Geology and Soil Mechanics
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Lecture - 12
Soil Compaction- B

Welcome back to the course Geology and Soil Mechanics. So, in the last lecture we just started the soil compaction and we have seen what are the different say aspects of soil compaction. We have seen the definition of soil compaction and then we found out that expulsion of air from the matric without any entry of your external thing I mean basically you are getting the air expulsion from the soil matrix and ultimately soil will be getting compacted.

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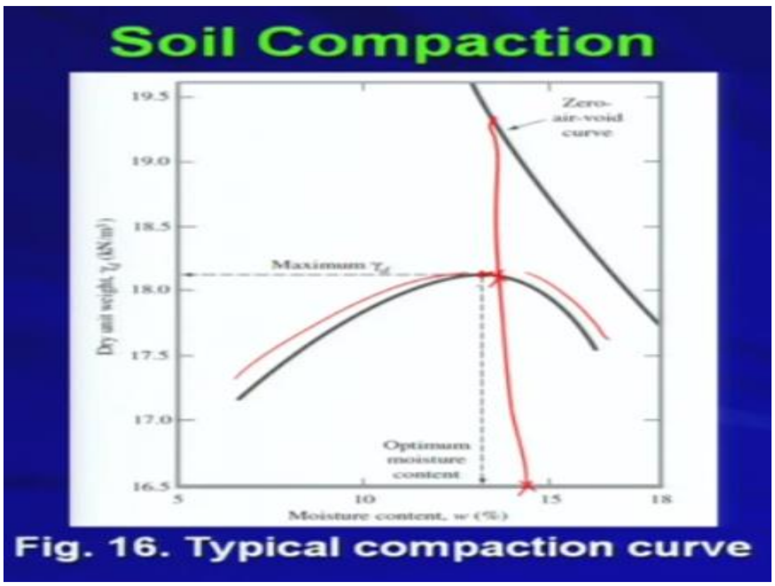

So, this is the procedure of soil compaction and then we saw that what is the laboratory experiment we can do for getting the soil compaction parameters that is standard proctor test and we have defined different say dimensions of the standard proctor test setup and then we have seen what is our gamma d that is dry unit weight and to obtain the maximum dry unit weight you have to vary the moisture content that is the water content in the soil matrix and you have seen in the last lecture that if you increase, initially if you increase the water content your gamma d will be going on increasing and at certain point it will reach the maximum that is defined as gamma d max and corresponding water content will be defined as the optimum moisture content that is OMC and then if you increase water content further you will get the reduction in dry unit weight that is gamma d and we have discussed why you are getting this kind of say behaviour that is if you continuously increase water content, initially gamma d will increase and then it will reach the peak and then it will come down.

So, we have discussed this aspect and then basically we have established one curve that is known as zero air void curve for different magnitude of water content and we have seen that at zero air void line basically if you if the point is lying on zero air void line that means there is no air inside the soil matrix.

So, soil will be completely saturated that means your degree of saturation is 1 and there will be no air inside the soil matrix as it will form the 2 face diagram that means soil solid and water that is all and then basically we have seen that as you can see from this figure, so you have got the compaction curve like this okay. So, initially increment in the gamma d it will reach the maximum and then it will fall down due to the dispersion of the soil particles.

Now I mean we have discussed in the last class that in no case basically your theoretical maximum say at this at any water content say if I consider this is my water content, at any water content this will be your theoretical maximum gamma d that means when you have zero air void in the soil matrix, but it is not achievable and practically you will be getting the gamma d at this point which is lying on the compaction curve right. So, the compaction whenever you are showing the zero air void line so that will draw the limit of the gamma d for different magnitude of water content.

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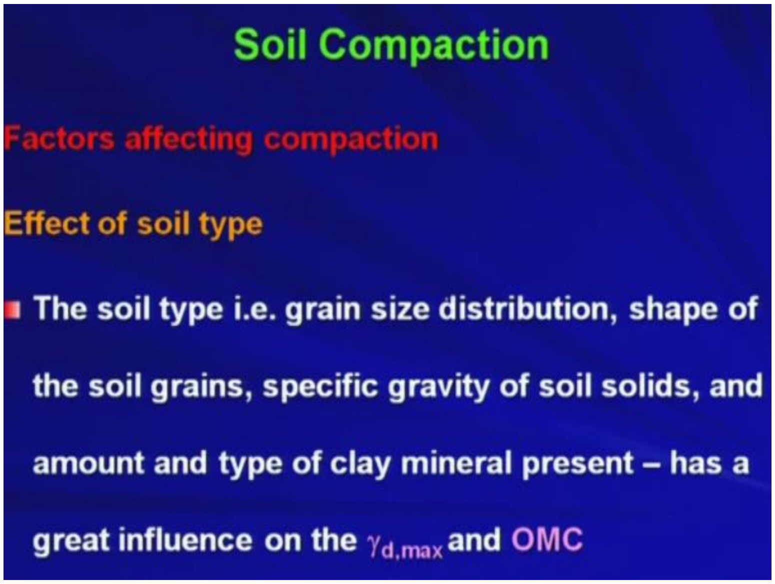

Now we have seen in the last lecture but anyway we are going to repeat little bit. So, what are the different factors affecting compaction. So, effect of soil type. The soil type that is grain size distribution as we discussed in the last lecture, grain size distribution, shape of the soil grains, specific gravity of soil solids, and amount and type of clay mineral present has a great influence on the gamma d max that means the maximum dry unit weight and OMC and we have discussed that why these factors are affecting the compaction because the grain size distribution based on that you will be getting well graded or poorly graded.

So, if the soil is poorly graded then your compaction will be lesser than the well graded sample. Similarly, the shape of soil grains if you have the angular soil grain as well as the rounded soil grain so depending on that you will be getting different compaction. The rounded one will be giving you less compaction degree of compaction as compared to the angular grain.

Similarly, the clay minerals right, so clay minerals will be having some charge on the particles, already we have seen from the clay mineral topic that and because of that basically your water affinity as well as the when you add water in in the soil basically whether soil will be soil particles will be getting attracted or getting dispersed so based on that you will getting different degree of compaction. So, these are the issues and of course the specific gravity if the soil solid or the solid particles are little bit heavier so it will be compacted more. So, these are the factors which I mean will be affecting the compaction effort of the soil.

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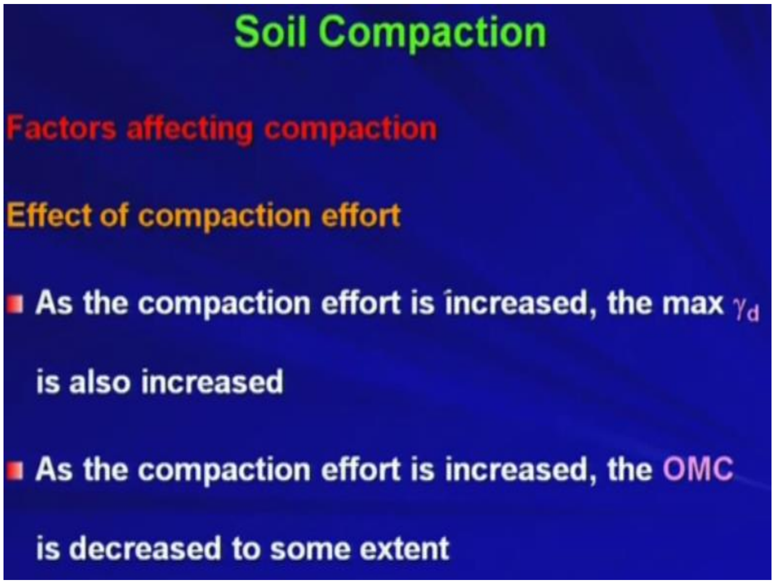

Now coming to the effect of compaction effort. Now as the compaction effort is increased, compaction effort means that means if you have seen the standard proctor test basically we are giving 25 number of blows on each layer right and we are compacting each layer by 25 blows of the standard hammer. Now if you increase the number of blows that means you are giving more energy to the matrix or if you are you are giving more compaction effort basically. So, you are providing more compaction effort. So, if you increase the number of blows or if you increase the compaction effort the maximum gamma d is also increased.

That means your maximum gamma d will be continuously increasing with the increase in compaction effort whereas as the compaction effort is increased, the OMC is decreased to some extent I mean when your gamma d is going on increasing that is gamma d max you will be also increasing and the gamma d that means the curve will be getting shifted towards the left whereas OMC will be decreasing with increase in compaction effort and so that means your compaction curve, if you get the compaction curve and if you increase the compaction effort basically the compaction curve will be getting shifted towards the left side of the plot.

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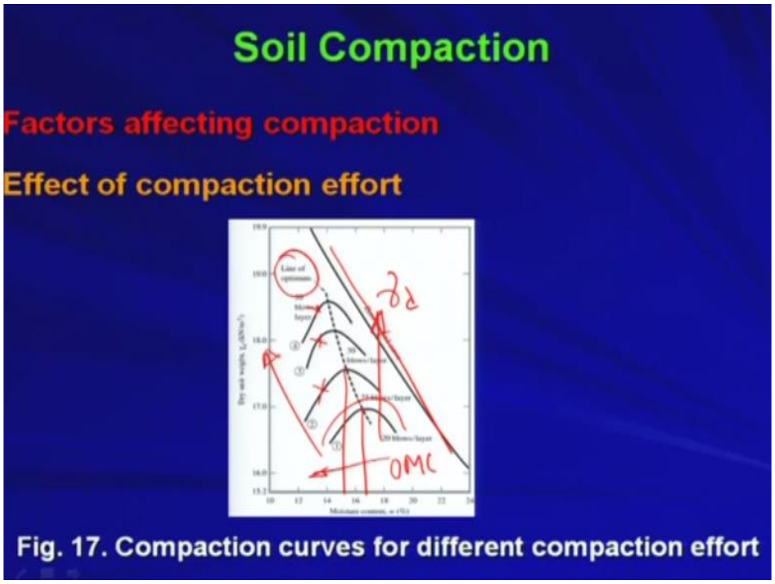

That means if you look at this figure, so this is your zero air void line so as we can establish that thing for different magnitude of water content. Now with 20 number of blows per layer, so you are getting this compaction curve, and for 25 number of blows you are getting this compaction curve, for 30 you are getting this, for 50 you are getting this. That means your compaction curve is moving in the left direction and basically your OMC, this was your OMC for 20 number of blows, this is the OMC for 25 number of blows, so your OMC is decreasing in this direction whereas your gamma d is increasing.

If you look at your gamma d is increasing. So, this is your gamma d and this is your OMC is decreasing right and if you join all the peaks basically you will be getting a line which is shown by the dash line and that is known as line of optimum that means you are connecting all the OMC point and you are getting the line of optimum okay. So, this is the plot which will indicate the effect of compaction effort on the degree of compaction.

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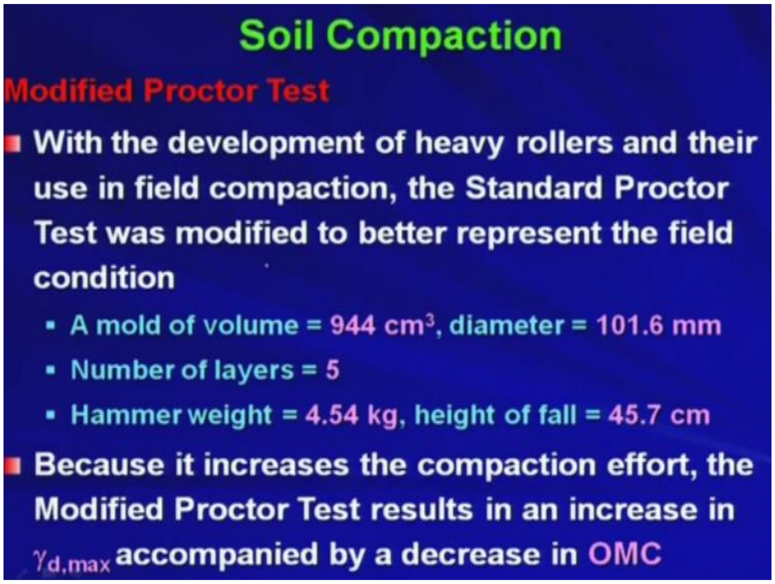

Now coming to the modified proctor test so as you have seen the standard proctor test we generally used in the laboratory and we still use that but with the development of heavy rollers that means if you go to the field in earlier days you have seen very conventional kind of roller, there will be one wheel at the front and there will be 2 wheels at the back.

Still in India there are lot of agencies are using this kind of rollers but these are very old type of rollers but with the development of heavy rollers nowadays and you might have seen those heavy rollers as well as the modern rollers and their use in field compaction the standard proctor test was modified to better represent the field condition. So, that means now you are having more modern rollers as well as which those rollers are giving more compaction effort or the compaction energy to the ground.

Now to simulate that thing the standard proctor test has been modified to get those results or those predictions and then basically that is known as or that is termed as modified proctor test.

Now the test procedure and all those things will be remaining same. Only thing is that the dimensions of the I mean setup this setup are going to be different.

Now a mold volume of 944 centimeter cube is used in modified proctor. Diameter of the mold is 101.6 millimeter. The number of layers, instead of 3 layers earlier in case of standard proctor test you have used 3 layers, now you are going to use 5 layers 5 I mean subsequent layers. Now hammer weight has been increased that is 4.54 kg for modified proctor and height of fall also has been increased 45.7 centimeter. So, now you will be giving the number of blows on each layer and you will be compacting the soil.

Now because it increases the compaction effort, the modified proctor test results in an increase in gamma d max accompanied by a decrease in OMC which is quite obvious right. In just now we have seen that if you increase the compaction effort your gamma d will be increasing whereas OMC will be decreasing. So, modified proctor means you are giving more compaction effort as compared to the standard proctor. So, you are expecting that your gamma d max will be increasing if you use standard proctor and if you use modified proctor, in the modified proctor as compared to the standard proctor you will be getting higher gamma d max as well as decrement or the reduction in OMC.

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Now coming to the field compaction, so what are the different types of rollers you generally see in the field for field compaction. First one is the smooth-wheel rollers which is also known as smooth drum rollers. So, these are suitable for proof rolling subgrades and for finishing operations of fills with sandy and clayey soils. So, both sandy and clayey soils you can use this smooth-wheel rollers and this will be used for proof rolling for subgrades and for finishing of operation, finishing means just on the top surface of the fields or something like that when you are going to finish the compaction operation right.

Provide 100% coverage under the wheels. We will see those I mean photos of different types of rollers and you will appreciate that in case of smooth-wheel roller that means you will be having a complete drum kind of wheel right. In the drum kind of wheel, you will be getting or you expect that 100% coverage under the wheels will be achieved.

Now coming to the next type of roller that is pneumatic rubber-tired roller. So, I will be showing all the photos so you will be differentiating among the rollers. So, pneumatic rubber-tired rollers basically these are better in many respects than smooth-wheel rollers and can be used for sandy as well as clayey soil compaction which is achieved by a combination of pressure and kneading action.

So, in the pneumatic tired roller, in case of smooth-wheel roller only you are getting the pressure on the soil layer and the soil layer is getting compacted due to the pressure created by the smooth wheel. Whereas in case of pneumatic rubber-tired roller you are getting pressure coming from the tires as well as you are getting some kneading action.

So, kneading action means you generally you have you might have seen the preparation of roti, so at that time you basically mix water with the flour and then you do some kneading action. So, that kind of action you are expecting from this kind of roller, rubber-tired roller and you will be getting more compaction. So, you are getting pressure as well as the kneading action from this rubber, pneumatic rubber-tired roller.

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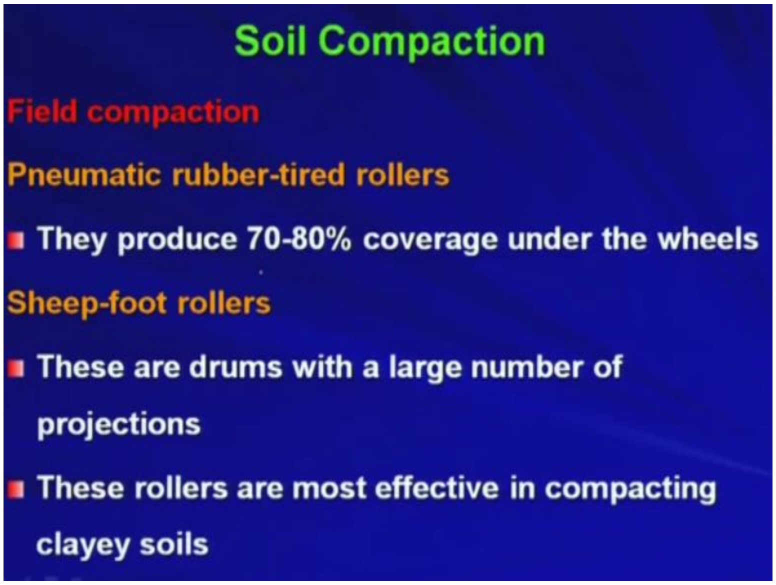

They produce 70 to 80 percent coverage under the wheels but as compared to the smooth-wheel roller there you are getting 100% coverage below the wheel base, wheel, but here actually you will be getting 70 to 80 percent coverage. So, the coverage means some areas below the wheel will be will not be covered or will not be compacted. So, basically that thing you need to think about when you are talking about the number of passage and how you are orienting the roller on the soil layer.

Now coming to the another kind of roller that is sheep-foot rollers. These are drums with a large number of projections. So, you have very similar to the smooth-wheel roller where you have a cylindrical drum which will be acting as a wheel okay and on the wheel basically you will be having a number of large number of projections, projection means some spikes okay. So, those spikes basically will try to compact the soil in a more effective way.

Now what you can consider suppose if you I mean what you can draw the analogy. Suppose you have the elephant which is going to compact the soil and you have some sheep okay which is going to I mean compact the soil. Now as compared to the, though elephant is very heavy and bulky, but you will be getting more compaction or very effective compaction from the sheep foot because it will give some point point kind of say compaction thing.

So, it will try to knead or the kneading action will be more in case of sheep foot as compared to the elephant foot okay. These rollers are most effective in compacting clayey soil. So, in case of clayey soil this I mean sheep foot rollers will be more effective because you it will be having the spikes and those spikes will compact the soil in a more effective way.

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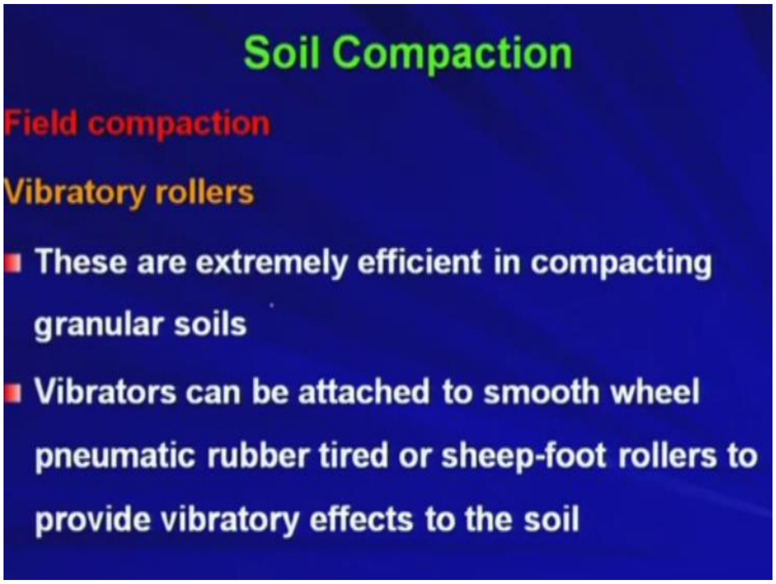

Now coming to the next type of rollers that is vibratory rollers. These are extremely efficient in compacting granular soils that means sandy soil or gravely soil because as I told you if you want to put some food grains in the glass jar or plastic jar basically you shake it right. So, this kind of shaking is being produced by this vibratory rollers and this kind of shaking will try to compact the soil so and from the from your own experience you can appreciate that in case of granular soil that means which is having some larger particle size or larger grain size those will be compacted in a more effective way than the other soils right in case of vibration.

So, this vibratory rollers their wheels will be producing some vibration, it will shake and it will try to compact the soil. The vibrators can be attached to smooth wheel pneumatic rubber-tired or sheep-foot rollers to provide vibratory effects to the soil. So, whatever rollers you have seen that is smooth-wheel roller or pneumatic rubber-tired roller or sheep-foot rollers, so all the wheels can be attached with some vibrators which will generate the vibration and the whole wheel base will vibrate and it will try to compact the soil

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Now you see some photos of these different types of rollers. So, this is your smooth-wheel roller. So, as I told you, you will be having some cylindrical drum, so this will act as the wheel. So, this wheel will be compacting basically the soil and you are getting 100% coverage because below the wheel you are getting the 100% coverage as I told you.

So, this is known as smooth-wheel roller whereas this is your pneumatic rubber-tired roller. These are all pneumatic rubber tires okay. Now below the wheel you can see that 70 to 80 percent coverage is possible and these kind of because this the rubber tires are flexible. Because of that you are getting pressure as well as the kneading action as we have discussed.

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Now this is your sheep-foot roller. This is a wheel kind of, smooth wheel kind of wheel whereas you have the large number of projections. So, you see these are all projection. So, this will try to give or try to provide some kneading action in the soil and this is very effective for clayey type of soil compaction.

This is coming for your vibratory rollers. As you can see this is known as if you have single drum that means there are these are 2 drums, 2 drums means 2 wheels. So, if you have both the drums which are vibrating so this is known as dual drum vibratory rollers whereas if you have the single drum which is vibrating then it will be known as single drum vibratory roller.

Now if you go back to the smooth wheel roller, so now you can attach vibrator with this smooth wheel and because of that this wheel will be vibrating and it will try to compact the soil whereas the back side, this is your rubber tire so that will not be vibrating. So, this kind of roller is known as single drum vibratory roller. Whereas whatever we have seen here so this is I mean if both the drums are vibrating so this is known as dual drum vibratory roller okay.

So, at least we have got some idea that how the different rollers are I mean now you can appreciate if you go to the site and if you see this kind of rollers at least you can predict okay what type of vibration, what type of compaction they are providing and what type of soil basically you are using.

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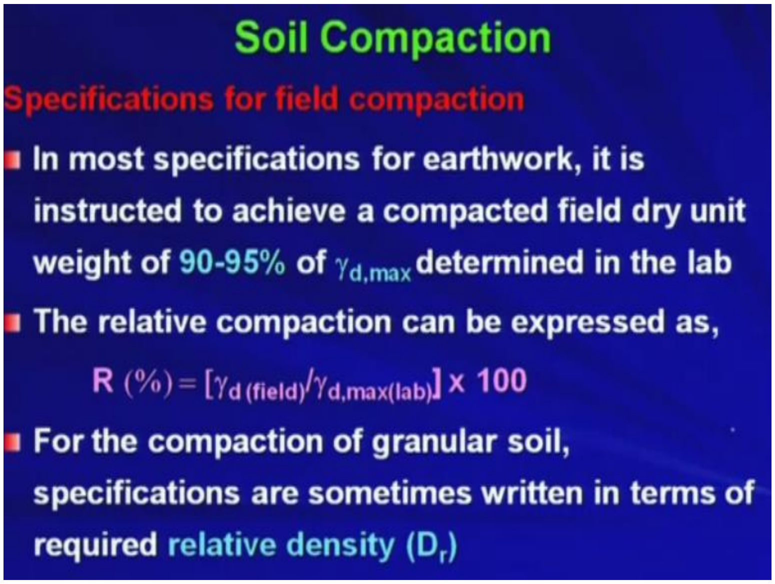

Now specifications for field compaction. In most specifications for earthwork, it is instructed to achieve a compacted field dry unit weight of 90 to 95 percent of gamma d max determined in the laboratory. Now if I ask you that what should be the field compaction, degree of field compaction. Now basically you are doing some test or performing some test in the laboratory either by standard proctor test or modified proctor test and then basically you are going to the field and then that will be simulated whatever proctor test you have performed that will be simulated by putting the layers of soil and then you are compacting that thing with the help of rollers right.

So, I mean these 2 things must be simulated. Now at some point of time you will be saying okay my compaction in the field is over when the condition or the requirement is it should achieve 90 to 95 percent of gamma d max determined in the laboratory. So, in the laboratory you have got either from standard proctor or modified proctor you have got some gamma d max from the compaction curve and in the field if you can achieve 90 to 95 percent of gamma d max then you say okay my compaction is over or I mean whatever compaction I have achieved that is sufficient enough to take care of the further activities.

Now the elective compaction can be expressed as, so you need to quantify that how much compaction you have got in the field so therefore the relative compaction word has come into the picture. So, relative compaction can be expressed as R in percentage that is gamma d field whatever you are observing in the field that is the dry unit weight available in the field by gamma d max in the laboratory okay so whatever you have observed in the laboratory into 100%. So, this should be say gamma d field by gamma d max into 100 it should be 90 to 95 percent. So, 95% if you achieve or if you more if you achieve more than that then it will be said as very good compaction you have performed.

For the compaction of granular soil, specifications are sometimes written in terms of required relative density right. So, basically in case of granular soil if you try to compact the sandy soil or gravely soil so basically the word relative density will be coming into the picture and you know from your earlier background or earlier discussion that relative density is very handy parameter to talk about the densification or the denseness of the I mean sandy particle right or the granular soil right.

So, in case of compaction also if we say okay my relative density okay if our relative density is this much in the field then you can compact or you can provide the rollers number of passage or vibration energy or all those things you can vary to obtain or to achieve that much relative density. So, in granular soil this is a very important parameter which will define the compaction, degree of compaction basically.

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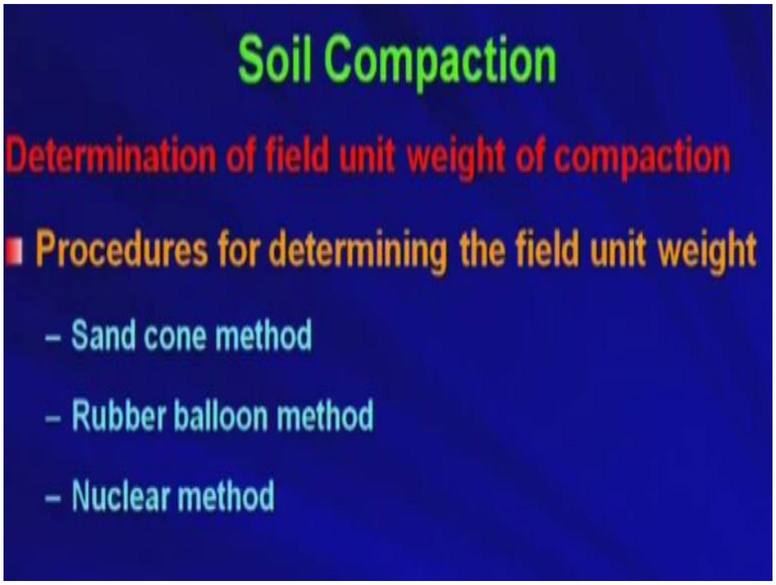

Now determination of field unit weight of compaction. Procedures for determining the field unit weight. Now there are several procedures available. That means basically you can find out the unit weight in the laboratory, there is no issue and you know there are several methods available to find out the unit weight in the laboratory right so I have though I have not discussed that thing specifically but if you do any lab course or if you perform some laboratory experiments you can find out.

There are several ways you can find out the unit weight of soil in the laboratory but in the field how we will obtain or how we will find out the unit weight because already you have compacted the layers right so already I mean in the layer wise you have compacted through the passage of your rollers, different rollers and you have compacted and now if you are so basically you need to find out gamma d in the field right.

You know gamma d max in the laboratory okay but you need to know gamma d observed in the field, so how to find out those thing. So, there are several procedures available. First one is sand cone method, second one is rubber balloon method, and third method is nuclear method okay. Among these 3, I will be discussing the sand cone method in the next lecture. So, thank you very much. So, in the next lecture we will be talking about sand cone method and other details of the compaction topic. Thank you.