Geosynthetics Testing Laboratory
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Lecture – 19
Tensile and Shear Properties of Geofoam

Earlier, we have discuss the Tensile strength of the EPS Geofoam material and we have determine the initial tangent modulus and also the stress strain curve in which you can determine the what should be the strength, tensile strength at the yield or certain percentage; 1 percent, 5 percent or 10 percentage with the different densities of the EPS Geofoam.

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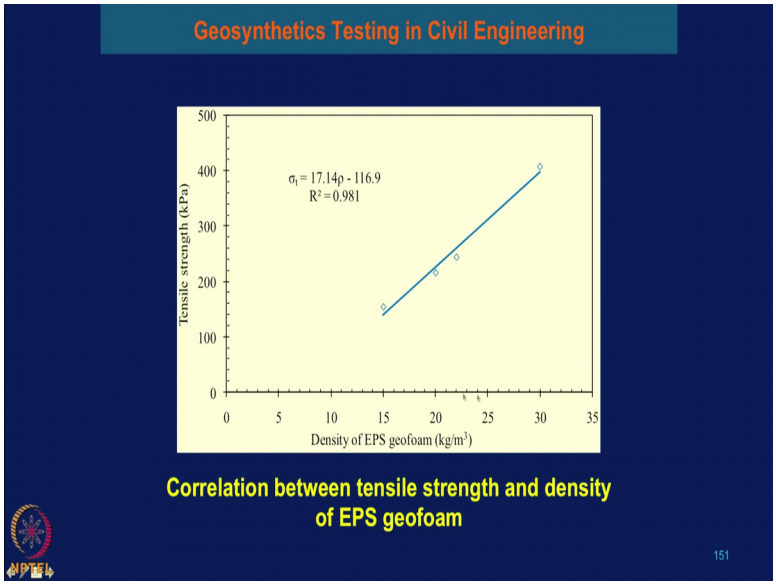

Now, I will show you one in the slides that this is correlation between the tensile strength in kilo Pascal and the density of EPS geofoam kg per meter cube. What will be the correlation between the tensile strength and the density of the EPS geofoam under different density of the EPS geofoam; starting from may be 15, 20, 22 and the 30. You can see you can draw each line and you can determine that what will be the sigma t that is 17.14 into rho minus 116.9 or R square is equal to 0.981. So, for knowing the density of the EPS geofoam material, you can determine what should be the sigma t value.

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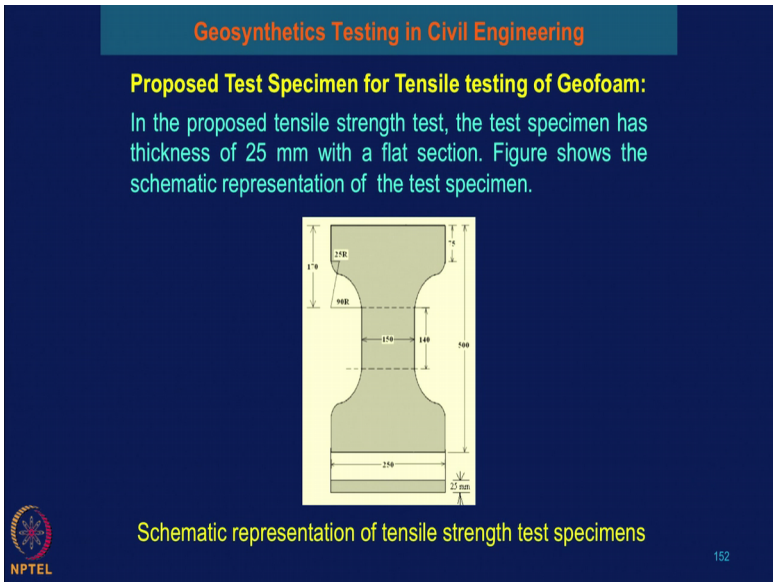

Now, we will show you that Proposed Tensile Specimen Test measurement of the tensile strength of the geofoam material and this proposed tensile strength of the geofoam material is developed by IIT Bombay and it is much more simplified than the earlier ASTM tensile strength of the EPS geofoam material. In this proposed tensile strength test, the test specimen has a thickness of about 25 millimeter with a plat section.

We can show the figure here and in this figure, here the shape of the sample is like this and the size of the sample is from here to here is 500 millimeter and from here to here is 250 millimeter and this is 25 millimeter and from here to here is 75 millimeter. And from here to here is 170 millimeter and this arch is 25 R and this arch is 90 R and this distance is 150 millimeter and this is 140 millimeter.

So, this is the schematic representation of the tensile strength of the proposed testing specimen. So, this shape of the EPS geofoam sample is like this and whose thickness is also 25 millimeter. So, from any panel on any density of the EPS geofoam, you can simply cut the sample as it is shown in earlier figure and then, you can perform the test in a universal testing machine. So, this is much more simpler way to prepare the sample then the ASTM method which is very complex to prepare the specimen for the EPS geofoam material. So, next I will show you the different types of the specimen.

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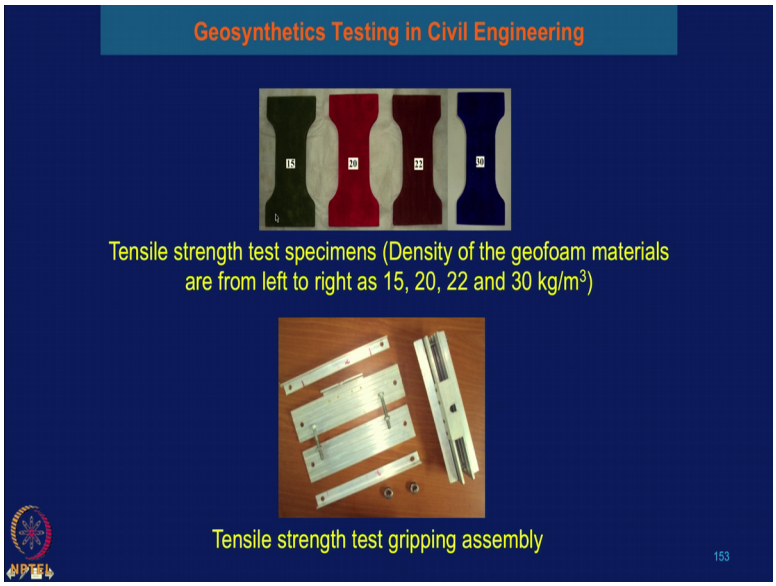

So, you can see that this is under the different density of the sample that is 15; this one is 20; this is 22 and this is 30. So, tensile strength of the test specimen from left right is 15, 20, 22 and 30 kg per meter cube. So, these sample are to be test in this griping assembly, here is the griping assembly. So, these sample as to be gripped with this gripping equipment.

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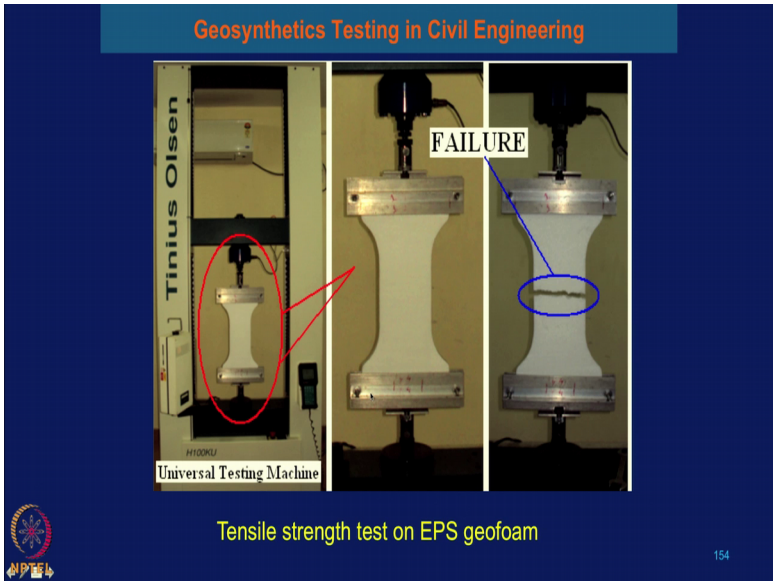

So, if you can perform the test, you can see here this is the sample and you are using the universal testing machine to perform the tensile strength of the EPS geofoam under

deferent density and this is the sample you can see here. After the test you can find there is a failure, here you can see there is a failure of the EPS geofoam. It is failed at the center of the sample; it should not fail at the edge or near to the sampling. So, you can discard the sample, again you prepare the another sample and then you perform the test in order that sample generally should fail at the middle of the EPS geofoam material. I will show you some other type of the EPS geofoam sample with the different density and you can observe that what kind of the failure it is.

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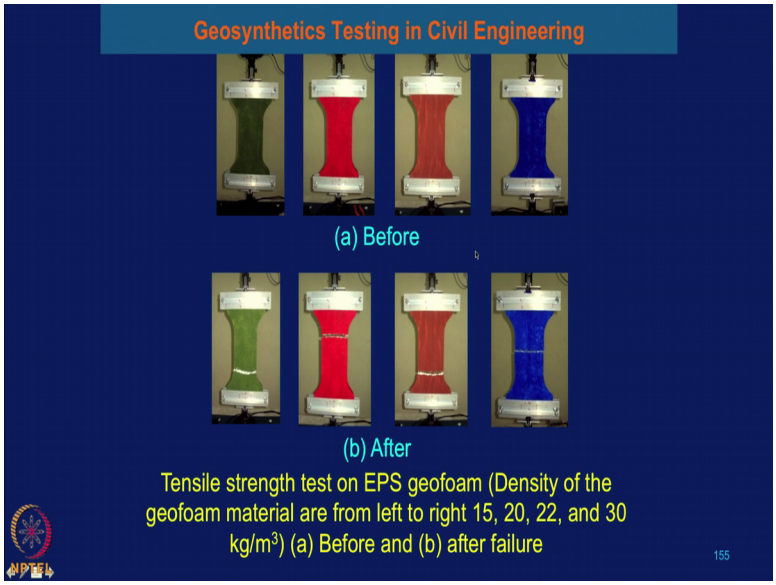

So, here tensile test strength test of EPS geofoam and as I say with density 15, 20, 22 and the 30 kg per meter cube. This is before the test. This four before the test and you can see after the test. In some sample is not at the edge some sample at the top and sometimes is at the bottom and some sample at the centre of the EPS geofoam material. So, it is preferable that sample should fail at the middle of the sample.

I am showing you that when you perform the test you can see of the sample and showing you that when you perform the test you can see that different types of the failure pattern. So, what type of failure pattern you should accept and what you can have the exact result for the tensile strength of the EPS geofoam material. So, from this EPS geofoam on tensile strength of the EPS geofoam material, you can draw a relationship between the tensile strength and the strain value. I am show you some curve.

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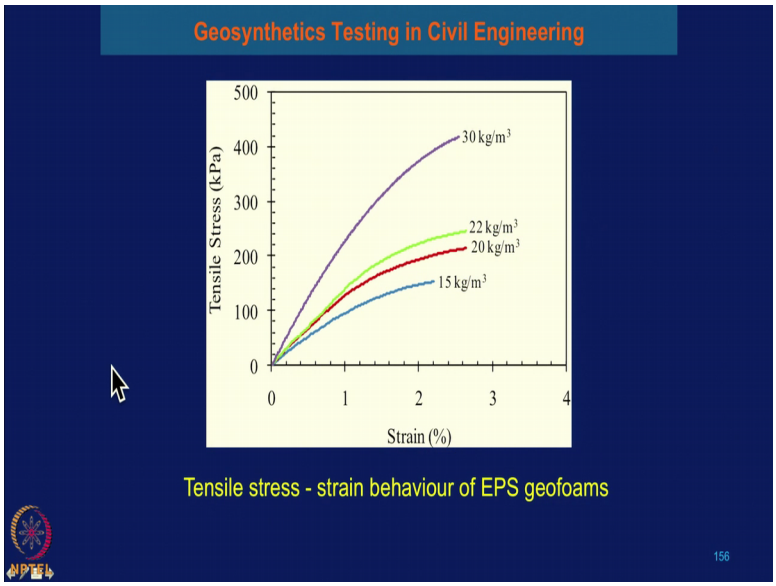

This is the figure tensile strength first Strain behavior of EPS geofoam. This is the tensile stress in kilo Pascal and this is a strain in percentage and this is also in different density of the EPS geofoam. This is 15 kg per meter cube, 20 kg per meter cube, 22 kg per meter cube, 30 kg per meter cube and you can see the stress strain curve. The stress is tensile stress is increasing with the increasing of the strain of the EPS geofoam material, there is no specified value of the EPS geofoam during the testing of the tensile strength of the EPS geofoam material. But you can also observe from this figure that there is a increasing of the tensile strength of the EPS geofoam material with increasing the density of the EPS geofoam material.

You can observe that 15, then you are having the more value for tensile strength for the 20, if you are having more value 22 kg per meter cube, even then more 30 kg per meter cube. So, whatever you required for your particular project so then, you can select that what tensile strength is required and what density of the EPS geofoam you should accept. So, you can have the idea from this.

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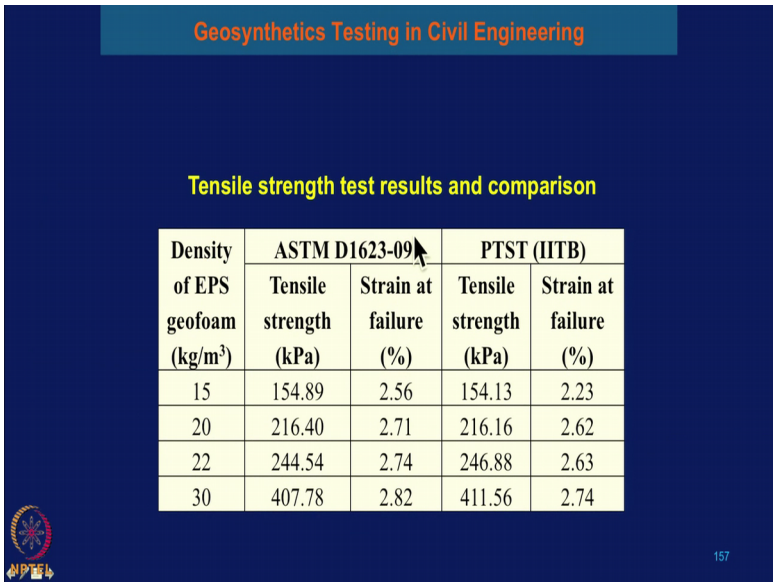

Density of EPS geofoam (kg/m^3)	ASTM D1623-09		PTST (IITB)	
	Tensile strength (kPa)	Strain at failure (%)	Tensile strength (kPa)	Strain at failure (%)
15	154.89	2.56	154.13	2.23
20	216.40	2.71	216.16	2.62
22	244.54	2.74	246.88	2.63
30	407.78	2.82	411.56	2.74

So, next I will show you that what should be the table; that which we have prepared for the ASTM D1623-09 and with respect to what are the proposed tensile strength test at IIT Bombay. So, here look that density of the EPS geofoam is kg per meter cube. This is 15, 20, 22 and the 30. As per ASTM D1623-09, the tensile strength of the EPS geofoam for 15 density, it is 154.89 and corresponding strength at failure in terms of percentage is 2.56. Similarly for the EPS density of 20 kg per meter cube and tensile strength is 216.40 and strain at failure is 2.71 percentage.

For the density of EPS is 22 kg per meter cube, then tensile strength of the EPS geofoam 244.54 kilo Pascal and corresponding strain value is 2.74 percentage. For density of 30 kg per meter cube of EPS geofoam, the tensile strength is 407.78 and corresponding strain value is 2.82. So, this is as for ASTM D1623 and this value, we have compared with the value of our proposed tensile strain stress machine in IIT Bombay which is (Refer Time: 12:18) type of the sample.

So, tensile strength you can see for the density of EPS geofoam 15 kg per meter cube and tensile strength as for IIT Bombay is 154.13 and the corresponding strain at failure is 2.23. Similarly, for the density of EPS geofoam 20 kg per meter cube and the as for PTST this tensile strength of the EPS geofoam 216.16 and corresponding the strain at failure is 2.62 percentage. Now, for a density of EPS geofoam 22 kg per meter cube, this as for PTST the tensile strength of EPS geofoam is 246.88 kilopascal and corresponding

stain value at failure is 2.63. For the density of EPS geofoam 30 kg per meter cube, the tensile strength of the geofoam material as for PTST is 411.56 kilo Pascal and corresponding strain is 2.74.

So, if you can compare the both the ASTM and the PTST method, you find there is almost the similarity of the tensile strength and the corresponding the strain at failure. So, there is no differences between the ASTM specification and with the IIT Bombay propose tensile strength machine. As we see in our case that sample preparation is very easy. You can take a panel of the EPS geofoam whose thickness will be about 25 millimeter and then you can cut the sample in the eye shape. So, it is easy to cut in the eye shape and then, you can perform the test of the EPS geofoam material.

So, your having quite good or reasonable result with respect to the ASTM test specification or method. So, for the present IT model, it will be very easy to prepare the sample and to perform the test. So, so far we discussed about the tensile strength of the EPS geofoam material and the different density of the EPI geofoam as for ASTM method and as well as for the IIT Bombay method.

So, now we want to discuss the shear properties of the EPS geofoam material. So, shear is important, one of the properties because there will be the shear between the geofoam to geofoam material; what there may be the shear between through geofoam in the concrete geofoam in the soil or geofoam with any other foreign material, when will come in contact. So, how you have to perform the test the shear properties of the geofoam material?

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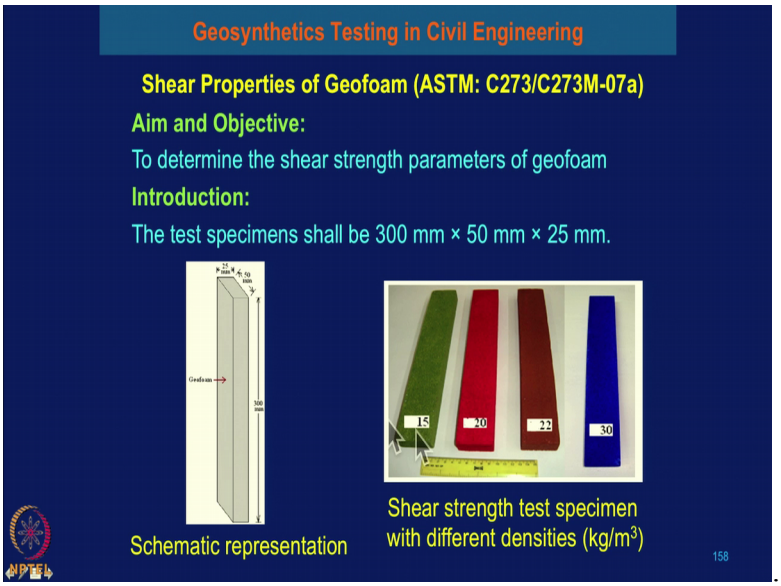

This is as for ASTM C273 and this is as for ASTM C273 C273M-07a. So, here main objective to determine the shear strength parameter of the EPS geofoam material and this test specimen shall be 300 millimeter by 50 millimeter into 25 millimeter. So, here you can see that this is the EPS geofoam specimen and this is about 300 millimeter and this side is 25 millimeter and this side is the 50 millimeter; from here to here 50 millimeter; here to here 25 millimeter and from here to here is about 300 millimeter.

So, this is the schematic representation of the EPS geofoam material. Here the shear strength test specimen with different density. So, this is for 15 kg per meter cube and this is the EPS geofoam with density is 20 kg per meter cube, this is the EPS geofoam with density about 22 kg per meter cube and this is the EPS geofoam with density 30 kg per meter cube. So, will perform all the test under all the different density of the EPS geofoam material.

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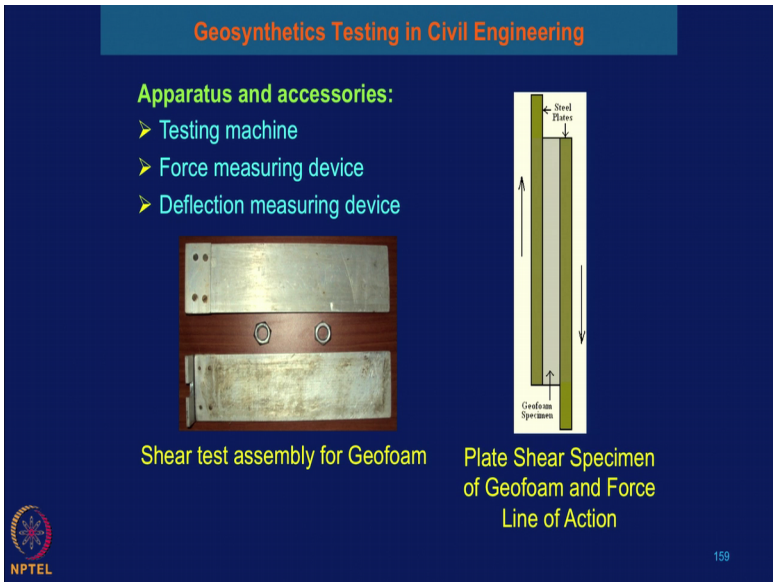

So, for this kind of the test you recall that apparatus; what kind of apparatus you want to use and how you will perform the shear between the two geofoam material? So, here I will show you that apparatus that is required testing machine and this is force measuring device and deflection measuring device.

So, this is the shear stress assembly for geofoam, it is developed in IIT Bombay and you can see here this one plate on the left hand side, another plate in the right and geofoam EPS geofoam material is placed between the 2 plates, it is here. So, this plate shears specimen of the EPS geofoam and the force of line of action. So, it is acting on the acting upon and this is also force acting in the downward. So, this is the steel plate. So, you can perform the test using this shear machine.

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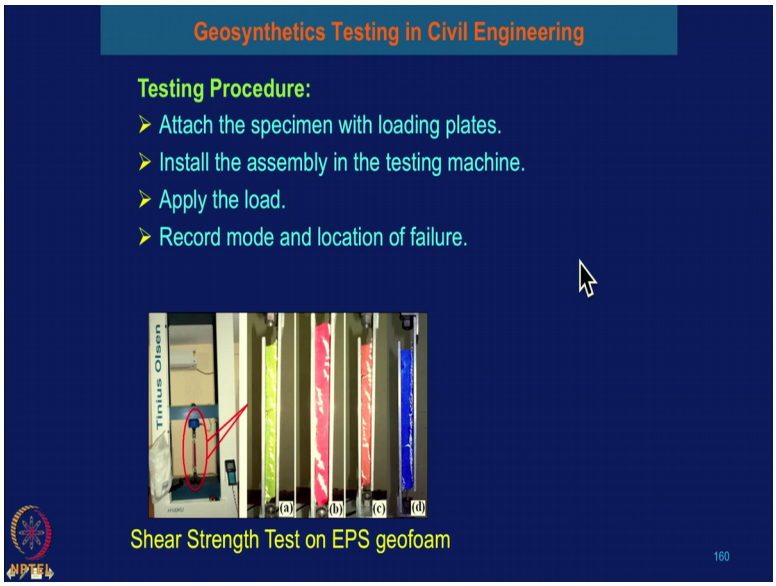

So, from this testing method, how you are attaching the sample and what will be the testing procedure that I wanted to show you. Here you can see that attach the specimen ok. This is the specimen attached with the loading, loading plate and here is the attached with the loading plate and install the assembly in the testing machine and then you can apply the load and record the mode and the location of the failure.

So, here it is the shear strain stress shear strength test of the EPS geofoam under different density of the EPS geofoam material. So, now, from this test how you can calculate the shear stress? So, I will show you how to calculate the shear stress of the EPS geofoam material.

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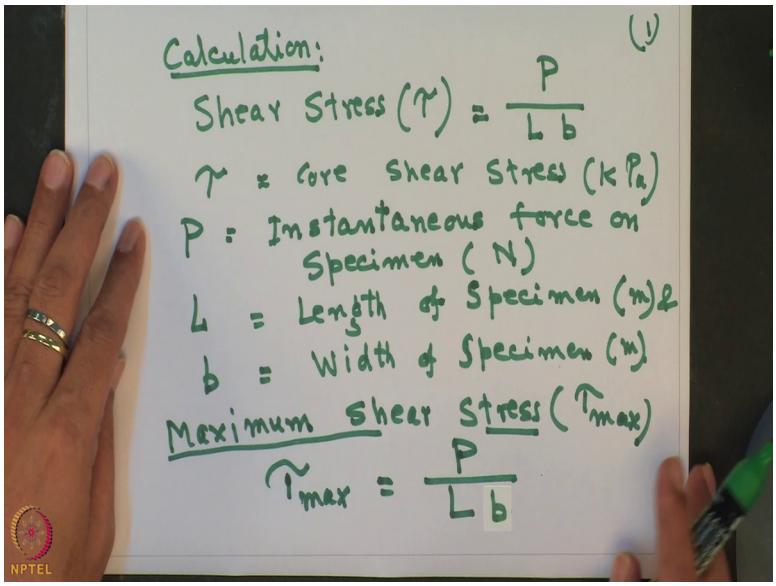

So, here I am showing some calculation how to determine the shear stress. So, it is expressed as tau. So, shear stress tau is equal to P divided by L into b. So, where this tau is the core shear stress ok; so, let us say this tau is the core shear stress and unit is kilo Pascal and P is the instantaneous force on specimen on specimen. So, this unit is Newton and L is the length of the specimen, length of specimen and that is in meter and this is b; b is width of the specimen, width of the specimen and that also in meter.

So, from this test you can determine what will be the maximum shear stress, you can determine maximum shear stress shear stress and that is designated at tau of max. And this tau of max, I am writing that again that tau of max is equal to P divided by L into b. So, this is maximum shear stress you can determine. So, if you know the P, if you know the L, if you know the b, you can determine maximum shear stress value; you can also determine what will be the core shear modulus.

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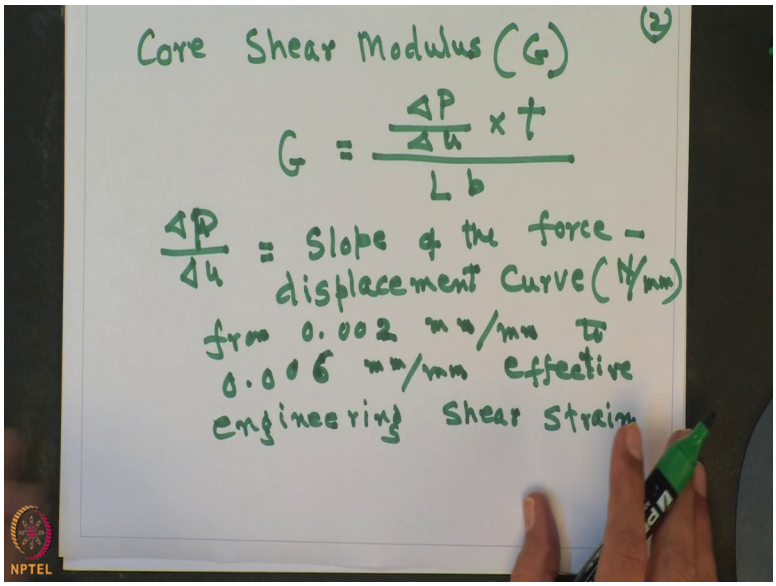

So, you can determine Core Shear Modulus which is designated as G. So, G you can write is del of P divided by del of u into t this divided by L into b. Where, del P by sorry del of P by del of u is equal to the slope of the force displacement curve. So, this is the slope of the force, force displacement curve; that is Newton per millimeter.

And this from 0.002 millimeter by per millimeter to 0.006 millimeter per millimeter effective, effective engineering shear strain engineering shear strain shear strain. So, why I am showing you one the table in this slides that how the specimen calculation for the determination of the shear strength of the geofoam material.

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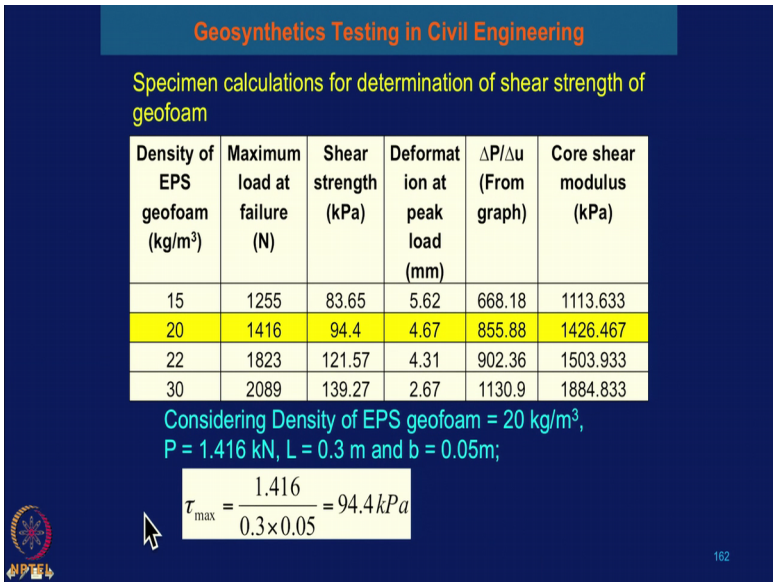

So, this is the density of the EPS geofoam in kg per meter cube for 15, 20, 22 and 30 and this is the maximum load at failure; let us say for 15 density 1255 Newton for 20 density 1416 Newton and for 22 density is 1823 Newton and for 30 EPS density is 2089 Newton. This the maximum load at failure and it determine what will be the shear strength in terms of kilo Pascal. You can see for 15 density 83.65 kilo Pascal; for 20, it is 94.4 kilo Pascal; for 22 is 121.57 kilo Pascal and for 30 EPS geofoam is 139.27 kilo Pascal.

You can measure the deformation at peak load in millimeter is for 15 density is 5.62 millimeter; for 20 density is 4.67 millimeter and for 22 density is 4.31 millimeter and for 30 density, it is 2.67 millimeter. So, from this you can calculate the what is delta P by delta u from the graph. So, this is for 15 density, delta P by delta u is 668.18 and for this 20 density, it is 855.88 and for 22 density, it is 902.36 and for the 30 density, it is 1130.9.

And you can determine: what is core shear modulus. I shown you the earlier equation and from there you can determine the core shear modulus. So, Core shear modulus value is given here for the 15 density, 1113.633; for 20 density, 1426.467 and for 22 density 1503.933 and for 30 density 1884.833 and here, I am showing only one calculation for 20 density. Consider density of the EPS geofoam is 20 kg per meter cube.

And P is equal to the this is 1.416 in kilo Newton and then, you know the P and you know the length of the sample 0.3 meter and you know the width that is about 0.05

meter. So, from the tau maximum; that means, core value you can determine from this 1.416 P divided by L into b. L value is 0.3; b value is 0.05, this is 94.4 kilo Pascal.

So, you can see that shear strength value for the 20 kg per meter cube of geofoam material is 94.4. So, what you find from this shear strength value that shear strength value is increasing with the increasing of the density of the EPS geofoam material. So, this shear strength of the EPS geofoam is required, when there is a interaction between the geofoam to geofoam material.