Ground Improvement

Professor. Dilip Kumar Baidya

Department of Civil Engineering

Indian Institute of Technology, Kharagpur

Lecture No. 08

Quality Control and Quality Assurance

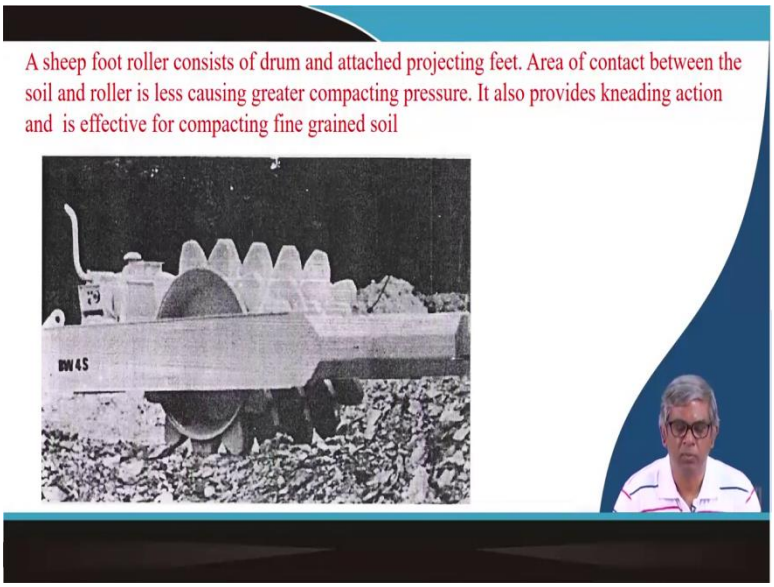
Hello everyone, once again I welcome you to this lecture series on ground improvement and this is the perhaps the second module that is shallow densification. Various aspects of shallow densification already I have discussed and finally, depending upon the type of soil what are the different types of equipment can be used and what would be the thickness for each rise, how many passes all details are given and before that of course, when we do compaction this way what is the relationship with density and water that also you have discussed.

So, density and water content this is two aspects in this compaction's shallow densification and of course, we have discussed all those things and when you mentioned that you have to add this much of moisture this many, this type of equipment, this many passes and that was thickness and the field when its large area to be done it cannot be done at a time first of all.

Secondly, it cannot be done by one person again because of many other reasons, there can be variation, even though you do same activities, that same thickness same number of passes same machine, but still there is a chance of variation and so, the field how to ensure that what do you want that is achieved.

For that actually, there are some quality control and quality assurance work will be there that will be the theme or lecture topic today even the sub topic you can say the main topic is shallow densification under that the quality control and quality assurance and under these again, before going to that I will just mention different types of rollers. I will just show some of the picture and how it works very briefly and then I will go to the one.

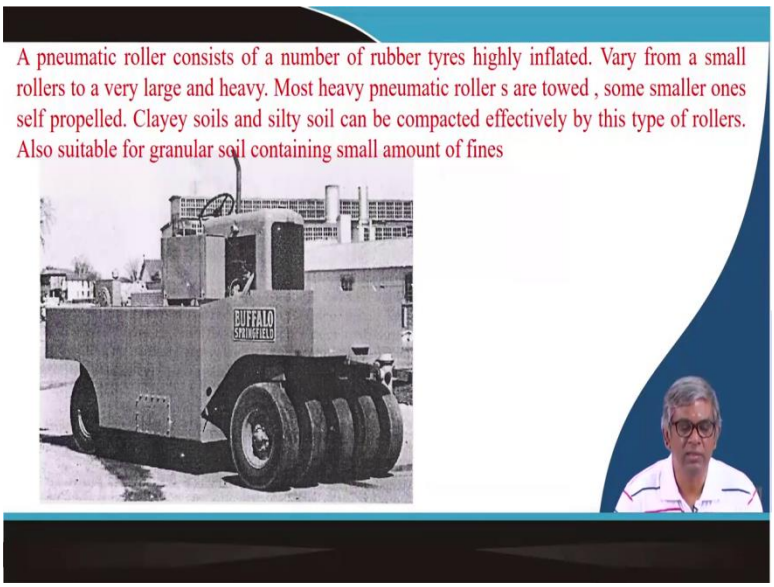
(Refer Slide Time: 2:52)



See I have mentioned perhaps one of the roller types that is sheep foot rollers and as you can see here, the sheep foot roller means actually the main roller and on that there is a protruded part and what is the purpose of these actually, when the roller is only passing the roller resting on those extended portion and as a result contract area will be reduced and more pressure can be applied to the soil and at the same time there will be kneading effect.

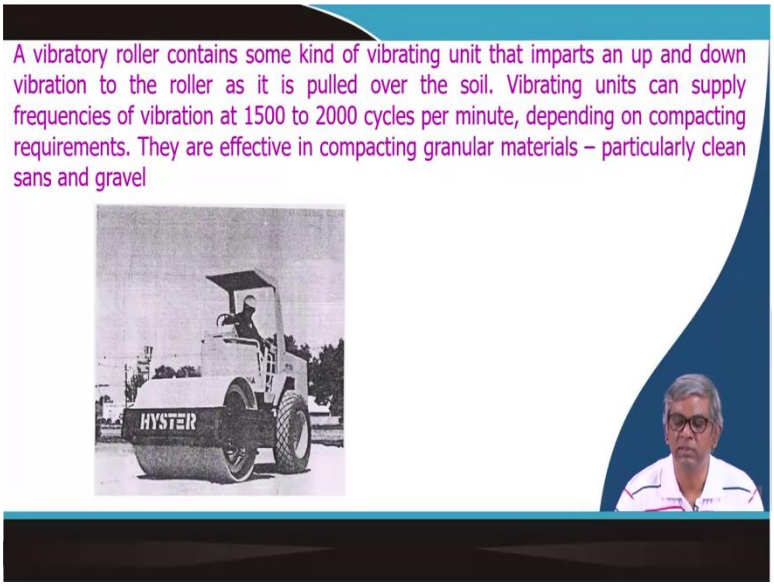
Because first pass the wherever the punching is happening second pass next somewhere else will happen as a result there will be kneading. So, this type of roller generally suitable for sharp soil where compaction by weight itself very difficult need some sort of high pressure and kneading so the clay type of soil is suitable for this type of rollers.

(Refer Slide Time: 3:47)



And then this is actually a pneumatic roller actually. This is again can be used for different types of soils. So, pneumatic rollers are number of rubber tires will be there and highly inflated and vary from very small to very large and not very small, small to large and it is generally heavy and most new heavy pneumatic roller will be towed that when engine will be separated and it will be and same, will be smaller one will be propelled and clayey soil and silty soil can be compacted effectively by this type of roller and of course a granular soil with some fine also can be used this type of roller.

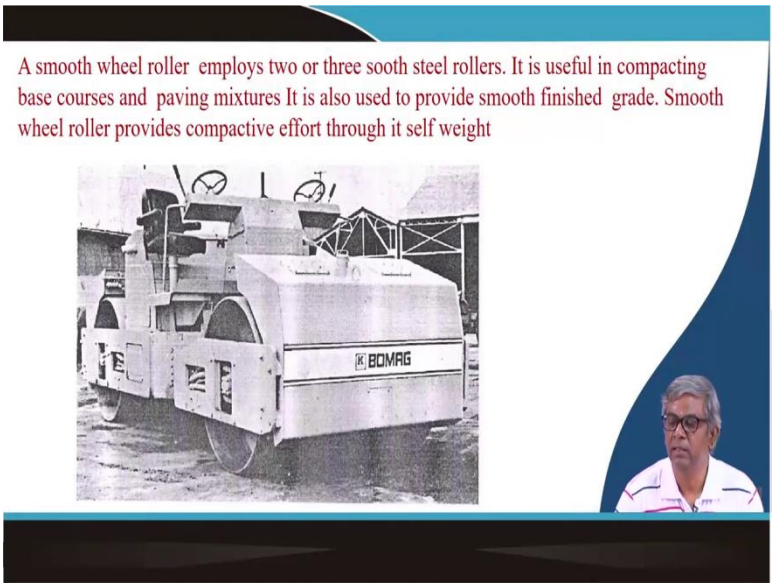
(Refer Slide Time: 4:30)



And then this is actually vibratory roller. I have already mentioned perhaps the sandy type of soil, granular soil. It is good regular soil actually when you will give some vibration then actually the smaller particles can enter easily the larger particle and more compact state we can be achieved.

So, for this purpose in the roller itself, there will be a vibrating part it gives up and down motion and when it is moving at 70° up down motion and based on that, because of that actually the soil get densified and it can be these different frequencies it can be rotated at 1500 to 2000 cycles depending upon compacting or compaction requirements. So, generally granular soil like clean sand and gravel they are suitable.

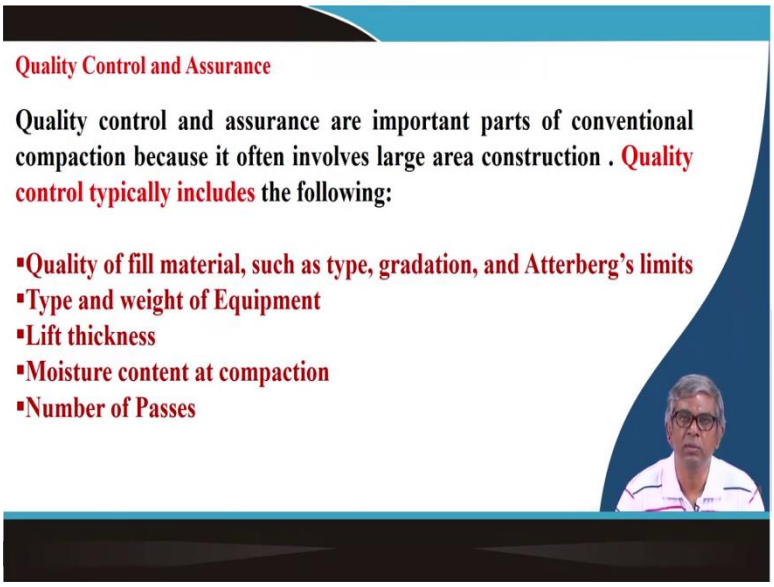
(Refer Slide Time: 5:21)



And this is again smooth wheel rollers most of the time finished surface generally smooth wheel rollers or rollers are used. In addition to that compacting base course, are also paving mixtures also can use it is also used to provide smooth finish surface as I mentioned the beginning.

So, it will be generally wheel itself heavy at that pressure it will it can give you the finished surface. So, these are all there are many other types, but these are major type of roller is used and so, because of that, they mostly what type of soil they are used and of how they are beneficial or effective, that is the thing I just mentioned.

(Refer Slide Time: 6:03)



So, now let us reach or come to the point that is quality control and quality assurance. As we have mentioned that different types of rollers already have shown this roller will be when there will be a 10 meter or more wide road and then all the first stretch actually initial states that it can cover all the maybe two meter or something or even less, then the next one will be another like that one after another it has to be covered.

And then again it has to be given a second pass, then third pass if it is a greater number of passes the card again subsequent passes will be given. But while doing this, there can be variation that is what quality cause checking is required that whether whatever you want it whether that is achieved or not.

So, quality control and assurance are important parts of conventional compaction because it often involves large area construction, that is what I have mentioned the beginning and quality control typically includes the following that quality of field material that means particular site actually you have to compact it by granular soil. So, granular means what we have to do with a fine, what is the minimum maximum fine contents is suitably specified so those to be checked.

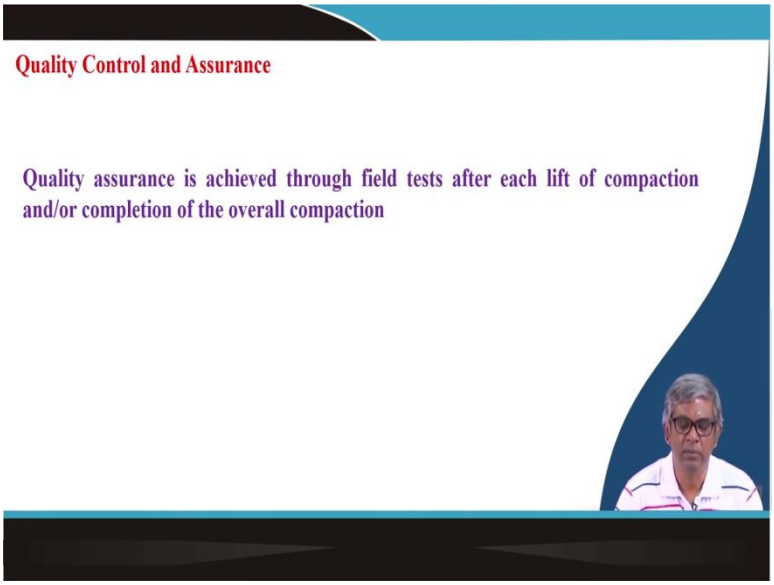
So, quality of field materials, the type, gradation and Atterberg's limit these are the things generally we check for field material and they are classified, specification is given based on those parameters and that has to be checked. Type and weight of equipment, what type of equipment is recommended for what type of material, sometimes material is something and corresponding whatever suitable equipment we are not might have not at all recommended or it is recommended but contractor using something else, in that case you have to check and point it out or point out that this is not suitable.

Similarly, lift thickness about 30 centimeter or 40 centimeter or even less sometime that is specified. That is whether that is exactly generally do not measure every point but by a large few place can be checked and then it will be approximately otherwise done. And moisture content at compaction that is as I have mentioned that maximum dry density is achieved at maximum optimum moisture content.

So, at what is the moisture range to be used that is also specified in the compaction work if it is not, then convection will not be achieved that has to be also checked and number of passes again that is also important that some soil required lesser number of passes, some soil will be required a greater number of passes if use like that. So, that whether it is done or not or even

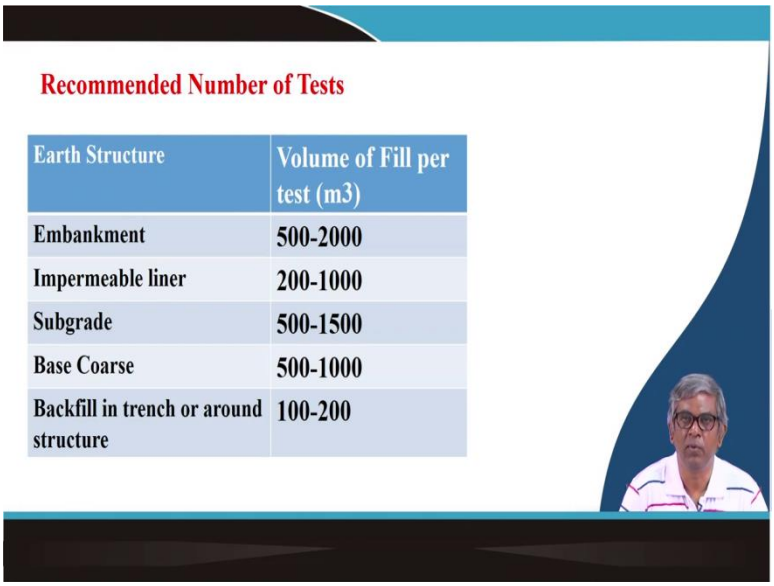
then it is done still whether it is achieved or not that has to be checked. So, these are all coming under quality control.

(Refer Slide Time: 9:00)



Next part is quality assurance it is achieved through field test after each lift of compaction that means each and every compaction Atterberg's will check, then to the bottom three layers are under compacted and topmost layer is compacted well that does not give you satisfactory result finally, because the you are getting weak foundation. So, because of that generally after each lift technique, it is necessary sometime to check otherwise also at the end of the compaction is required to check.

(Refer Slide Time: 9:34)



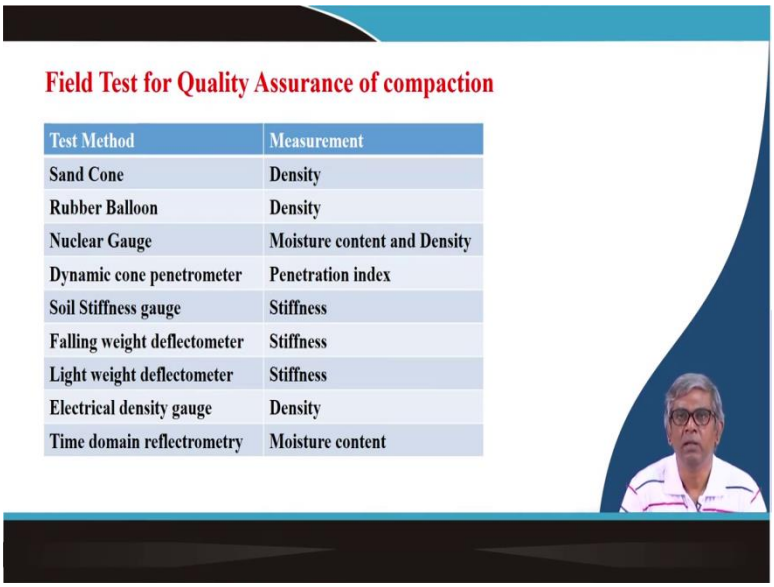
And how and what are the recommendations generally will be there and how it will be tested or checked? You can see here that different type of earthwork or earthwork can be there. It can be embankment work, by borrow material. It can be impermeable liner. Some time that some type of some used for a dump actually that is waste actually that should be dangerous or harmful chemicals may come out to the natural soil or even natural groundwater.

So, to prevent that sometimes we give impermeable liner and some of the most frequently used subgrade compaction also then base coarse, then backfill in trench or are around structure, these are the activities earthwork activity, and when you do this, the specification for each and every one will not be the same.

You can see when you do embedment work the volume of field per test so, 500 to 2000 cubic meter of embankment work you need to do one test. So, that is the requirement minimum you can do more, but this should be done max. So, in one liner when you do for work like impermeable liner, then 200 to 1000meter cube of work, you need at least one test, quality test.

Similarly, hundreds of sub grade work then for 500 to 150, 1500 cubic meter of work, you need to have one quality check test, if it is a base course, then again 500 to 1000 cubic meter of work, you have to do on a sub similarly backfill trench or around the structure sometimes you compact they are actually since it is close to the building. So, they are actually quality should be more accurate and so, because of that, you can see that every 100 to 200meter work, you need to do one test. So, this is the quality assurance program, this is a requirement or recommendation.

(Refer Slide Time: 11:59)



Similarly, you got to have to test what the test you will be using and corresponding to this test, what exactly you can measure. So, you can see that you can have different types of tests for shallow density work, one is sand cone and the rubber balloon, nuclear gauge, dynamic cone penetrometer, soil stiffness gauge, falling weight deflectometer, lightweight deflectometer, electrical density gauge, time domain reflectometry.

So, these are the different latest method is there and if you use this what you can do most of the time we required to determine the density or stiffness and you can see if you use sand cone, sand cone means actually what it is actually insitu density that means, you have to dig at the site certain volume of work or soil to be removed and you have to take weight and then that volume created by digging while collecting the sample that volume to determine that that volume can be determined by two methods, one is sand cone and other is by rubber balloon method.

So, that both the cases actually either of these two can be used for determining the density at the in-stitu. And nuclear gauge, they are actually moisture content and density both can be determined this is some art machine and that I will try to discuss at the end and it will give you directly some reading and actually it will change your voltage and that will be calibrated to those desired parameters like moisture content and density and that can be obtained.

And dynamic content shows that if you then penetration index you will get and that penetration index will be correlated to stiffness or density and whatever are required and soil stiffness gauges, there also gets thickness and then from there we can correlate and then

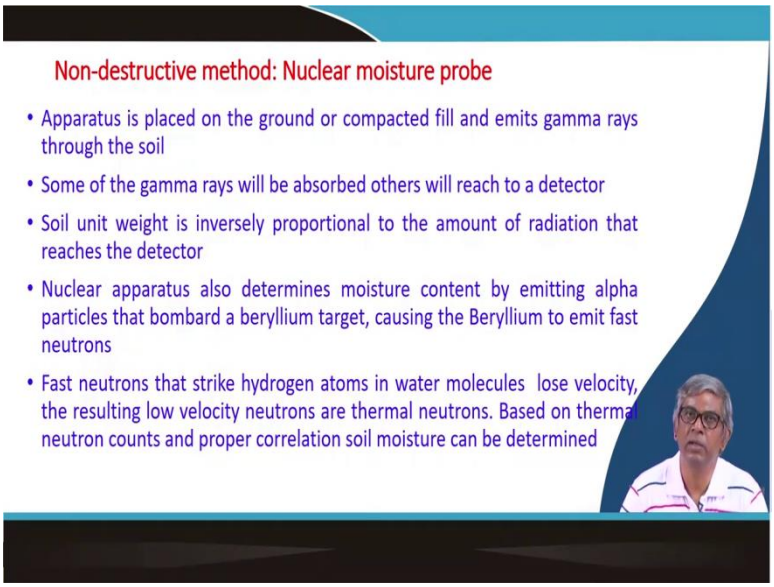
falling weight deflectometer. There also you get stiffness that also can be correlated to strip down density, then electro lightweight development same.

Electrical density gauge directly can measure the density that is also so that we three directly you can measure density and other are actually indirect measurement of quality of work or compaction and time domain reflectometry they are moisture content actually sometime you use sand cone or rubber balloon method you get the density bulk density immediately, but to get the moisture content because moisture content and dry density is related.

So, to get the moisture content, sand cone or rubber balloon method required to wait 24 hours because after collecting the sample you have to keep it in the oven. And after 24 hours you have to take the water content measurement and from there you can find out the water content. So, that is required 24 hours.

So, if you want you can you cannot have or do not have time to wait 24 hours, then there are alternative like nuclear gauge can be used, immediately we will get, then time domain reflectometry can we use to get directed immediately get moisture content. So, these are all different alternatives whatever available based on that you have to work with.

(Refer Slide Time: 15:25)



And this is the actually the equipment as I have mentioned in that moisture gauge. Its working principle is something like this, it is a nondestructive method and nuclear mass moisture proof and this apparatus is placed on the ground or compacted field where it is compacted and emits gamma rays through the soil. So, that is the machine that is the arrangement is there you have to place on the ground and then you have to gamma ray you have to pull through soil.

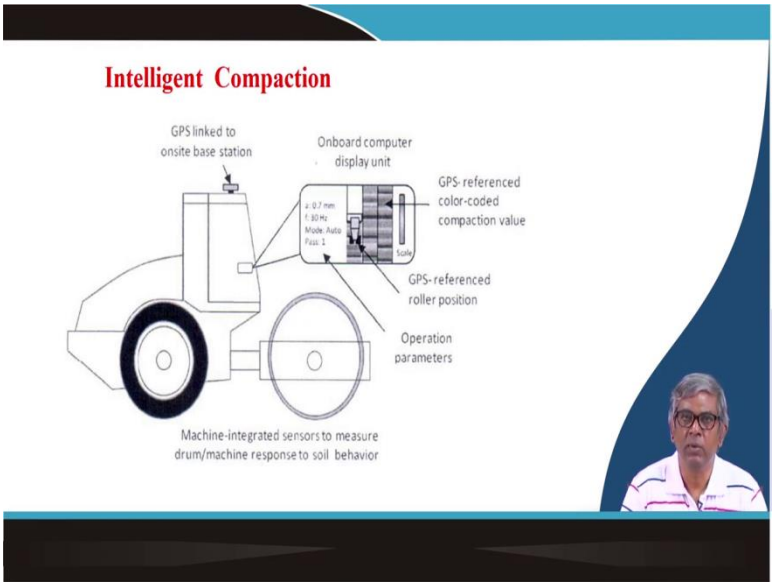
And some of the gamma rays will be absorbed others will be reached to a detector there is another detector will be there. And so, some will be observed how will be reaching to the detector. While, unit rate is inversely proportional to the amount of radiation that reaches that detector. So, that detector that how much is reaching to the detector that is inversely proportional to the density, unit rate and nuclear operators also determines moisture content by emitting alpha particles that bombard a beryllium target causing the beryllium to emit fast neutrons.

So, this is the mechanism and then fast neutrons turn that strike hydrogen atoms in water molecules lose velocity, the resulting low velocity neutrons or thermal neutrons based on the based on thermal neutron counts and proper correlation soil moisture can be also determined. So, this is the equipment whatever I have shown and that can be used and both of course, by saying so, it is not be clear until unless you do have our hands on experience.

There are γ-rays and there will be α-particles and one will be used for moisture or other will be for determining the unit weight. So, once you know the unit weight, then divided by minus 1 plus w will get dry density. So, this is the mechanism by which you can determine the both parameter of the compaction whether it is compacted soil or not.

$$\gamma_d = \frac{\gamma}{1 \pm w}$$

(Refer Slide Time: 18:07)



So, this is actually as I have told you that conventional way that you are using some equipment and you are using, you are giving a number of passes with the definite amount of lift thickness and then based on that you are adding water if needed and based on that you are then based on that compaction the soil compaction is completed, then quality assurance people will come and do some tests and then make sure that whatever quality is required is achieved.

So, this is manual way of checking, but nowadays there are some compaction equipment in the market available which is called intelligent compaction and in these actually by the name intelligent itself everything it indicates it has so, many attachments you can say GPS link to on site a base station that is location etcetera to be fixed and then on board computer display unit there will be one then GPS referenced color coded compaction value that is also will be there, then GPS referenced roller position and then operation parameters and many machine integrated sensors to measure drum machine response to soil behavior.

So, this is all those things are there. So, what we do here by this machine when shown sensors are there and the operator will be it will be will be able to see the all details what is happening whether what, what is the compaction level etc. While using this type of

compaction machine then the machine will guide you where you have to compact and where you do not have to compact.

That will or where compaction is achieved and where compaction is not achieved. So, like that it will be it will be guiding you that ultimately. So, no need to do any quality control afterwards because I am getting directly through the sensors and all display that it at every places how is the compaction level and so, because of that we do not need to do any separately any quality control test.

So, what is exactly, what is the disadvantage of these machines actually, if you use this type of machine first of all, it is very expensive and it is not readily available. And also, the operator generally, regular compaction operator generally can be anybody who can run steer the wind and like that, but here actually needs they are actually I am so experience is required because heavy machine, but not that since it is not high speed, it may not be that experienced that much skill is required.

Whereas here, one has to understand many things because computer is there then there are many digital things are there. So, everything on has to understand. So, because of that it has some disadvantage, but mostly that advantage is that you are once you are finished with finish no other work is required.

(Refer Slide Time: 21:36)

And basic concept of intelligent compaction already I have mentioned but once again I will organize way let me read once an intelligent compaction is a continuous construction technique with quality assurance and control process incorporated in the construction.

As you have mentioned that when it is a compaction by roller, then you have to do in stages actually firstly, second here also same thing can be done, but when initially some portion the next portion like that, as much as you can control, but here is a continuous you can do and then this technique includes automatic measurements of the ground geometrical properties to pre-installed sensors on the machine and adjustment and optimization of the vibration amplitude, frequency and speed uses a feedback control system by the machine operator to achieve uniform compaction and desired target values.

This is the one that continuously are getting the feedback and through that the operator can accordingly adjust the machine different location and based on that the uniform better uniform compaction can be achieved. Suitability and application, same of course, with this type of machine as I have mentioned that is the same machine the same type of soil wherever you can use the other compact to compaction equipment same thing can be used only thing is it is intelligent one.

There is no specific area where it can be used that is not like that no limitation, with about limitation is that already I have mentioned that where actually you the operators actually has to be very skilled and at the same time that machine is costly expensive, and it is also not readily available. So, because of all these though it is suitable and very useful, but very limited you still in our country.

So, but just I have introduced this on that as an intelligent compaction machine, otherwise most of the compaction if you see around the road work or any other work, then we will whatever type of equipment I have shown mostly they are used. With this, I will just stop this module. Thank you.