Geosynthetics Testing Laboratory
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Lecture -17
Compressive Properties of Geofoam

I Professor J. N. Mandal; Department of Civil Engineering, IIT, Bombay. I have discussed earlier how to determine the compressive strength of the EPS geofoam material and how you can calculate the initial tangent modulus at different percentage of strain it may be 1 percent, 5 percent, 10 percent and also we have also discussed how to determine density of the EPS geofoam.

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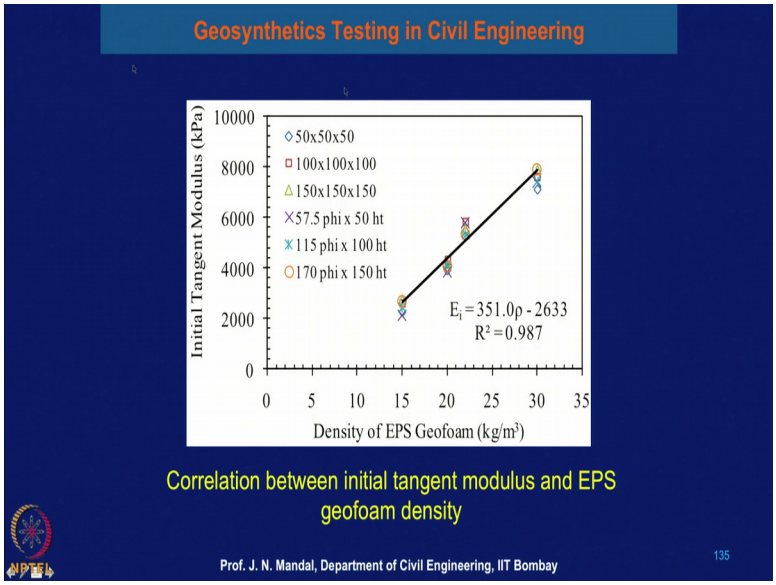

I will now, show you a relationship between the EPS geofoam and the tangent modulus. So, here this diagram show the correlation between the initial tangent modulus and EPS geofoam block.

This is the initial tangent modulus of the geofoam and this one the density of the geofoam material. And here the density we have taken variation of the density and size of the sample is 50 into 50 into 50 millimeter. And we have adopted here the different size 100 millimeter, 100 millimeter, 100 millimeter, 150 millimeter, 150 millimeter and 150 millimeter. And some also has a diameter of about 57.5 and height is about 50 and

115 millimeter size diameter and height is 100 millimeter, 170 millimeter of diameter and 150 meter of height.

So, we have taken the different size and shape of the geofoam material and whose density may be 15, 20, 25 or 30 and here show that correlation between initial tangent modulus and density of the EPS geofoam. If we can see with the different size and the shape,so you can have a one straight line like this. So, from this straight line you can see all those points either is a cubical specimen or the cylindrical specimen this is lies in the one straight line. So, from this curve you can determine what is the initial tangent modulus in terms of the density of the geofoam, so that means initial tangent modulus will be 350.0 into rho minus 2633 for R square value is 0.987. So, if you know the density of the sample or density of the EPS geofoam then you can determine the initial tangent modulus of the geofoam material.

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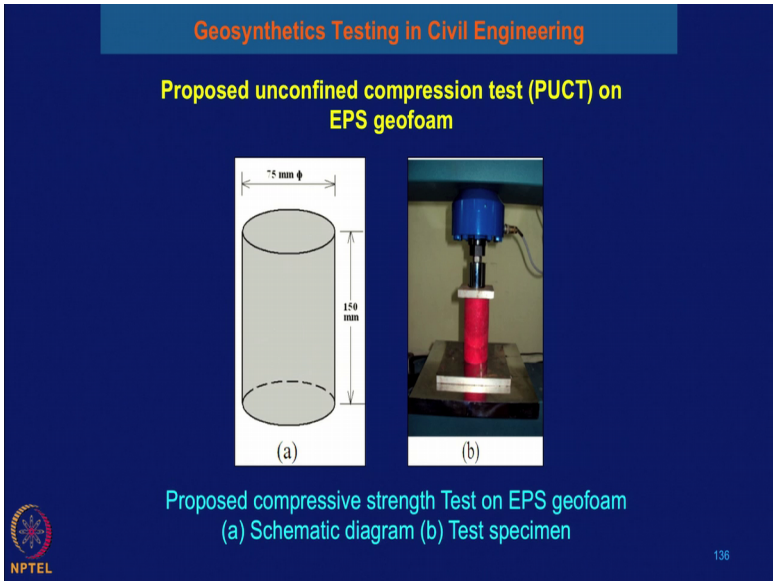

Now, apart from this initial tangent modulus of the geofoam the another interesting property I just explained you about the creep behavior. What is compression creep behavior?

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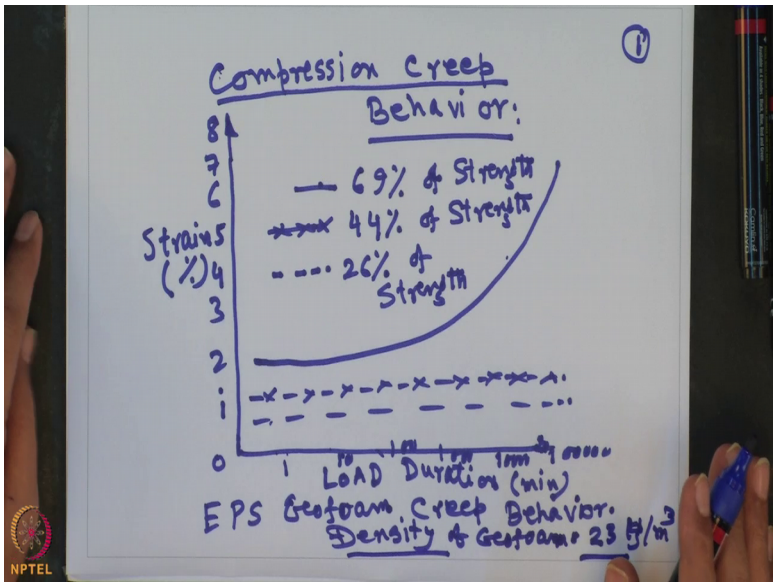

That it call the compression creep behavior. So, compression creep behavior of the geofoam is very interesting and if you know the compression creep of the EPS geofoam, so you can design that what should be the thickness of the EPS geofoam material. But these test is very long term testing and this is time temperature superposition, and it takes long time to perform this kind of compression creep behavior of the EPS geofoam material it may be 100, 1000, 2000, 5000, 1 lakh minutes.

So, you can draw a co relationship between suppose this is the load duration in minute l this is may be 1, may be 10, may be 100, it may be 1000, it may be 1 lakh or like this. So, this is time in minute and this is the strain y axis is a strain in terms of percentage, ok. So, it may be the 0 1 2 3 4 5 6 7 8 and this is the EPS geofoam creep behavior. So, what will be the nature or the relationship between the strain and the load duration in minute? So, you can have this kind of strain verses load relationship or you can have this kind of strain verses load relationship. So, this is for this form line is for 69 percentage of strength, ok.

And let us say this one is for the 44 percentage of strength and this one is 26 percentage of strength. So, this compression creep behavior of EPS geofoam or you can say this is the EPS geofoam creep behavior, and this for a particular EPS geofoam density and let us say density of geofoam is equal to 23 kg per meter cube. So, for a particular density of

the geofoam you can determine what should be the creep behavior. So, what should be the load verses strain relationship?

For example that if you wanted to use the EPS geofoam material for the back of the retaining wall that means, one EPS geofoam will acts as a compressible inclusion. So, you should know what should be the load required and what should be the strain or for a particular time. So, for that displacement, so you can determine what load and then you can determine what should be the thickness of the EPS geofoam. And particularly that kind of the thickness of the EPS geofoam should be designed. So, this is based on the creep behavior of the EPS geofoam, though it is a long term and it is a time consuming, but one has to perform the creep of the EPS geofoam material.

I will show you. So, different types of the EPS geofoam material and what should be their primarily value for the particular strain value may be 1 percent, 5 percent or the 10 percent and what should be the value of EPS geofoam material. Let us say that I am saying some of the physical properties of the EPS geofoam material.

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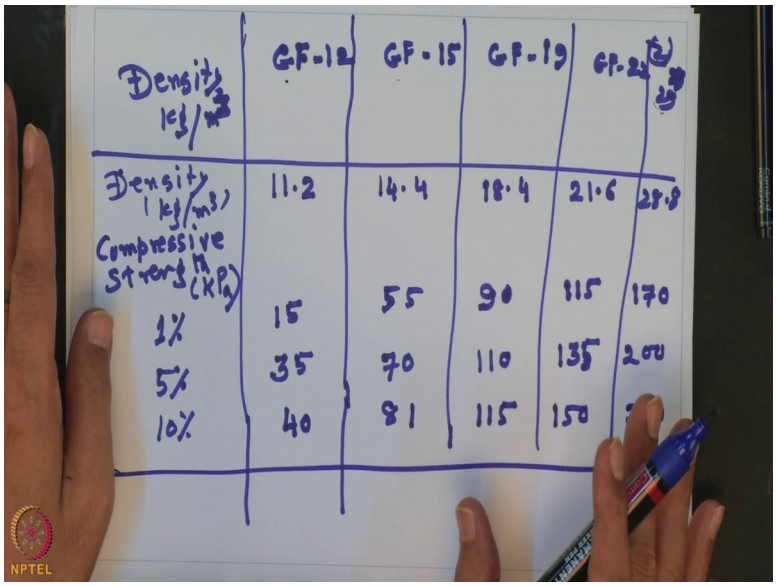

So, let us consider that density of the geofoam. This is kg per meter cube and this is geofoam let us say GF whose density is about 12 or geofoam density may be 15 or geofoam density may be 19 or geofoam density may be 22 or geofoam density may be 20, 29.

So, for this density this is you find from the manufacturer point of the view and if you can perform the test the density which unit is kg per meter cube, you can have some value very near up to 12, 11.2. So, this is the density for the EPS geofoam would density when then is dignited by the manufactured by round figure like a 12. So, if you perform the test this value may be 11.2 this value for 14.4 and this value will be 18.4, this value 21.6 and this is 28.8 when the EPS geofoam GF is 29. So, you can calculate the density.

You can calculate the compressive strength compressive strength ok, that unit is K Pa. For example, that compressive strength for a particular strain value let us say for compressive strength if one to determine for a particular strain. You know that what is the testing cure and you know the how to determine the initial tangent modulus for a particular 1 percent strain what should be the compressive strength of the EPS geofoam material. So, for compression for 1 percentage, so this value is 15 kilopascal for this geofoam material with density let us say 12.

And for 15, GF 15 let us say compressive strength is about 55, for GF 19 compressive strength value is 90 and for GF 22 compressive strength is about 115 and for 29 density compressive strength may be 170. So, this is your determined compressive strength of the EPS geofoam for 1 percentage strain value or you can determine for compressive strength of the EPS geofoam for 5 percent distance, it is a 5 percent distance. So, this for the EPS geofoam 12 for 5 percent the compressive strength will be 35 and for the 5 percentage strength this will be about 70 kilopascal and for the compressive strength of the geofoam 19 density this will be around 110 and for geofoam 22 this compressive strength will be 135, and for GF 29 density so this value will be 200.

So, again you have to determine that compression strength for 10 percent distance in kilopascal. So, 10 percentage strength for the geofoam density is 12, this will be 40 and this for the 15 value, let us say this value will be about 81, and for the geofoam 19 let us say these value will be the 115 and for the EPS geofoam 22 so this value may be 150 and for the 32 let us say 250. So, what you can observe from this table that density is of the EPS geofoam is increasing and the compressive strength under 1 percent or the 5 percent and 10 percent it is increasing. So, depending upon the type of the application we have to select that what percentage of strength is required and accordingly you can select the compressive strength of the EPS geofoam material. So, this from this table you can have

some idea that compressive strength is increasing with the increase of the EPS geofoam material.

Well, now we will discuss that some alternative compressive strength of the EPS geofoam material and this is the proposed unconfined compression strength test.

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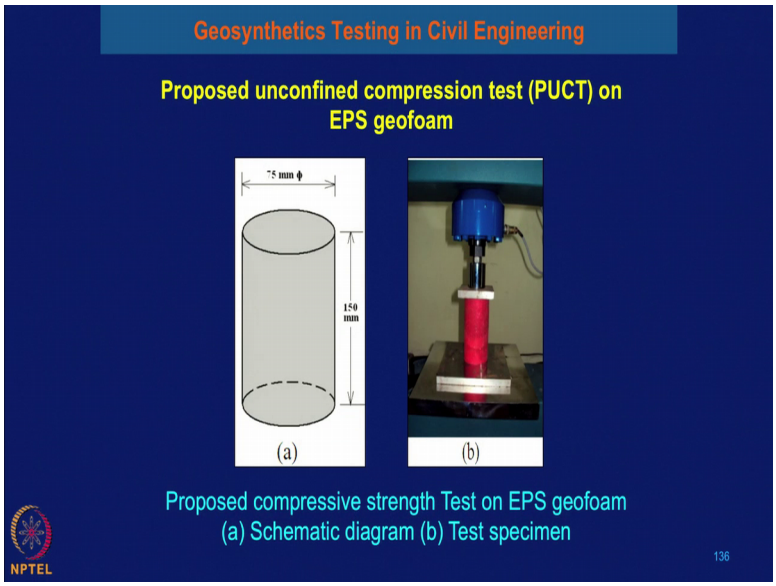

And this proposed unconfined compressive test has been developed in IIT, Bombay. And instead of the cubical shape of the specimen as you have observed that we are perform the compressive strength of the EPS geofoam material under different cubical type it may be 50 into 50 into 50 or 75 into 75 into 75 millimeter or 100 into 100 into 100 millimeter and 200 into 200 into 200 millimeter.

So, there is no particular specification what cubical size of the EPS geofoam should select to perform the compressive strength of the EPS geofoam. But we have selected some cylindrical sample and have performed the unconfined compressive strength of the EPS density under various density and we compare with the other results like ASTM or IS or the dean specification that what I will show you.

So, here you can see this is the cylindrical sample and this has a height is about 150 millimeter and this diameter about 75 millimeter, it is a cylindrical sample. So, this is the proposed compress proposed, compressive strength test on EPS geofoam these are schematic diagram is on the left and right hand side you can see this is the sample and

this is the universal testing machine and the test has been performed to determine the compressive strength of the EPS geofoam material.

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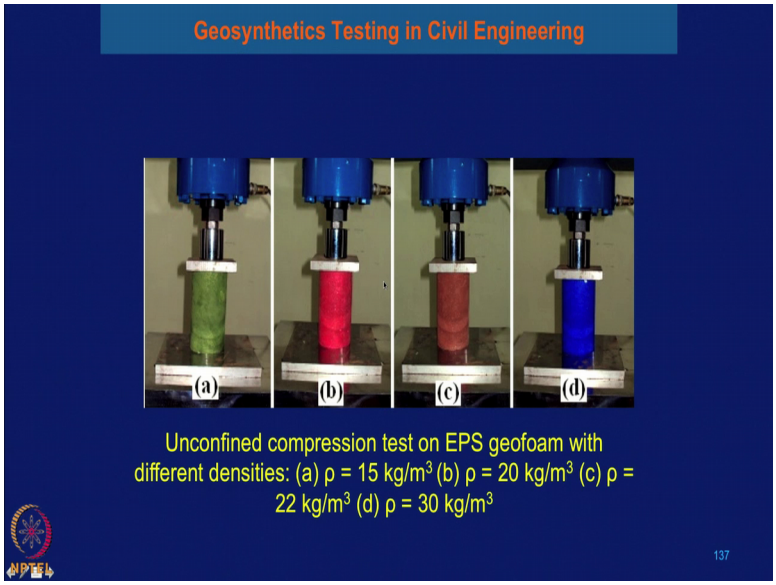

So, here in this slide because we have use the different types of the density of the geofoam material and different color has been shown here you can see this a sample, that means whose EPS material whose density is about 15 kg per meter cube for this red one, that is b sample whose density is about 20 kg per meter cube and for the c sample this one whose density is about 22 kg per meter cube and the this d sample whose density is 30 kg per meter cube. So, we have performed with the different types of the density of the EPS geofoam. It may be the 15, it may be the 20, it may be the 22 or it may be the 30 kg per meter cube.

Now, if you perform the test you can have a co relation between the compressive stress and the strain value of the EPS geofoam under various density of the EPS geofoam. Now, I will show you here.

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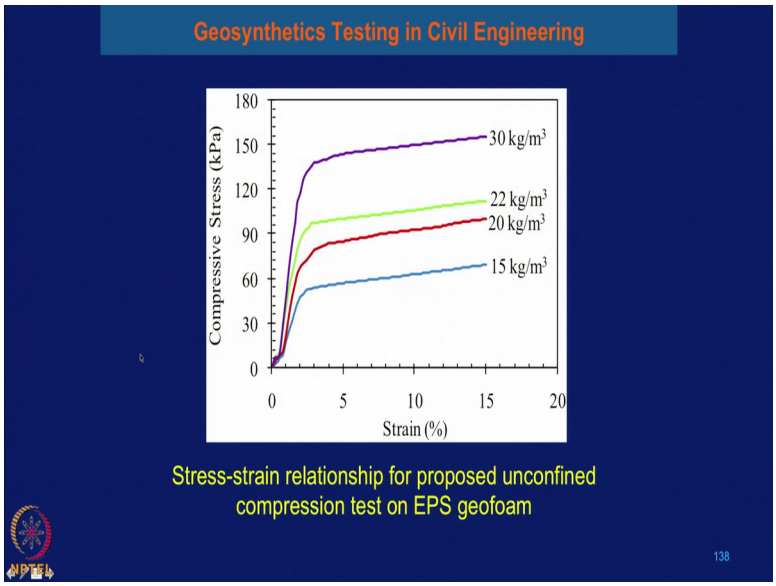

You can see this is the compressive stress and this is the strain and compressive strain is in terms of kilopascal and this is the stress and strength relationship for the proposed unconfined compression test on EPS geofoam. So, you can see these one for a particular density of 15 kg per meter cube, then 20 kg per meter cube, 22 kg per meter cube and 30 kg per meter cube.

Look here that initially the compressive stress and strain almost constant and after that it is increasing. So, there is no definite failure of the EPS geofoam material under any density or under any condition. And you also observe from this testing relationship that the density is increasing and compressive strength of the EPS geofoam also it is increasing. So, from this curve I will show you that what will be the test result and what will be the size of the EPS geofoam material and density, and under the different strain value 5 percent, 10 percent and what should be the yield value and what should be the initial tangent modulus value because these value is very important for the design of EPS geofoam infrastructure.

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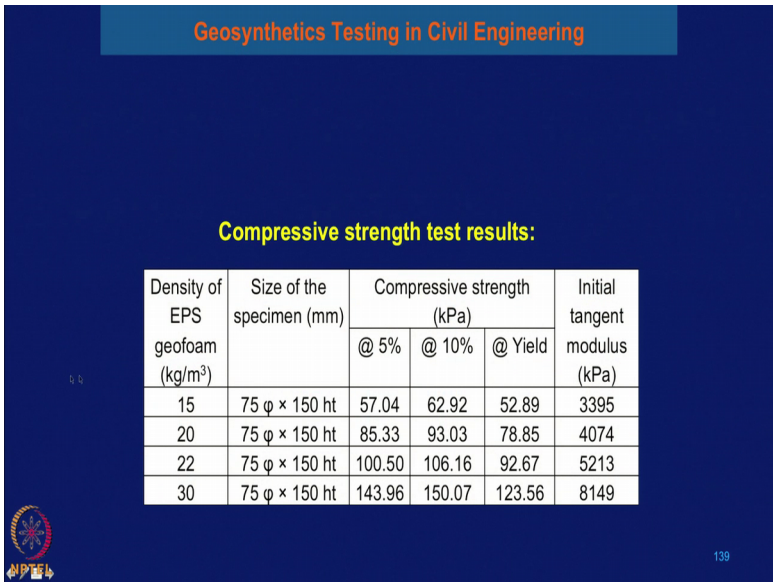

So, this is here that you can say that density of the EPS geofoam 15, 20, 22 and 30 and the size of the specimen is 75 into 150 this is same this is the cylindrical type of the sample with diameter is 75 and height is 150 and if determine the compressive strength at 5 percent, 10 percent also you can determine what is the yield value and also you can determine initial tangent value. So, this has been determined from this curve from this curve. So, for the 5 percent, so what will be the compressive stress; for the 10 percent, 5 percent what will the compressive strength for 15 kg per meter cube, for 20 kg per meter cube, 22 kg per meter cube and 30 kg per meter cube.

Similarly, for the 10 percent is 10 percent is strain what will be the compressive strain, for 15 kg per meter cube, then what will be the compressive stress for here for 10 percentage and similarly for 22 and similarly for here is 30 kg per meter cube. So, you can determine what will be the compressive stress. Also you can determine yield value for different density of the EPS geofoam and you can also determine the initial tangent value if you can draw a tangent here. So, and slope of this straight line will be the will be the initial tangent modulus for 30 kg per meter cube, for 22 kg per meter cube, for 20 kg per meter cube and 15 kg per meter cube or we are showing in the next slide here. You can see here for the compressive strength for 5 percent, so these are the value 57, 87.33, 100.50, 143.96 under different density of EPS geofoam; similarly, for 10 percentage 62.92, 93.0, 106.1615.07.

So, even then you can determine what will be the compressive strength at 1 percentage strain also. So, you can determine yield value 52.89, for a density of 15 kg per meter cube 78.85, for a density of 20 kg per meter cube and yield value 92.67 for the density of 22 kg per meter cube and 123.56 yield value for the density of 30 kg per meter cube.

You can also determine what will be the initial tangent modulus under different density of EPS geofoam. For the 15 kg per meter cube geofoam that initial tangent modulus value is 3395 kilopascal, for EPS geofoam density of 20 kg per meter cube then initial tangent modulus value is 4074, for a EPS density of 22 kg per meter cube this initial tangent modulus 5213 and for 30 density the initial tangent modulus is 8149 kilopascal. So, you can see from this table that density is increasing initial tangent modulus value also increasing, density is increasing yield value also increasing, density is increasing the compressive strength of the EPS geofoam value is increasing with increasing of the density of the EPS geofoam.