Ground Improvement

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Lecture 18

Rapid Impact Compaction (Contd.)

Once again, I welcome you all in this Ground Improvement class. Now I am right now in the topic rapid impact compaction this is a typically intermediate type of compaction mainly because the depth of improvement achieved by this method is greater than by shallow densification but less than deep dynamic compaction. And this method has several advantages and several, and some disadvantages and all those things I have discussed.

And what are the major advantages all those things we have mentioned. At the same time, we have discussed also while doing this ground improvement by this method. What are the different parameters? And the where actually they are suitable. And what is the energy requirement all those things we have discussed. And finally, we have discussed about the design steps it is not so many steps are there but a few steps.

And of course, we have to while doing this design you have to refer the equation, you have to refer some tables recommended by the researchers or some people, experienced people. Those things are there. And finally, I have also mentioned very clearly what are the steps to be followed to achieve successful design of rapid impact compaction. I have done those things with into my previous two lecture.

And there is a when there is a design this type of design particularly ground improvement design it needs some experience and of course, why it is, because they are not based on some mathematics it is based on some time from experience. And based on experience people have given some recommendation you have to follow those recommendations. And there are in between some equations also to be used.

Because of that it is sometime critical how to proceed or how to start for a particular design. So, I will take one example now to illustrate how to go for the design of a rapid impact compaction. Let me take the problem now.

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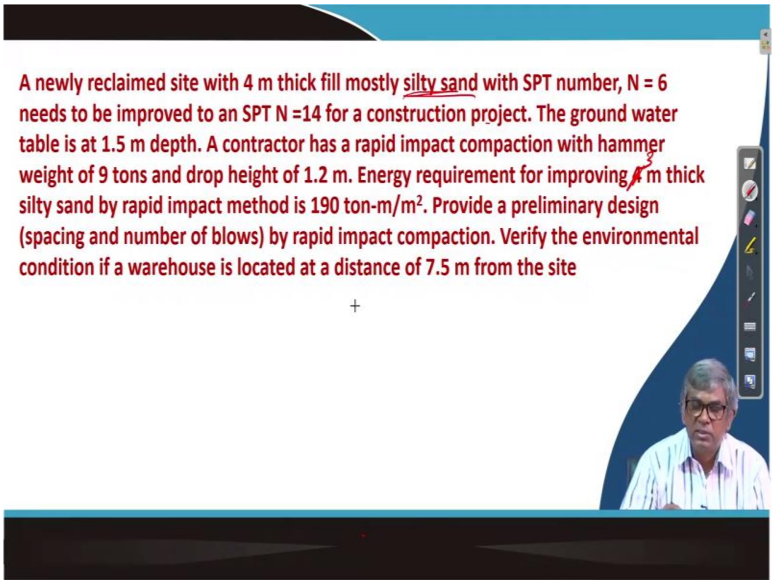

This problem is here is mentioned a newly reclaimed site with 4meter thick field mostly silty sand with SPT number N equal to 6 needs to be improved to an SPTN equal to 14 for a construction project. So, that means there is a particular site is selected for construction and it is a reclaimed ground. And it is a 4meter thick and it is basically silty sand and it has only SPT value 6 which is not suitable for construction it has to be at least supporting.

That is the requirement and that is the soil type. And then another thing is given that groundwater table is at one 1.5meter depth. A contractor has a rapid impact compaction with hammer weight of 9 tons and drop height of 1.2 meter. 9ton hammer 1.2 drop 1.2meter drop energy requirement for this is the one actually to be corrected. This energy requirement is given for 3 meter I also the table actually this is 3meter though it is 4 meter thick.

Energy requirement for improving 3meter thick silty sand by rapid impact method is 190ton meter per meter square. Provide a preliminary design spacing and number of blows by rapid impact compaction. Preliminary design means ultimately a number of drops and verify the environmental condition if a warehouse is located at a distance of 7.5 meter from the site. From the site is 7.5meter warehouse is there.

That warehouse can be affected by noise and vibration because of these rapid impact compaction. We have to also satisfy by calculation that because of the noise and vibration by rapid impact compaction the warehouse the degree of PPV or reaching is not that are beyond the recommended value. you have to check that. This is the actually by enlarge problem and you can see now in the design itself in the first step I have mentioned that you have to select, you have to first find out what is the problematic soil.

Here problematic soil is silty sand and it has a N value 6. Because of that it is problematic if would have N value 15 then directly this site could have been used as a construction site. So, this is the problematic site first identification. Second identification is the depth of improvement you can see here that is a declaimed up to 4meter so that means depth of improvement also 4meter. Now, a third thing actually you can see groundwater level is 1.5 meter deep.

If the water table is at least below 1 meter depth this technique can be adopted. So, that means all three requirements or criteria is satisfied. So, we can select rapid impact compaction methods so that is the first phase of selection of method can be decided. Second part is the design part that means number of drops and energy requirement etcetera. But contractor we are going to hire he has a hammer of 9 ton and his hammer drop is 1.2 meter.

And again, for this type of soil the inner from the past experience it is shown that for 3meter thick silty sand by rapid impact method energy requirement is 190ton meter per meter square. So, you have to now do the preliminary design. So, if you want to do this and then finally you have to check for PPV. So, if I want to do this.

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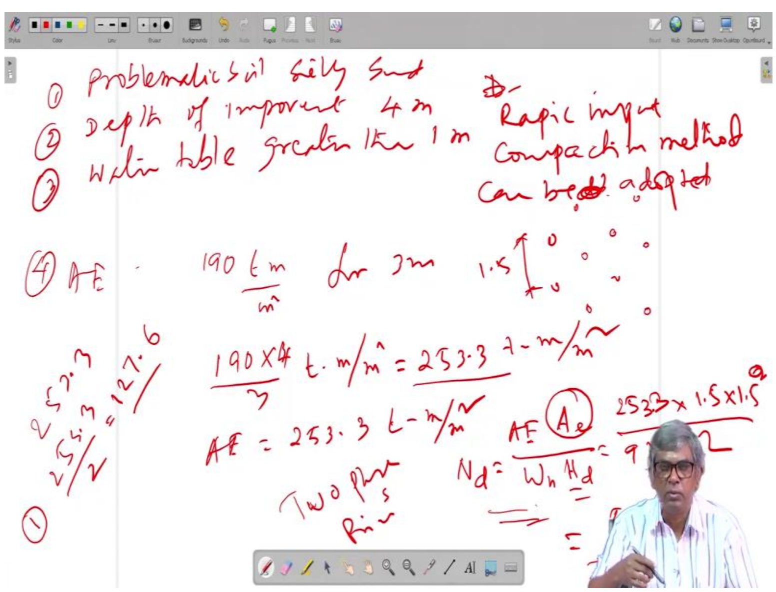

First thing is I will write that the first one the problematic soil is silty sand. Second is depth of improvement is 4meter. Third thing is water table greater than 1 meter. Show deep dynamic no rapid impact compaction method can be adopted. This is first thing over and next is energy requirement you can see it is given. Fourth is AE 190ton meter per meter square for 3meter. We have 4 meters so it will be 190 minus multiplied by 4 divided by 3ton meter per meter square.

This if you calculate it gives you around 253.3ton meter per meter square. That means you are getting energy requirement. So, AE equal to 253ton meter per meter square. Next part is a square plate of 1.5meter size or diameter can be used and then spacing also can be used 1.5 meters. And then your N_d will be equal to AE multiplied by area Ae divided by Wh multiplied by H_d.

$$190\ tm/m^2$$

$$\frac{190\times 4}{3} tm/m^2 = 253.3 tm/m^2$$

$$N_d = \frac{253.3\times 1.5\times 1.5}{9\times 1.2}$$

This one is 253.3 and this Ae so if I square pattern if I choose and spacing become 1.5 meter then this distance will be 1.5 Ae will be area of influence is 1.5 meter by 1.5 meter. And Wh equal to 9 meter and H_d equal to 1.2 meter. So, this gives you some value equal to 52.75. So, 52.75 and we have seen that rapid impact compaction they use up to 40 drops. So, if you have 52 drops coming at so you can use primary and secondary actually.

And based on that you accordingly you can choose the energy requirement and from that energy requirement we can again find out how much drops are required. That so this is the one so again based on this calculation this is recommended that you can have that two phase actually primary and secondary. You can have in two phases primary and secondary. That means if you have these then we can have another like this we can have another like this.

And then accordingly if you do in two phases then the energy requirement will become half 253.3 this was the energy requirement. So, primary phase will be equal to 253.3 by 22. So, it will be 1 2 and 7 this much. So, N_d can be calculated based on this equation. And we can find out what is the number of drops. So, it will be just half so it will come.

So, this is the way actually we can get number of drops and how many phases you will do that I can be decided. Next part is actually peak particle velocity to be calculated. And you have to find out scale energy factor. And that one actually what how much it is? This is actually under root.

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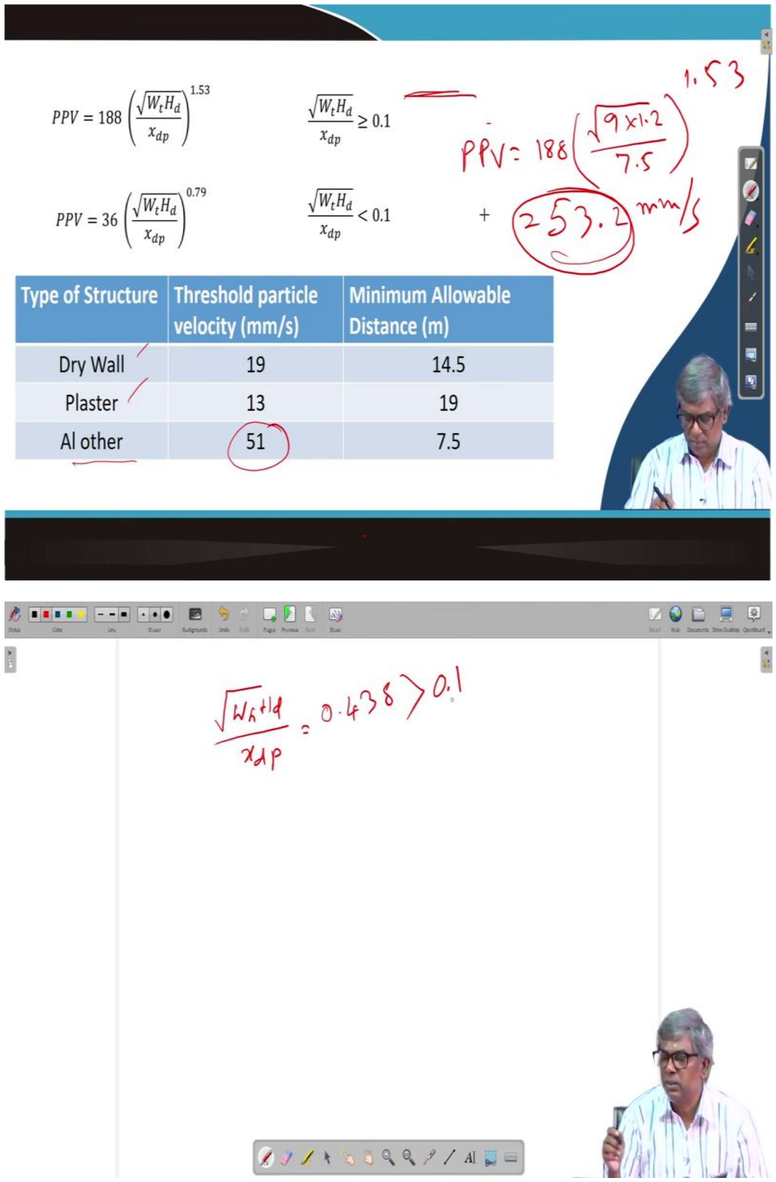

So, now peak particle velocity for calculating peak particle velocity actually you have to check first scale energy factor. Scale energy factor is what? This is actually under root Wh by H_d divided by X_{dp}. And you can see if I calculate this value, it comes 9 multiplied by 1.2 under root divided by 7.5 so it is 0.438, 0.438. So, greater than 0.1 so if it is greater than 0.1, then what equation we have to use? So, equation we have to use equation we have to use if it see the greater than so this is the equation to be used.

$$PPV = 188\left(\frac{\sqrt{W_t H_d}}{x_{dp}}\right)^{1.53}$$

$$if\left(\frac{\sqrt{W_t H_d}}{x_{dp}}\right) \geq 0.1$$

$$PPV = 36\left(\frac{\sqrt{W_t H_d}}{x_{dp}}\right)^{0.79} \quad if\left(\frac{\sqrt{W_t H_d}}{x_{dp}}\right) \leq 0.1$$

$$PPV = 188\left(\frac{\sqrt{9\times 1.2}}{7.5}\right)^{1.53} \quad = 253.3mm/s$$

$$\frac{\sqrt{W_t H_d}}{x_{dp}} = 0.438 > 0.1$$

And if you use this equation then that means I can find out what is the peak particle velocity. So, PPV will be 188. This one and this will be under root 9 multiplied by 1.2 divided by 7.5 to the power 1.53. So, this value can be calculated. So, it is 0.538, 0.438 divided by 7.5 to the power 1.53. This one Wt 9 multiplied by 1.2 under root divided by 7.5 this is to the power 1.53 this equal to 0.282 multiplied by 188.

So, it gives you actually give you 53.2 millimeter per second. So, this is the value it is giving but your requirement is you can see here for all other so dry wall plaster is different for all other actually the threshold velocity is 51 it is just crossing. Because of that maybe you have to adjust hammer weight or drop height something some arrangement to be done or you have to, you have to keep some more distance away from the warehouse this is the recommendation. This is the, this problem is this much can be done or not more than that. And next one is as I have mentioned that certain other aspect is there. So, let me go to that part.

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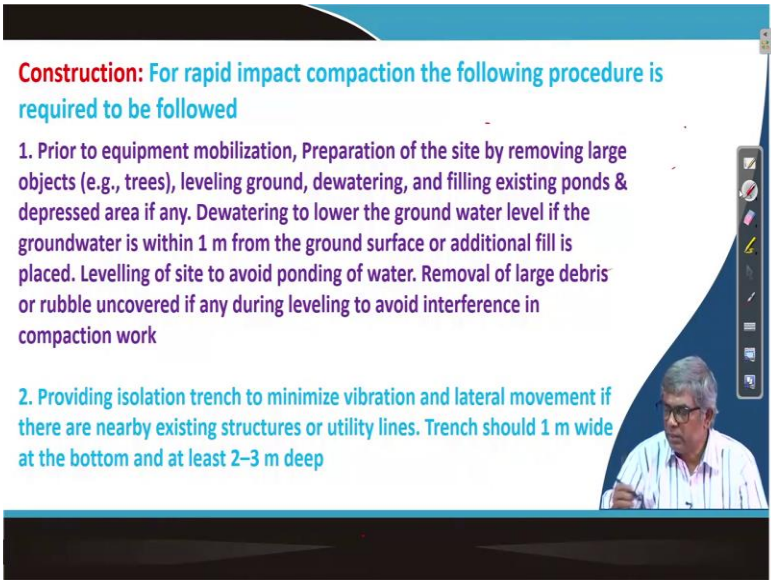

Construction so once you decided selected a method and then you have checked that they are suitable. Ones this is done then you have designed then after design you might have done the trial. And then for that you had to do a number of things how to do that let me explain one by one, the construction, for rapid impact construction the following procedure to be required to be followed.

Those what are the procedure? First of all, prior to that we are reaching to a mobilization and you have to prepare the site. So, that from site may have number of trees. There may be unevenness, there may be somewhere water bodies, somewhere maybe elevated ground. So, all those things to be a preparation means you have to by enlarge you have to make level. And you have to remove the trees and if the water table is close within 1meter then you have to dewater or put some field with some over excavation if you can do.

After all those things if you do and then you have to do the site approximately you have to level not exact perfect leveling some leveling should be done. And that while compaction some area cannot have a ponding and all those things to avoid ponding, some area may water may come out although if you put some depression. Those, doing all those activities is called the preparation of site.

Before mobilizing the equipment at the site, you have to prepare the site. And sometimes again during removal of large debris and rubble uncovered if any during leveling. Those big size of things are there rock are like things or if it is there while cleaning. Then on that actually you cannot do rapid impact compaction if possible that to be removed. So, those are the, that is actually all together is called preparation of the site.

Once the site is prepared then what you have to do we know that during rapid impact compaction of deep dynamic compaction the vibration noise and vibration will create and that can affect the surrounding people. Because of that you do the calculation, satisfy the value is not reaching that still on the construction site you can make a trench all around. And that trench actually at the bottom it should have at least 1 meter width.

And at least you should go 2 to 3meter deep. That mean trench you have to make all around your construction site a trench to be made. And that trench the bottom width should be 1 meter at least. And it should go at least about 2 to 3meter that trench. After so first of all you had to prepare the site. Next is that if you make a trench all around before doing the compaction.

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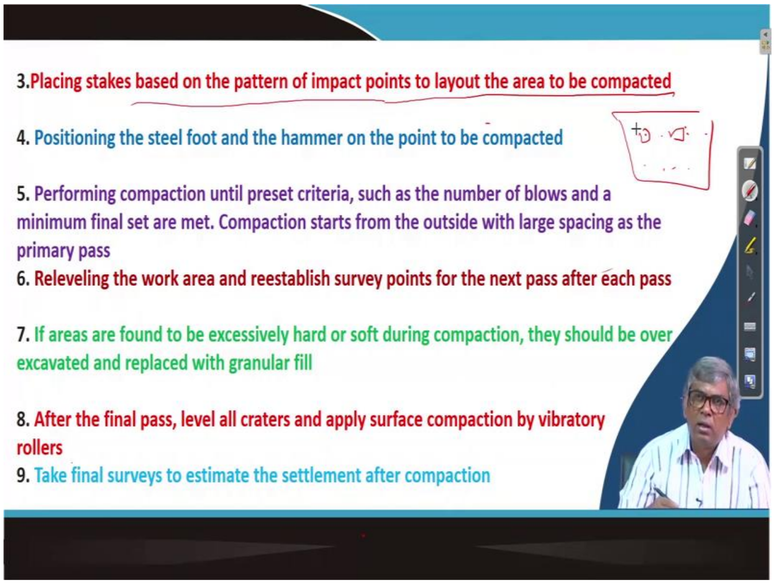

And next one will be your placing the stakes based on the pattern of impact to layout the area has to be compacted. That means your area is there. Then you had to mark actually where actually that the impact by rapid impact compaction that foot plate will be placed. That has to be marked properly. You have to go to that place and then required number of blows will give there and then move to the next. So, that is third step.

And then fourth step is the positioning the steel foot and the hammer on that point to be compact. Initial was a marking then you by that excavator move that point. And then you put the plate exactly on that and then and hammer above that to be fixed so, that part. The fifth point is the performing compaction until preset criteria that means you have mentioned how much, you have decided only to what you have to do until and unless that much is achieved you have to continue hammering.

That is a performing compaction until preset criteria such as number of blows and a minimum final set is made. Final set means the actually some amount of depression or depression power per blows how much has to be there that actually already set in the design. That you have to monitor and when you see that is achieved then it can be terminated. And compaction starts from the outside with large spacing as the primary pass.

So, if you have primary, secondary then you have to from the outside you have to do first and then you have to go inside then compaction will be effective. Then releveling the work area and reestablish survey points for the next pass after each pass. After compaction generally rapid impact compaction does not give a very disturbed surface till whatever each point will be visible. That by enlarge to be removed and level it and for proceeding for the second pass.

And if areas are found to be excessively hard or soft that means if it is soft actually then we will not be able to compact. And if it is hard also in between we will not be able to compact so some area if it is found like that then this would be over excavated and replaced with granular field. In the overall site is suppose suitable for rapid impact compaction. But some spot is available where actually this is not suitable.

In those areas actually what you have to do? You have to excavate, remove those unwanted thing or unsuitable things and bring some at least similar type of material and fill it and then proceed for the rapid compaction. And after the final plus level the craters and apply surface compaction with vibratory roller. This is the last one though we say this is the advantage that ironing pass is not required.

But after doing all a number of passes a number of impacts in each point still surface will be little disturbed. And that disturbance can be finally corrected or finished by vibratory roller. It can be level first by using some equipment and then vibratory roller can be run through that and based on that in our finish surface can be produced. And then take final surveys to estimate the settlement after compaction.

And that means if there is inequality to work to some way you have to do the test SPT, CPT and all those things may be can well conducted after completing those. So, this is actually by enlarge construction step for this rapid impact compaction.

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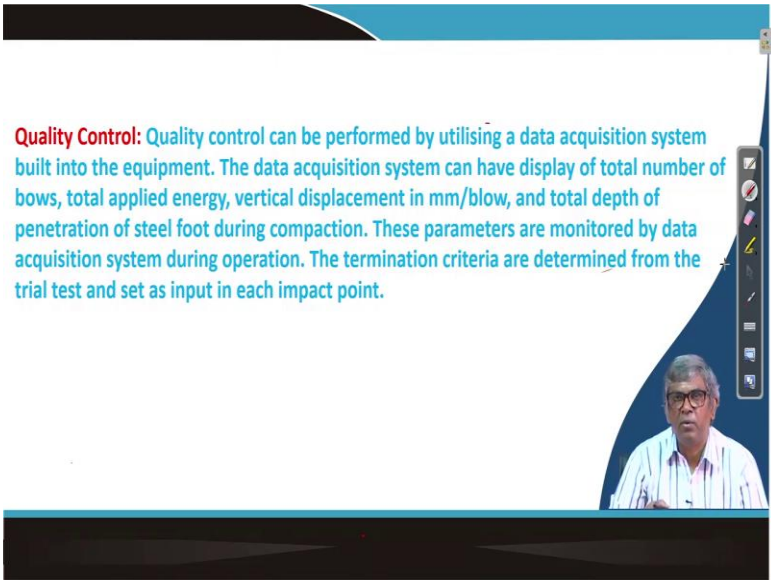

Next slide will be quality of course not much quality under it is there. A quality control can be performed by utilizing a data acquisition system in this particularly in rapid impact compaction data acquisition system can be used. Which is the built into the equipment. And the data acquisition system can have display of total number of blows, total applied energy, vertical displacement in millimeter per blow.

The total depth of penetration of steel foot during compaction all those things can be displayed. And with this display operator can decide that completion or termination of the compaction. And also say at the same time so this is actually quality control that means if you want to count by while dropping in that case actually sometimes you miss 1 or 2 drops or we may it is done 20 but you may count 25 but sometime it is done 20 you may count 15 so that is actually something.

Because of that the data acquisition system can use where automatically we will get the display or how many drops are going. So, you can immediately stop it if it is number of achieve drops whatever required is achieved you can immediately switch off. Similarly, other things whatever is mentioned that total number of blows, total applied energy all those things can be monitored it will be shown there.

And these parameters are monitored by a data acquisition system during operation. And a termination criterion of course how many drops and I said how what is the energy etcetera required. That actually design is there again that design aspect is in the confirm by trial and based on that trial some of the additional things can be fed in the data acquisition system to monitor. That means to control the quality.

This is by enlarge for rapid impact compaction partly mechanized. Because of that it is easy to do quality control. And we have mentioned that this is the one of the advantageous points for rapid impact compaction compared to deep dynamic compaction.

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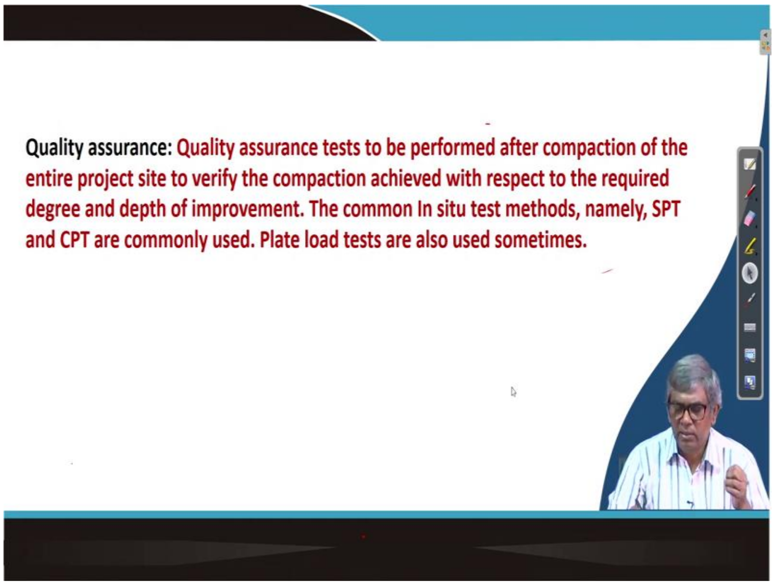

Next part is the quality assurance. In the quality assurance here actually deep dynamic whatever compaction actually is ultimate aim is that you have to densify the soil up to certain depth. So, that you have to make sure that it is done. And also, at the same time that you have to achieve the certain density or some the stiffness of the soil up to certain depth that to be checked, so this two aspect after doing all over design as per design after the completion you can do very easily that quality check by conducting a few field test and those field test typically we do is SPT or CPT.

And after compaction by rapid impact compaction for different types of soil what is the target value of a SPT, CPT is there. And you have also set your target and you can see whether they are matching or not if it is matches then your quality is assured. So, this is the way actually we can do complete project. So, with this I am almost at the end of this module 3 though it is mentioned in the initially that I have module actually I have tried to keep 1 week.

But this module since lot of similarities there with deep dynamic compaction it is a shorter module so 3 lectures. So, 2 lectures I will be giving with from some other module. And there may be somewhere we will be again reaching with 5 lectures module somewhere. But in between 2, 3 modules will be where some module will have 3, some modules will have 6 like that it will be adjusted.

Otherwise, that we have completed introduction part, and then we have completed the shallow densification, we have completed deep dynamic compaction, we have now completed rapid impact compaction. These are the things by mechanical method of impaction. Almost done. Now, we will do some more methods subsequently. And with this today I will close here and with next class I will start some new topic. Thank you.