Geosynthetics Testing Laboratory
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Lecture – 21
Flexural Properties and Flammability Test of Geofoam

I am Professor J. N. Mandal; Department of Civil Engineering, IIT Bombay. I earlier explained how to determine the flexural strength of different types of EPS geofoam material. I will show you what are the properties of flexural strength of EPS geofoam can be determined. And how we can calculate; I will show particularly one type EPS geofoam material densities, now you have calculate it.

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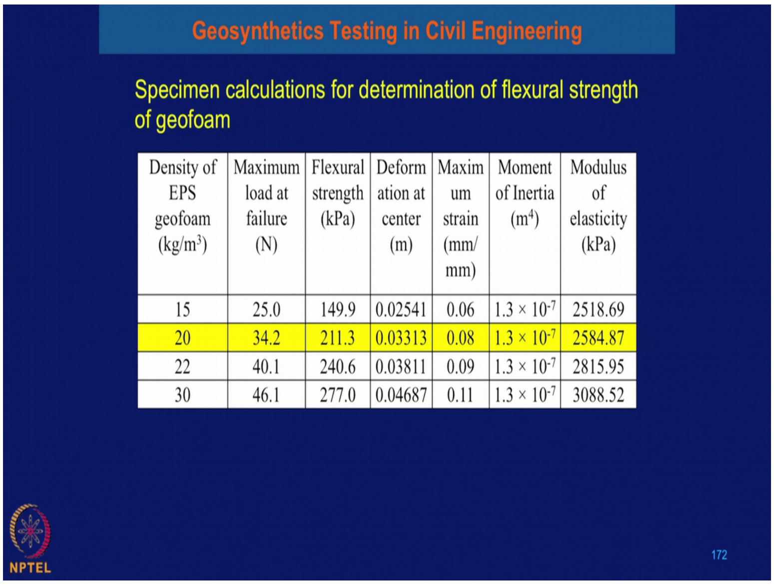

Density of EPS geofoam (kg/m³)	Maximum load at failure (N)	Flexural strength (kPa)	Deformation at center (m)	Maximum strain (mm/mm)	Moment of Inertia (m⁴)	Modulus of elasticity (kPa)
15	25.0	149.9	0.02541	0.06	1.3×10^{-7}	2518.69
20	34.2	211.3	0.03313	0.08	1.3×10^{-7}	2584.87
22	40.1	240.6	0.03811	0.09	1.3×10^{-7}	2815.95
30	46.1	277.0	0.04687	0.11	1.3×10^{-7}	3088.52

So, in this table, that some specimen calculation for the determination of the flexural strength of geofoam. So density of geofoam 15, 20, 22 and 30; so maximum load at failure which we obtained you know for 15 density; it is 25 Newton, for 20 density of EPS geofoam 34.2 and 22 density of EPS geofoam; 40.1 and 30 density of EPS geofoam 46.1 this is a maximum load at failure.

So, from this we have calculate the flexural strength for 15 kg per meter cube EPS density, the flexural strength of the EPS geofoam 149.9 for 20 density 211.3 kilo Pascal, for 22 density it is 240.6 kilo Pascal flexural strength of EPS geofoam. And for 30 EPS density the flexural strength is 277.0 kilo Pascal. You can also measure the deformation at the centre for 15 density 0.02541 meter, for 20 density it is 0.3313 meter and for 22 density; it is 0.03811 meter and for 30 density 0.04687.

And you can determine what will be the maximum strain millimeter per millimeter that is for 15 density 0.06, for 20 density 0.08, for 22 density 0.09 and for 30 density 0.11. From this data you can also determine what will be the moment of inertia that is m to the power 4, where 20 density 1.3 into 10 to the power minus 7, for 20 density 0.08; 1.3 into 10 to the power minus 7. And for 22 density it is 1.3 into 10 to the power minus 7 and for 30 density also 1.3 into 10 to the power minus 7.

You can calculate also the modulus of elasticity of EPS geophone; for 15 density 2518.69 kilo Pascal, for 20 density 2584.87 kilo Pascal and for 22 density it is 2815.95 and for 30 density 3088.52 kilo Pascal. So, for the different density of the EPS geofoam, you see that modulus value also is increasing. And this flexural strength of the is very important in various application of civil engineering project. And I will show you for a particular density of 20 of EPS geofoam with density is 25 kg per meter cube. And how we have calculate it the value of the flexural strength etcetera.

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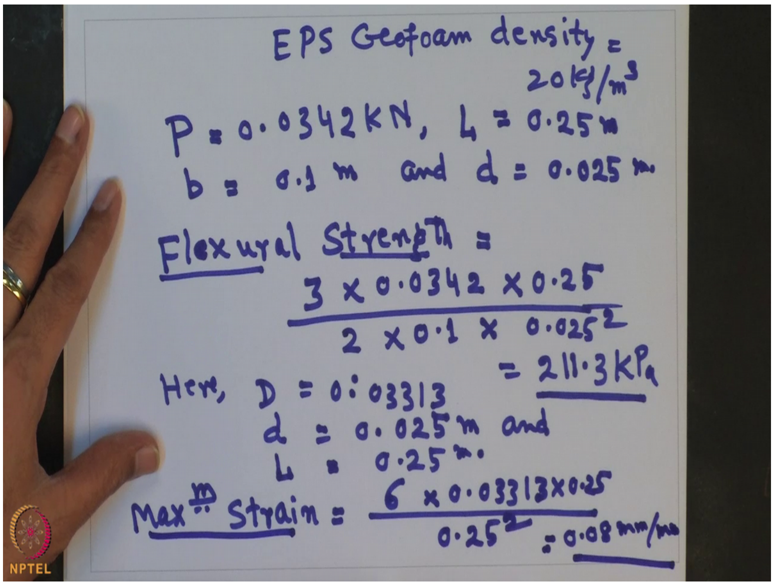

So, we are considering that EPS geofoam density is let us say EPS geofoam whose geofoam density is 20 kg per meter cube; EPS density showing here.

Let us consider the EPS geofoam density is 20 kg per meter cube. So, let us say from the testing result you obtain that P is equal to 0.0342 kilo Newton ok. And length of the EPS geofoam material is 0.25 meter and b is equal to 0.1 meter and depth d is equal to 0.025 meter. So, from this data you can calculate, what will be the flexural strength; so, flexural strength flexural strength this will be equal to 3 into P 0.0342 into length 0.25 this divided by 2 into b; 0.1 into d square; that means, 0.025 this square.

Here d is equal to see we can calculate this then you can have the 211.3 kilo Pascal. So, flexural strength we calculated 211.3 kilo; Pascal; now d is equal to 0.03313 kilo Pascal; small d is equal to 0.025 meter and L is equal to 0.25 meter. So, you can determine from this data what will be the maximum strain; so maximum let us say strain is equal to 6 into 0.03313 into 0.25 this divided by 0.25 square; this is 0.25 square.

So, this will give the maximum strain value is 0.08 millimeter by millimeter; so this is the maximum strain is this. So, what I showed you earlier in this table? You can see that flexural strength is 211.3 and the maximum strain is 0.08; that means, here the flexural strength is 211.3 kilo Pascal. And the maximum strain value here maximum stain value is 0.08 millimeter per minute.

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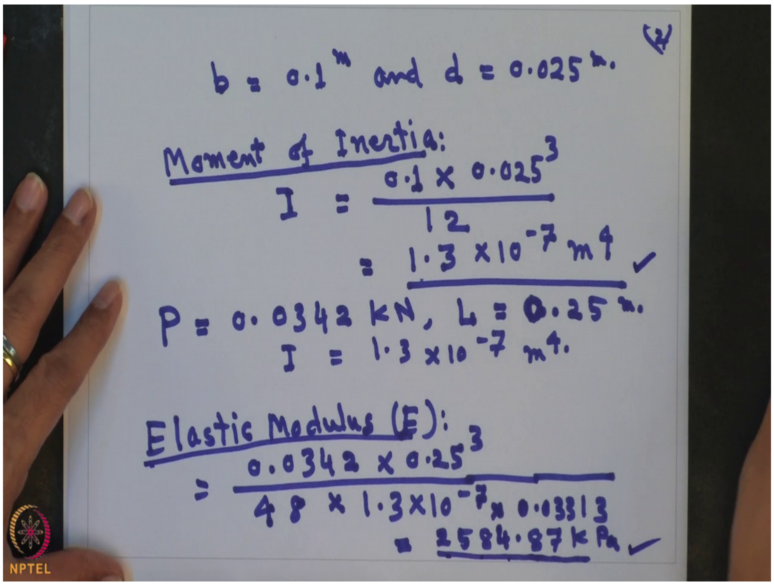

Now, if b here is 0.1 meter and d is equal to 0.025 meter; so you can calculate moment of inertia, moment of moment of inertia that is I will be equal to 0.1 you know bd to the power cube; that means, 0.025 cube; this divided by 12 ok. So, this moment of inertia if you calculate we can have 1.3 into 10 to the power minus 7 meter 4. So, you can calculate moment of inertia is equal to 1.3 into 10 to the power minus 7 meter 4.

Now next we will calculate this elastic modulus; so, for this you know P is equal to you know 0.0342 kilo Newton; L is equal to 0.25 meter and you know that I, I you know that is 1.3 into 10 to the power minus 7 meter 4. So, you can calculate elastic modulus, elastic elastic modulus; the designated at E, E will be equal to 0.0342 that is P into 0.25, this is cube P L to the power cube.

And this divided by 40 of 8 into 1.3 into 10 to the power minus 7 into your 0.03313; 0.03313. So, if you can calculate you can have 2584.87 that is kilo Pascal. So, so elastic modulus this is 2584.87 that is kilo Pascal; so you calculate the moment of inertia, you can calculate the elastic modulus E. So, in this they will also it is shown that we have calculated maximum strain 0.08 and this is the moment of inertia 1.3 into 10 to the power minus 7 meter 4. And this is the modulus of elasticity 2584.87 kilo Pascal for a density of 20.

So, here also we have calculated that moment of inertia 1.3; 10 to the minus 7 and elastic modulus value is 2584.87. So, this way you can you know the equation; so, you can calculate the movement of inertia and more elastic modulus of EPS geofoam material. Now I will discuss the flamability test on the expanded polystyrene material or EPS material as per the code specification IS 4671 1984.

Because this material is combustible; so, you cannot keep it on the open sunlight. You all it prefer to cover with some the soil on the top of the EPS geofoam material. Even then when if you stock any kind of the EPS geofoam material, you should always cover it and sometimes if the you know that when the EPS come in contact with the gasoline or acetone or the petrol or diesel; so, it will destroy or it eliminating.

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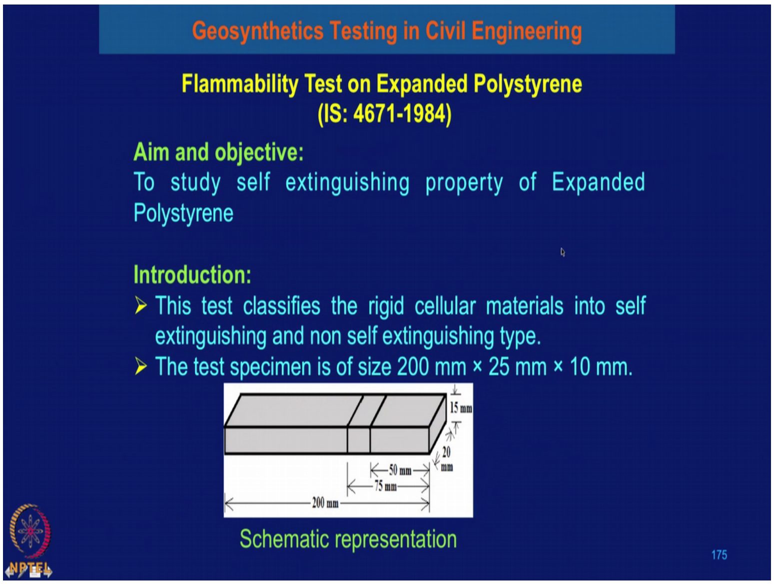

So, here for this test flammability test on expanded polystyrene; so, main objective of this test to study self extinguishing property of expanded polystyrene. So, these test classify the rigid cellular material into self extinguishing and non self extinguishing type.

The test specimen size here you can see the test specimen size is about 200 from here to here is the 200 millimeter and from here to here is 75 millimeter and from here to here it is 50 millimeter. And sample size is from here to here, which is 20 and from here to here it is the 15 millimeter; that means, test specimen of size is 200 millimeter into 25 into 20 centimeter; so, this is the sample size.

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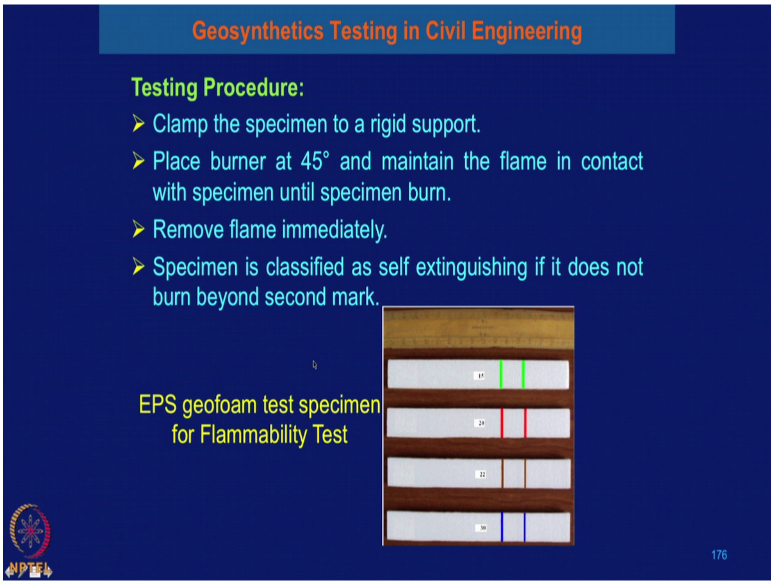

So, the testing procedure is that you clamp the specimen to a rigid support and place the place the burner at an angle of 45 degree and maintain the flame in contact with specimen until the specimen burn. Remove the flame immediately and specimen is classified as self extinguishing if it does not burn beyond the second mark.

I will show you the 2 mark and what parts of the mark it with go, then you will be able to say that it is a self extinguishing and if beyond that then the sample will not be considered. So, here in this figure we can see some EPS gefoam test specimen of flammability test. So, there are 2 line has been drawn here I will show you that what will be the 2 line. And this is the different types of the density of the EPS geofoam is shown here, it maybe 15, 22, 20 and 30 density of EPS geofoam material.

Now, how to how to perform the test and how to part this EPS geofoam material and the; what angle and their part should go certain distance not beyond the certain distance.

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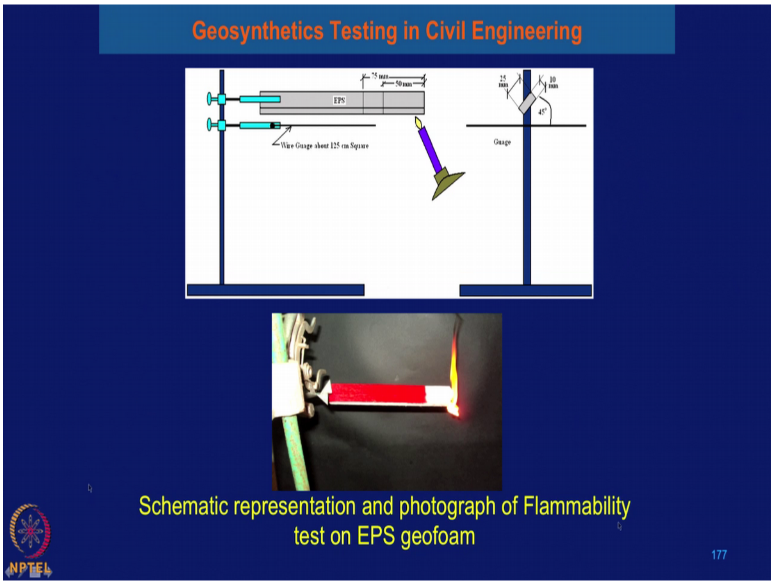

So, here I am showing that we can see we can see here and this is the; this is a specimen is straitening here. And this distance is the 50 millimeter and this is the 75 millimeter. And this sample is tightened, this sample is tightened; this is the wire guage around 1.25 centimeter and this is making at an angle of 45 degree and then you burn.

You can see here then you lied this EPS geofoam material and it is burning. And it should reach up to this not beyond that if it is does behind this mark, then this material will not be considered a for self extinguish. So, this is the sample this you can see this material is burning; this is the schematic representation and photograph of the flammability test for a particular density of the EPS geofoam material.

I will show you that after this claim and what how much this; it has reached and how it stop the burning.

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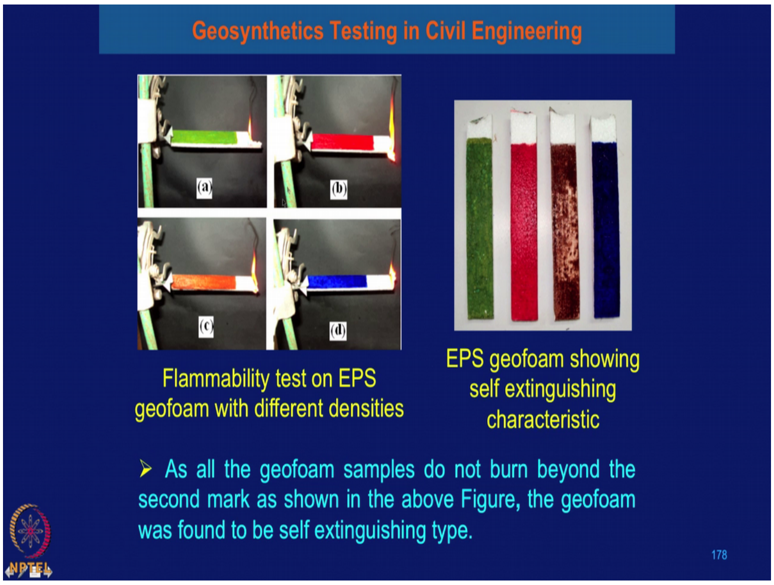

If you can see the next slide here; this is the flammability test on the EPS geofoam with the different density; this is 20, this is 22, this is 23 and this is 30 of density of EPS geofoam.

And after the test you can find here, you can see that it reached up to this not beyond this it reach up to this; that means, EPS geofoam showing self extinguish characteristics; it goes here not beyond this. Next density you can see it reach says here; not beyond this line; it reaches here not beyond this line. So, these are the shown for different density of the EPS geofoam and showing the self extinguishing characteristic.

So, as the all geofoam sample do not burn; this beyond this second mark which I have shown you the second mark here. It is beyond the second mark as I have shown in this figure; so, geofoam was found to be self extinguish style. So, we have some idea that how to perform the test this test is very simple and you always keep it in mind that flames parts should not go beyond that second line, then it will not be the self extinguish.

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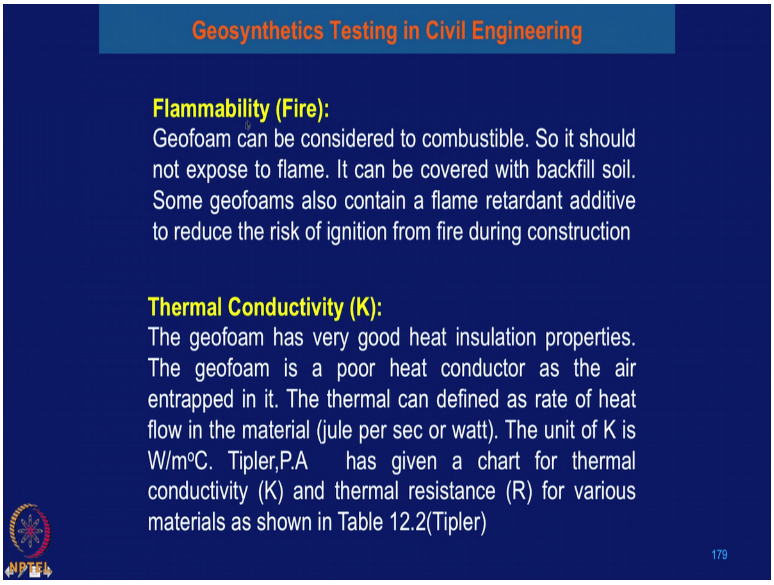

Now flammability mean; this is a fire, so geofoam can be considered a; to combustible. So, it should not exposed to flame as I told you it should not express to any flame and it can be always covered with the backfill soil, some geofoam also contain a flame retardant additive to reduce the risk of ignition from during the construction.

So, you know that how to how to perform this kind of the test; apart from this kind of the flame, flame test; we have the some other test, which you call the thermal property or thermal resistance or thermal conductivity. Now this is important that thermal resistance and thermal conductivity of the EPS geofoam material.

In case of the refrigerator or if you want to store the any kind of the food and when the water level that is certain depth. So, you have to construct a foundation construct a house or a container in water that water level should not the reach and the top of the refrigerator or the container; so, there will be a difference in the temperature. So, if the difference in the temperature in the conventional method most of the cases we use the gravel and the concrete as a thermal insulation.

So, now, alternative to this system and you can adopt the EPS geofoam material instead of the gravel. And you can observed that what will be the difference in the temperature; how much you can save the water that just I will show you with one of the example.

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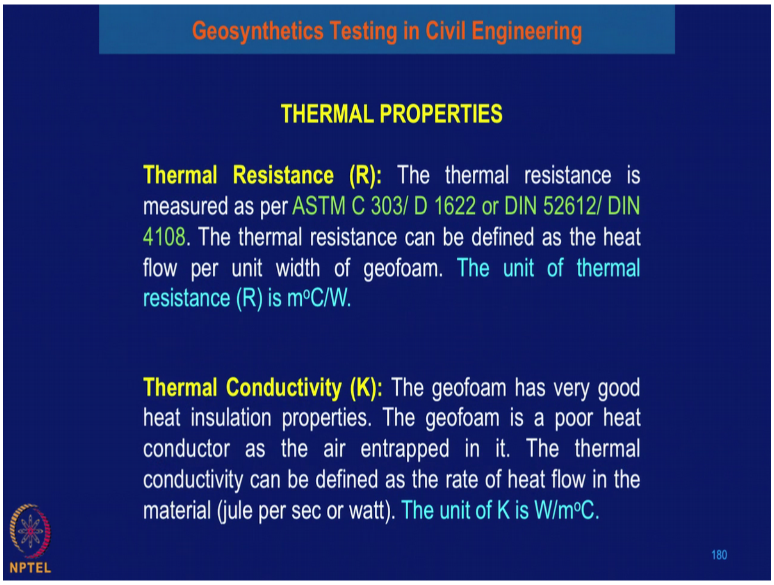

But you just to know that thermal property thermal resistance of the EPS geofoam material, the thermal resistance is measured as per ASTM C 303 D 1622 or DIN that is German specification 52612 or DIN 4108. And thermal resistance can be defined as the heat flow per unit of geofoam, the unit of thermal resistance R is m degree Centigrade per Watt; so, as you have studied in the subject of physics.

And similarly what is thermal conductivity that is designated at K. So, geofoam has very good heat insulation property; so geofoam is poor heat conductor as the air entrapped in it. The thermal conductivity can be defined as the rate of heat of flow in the material that is designated at jule per second or the watt and the unit K is Watt per m degree centigrade.

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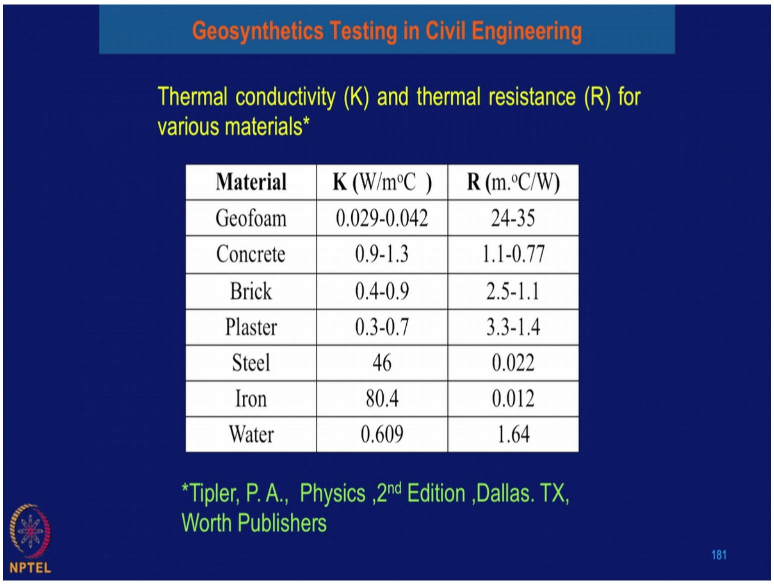

. So, I will show you this one of the slide that what is the thermal conductivity K and thermal resistance R for various material? So, you can obtain the thermal conductivity of the different material geofoam, concrete, brick, plaster, steel, iron and the water. So, this is the K thermal conductivity; these are the value is given and this is the thermal resistance R for the different types of the material. We can we can observe here what is the thermal conductivity and thermal resistance for the geofoam and other materials.

I will just show you that one example that how you can you can determine the thermal conductivity of a material.

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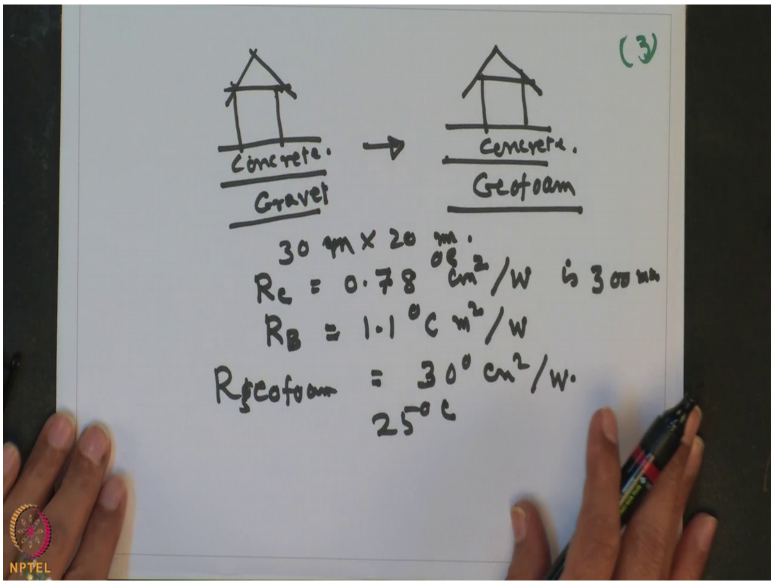

For example, you want a construct a house and here and the lower part is the concrete and this part is the gravel. So, alternative to this you can construct the any kind of the house; let us see here and this top part let us say concrete and bottom part is the geofoam material.

So, let say the building area is 30 centimeter into 30 meter into 20 meter and thermal resistance of the concrete let us say it is given you can have from the table also 0.78 degree centimeter square watt is 300 millimeter, rest on gravel or the concrete. Now thermal resistance for the brick is 1.1 degree centigrade per meter square per watt; this in the traditional system what we adopt.

Alternatively, if we add of the geofoam system then thermal resistance of the geofoam or EPS geofoam; thermal resistance of the EPS geofoam is 30 degree centimetre square per watt. And temperature between the ground and the basement is let us say 25 degree centigrade. Now, you have to find out what will be the; what will be the difference in the temperature between the 2 system? So, one system conventional another system is the concrete geofoam material. If you add of these 2 system you can calculate that what should be the temperature difference between these 2 system?

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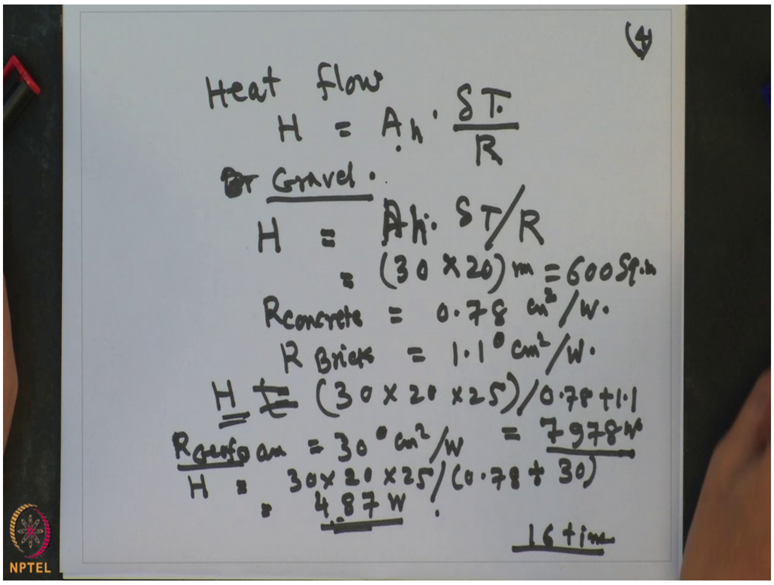

So, you know that equation for heat flow; heat flow that is H is equal to A h into delta T divided by R. So, delta this H is equal to heat flow A h is equal to cross action area of the heat flow and delta T is the different temperature across the material and R is equal to thermal resistance.

So, when you use the let us say or the gravel; when is gravel or the brick that is the traditional method if you adopt, then heat flow H will be equal to A h into delta of T, this divided by R; that means, A h is 30 that is area A h 30 into 20 meter; so this is 30 into 20 meter; that means, this will be giving about 600 square meter. And R of concrete is 0.78 centimeter square per watt and R of brick is 1.1 degree centimeter square per watt.

So, we can calculate the H will be equal to 30 into 20 into 25 this sorry this divided by 0.78 plus 1.1. So, if you calculate; you can have the heat about 7978 watt; whereas, if we use the geofoam material ok. So, let us say R of geofoam is equal to 30 degree centimeter square per watt. So, if you can calculate the H will be equal to 30 into 20 into 25; so this divided by plus 0.78 plus 30.

So, if you can calculate you can have 487 watt; so, when if you use geofoam watt say 487 watt, when you use the conventional method that heat generated is 7978; that means, it is 16 times less, when you use the geofoam material. So, you see from this example; if we use the expanded policy in geofoam material that heat can be substantially can be decreased with respect to the conventional method.

Thank you.