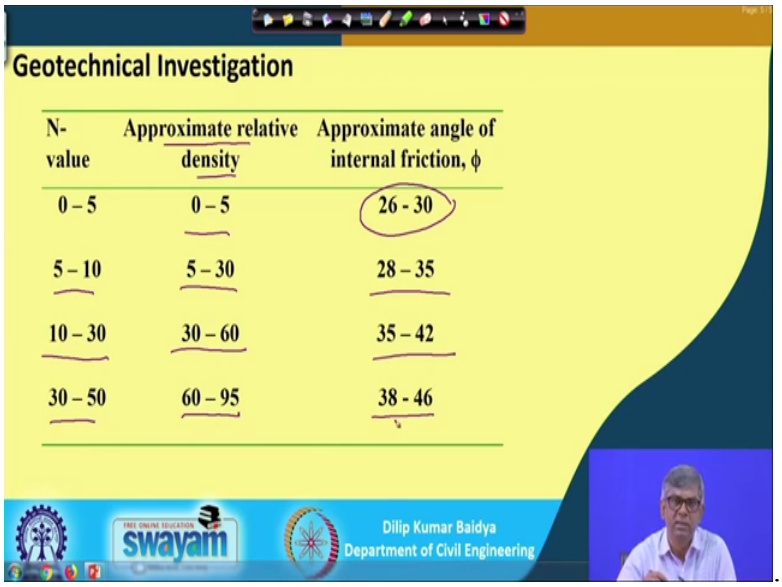
And, in the same soil if the soil, but it water table is at the surface then you can see that your effective stress become 100 divided not effective stress correction factor become under root 100 divided by 20 minus 10 actually taken as gamma W so, 20 minus 10 multiplied by 10. So, if I there 20 into 20 minus 10 is 10 10 multiplied by 10 100 or 100 by 100 it become 1. So; that means, in that case in that case when water table is at the surface the correction factor is 1 whereas, when water table is that quite depth quite deep then correction factor will be 1 by root 2; that means, when there is no water then your N corrected N corrected will be equal to one by root 2 multiplied by 20 ok. So, this is the 1.

So; that means, it become around the 1.44 multiplied by 2. So, it will be it will be actually increased N value will be increased, that is obvious because as I have told you that because of the overburden pressure you have to normalize. So, because of this depth actually you have to if I apply overburden correction the N value will be more than 20 actually.

So, and that value to be used for other correlation later on that I will tell you subsequently so, this is the what is the meaning of C N correction factor by this (Refer Time: 18:44) I have tried to explain by this 2 things; one dry actually it is expressed in

terms of effective stress. So, I have tried to show how effective stress will differ this calculation, when there is no water condition water table then this is the one when water table is there this is the one. And, water table can be in between also in that case I have to calculate effective stress accordingly so, that I will show you in the problem.

(Refer Slide Time: 19:19)

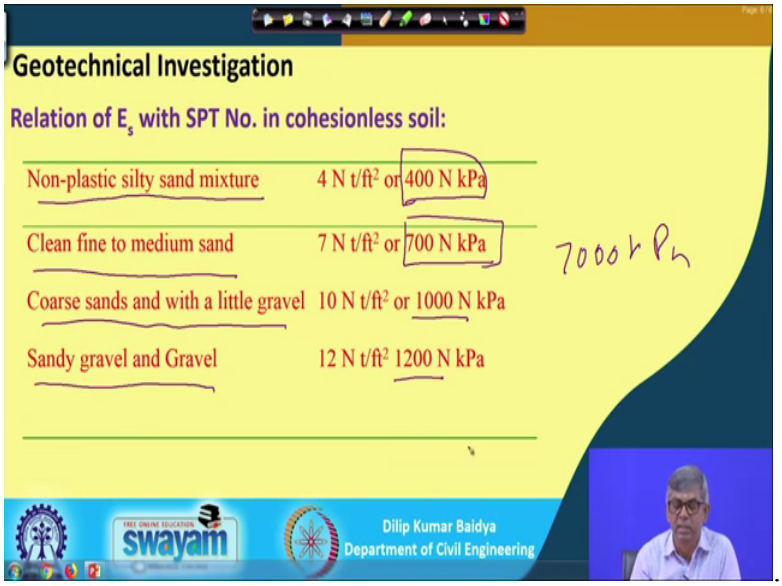



Now, you can see as I have mentioned that it has a very good correlation with number of things, you can see one correlation is given actually N value if it is known that is corrected obvious approximate relative density. You can see so, if I find N value is between 0 to 5 suppose 3. Then your relative density will be between 0 to 5 percent. And approximate angle of internal friction will be 26 to 30 degrees. And, similarly if I N value is 5 to 10 then your approximate relative density 5 to 5 percent to 30 percent and your angle of internal friction will internal friction will be 28 to 35.

Similarly, if the N value is 10 to 30 between 10 and thirty then your approximate relative density will be 30 percent to 60 percent, and your approximate angle of internal friction will be 35 to 42, and if it is thirty between N value between 30 and 50, then the approximate relative density between 60 and 90 percent, and your angle of internal friction will be 38 to 46 percent. In fact, if the N value if you get more than 50 and generally considered as refusal; that means, sometime it may have rock and all. So, for that penetration test will not be useful.

So, 50 and above it will be refusal sometimes you can go more than that because if there is a thin layer of rock is there then it can penetrate. So, because of that we go up to some values, but beyond 50 generally considered as refusal ; that means, SPT refusal; that means, that depth actually soil is not there is something else similar to this there are yeah.

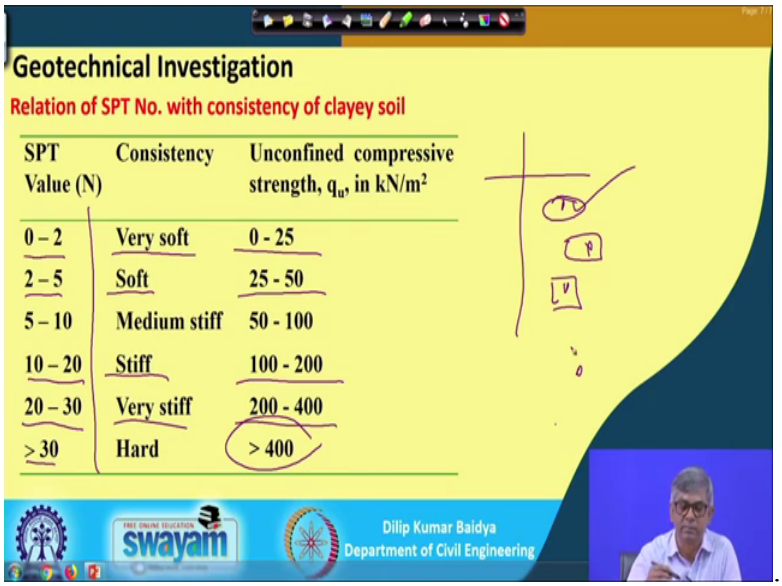
(Refer Slide Time: 21:19)




This is the one with SPT you can see different soil and if you know the SPT number different soil where E value will be correlated like this you can see, non-plastic silty sand mixture and then we can if you have the N value then the E value can be estimated by this empirical equation, people from their experience they have given this. Similarly clean fine sand to medium sand if it is there and if you know the SPT value, we can find out the E value by this equation; that means, 700 times N a 700 N is sum of 10.

So, 7000 kPa will be your E value. Similarly coarse sand with little gravel, then if you know their value it is 1000 times N ok. So, if it is a suppose N value is 10. So, it will 10,000 kPa. Similarly, sandy gravel and gravel then if you know the value N value then it is 1200 N. So; that means, if the N value is 10 then it will 1200 kPa will be the E value.

(Refer Slide Time: 22:31)

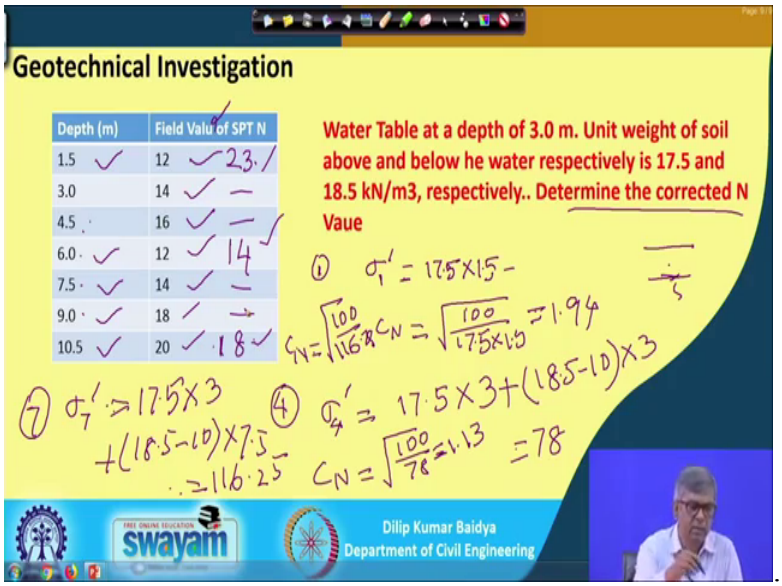



And, similarly for other soil soft soil there is some correlation also, you can see here if the SPT value fall between 0 and 2, then soil consistency will be considered as a very soft and unconfined compressive strength will fall between 0 and 25. Similarly, if it is N value 2 to 5 then it will be treated as soft and q u become 25 to 50 like that, if N value between 10 and 20 then soil will be treated as stiff and your q u will be 100 and between 100 and 200.

And, if it is N value between 20 and 30, then this will be treated as very stiff and their value will be unconfined compressive strength between will be between 200 to 400. And, if SPT become more than 30, then this soil be treated as hard and your unconfined compressive strength will be more than 400 kilo Newton per metre square. So, this is another correlation we can say or guideline you can say, that if you get the SPT suppose what the depth you are getting.

So, SPT value like this some numbers. So, from there actually at this depth if I know the SPT number I will be get what soil is there at this number what they are, what soil is there, if it is this number I know what is the soil type, if there that I can find out approximately.

(Refer Slide Time: 24:01)




So, now I will try to see this is a this is a suppose soil data SPT data is given at a particular site. And you can see here a depth actually the SPT test actually generally carried out every 5 feet interval; that means, 1.5 meter. Generally so, suppose one set of data is given like this test data 1.5 meter the SPT value is field E is missing field value of SPT is bat 12, 3 meter 14, 4.5 meter 16, 6 meter is 12, 7.5 meter 14, 9 meter 18, 12.5 meter 20 like that it is given. So, I have to find out the corrected N value. And for that you can see water table at depth of 3 metre unit weight of soil above and below the water table respectively 17.5 and 18.5 determine the corrected N value.

So, for first one the correction is the first one sigma 1 dash will be how much water table at suppose this is soil and water table at 3 meter depth. So, 1.5 when it dry soil there is no correction. So, sigma dash itself will be 17.5 multiplied by 17.5 multiplied by 1.5 ok. So, that gives you your C N will be C N will be under root 100 divided by 17.5 multiplied by 1.5, that will be your C N. And you see now it is 100 divided by 17.5 divided by 1.5. So, this is become 3.8 so, under root 3.8. So, it become 1.94 it is 1.94.

That means your connected N value will be multiplied by 12. So, it will be 23 actually it will be 23.4 or it is actually 23 itself I will not take fraction. Similarly, if I go at 6 meter depth suppose 6 meter actually suppose 1 2 3 4 reading. So, forth reading I will know. So, it will be sigma 4 dash sigma 4 dash. So, it will be the unit your sigma dash will be

sigma dash will be 17.5 multiplied by 3 and plus your 18.5, 18.5 minus I will 10 I will take water unit weight of water multiplied by again 3 meter.

So, this gives you 18.5. So, 18.5 minus 10 means 8.5 multiplied by 3 plus 17.5 multiplied by 3. So, this will be 78. So, your C N for these will be 100 divided by 78. So, 100 divided by 78, it is given it become 1.2 so, it will be under root 1.28, see it become 1.13 1.13. So; that means, your this value will be 12 multiplied by 1.13. So, it will be 13.56. So, it will be around this will be 12 become 14 approximately.

Similarly, if I 10.5 meter if I find out, similarly I will find out that suppose 1 2 3 4 5 6 7. So, that is 7 data I will do sigma 7 dash. So, for that I will do 17.5 multiplied by 3 plus 18.5 minus 10 and multiplied by it is 10.5 minus 3; that means 7.5. So, this gives you 8.5 multiplied by 7.5 plus 17.5 multiplied by 3 that become 116 116.25.

So, your C N will become C N will become under root 100 divided by 116 116.2 5, then it will be 100 divided by 116.2 5.8 6 under root.8 6 it become.9 2, and 0.9 2 multiplied by 20, it will be 18.5. So, it is 18 actually. So, we can see most of the places up to some depth this value are corrected value are more, but if you go deeper then SPT value will be reduced. So, this is the way actually one has to find out the corrected N value in between you can also complete the way I have done and fill the table so, corrected N value ok. So, I think with this I can close here thank you actually I will do rest of the things maybe in the next part.

Thank you.