Geosynthetics and ReinForced Soil Structures
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Lecture - 8
Testing of Geosynthetics – III

Good morning students, let us continue our discussion on the testing of geosynthetics in the previous lectures.

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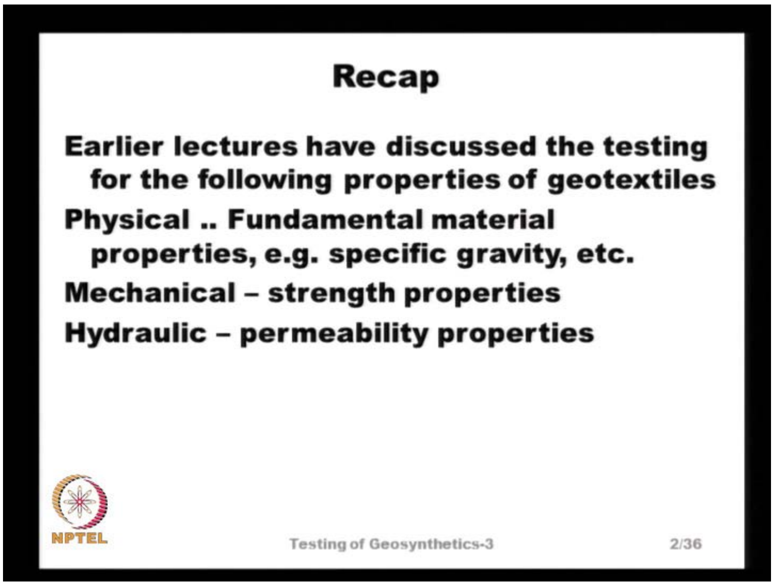

We have discussed the different tests or that we can perform on the geotextiles on the on the strength of the geotextiles, and then the hydraulic and filtration properties of the of the geotextiles, and by for the geotextiles have the maximum number of applications in very diverse areas like the pavements. And the railway tracks and the retaining walls as a separator or as a as a reinforcemental air and so on. So, the number of tests that we have for the geotextiles is very large and there are few more test that we can perform on the geotextiles, those are listed here the abrasion resistance test the durability properties melt flow index ashphalt retention and so on.

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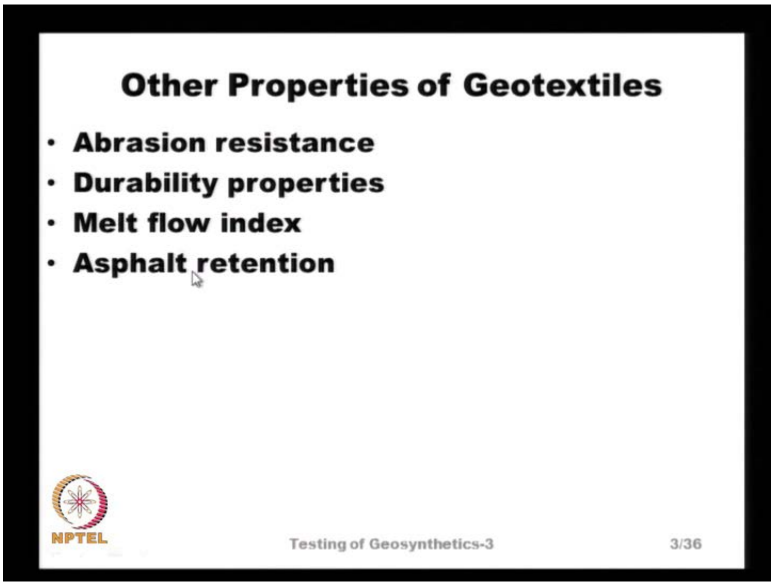
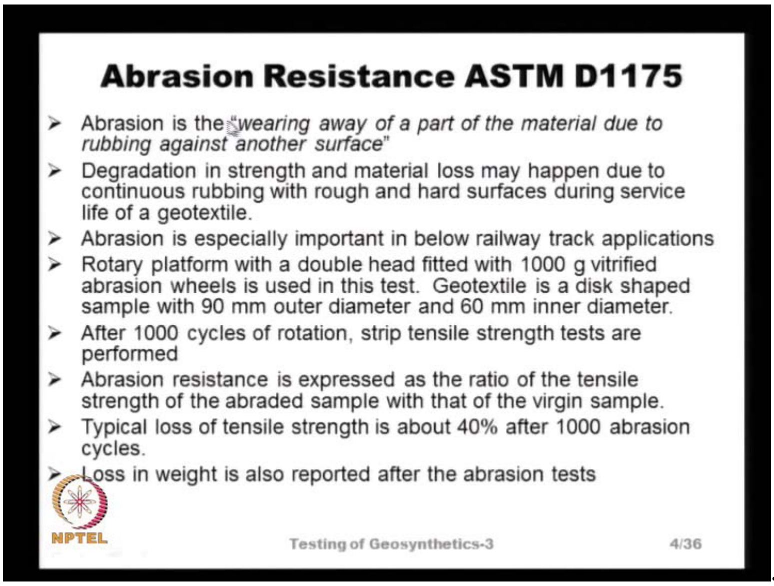


The abrasion is defined as the wearing away of a part of the material, due to rubbing against another surface just imagine that you have a product and you continuously rub.



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It against some hard surface reputedly, and after some time the surface gets eroded or the material may degrade say if you have a oven geotextile the the view pattern might change or if you have a non oven geotextile some of the fibers might come out. And because of that the strength may change or structurally it may under goes some changes with larger openings, and so on. And the degradation in the strength and the material loss may happen due to continues rubbing with rough, and hard surfaces during the service life of a geotextile. And especially the abrasion is a very important factor to be considered in the railway track applications because under the railway tracks the geotextiles or the geo geosynthetics are subjected to repeted loading at a very high frequency and. So, there are two different test that we can perform.

One is the ASTMD; 1175 in which we use a e use a circular disk of a geotextile having outer diameter of ninety millimeters, and inters inner diameter of 60 millimeters on that we move an abrasion wheel of some standard dimensions. And after thousand cycles of rotation we perform strip tensile tests on the abraded sample to determine the abrasion resistance.

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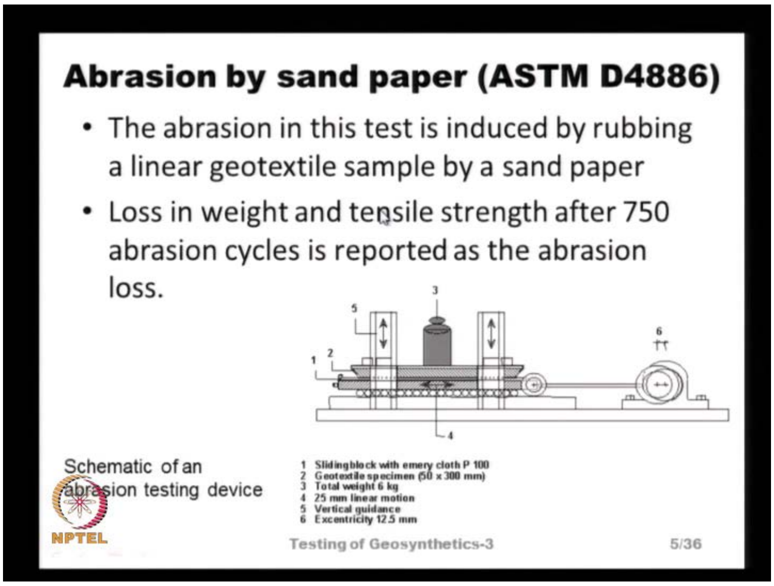

The abrasion resistance is expressed as the ratio of the tensile strength of the abraded sample with that of the virgin sample that is a fresh sample in the typical loss in the tensile strength is about 40 percent after about a 1000 abrasion cycles. And we normally also report the loss in the weight along with the loss tensile tensile strength where as the previous method is performed an a on a circular sample on a rotating wheel there is another test that is the ASTM D4886, this is done by using a sand paper this schematic of this operators is shown here. Here we take a linear sample and this abrasion is induced in in linear direction like both this side and that in the backward side and so on.

And the once again a we look at the loss in the weight, and the loss in the tensile strength,, but this time this is after 750 abrasion cycles, and schematic of this operators is shown here we have the sliding block with with memory paper that is the sand paper of grade 100. And this is this moves horizontally, where as the geotextile specimen of size fifty millimeters by three hundred millimeters is fixed and the just above the the sand paper. And then we apply a load of six kilo grams as professor the standards and then we subject this to linear motions of 25 millimeters and then after seven hundred fifty abrasion cycles. We remove the sample and then perform the the test like the we take the weight, and also we perform some tensile strength test in this case this the strip tensile strength test to assist the damage that the geotextile undergoes under this abrasion test later.

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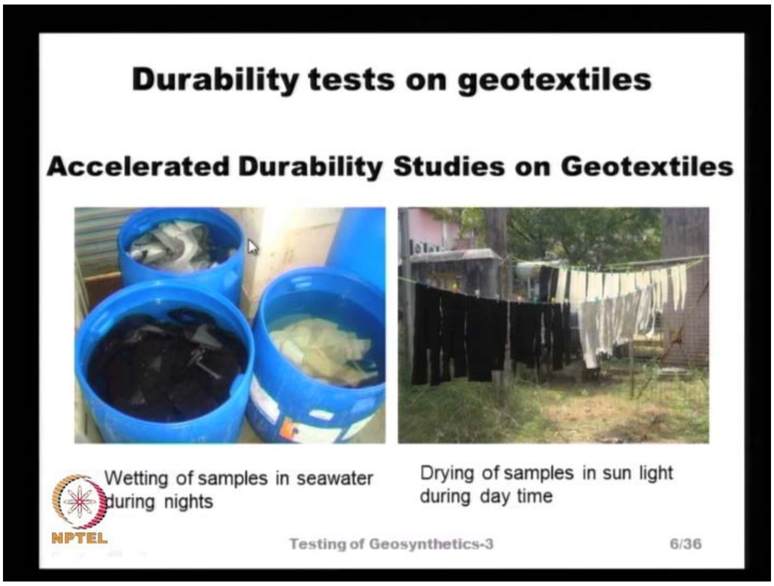

The varieties of durability tests that we can perform the durability is basically how best the geotextile preserves it s tensile strength, and the other properties after repeated exposed it to some atmospheric like either the sun light or the wind or the wave action and so on.

In this particular case I am showing you some results from durability test on geotextile it exposed to marine environment, and on the left hand side, you see some geotextile samples, that are emerged in sea water this is actually these tests there called is a accelerated tests. Because the repeatedly these samples are repeatedly dipped in sea water during the nights when there taken out during day time and allow to dry in the sun light and. So, because of that these geotextiles they are subjected to lot of changes the emersion in sea water and then the drying in the sun light, and because of that the some type of geotextiles may lose the strength and this particular this particular test, they were performed to assist the their suitability for applications in the coastal protection structures.

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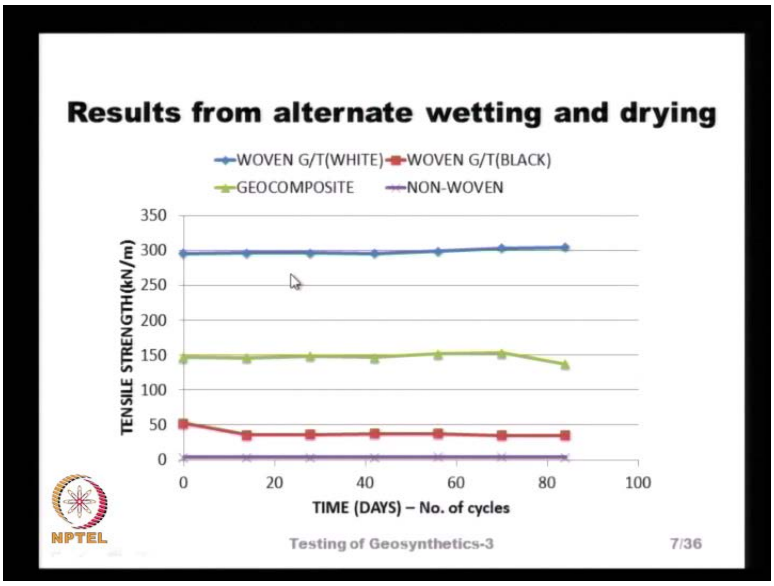

And when we plot the the number of cycles on the x axis against the tensile strength, and the you axis the results are something like this the blue one is a oven white geotextile, and as I mentioned earlier the oven geotextile, they have very high strength. This particular case their initial strength is 300 kilo newtons per meter and their strength more or less remained constant. And then this another geocomposite that consist of both geotextile and and geogrid, and that also has very relatively high strength of one fifty kilo newtons, which are more or less remained constant. Then there is another type of geotextile the once again the woven that has undergone some loss in the strength initial loss which has remained constant, then the non woven geotextiles they have very low strength of the order of about 10 kilo newtons per meter. And their strength has not changed during the during this alterantive wetting and drying cycles.

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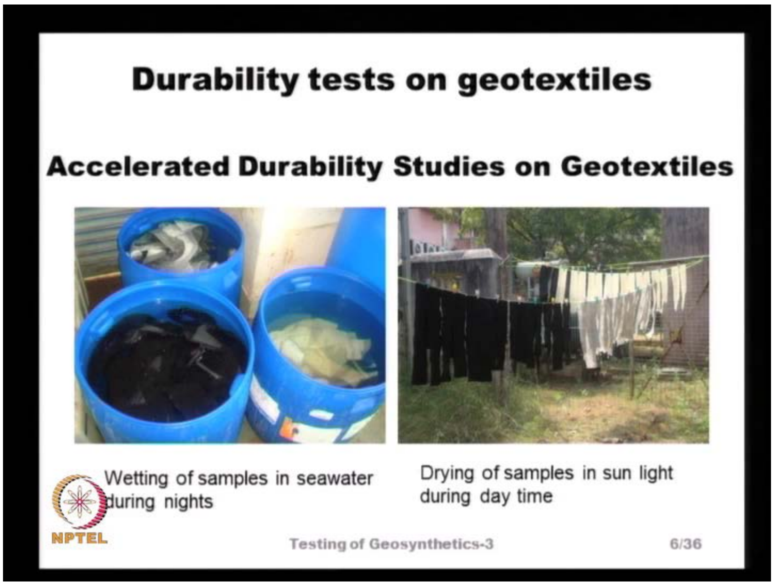

Basically the durability test they tell us how durable the material is with repeated exposed atmospheric or at loading we also apply the geotextile as paver fabrics this paver fabrics are overlay fabrics there also called as overlays.

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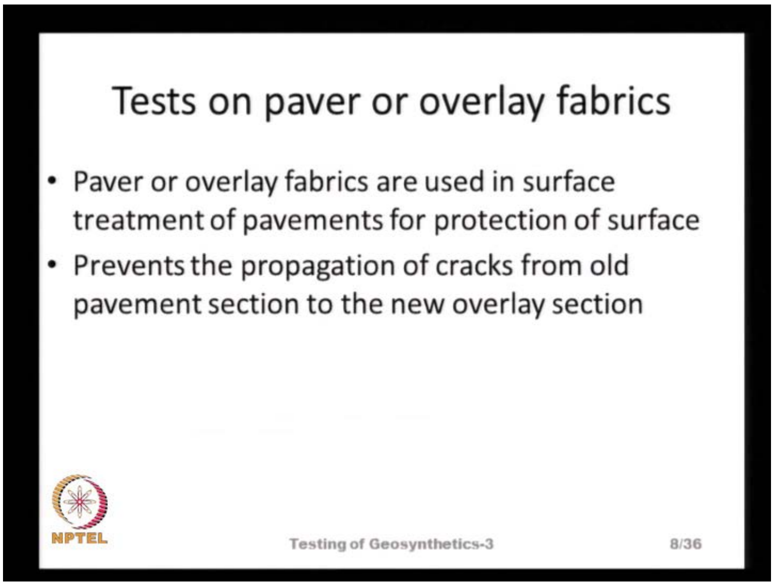

Because they are laid on top the existing pavement surface. So, they are used frequently in surface treatments of pavements for the protection of the surface, and basically these overlay the purpose these overlay fabrics is tom prevent the propagation of the reflection cracks.

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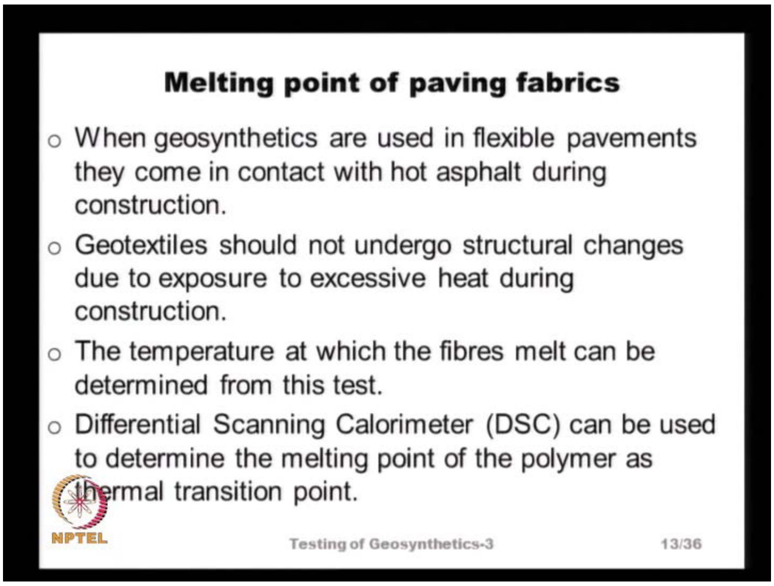

When we apply this geotextiles on the pavement applications we should make sure that the geotextile is not adversely affected, because of the the high heat of the bitumen because the bitumen is placed in the in the pavement at 135 degrees. And the geotextile should not undergo any structural changes it should not melt or it should not degrade in its property and. So, the we need to determine the melting point of the geotextile and make sure that it is much above the the temperature at which the bitumen is placed in the in the pavement, basically this melt point indexer melt point of the frame fabric, it measures the temperature at which the fibers in the geotextile melt. And one method that we can use is the differential scanning calorimeter for determining the melt point of the polymer.

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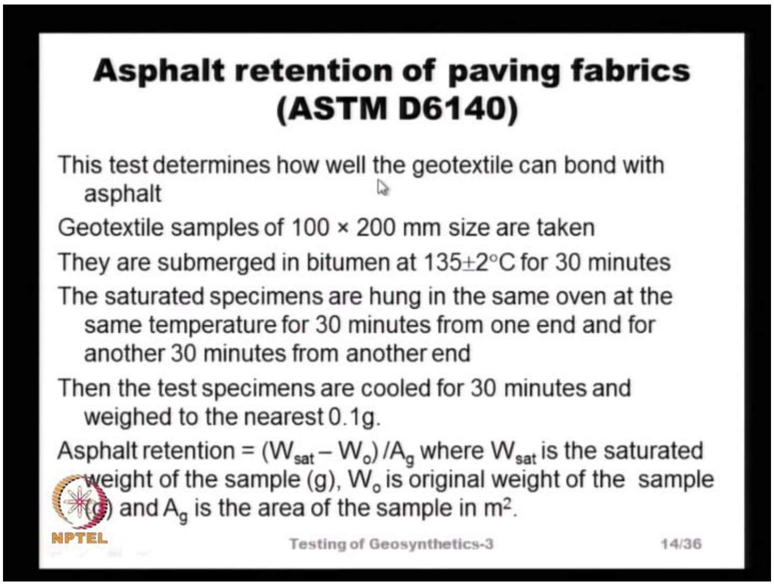

So, basically we look at the thermal transition as the temperature is increased at one point it gives out the heat the the geotextile, and that particular point is captured and t point is defined as the melt point of the the paving fabric. Then another test very important test which we perform is the asphalt retention of the pavement fabrics. Because the once the geotextile is laid, it should be able to hold the the asphalt together, it should not ripple it and this particular test it looks at the compatibility between the given geotextile. And the asphalt and it is a it is a very simple test we take geotextile samples of hundred by two hundred millimeters, and we submerge the the geotextile samples in bitumen in moltan bitumen at one thirty five degree centigrade plus or minus two degrees for thirty minutes.

And these saturated geotextile samples there hung in an oven for 30 minutes from one end for thirty minutes, and from the other end for another 30 minutes, and then these test smaples are cooled for thirty minutes. And there weighed to the nearest point one gram and asphalt retention is calculated as the saturated weight of the the geotextile minus the original weight of the geotextile that is without the asphalt divide by a g a g is the area of the sample in square meters, and the weight they are all given in. So, many grams and the asphalt retention is usually expressed in grams per meter square, and this value should be as high as possible that indicates that the the given geotextile it can interact well with the with the asphalt and it can retain it in place.

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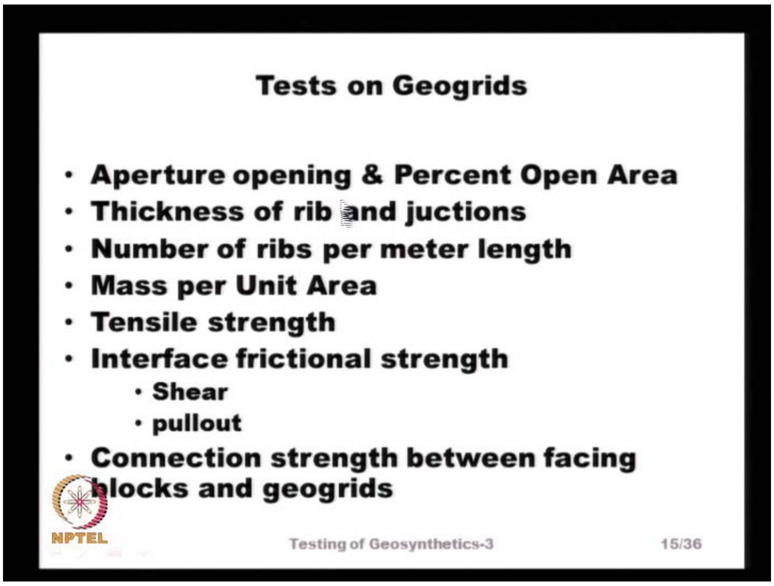

The another geosynthetic that si a very popular is the geogrid unlike the geotextiles these geogrids they have a open apreturs the geotextiles are they are like clothes they have a continues surface whereas, the geogrids they have some aperture openings. So, that they can interlock with this oil and some of the test that you perform in the geogrids their the aperture openings, and a percent open area cause the apereture openings are very important especially when we apply them along with some aggregates.

The aperture openings should be large enough. So, that the aggregates that we use they interlock inside this open area of the of the apertures and contribute. So, that the goegrid can contribute for this strength increase and the we need also look at the thickness of the rib and the junctions and so on. Then the number of ribs per meter length the mass per unit area the tensile strength and of course the other test that we perform along with the soli and aggregate that is the interface frictional strength, and then the connection strength between the facing blocks and the geogrids.

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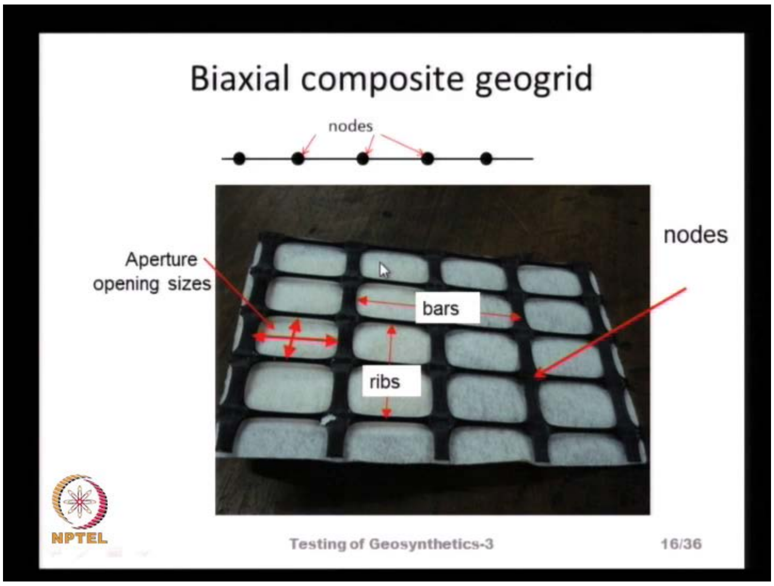

A typical geogrid is shown like this is actually what you are looking at is a geogrid combined with a geofabric any way it does not matter like. We will just look at the geogrid part of it and these open areas they are called as apertures and we have the ribs and the cross bars is actually some people refer. So, these as longitudinal ribs and transverse ribs or in some some other books they are called as ribs and bars. Rib is along the the longitudinal direction where as the bar is in the transverse direction, and we need to look at the aperture opening size in the longitudinal and the transverse direction.

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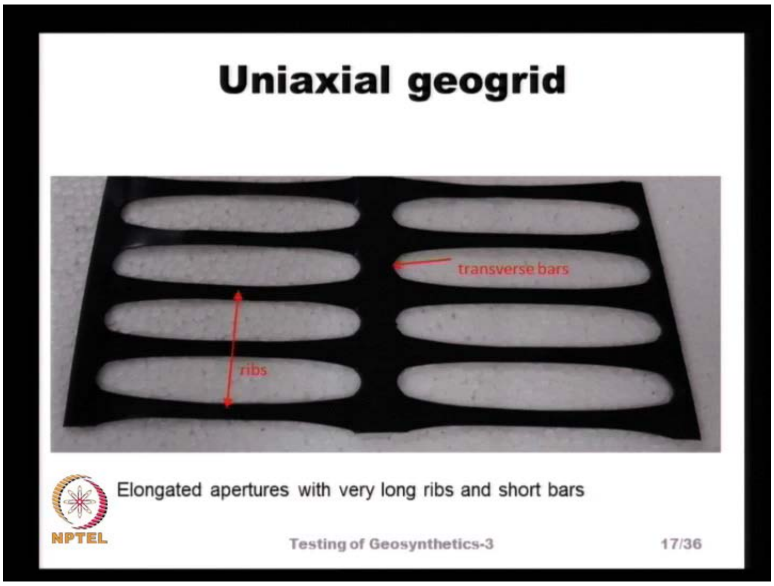

And the thickness and the width of this ribs this of the ribs and the width and thickness of these bars, and these are called as the nodes these junctions, and these nodes they are typically a bit inflated. So, the thickness are the nodes is much higher than the thickness of the of the ribs or the or the transverse bars, and this thickness is normally measured by any of the vernier calipers are something without applying to much of pressure. And this is a an example of uniaxial geogrid this has elongated apertures with very long length very long length for the ribs, and very short length for the transverse bars, and you can see this aperture is very long, but very narrow in the in the transverse direction.

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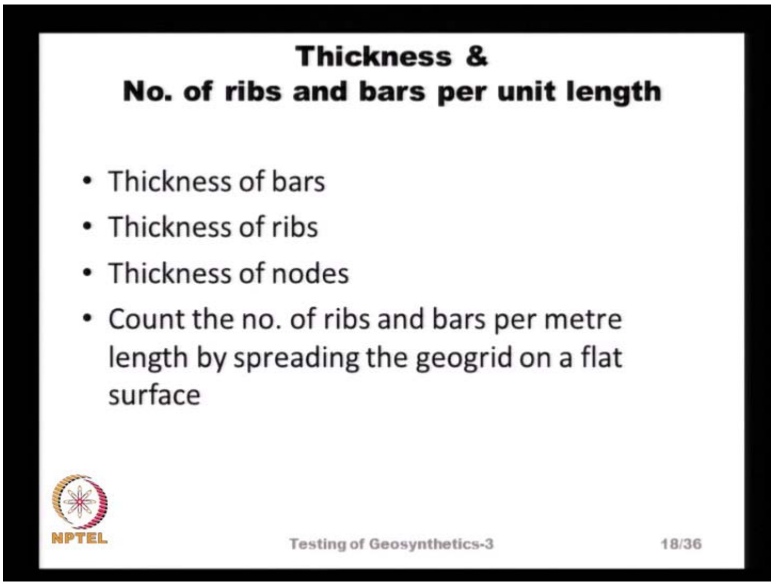

The some of the tests that we perform are we need to dil look at the thickness of the bars thickness of the ribs and thickness of nodes, because when we calculate the pull out resistance or the thickness of the the transverse members, it adds to the passive thickness that we given from the from the transverse members. So, they are refer interpreting the test results we required the thickness, and then we also need to count the number of ribs and bars per meter length by spreading the geogrid on a flat surface. And we count the number of these longitudinal ribs, and then the transverse ribs are the bars, because that is required for interpreting the this strength test data one important property that we have for the geogrids is the percent open area. That is in a unit area of geogrid how much is this this open area, because that constitutes the the amount of interaction that a given geogrid can have with the with the aggregate of the soil, and this test is performed by taking a sample of at least 200 millimeters by 250 millimeters; that is the minimum size.

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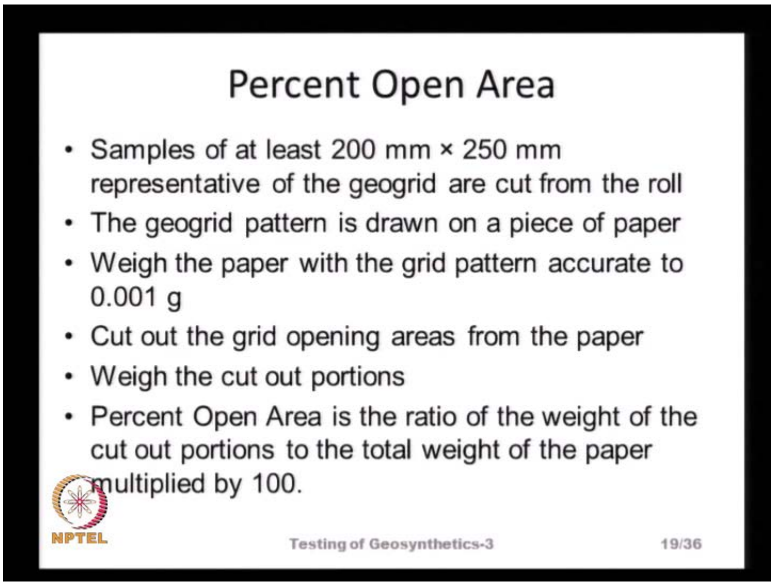

But when we have geogrid like a especially a uniaxial stretched geogrid in some in some cases the rib itself is is has a length of about 200, 25, 250 millimeters. In that case we take a longer sample of the geogrid at least this should be a representative of the geogrid and we cut it from the role and lay it on a on a piece of paper.

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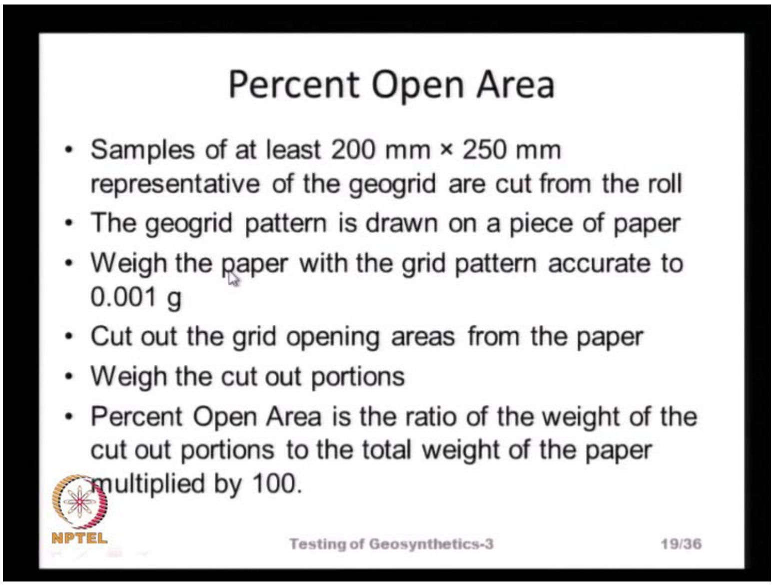

And then we before we do anything we weigh the the paper accurately with the after the grid pattern is drawn, and the outer excess paper is cut. We weigh the paper to an accuracy of point zero zero one grams, and then we mark all the aperture openings on the paper and then we cut out the gird from the paper and then we weigh the we take the weight of the cut out portions. Once again to an accuracy of point zero zero one grams and the percent open area is defined as the ratio of the weight of the cut out portions to the total weight of the paper multiplied by 100 to get the percent. And this percent open area, it should be as large as high as possible consistent with the strength requirements. So, if it is two high then the strength of the geogrid may be low the same time if it is too small then the interaction between geogrid.

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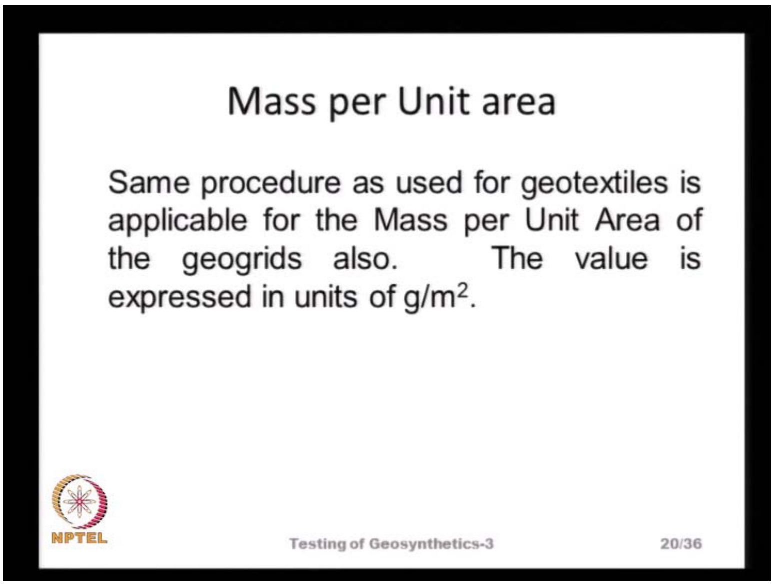

And the the aggregate may not be very good the mass per unit area once again, it tells us the amount of material that is used for producing a given product in in this particular case geosynthetic. And the procedure for doing this test is the same as what we discussed under the geotextiles, and this values expressed in the units of grams per meter square just as how we express for for a geotextile.

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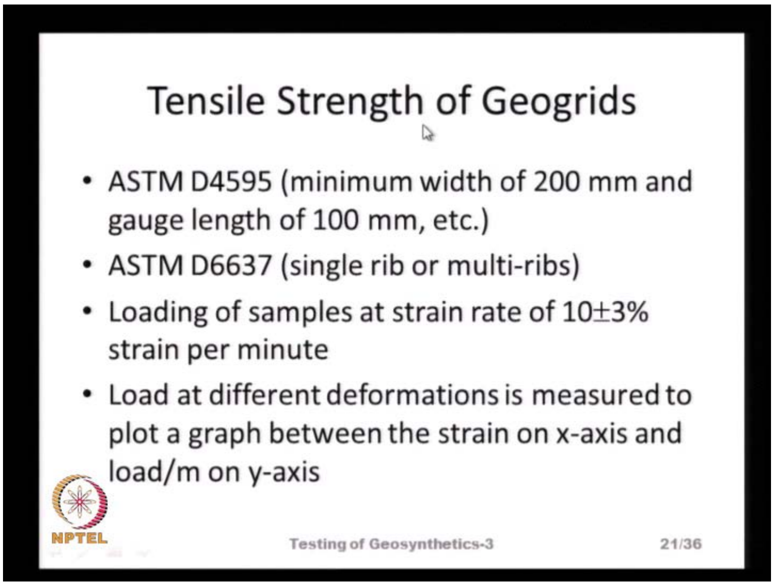

The tensile strength of the geogrids is a very important property because the geogrids are most of an employed as a reinforcement layer and there are different types of… So, tensile tests that we can perform the there is one standard that is the ASTM D4595 that also explains the tensile strength of the geotextile samples here we take a minimum width of two hundred millimeters. And a gage length of hundred millimeters for doing the test and more recent a s t m standard 66 37, it has slightly revised it and we can perform the test either on a single rib or multi ribs. And the loading the samples is at a strain rate of ten percent plus or minus three percent per minute and the the corresponding standard the european code is twenty percent strain per minute.

And we measure the load at different deformations to plot a graph a between the strain on the x axis and the load per unit width on the on the y axis when it comes to the strength of all these geosynthetics. We do not bother about calculating the stress mainly because when we apply the load the thickness goes on changing as we apply higher tensile loads the thickness reduces. And because of that is very difficult for us to keep track of the thickness and s of that the calculating the stress as the applied load divide by the cross sectional area becomes very difficult. And in order to avoid that problem we just simply divide the applied load by the width and not the not the area and the express the the tensile capacity of the geosynthetics as. So, many kilo newtons per meter width.

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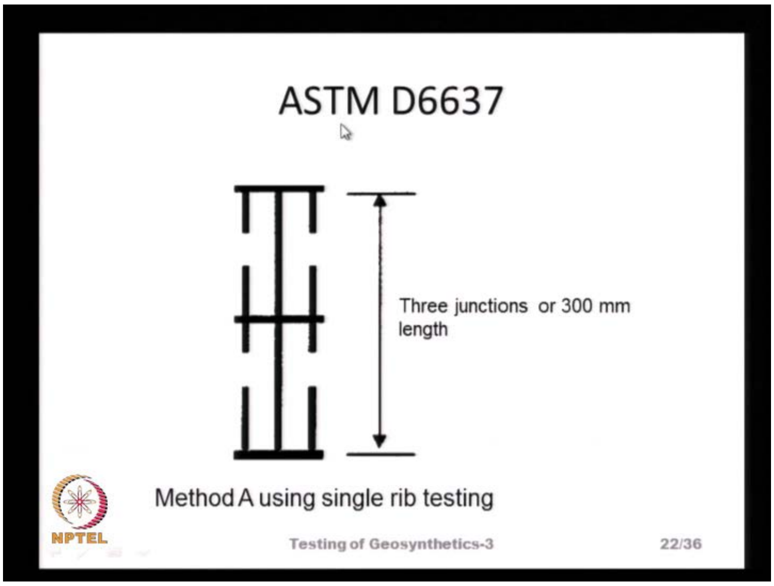

This ASTM D6637 it gives two different methods for testing one is the method a that uses a single rib for testing, and here you see a schematic of the of the geogrid and what we do is we take a few more ribs. So, that we have a good grip of the in the fixtures and and then we cut them out after we fix this geogrid in the clamps or in the in the roller clamps or in the fixed clamps. And then the load is applied on a on a single rib like this and a s t m standard it says that at least three transverse bars should be present in the sample and at least 300 millimeters length should be there at during the test.

And the failure should not be at the clamps, it should be somewhere in between in between the gage length of the of the samples. And the method b as per the a s t m sixty six thirty seven recommends that at least three ribs be tested for the in the tension test, and what we do is we take five ribs for the for the gripping purpose, and then we cut out the two outer ribs. So, that the load is applied only on the inner three ribs, and once again the minimum number of junctions are the transverse bars that we need is three and the length is three hundred millimeters at least, and when we do the test with method b.

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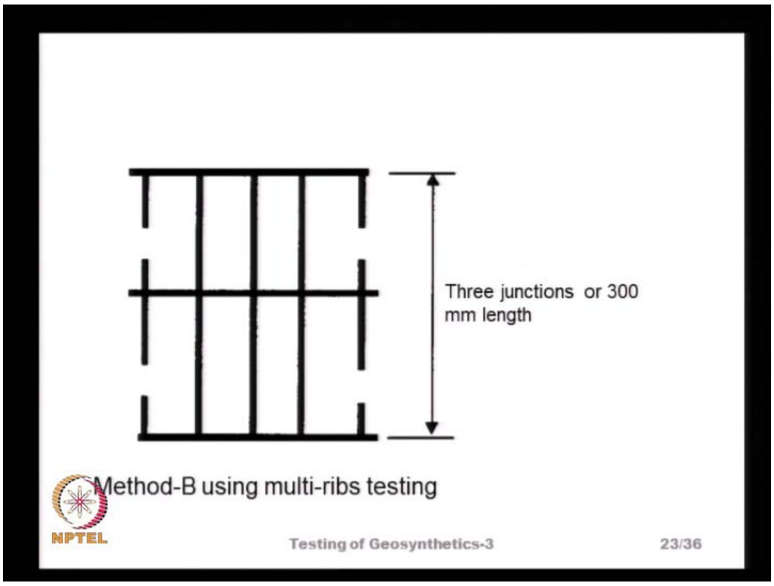

We have to make sure that this this transverse members are as horizontal as possible and they align with the with the roller grip or the the fixed grip. So, that the load is applied uniformly across the entire width it should not. So, happen that the entire load is applied only on one or two ribs and the other ribs does not take take the load and if you notice that in the test we just simply discard that result and and then take a fresh sample and and do the test until, we get a uniform cut across full width.

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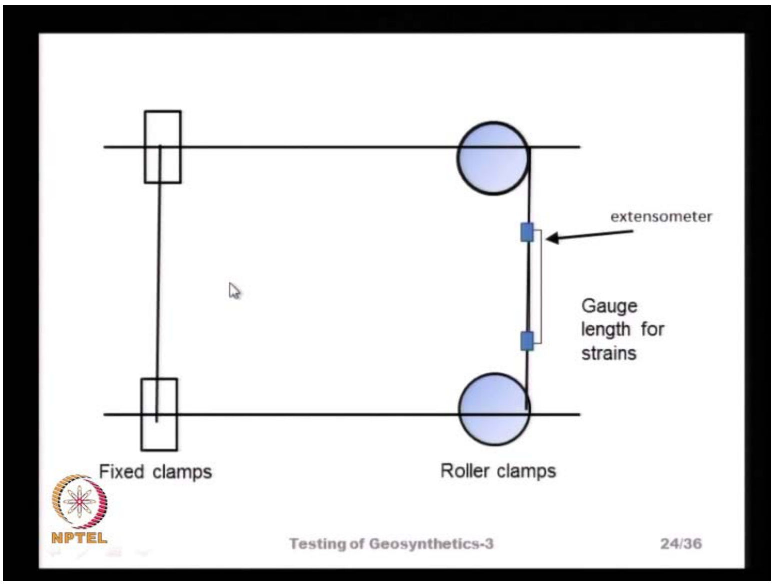

And the schematic of section is something like this is actually, we can have either fixed clamp I will show you the these clamps a bit later on or we can have roller roller grips. And we take some gage length and a fix either a mechanical extensometer or laser extensometer and for the purpose of calculating the strains and here we see three types of grips the…

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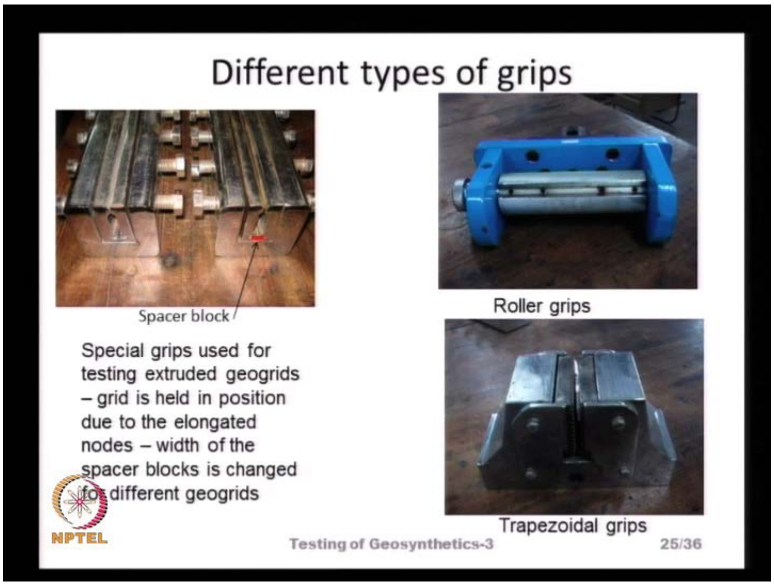

This particular grip is suitable for testing the extruded type geogrids especially made by tensor, and other similar companies because these extruded geogrids just lets go back to the extruded geogrid is actually these geogrids. They are very stiff and they cannot be held by a roller clamp or by a fixed clamp, and it requires some special type of clamp and in these geogrids the node is thicker than the than the rib and as you can see here the node is slightly elevated and what we do is we design this clamp. So, that the the this the the geogrid is held against this edge in the clamp and then we have a spacer that is shown in the red and we can have different type of pacer blocks for for different type of geogrids because each geogrid they may have different node thickness and. So, on and this particular one is specially designed at IIT, Madras for testing of the extruded geogrids.

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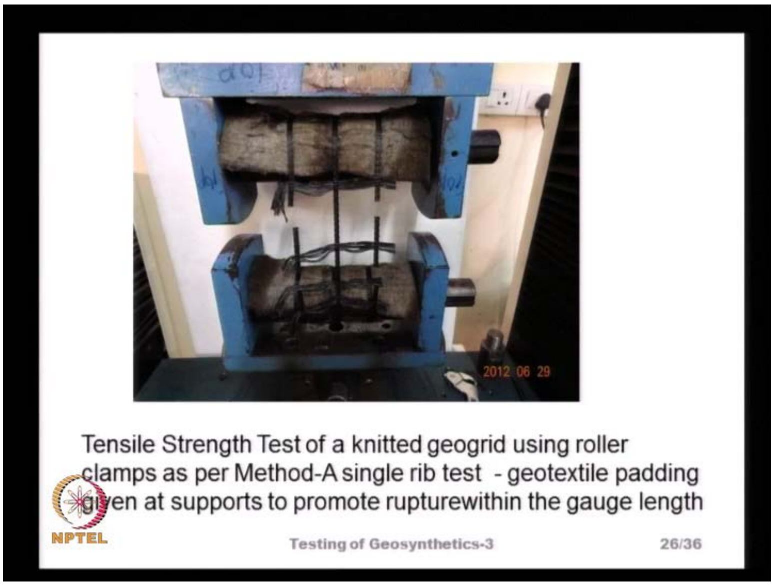

And here we see a roller roller clamp or roller grip for testing of flexible type geogrids or geotextiles, and most of the knitted are woven geogrids, they are flexible enough that they can bne rolled around this roller for doing the test and another type of grip that we have is the trapezoidal grip. This is a fixed grip and this is also a fixed grip and the the a s t m standard says that this should be at least 50 millimeters the gripped length should be at least 50 millimeters. So, that there is a good clamping here we see one geogrid being tested by using method a, and because it is a knitted sample we used a roller grip and just to promote failure and the gage length and not at the edges the geogrid is padded with with a geotextile at both ends. So, that they fail the load is uniformly distributed at the clamps and the failure is at the at the center of the sample somewhere in between the gage length.

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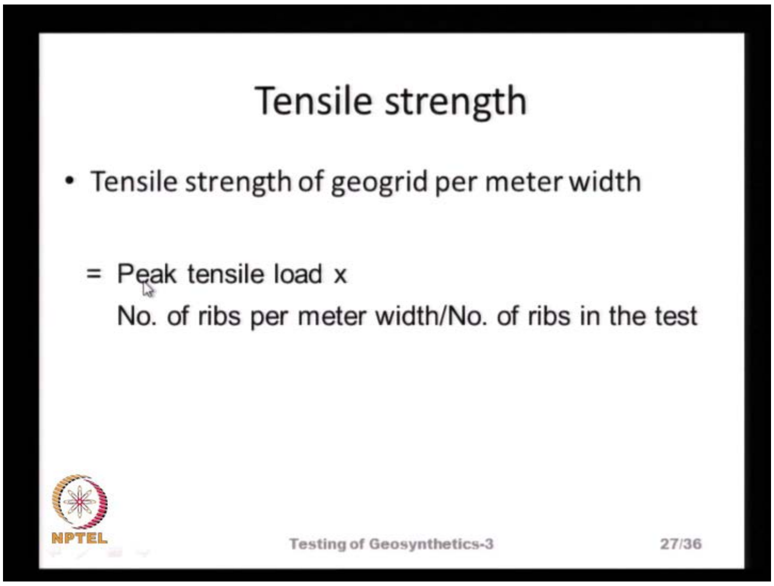

And the tensile strength of the geogrids is reported in in... So, many kilo newtons per meter width and how we calculate the tensile strength is peak tensile load, that we observe either on a single on a single rib or on multiple ribs and calculate the the tensile capacity like this. The peak tensile load multiplied by number of ribs per meter width divide by the number of ribs in the test wither one or three. And usually when we repote this tensile strength we should also report the the number of ribs, that are there in the the in the test specimen either one or three or if you have more more than that. We have to report and that is after consultation between the between the client and the testing lab some consequences arrived at.

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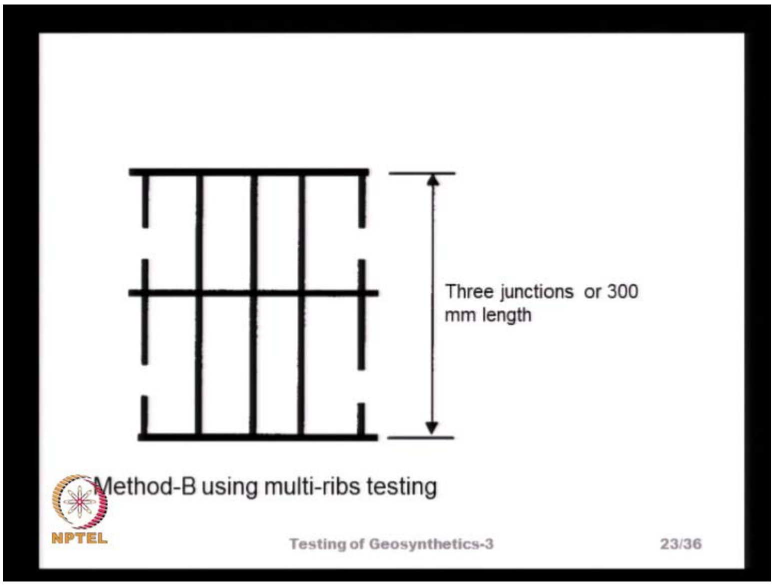

And we choose most appropriated type of test that is suitable for this application and the ASTM standard especially when when you have multiple ribs in the in the sample, it is likely that the test results from different test may differ by very large percentage that that is because the load may not be uniformly distributed. And if the tensile loads that we calculate they differ significantly between the test. We just simply discarded the data and and use only those values that are very close together, and how we report the tensile strength is at least we do six test which give consistently reasonable results very close to each other we take an average and we report that average strength. And we also need to report this standard deviation that we observe in the in the the deviation of the tensile strength.

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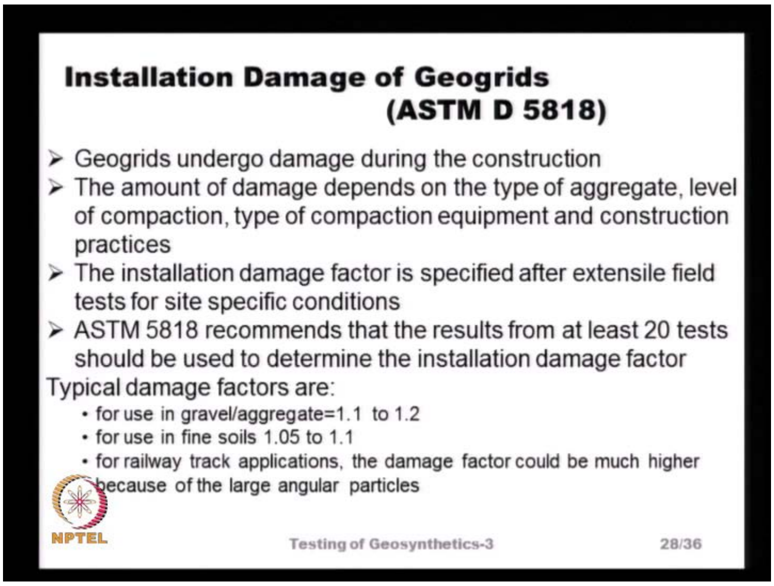

When we apply the geogrids or geotextiles as reinforcemental year in the field they may undergo significant damage during the construction itself, that is because when we lay the geogrid or a geotextile on the field spared the soil or aggregate. And do the compaction by by using their mechanical rollers or vibro rollers they undergo lot of vibrations and lot of compactions the soil undergoes lot of compactions.

And because of that the tensile strength of the geogrid may undergo the changes and this instillation damage test as per ASTM D5818, it allows us to determine the magnitude of the dam the the damage. And then come out with the strength reduction factor and the amount of damage that a geogrid or a geotextile undergoes depends on the type of aggregate that is whether it is a soil or whether it is aggregate or whether it is a railway ballast, and the level of compaction in some applications. We may compac the soil to only ninety percent of the maximum rare density whereas, in some other applications we may achieve ninety five to ninety eight percent of the maximum rare density for which e use higher compaction energies, and if you use higher compaction energy the likely dmage may be more. And then of course, the type of compaction equipment whether it is just simple mechanical roller or a vibro roller, and then the construction practice is because the depending on the on the situation the manner of applying the geogrids or geotextile may differ significantly.

And all those the construction practices they come in like. For example, in some cases we may expose the the geosynthetics to sun light for very long time, because of the delay in construction and so on even the exposure of these in the the polymeric products of the like the geogrids, and geotextile to sun light may result in some reduction in the strength. And the instillation damage factor is specified after extensive field test for a sites specific conditions that is the site specific condition refers to a case where exactly we are applying a for the typical site that we have like. For example, if you are construct in Chennai the site condition may be very different from the site conditions in Mumbai.

Depending on the on the type of terrene, and other factors and then the the type of aggregate of the infeil soil that we use, and then the level of compaction. We should be able to even during the test we should compact the aggregate of the soil to the same level that we expect in the in the actual construction then we should use the same type of compaction equipment even for doing this test and using the typical practices. See if you are going to expose the the geogrid for let us say one week in the sun then even in this instillation damage test we need to expose the the geogrids for one week. So, that even the effect of ultraviolet degradation is included in this this result. And the a s t m standard it recommends that the size of the sample that we install should be adequate to collect to collect at least twenty test samples, after we retrieve the the the geogrid.

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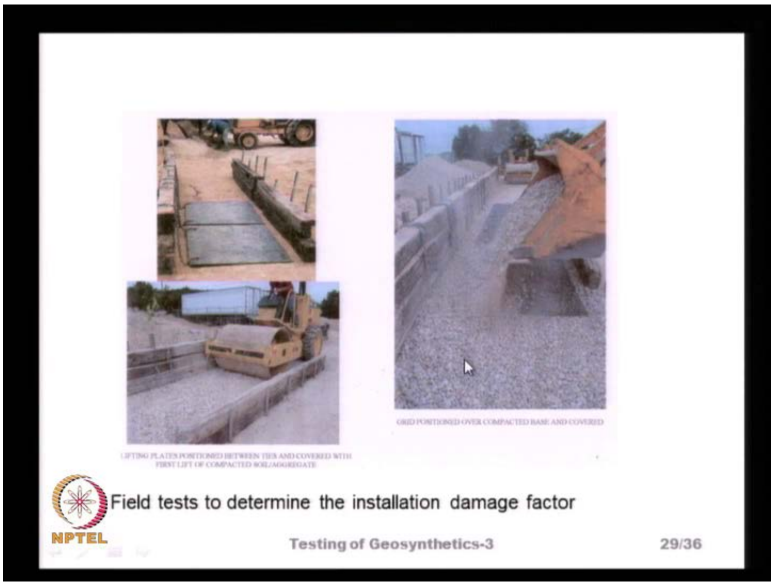

And I will just come back to this after looking through some photographs here we see some typical test sections where the candidate geo geogrids are subjected it instillation instillation test. This is the particular test track, and in this highway construction the aggregate is used as per the most standards ministry of surface transport standards and then we use a use a heavy tentan vibro compactor. And and we compact the aggregate and the soil to the to the desired the to the desired degree of compaction by by appropriate number of passes, and here we see the we see the test in progress.

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And we have to monitor the the compaction efficiency by looking at the density by measuring the density, and moisture content either by using clear density gage I shown here or by collecting core samples in the conventional manner. And then after we we finish the test we need to carefully retrieve the sample, and then we then we do the tensile test on he cut samples after retrieving the geogrid sample. And then the instillation damage factor is determined as the ratio between the strength of virgin sample to to that of the of the damage sample and the t value depends on on several factors on the size of the aggregate and then the compaction equipment and so on some typical damage factors.

When the geogrids are used in gravels or aggregate this damage factor could be anywhere from 1.1 to 1.2; it also depends on the type of geosynthetic material, because some geogrids are made of polyester material where as some others made of poly ethylene. And where as some others are made of poly propylene and usually these damage factors, they are instillation damage factors are suggested by the manufacturers based on extensive test that they perform in different site conditions using different compaction equipments and different type of aggregate and so on.

And the the instillation damage factor is slightly higher for for aggregates of large size of about 1.1 to 1.2 and when we use fine soils or sands the instillation damage is slightly lesser at about 1.05 to 1.1. And when it comes to railway track applications the instillation damage factor could be very high because the railway ballast is very large and its highly angular, and because of that the the damage could be high. And also the the railway loading is much different from the normal traffic loading or or in the case of retaining walls the loading is only during the only during the construction, and after that the load is more or less static load.

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So, depending on the application also the instillation damage factor may be different. So, I will come back to the other test that we perform on the geogrids, that is especially how well it can interact with the soil a by way of shear. And pull out test and then how well it can interact with the with the facing panels that we will we will see after we discuss some part of the design of the retaining walls there are number of tests that we perform on geonits. And other similar drainage products is actually these drainage products are some of them will are illustrated here this is a typical geonit which looks almost like a a geogrid except that here these these transverse members they are in two different planes whereas, in the geogrid they are in the same plane.

And the thickness of the geonit is much larger then here on the right hand side we have a trimpped mish as the core and then o both top and bottom, we have a geotextile as a filter layer. And here we have a retaining wall board that that is applied behind retaining walls here we have a geotextile cover, and then in side we have a corrugated plastic sheet through which the water can flow freely and the one major test that we perform on the geonit. And then these drainage products is the permeability test the incline permeability test on the ASTM standard that we have for geotextiles is the same as what we do for even for this drainage products. And the normal pressures, that we apply in these in these laboratory test it should correspond with the pressure that we expect in the field, because the thickness of drainage products is highly dependent on the on the normal pressures especially an highly compressible material like this.

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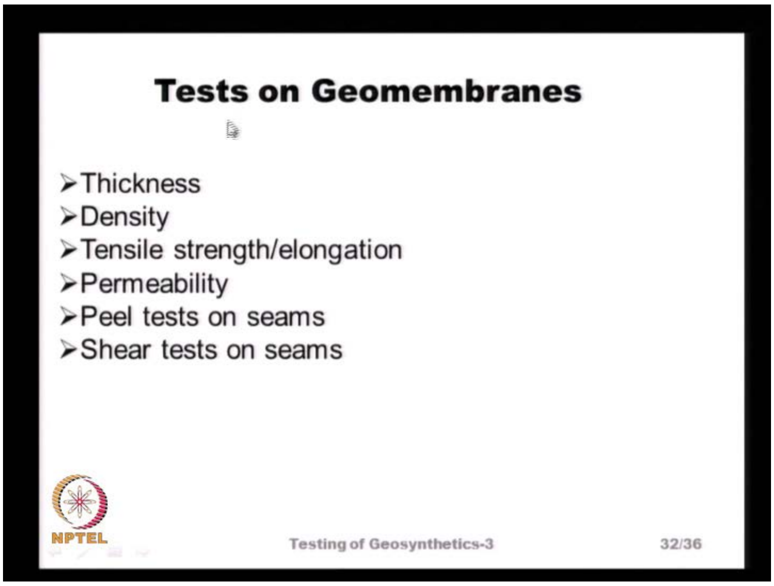

The the thickness make decrease at higher pressures leading to significant reduction permeability properties the another product that we have is geomembrane which is used as a barrier in land fields. And and other applications, where we do not want the fluid flow through the through a container the some tests that we perform on the geomembranes are the thickness density tensile strength. And elongation the permeability test the peel.

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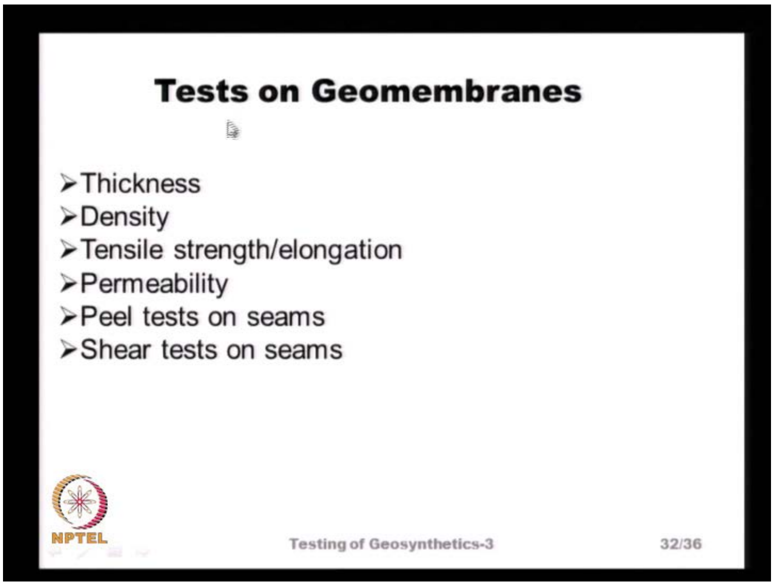

And the sheer test on the seams the ASTM standard for determining the thickness of geomembrane is the same as that we use for geotextiles except that the the pressure that we apply slightly different we take a geomembrane sample of at least 75 millimeters in diameter. And we apply a pressure of twenty kilo pascal's surface the pressure that we applied we we need to apply on geotextile is only two k p a, whereas on on geomembranes it is much higher twenty k p a and its also applied on a footer plate having diameter of only 6.3 millimeters. Whereas in the case of geotextiles we have applied on a much larger footer plate here its only applied on a on a very small footer plate six point three five millimeters. And sometimes the geomembranes may be very thick of the order of three millimeters which are very thick and we may need to apply much higher pressure. So, that the geo the geomembrane.

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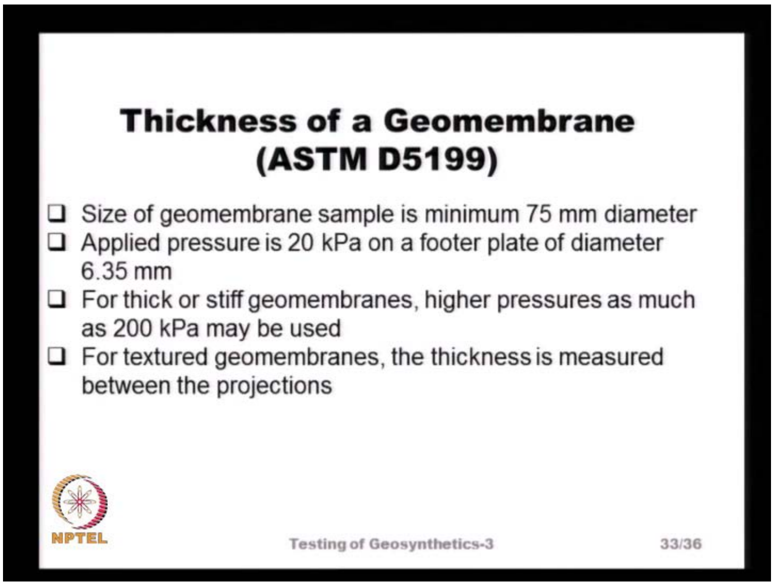

We get it of any warping that is there in the in the geomembrane, and we measure the true thickness of the of the geomembrane, in such case the codes recommend that we can apply even pressures as much as 200 k p a, but when we do this test at high pressures we have to measure. We have to report the thickness along with the along with the pressure that we apply and some geomembranes they have textures. So, t they have higher interface friction angle when it is applied along with the soil in that case the thickness of the geomembrane is is measured only in between the projections it is not the total thickness along with the projections, but is actually the thickness of the appetent material excluding the projections that we have in the geomembrane.

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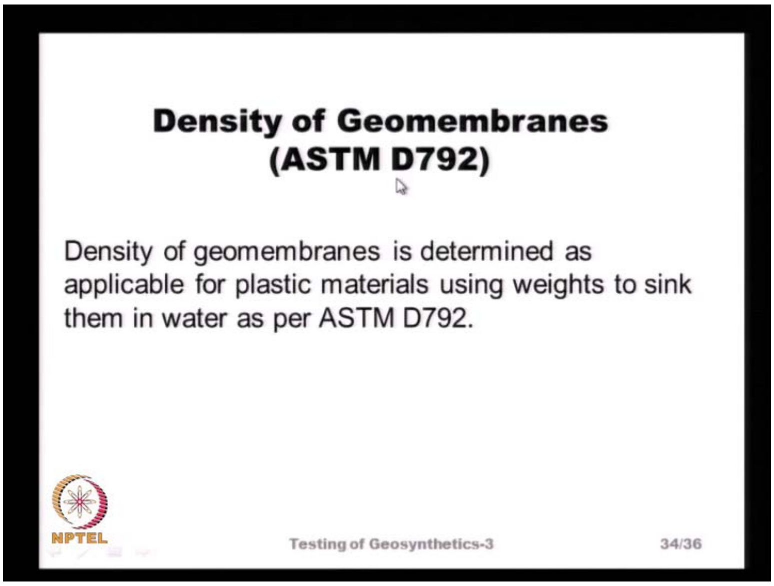

The density of a geomembrane is also very important property, because we have different verities of of geomembranes some are made of LDPE low density poly ethylene, whereas some others are made of of high density poly ethylene. And the a s t m standard ASTM D792 explains how to perform this, this test is basically the HDPE it has density less than that of water. So, if you put it in water it will just simply flow. So, we need to attach this geomembranes pieces to some weighs.

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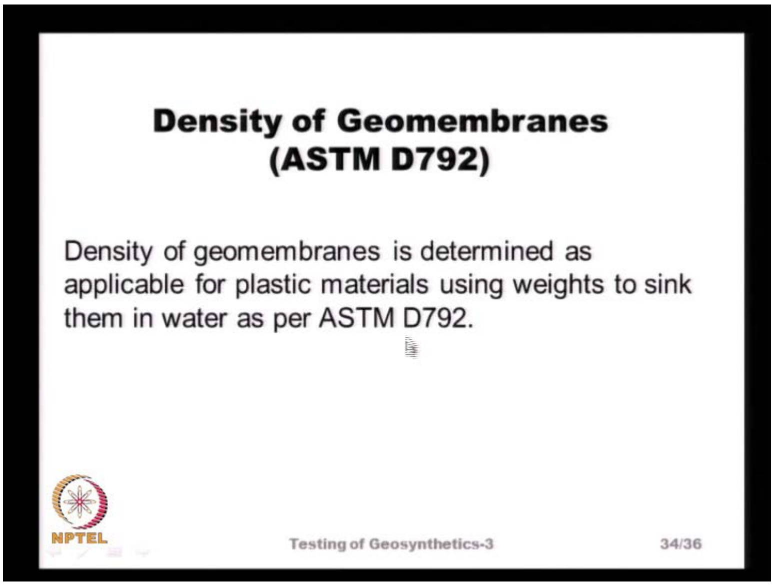

And then we sink them in water and then do this test and that procedure for testing is explain in this standard, because it is very common I am not explaining that test here.

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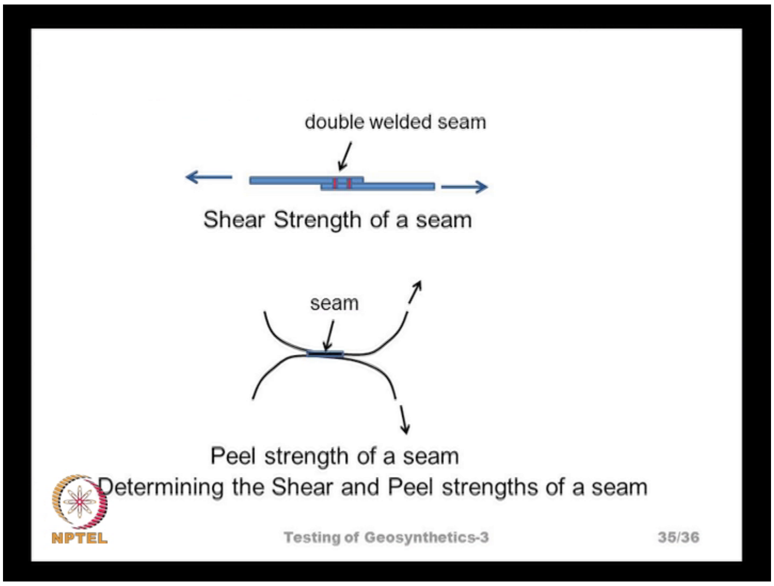

And the other test that we perform on the geomembranes are the scene test when we apply the geomembrane in land fields in variably, we have to join the geomembranes together, because the land fields they extend up to hundred meters or more whereas, the geomembranes they come in only 3 to 5 meters width. So, they have to be seemed together and there are different types of seems one is called as double welded seam and then single seam and so on and the the efficiency of this connection is determined either by doing a sheer test is actually here. Let us imagine that we have two geomembrane piece which are bonded together. And the sheet sheer test basically tries to sheer the sheer this seam, whereas there is another test called peel test here, we have the seam and let us say that these are the two geomembranes what we do is we take it and then try to peel the peel the seam and open the geomembrane. And the loading is applied in this manner and is actually these two tests they measure the strength of the seam, and the efficiency of the seam is expressed as as the strength of the seam divide by the strength of the apparent material.

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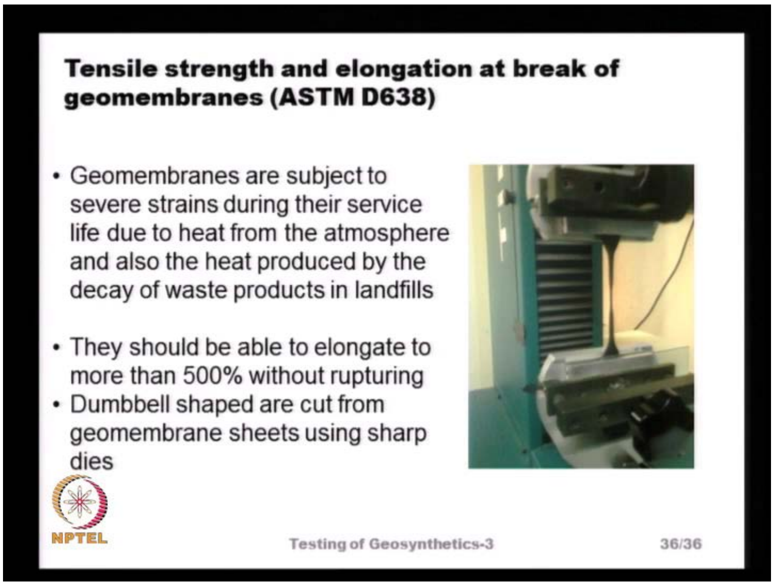

And the tensile strength of the geomembranes is determined as per the standards for the plastic material as per ASTM D638 more than the tensile strength the tensile elongation of the geomembranes is very important, because these geomembranes when they are applied in in land fields. They are subjected to very large temperature fluctuations either, because of the exposure to sun or because of the of the heat that is produced by the decaying waste with an a land field. And because of that the the geomembranesd be able to elongate two strains as much as five hundred percent or more without rupturing.

And this particular test d six thirty eight it explains how to do the test, and is actually we take very thn samples which are initially about six millimeters wide. And then elongate them and one particular test we see here its under progress is actually this the geomembrane it can in this particular case it has elongated to almost seven hundred percent without rupturing and. So, this the the tensile strength and the the elongation at rupture is reported for for the geomembranes. So, this concludes this particular lecture, and if you have any questions you can send an email to me at this address and I will try to respond as early as possible.

Thank you.