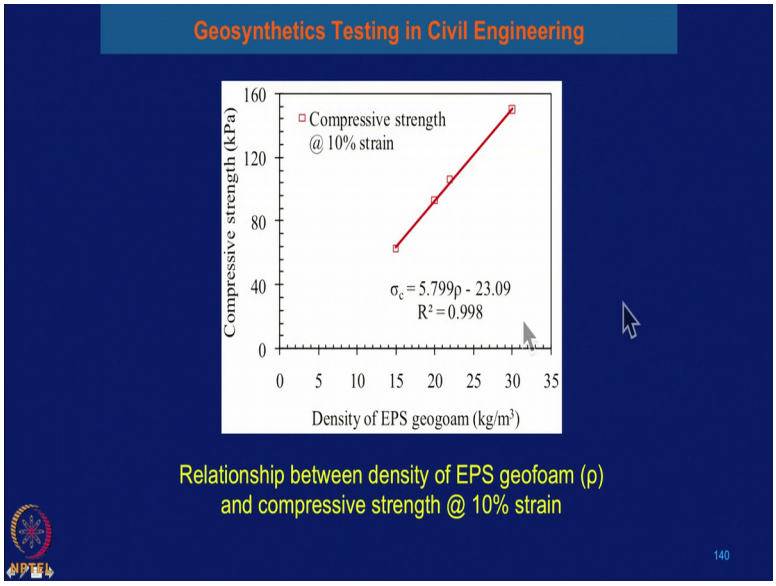
Geosynthetics Testing Laboratory
Prof. Jnanendra Nath Mandal
Department of Civil Engineering
Indian Institute of Technology, Bombay

Lecture - 18
Compression and Tensile Properties of Geofoam

So, as we have discussed earlier, the different types of the EPS geofoam density and their corresponding the initial tangent modulus, yield value and as well as compressive strength. So, now, I will show you a relationship between the density of the EPS geofoam and the compressive strength at a particular strain value. So, let us say, it is a 10 percent strain or 5 percent strain.

So, here I am just showing one example that what should be the relationship between density of the EPS of the geofoam and the compressive strength of the EPS geofoam material.

(Refer Slide Time: 01:23)



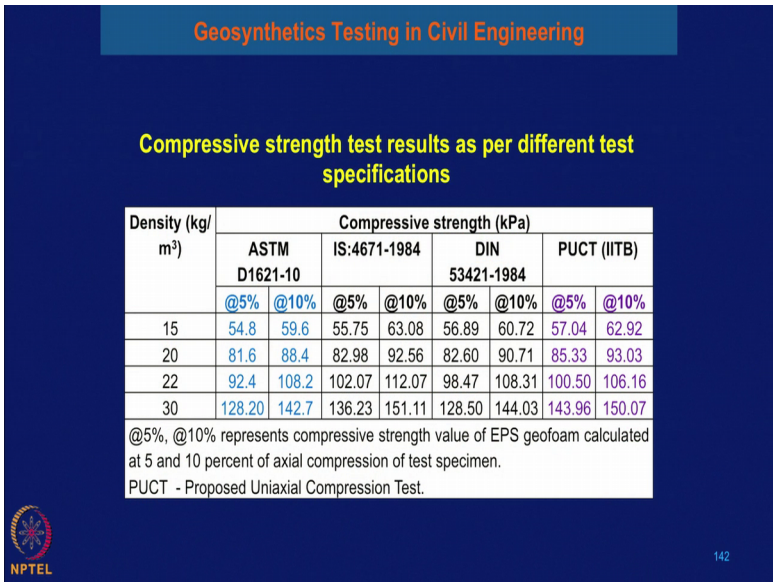
You can see here, this is the compressive strength in kilo Pascal and this is the density of the EPS geofoam material ok. It may be 15 to 30 with the four different types of the EPS geofoam material. And this is shown as a compressive strength at a 10 percent strain. So, this is the relationship between the density of EPS geofoam row and the compressive strength of the EPS geofoam at 10 percentage strength.

You can see, you can obtain a straight line like this under different density. So, you can have the a correlationship between the compressive strength of the geofoam sigma c with respect to the density of the EPS geofoam; that means, c will be equal to 5.799 rho minus 23.09 where this r square value is 0.998. So, this is for a particular strain value 10 percentage strain value. For example, if you know what will be the density of the EPS geofoam material, so then you can directly determine that what will be the compressive strength of the geofoam using those equations for a particular strain value. Similarly, you can draw a correlationship between the EPS geofoam density and versus the compressive strength of the geofoam and a particular strain, for example 5 percentage strain value.

So, then you can have a correlationship between the compressive strength and the density of the geofoam for a particular EPS geofoam. So, if you know the density then you can determine what should be the compressive strength of the EPS geofoam material now I am showing you a relationship between the density of the EPS geofoam and the compressive strength at yield. I have shown for a particular string value of 10 percentage, you can also draw a correlationship between the EPS geofoam and the compressive strength. Here, in slides shows that compressive strength versus density of EPS geofoam material for a compressive strength at yield.

So, you can draw a straight line for you can, you can draw a straight line here for the different density. So, it can determine that compressive strength value of the EPS geofoam material that is sigma c is equal to 4.689 rho minus 15.01 per R square is 0.988. So, from this equation you can determine what will be the compressive strength of the EPS geofoam material at yield. So, if you know the density, you can determine the sigma c with equation directly. I will show this another slide that is compressive strength result as well different test specimen.

(Refer Slide Time: 05:20)



So, we have perform the compressive strength of the EPS geofoam with different density, with a different type of the method of EPS geofoam material. Suppose we are perform as for ASTM, American Society for Testing Material, we are perform the strength as for the IS, we are perform the test as for the din and also we are perform the test as for the specification developed by IIT Bombay. And then we compare the result with the particularly with the ASTM with the propose unconfined compressive strength of the EPS geofoam material developed by IIT Bombay.

For this slide, I can show you that you can see this is density we have taken 15 kg per meter cube, 20 kg per meter cube, 22 kg per meter cube, 30 kg per meter cube and this is 5 percentage as for ASTM D 1621-10 this is for 5 percentage represent the compressive strength value of EPS geofoam is calculated. And then, 10 percent represent the compressive strength of the EPS geofoam is calculated for a 5 and 10 percent of axial compressive strength specimen. So, this is IS:4671-1984, also calculated the compressive strength in terms of kilo Pascal at a strain of 5 percentage.

This is 55.75, 82.98, 102.07, 136.23 and for 10 percentage this is 63.08, 92.56, for a density of 20 kg per meter cube, 112.07 for a density of 22 kg per meter cube and 151.11 for a density of 30. So, this is the DIN specification to determine the compressive strength of the EPS geofoam, that is as for 53421 in 1984, for 5 percentage for a density of 15 kg per meter cube, compressive strength is 56.89, for a density of 20 kg per meter

cube, this compressive strength is 82.60, for a density of 22 kg per meter cube, this for 5 percent, this 98.47 for a density of 30, this is 128.50.

Similarly, for the 10 percent strength for density of 15 is 60.72, for 20 density is in 90.71 and for the 22 density is 108.31 and for 30 density is hundred and 144.03 kilo Pascal and this is the proposed uniaxial compression test value, this is developed by IIT Bombay. For the 5 percentage strength, for a density of 15 kg per meter cube of EPS geofoam, this compressive strength value is 57.04; for a density of 20 kg per meter cube, this compressive strength is 85.33; for a density of 22 kg per meter cube, this compressive strength is 100.50 and for a density of 30 kg per meter cube, this compressive strength is 143.96.

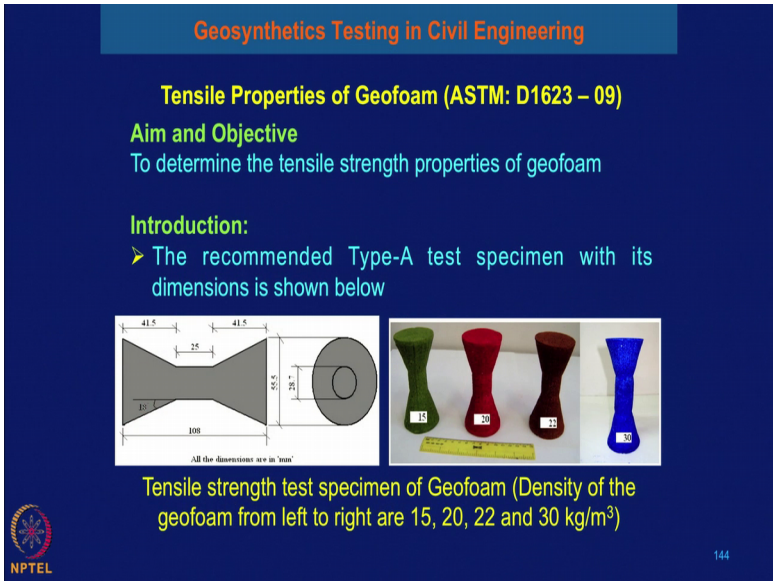
Similarly, for the 10 percent strength value when the EPS geofoam density is 15 is 62.92 and when it is 20, 93.03 and when it is 22, 106.16 and when the density of EPS geofoam is 30 kg per meter cube, this compressive strength 150.07. So, you can see that different types of the compressive strength of the EPS geofoam is given and if you can compare with the ASTM and with the proposed uniaxial compressive strength by IIT Bombay, you can see that is a similarity 54.8, this is 57.0, this is 59.6 at 10 percent, this is 62.92; for 20 density 81.66 and this is 85.33, this is 88.4, this is 93.03, this is for 22 density 92.4, this is 100.50 and for 10 percentage strength, 100, 108.22, this is 106.16.

And 30 density, it is 128.20 and this is 1439.6 and this is 142 for proposed this is 150.07. So, you can see there is a lot of similarity of the between the ASTM and the proposed PUCT test. So, and perform this you have observed that density is increasing, the compressive strength value also increasing. And this it propose value of almost the nearer or little bit more than the ASTM value and this is very simple test because everybody has a torsional testing machine and one can perform the unconfined compressive strength of the EPS geofoam material. And, it is very easy to prepare the sample and also perform the test. So, this compressive strength of the geofoam material is also interesting because one should know that what will be the compressive strength of the EPS geofoam material.

Next, we will discuss the tensile strength of the EPS geofoam. You know, so far we have discuss about the compressive strength of the EPS geofoam and now we will discuss

what will be the tensile properties of the EPS geofoam and this is as for ASTM D 1623-09.

(Refer Slide Time: 12:46)



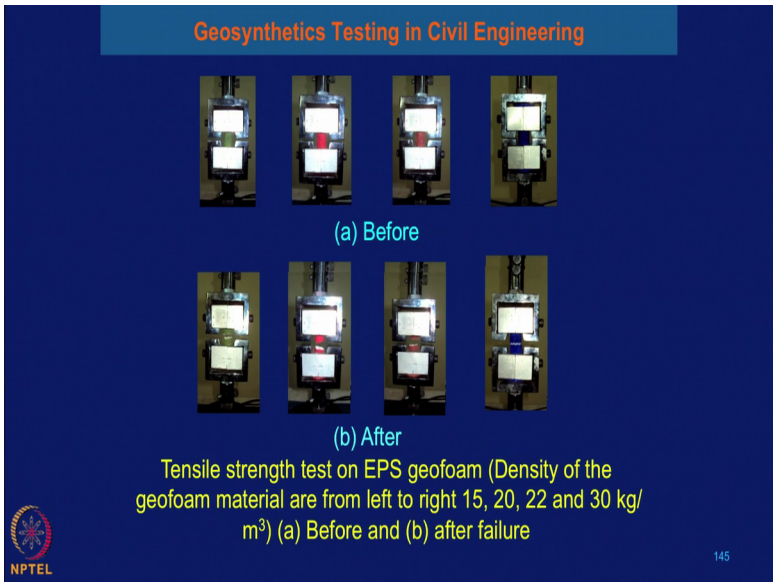
So, here the main objective of this test to determine the tensile strength property of the EPS geofoam; the recommended the type A test specimen with it is dimension is shown here because there are different types of the tensile strength of the EPS geofoam material. So, also equally that we have also develop certain kind of the tensile strength of the EPS geofoam where in our case, you can prepare the sample easily and you can perform the test very easily with respect to the ASTM code specification.

In case of the ASTM code specification, the preparation of the sample is very tricky and very difficult and also it is a time consuming. And we have performed the test as for ASTM and we have also perform the test as for our propose tensile strength of the EPS geofoam and compare the result and we find that is quite matching with the both the test. So, here that you can see that this is a kind of the tensile test specimen of the EPS geofoam and the size here to here about 25 millimeter and here to here is 41.5 and here to here is 41.5 and this is 55.5 millimeter and this total is about 108 millimeter and you can see here this is about 28 point 28.7 this diameter is 28.7. So, this is the tensile strength test specimen of geofoam.

And this kind of the dumbbell shape of the EPS geofoam material and the preparation of the dumbbell set of EPS geofoam material is complex. So, in the right hand side, I have

shown that this is the different colour because for different density of the EPS geofoam material, this is 15 kg per meter cube, this 120 kg per meter, this is 22 kg per meter cube and this is 30 kg per meter cube of the geofoam material.

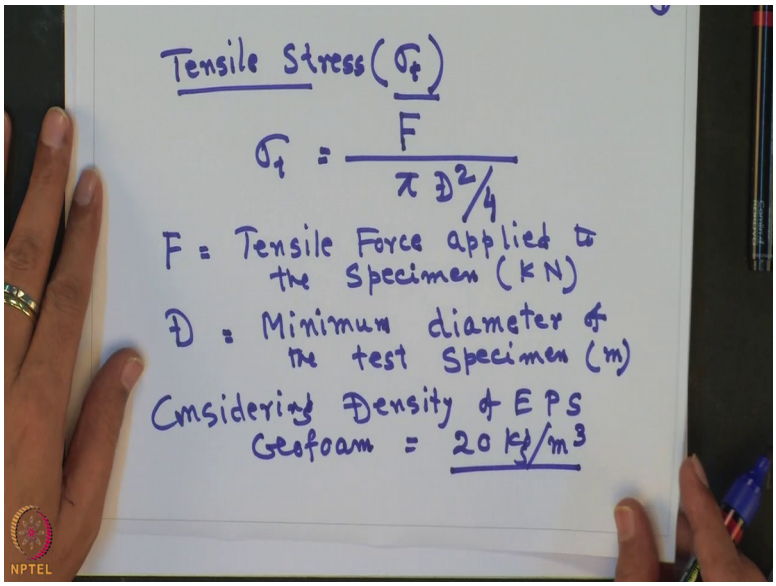
(Refer Slide Time: 15:40)



So, when will show you that different types of the test of the EPS geofoam and what kind of the failure of the EPS geofoam may occur. So, here you can see that before the test, this is in the universal testing machine and there is a clamp at the top and the bottom and then you perform the tensile strength of the EPS geofoam material under different density.

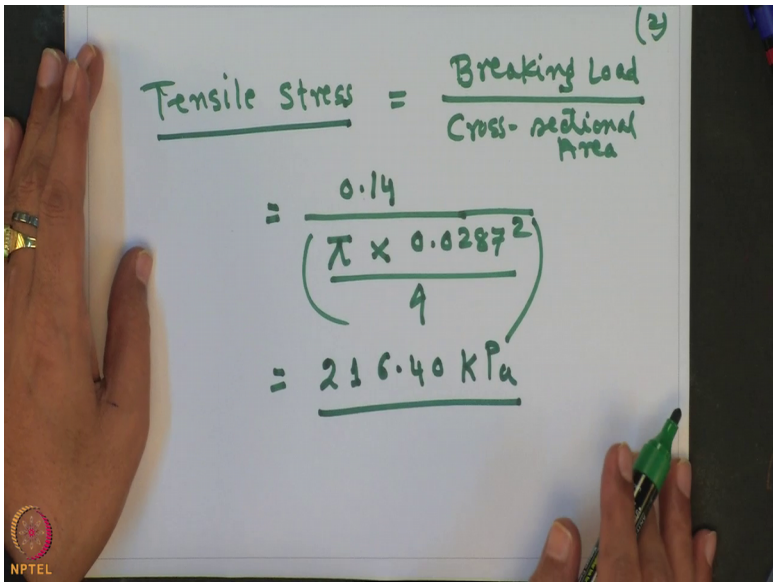
So, this is before and you can see after the test for the different density and this how the sample failed and fail almost at the middle of the up here, you can see this is the failure, this is the kind of the failure you can observe from this test. Now, you know that how to how to perform the test of the tensile strength of the EPS geofoam material and what is the kind of the failure and now how to calculate the tensile strength of the EPS geofoam material. So, I will show you that tensile strength is calculated divided by breaking load by the original minimum cross section of the specimen. So, tensile stress, so, let us designated as sigma of t ok.

(Refer Slide Time: 17:18)



Tensile stress so, sigma of t can be written as F this divided by pi into D square this divided by 4. So, what is F? F is the tensile force applied on the specimen. So, for F is the tensile force force applied to the specimen and unity kilo Newton. And what is D and D is minimum diameter diameter of the test specimen ok. Let us say that in terms of meter. So, you consider one of the density of the EPS geofoam material in which you want to determine what will be the tensile strength of the EPS geofoam. Let us say that considering density of EPS geofoam is 20 kg per meter cube, let us say for a density of 20 kg per meter square cube. Then, you have to determine what will be the tensile strength of the EPS geofoam.

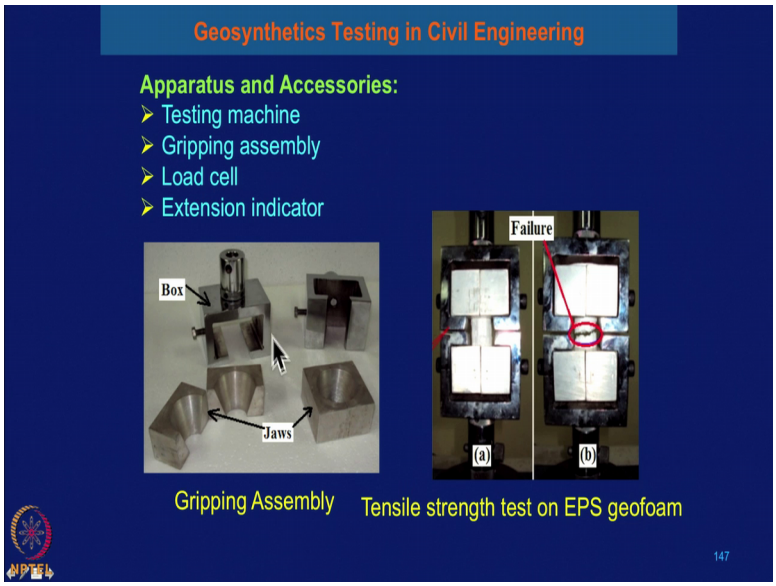
(Refer Slide Time: 20:13)



So, as I said that tensile stress is equal to Breaking, Breaking load divided by cross sectional area cross sectional area of the sample. So, here breaking load, let us say 0.14 this divided by pi into cross sectional area I have told 0.0287 this square this divided by 4 because this is pi by 4 into D A square and D is this. So, now, you can calculate and can determine what will be the tensile stress of the EPS geofoam for a density of 20 kg per meter cube.

So, this will give you 216.40 this kilo Pascal. So, this is the tensile stress of the EPS geofoam for a density of 20 kg per meter cube. So, you can determine the tensile strength of the geofoam EPS geofoam material because tensile strength also very important; you know for every infrastructure there is a compressive stress and there will be the tensile stress. If there is a requirement for any tensile stress of the geofoam material, so you should know what tensile stress value is adopt for a particular application and what should be the density of the EPS geofoam material.

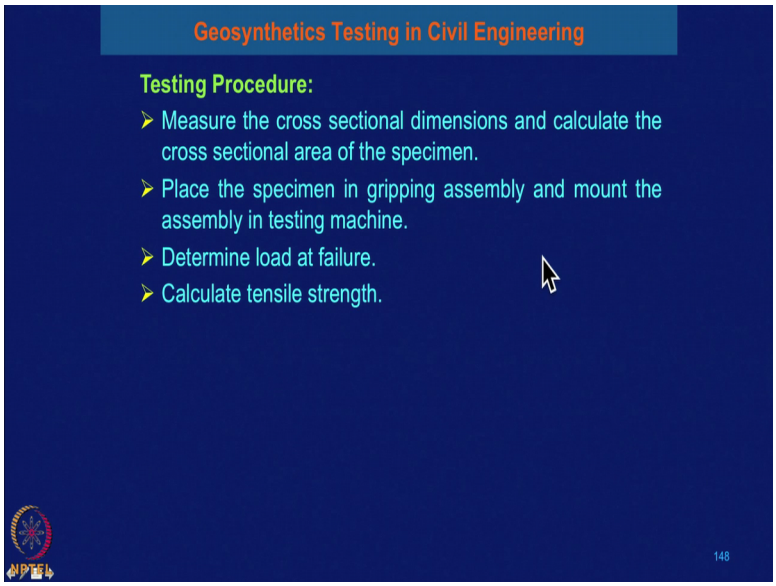
(Refer Slide Time: 22:46)



Now, to perform the test what I am showing that what kind of the apparatus and accessory required. You required testing machine; you required gripping assembly and load cell and the extension indicator. So, here you can see the box and this is this is a jaw and this kind of dumbbell shape of the preparation of the sample and the jaw and box is quite complex.

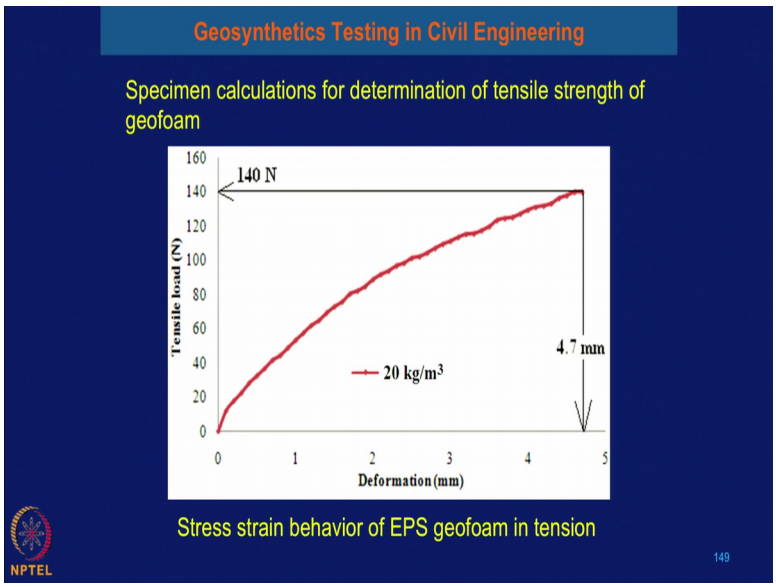
So, this is the kind of the gripping arrangement of gripping assembly. And this is the geofoam material for ready for the tensile strength and this is the before the tensile strength of the EPS geofoam material and you see after you perform the tensile strength test on EPS geofoam material, I can see there is a breaking of the EPS geofoam material here. It is almost almost at the middle of the sample. So, this is the indication that there is a failure of the EPS geofoam material.

(Refer Slide Time: 24:15)



And testing procedure, you measure the cross sectional dimension and calculate the cross sectional area of the specimen, place the specimen in the gripping assembly and mount the assembly in the testing machine. Determine the load at failure or break and then you can calculate the what should be the tensile strength of the EPS geofoam material. So, from this test, from this test

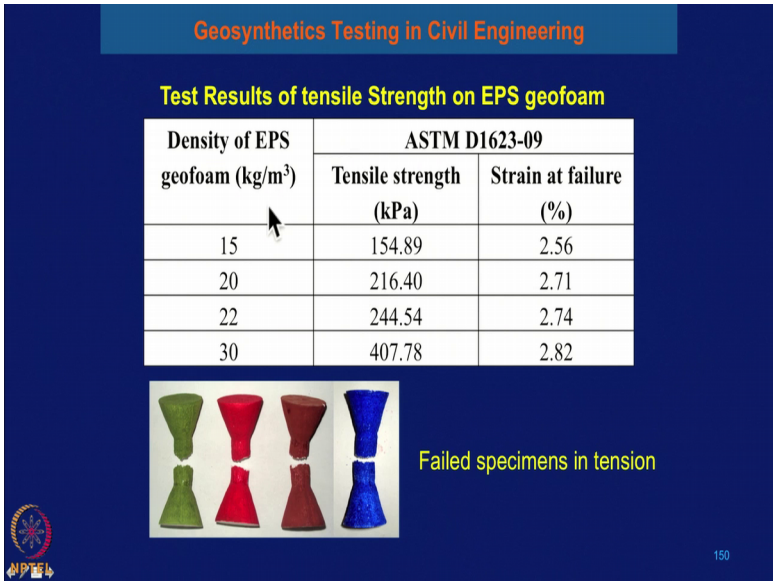
(Refer Slide Time: 24:54)



You can calculate you can draw a correlation between the tensile strength and the deformation or you can say, this is the stress strain behavior of EPS geofoam for a

particular density of 20 kg per meter cube. So, this is then tensile load in Newton and this is the deformation millimeter and this is the distance curve of the EPS geofoam of 20 kg per meter cube. So, for the particular deformation 4.7 millimeter, you can see the tensile load is 140 Newton. So, these materials not only that give the compressive stress of the EPS geofoam material, but also it provide us the tensile strength of the EPS geofoam material. And for the define strain value you can also determine what will be the tensile strength of the EPS geofoam material.

(Refer Slide Time: 26:19)



Suppose here, in this slide we have taken density, we have taken that 15 kg per meter cube, 20 kg per meter cube, 22 kg per meter cube, 30 kg per meter cube, this as for ASTM D 1623-09. So, tensile strength for 15 kg per meter cube 154.89 kilo Pascal; for 20 density, the tensile strength is 216.40 kilo Pascal; for EPS density of 22 kg per meter cube, the tensile strength is 244.54 and for density of EPS 30 kg per meter cube, the tensile strength is 407.78. And here, you can see that what will be the strain at failure. So, for this tensile strength value the strain value is 2.56, for case of 20 EPS and this strain value is 2.71 percentage and for EPS density of 22 kg per meter cube, the strain at failure is 2.74 percentage.

And for 30 EPS density and this strain value is 2.82 percentage, this is the strain at failure. Here, you can see for different density and different types of the failure pattern of the specimen in tensile. So, you can have the idea that different types of the density and

what will be the type of the failure pattern. And most of the cases, the failure of the sample has failed at the middle of the sample and also you find the tensile strength also is increasing with the increase of the density of the EPS geofoam material, but one observation that most of the cases, the strain value is almost 2 to 3 percentage, the sample fail within the 2 to 10 percentage failure. So, the tensile strength of the EPS geofoam is needed.