Geo synthetics Engineering: In Theory and Practices
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Lecture - 16
Geo synthetics for Filtrations Drainages and Erosion Control Systems

Welcome to Lecture 16, my name is Professor J. N. Mandal, Department of Civil Engineering, Indian Institute of Technology, Bombay, Mumbai, India. The name of the course Geo synthetics Engineering in Theory and Practice, this is module 4, lecture 16, Geo synthetics for Filtration, Drainage and Erosion Control System.

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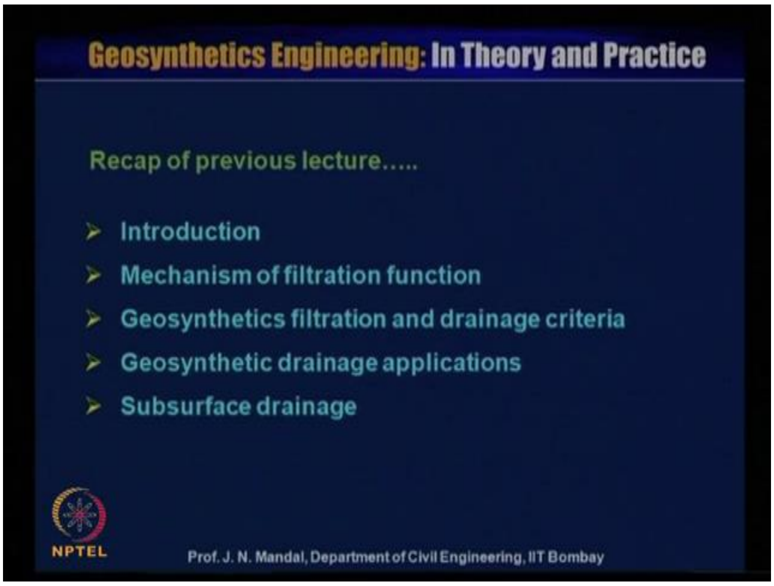

Recap of previous lecture we covered introduction, mechanism of filtration function, geo synthetics filtration and drainage criteria, geo synthetics drainage application and subsurface drainage.

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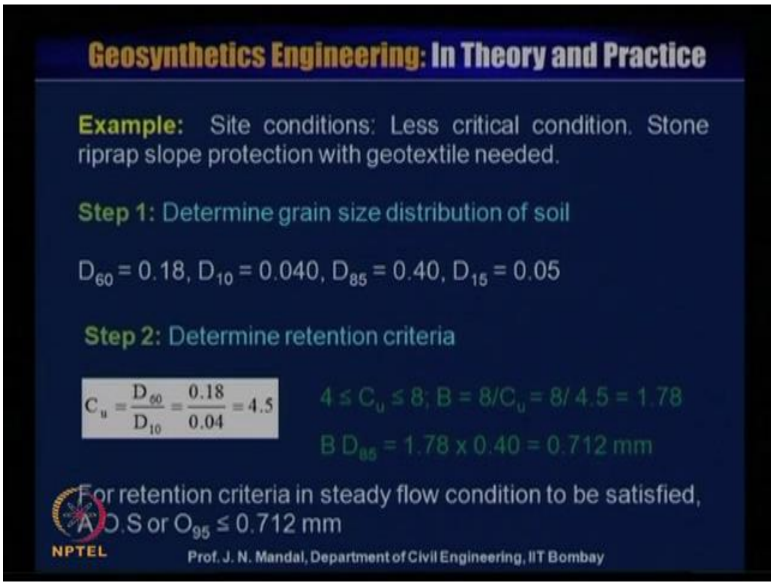

Now, we will cover some example, that let us say site condition, less critical condition, stone rip rap slope protection with geo textile needed. Step 1, determine the grain size distribution of the soil, from where you can find out D 60 0.18, D 10 0.040, D 85 0.40, D 15 0.05. So, you can obtain this all this parameter from the grain size distribution curve of the soil. Step 2, you have to calculate that retention criteria, you can calculate C u that is D 60 by D 10 you know what is the D 60 is 0.18, D 10 0.04. So, C u is equal to 4.5 and from the criteria, that is C u greater than 4 or less than 8 then B will be 8 by C u.

So, here C u is 4.5. So, 8 by C u is 8 by 4.5 is equal to 1.78. So, B into D 85 will be 1.78 that is B is 1.78 this is 1.78 into D 85, D 85 is 0.40, so it is 0.712 millimeter. So, for retention criteria in the steady flow condition to be satisfied, if the apparent opening size of the geo textile or O 95 less than equal to 0.712 millimeter.

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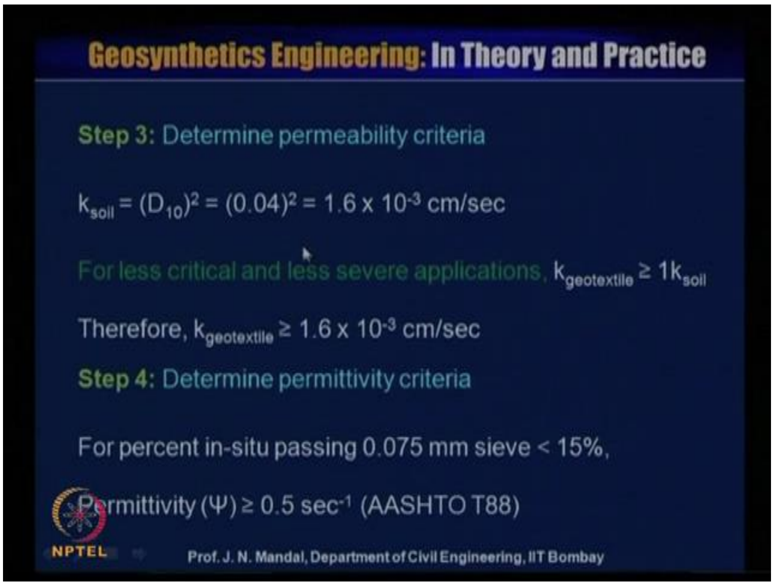

Step 3 I have to determine the permeability criteria. So, you can adopt that coefficient of permeability of the soil k soil is equal to D 10 square and D 10 value is known 0.04 into square this is equal to 1.6 into 10 to the power minus 3 centimeter per second, for less critical and less severe application k of geo textile should be greater than equal to 1 of k of soil. So, therefore, k geo textile is greater than equal to 1.6 10 to the power minus 3 centimeter per second.

Step 4, determine the permittivity criteria, for percent in-situ passing 0.075 millimeter sieve less than 15 percent. So, from the AASHTO T88, you can have the permittivity psi would be greater than equal to 0.5 per second.

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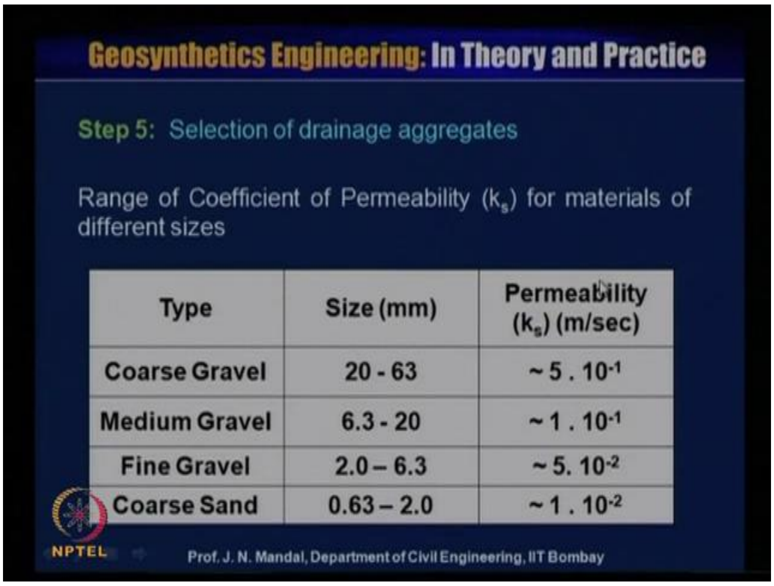

Step 5, you have to selection of the drainage aggregate, the range of coefficient of permeability k s of the material of different sizes is given. If it is a coarse gravel and size 20 to 63 millimeter, the permeability will be 5 into 10 to the power minus 1 meter per second is, medium gravel if the size 6.3 to 20 millimeter then 1 10 to the power minus 1 meter per second. Fine gravel size is 2 to 6.3 permeability will be 5 10 to the power minus 2 meter per second if it is a, coarse sand the grain size is 0.63 to 2 millimeter then permeability case will be 1 into 10 to the power minus 2 meter per second.

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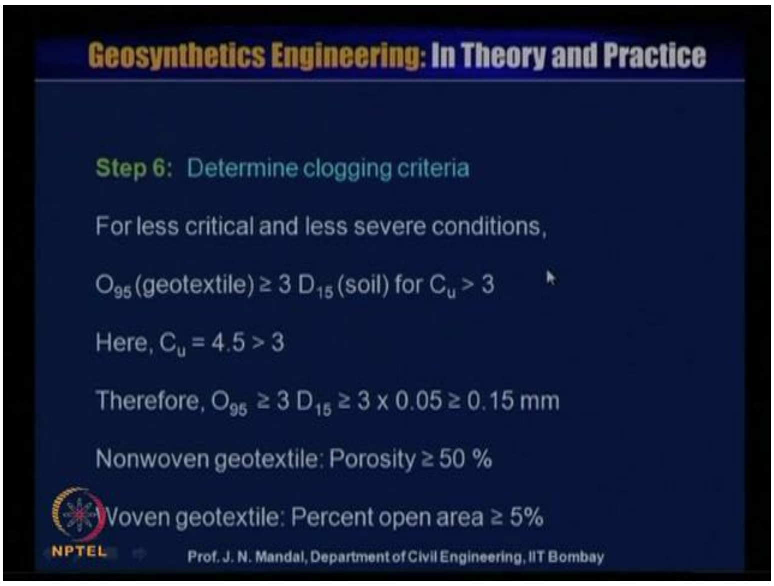

So, step 6 is determined the clogging criteria, for less critical, less severe condition O 95 geo textile should be greater than 3 D 15 soil for C u is greater than 3 which we have already discussed. So, based on this, you can calculate that what is C u? So, here C u is 4.5. So, it is greater than 3 therefore, O 95 greater than 3 into D 15 that is 3 into D 15 value is given 0.05 it should be greater than equal to 0.15 millimeter and nonwoven geo textile porosity greater than equal to 50 percentage, woven geo textile percent open area is greater than equal to 5 percentage.

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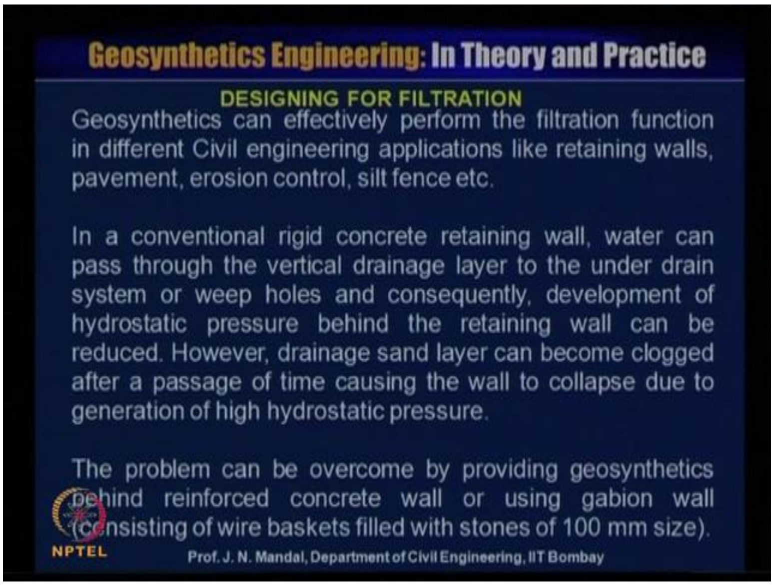

Now, designing for filtration, geo synthetic can effectively perform the filtration function in different civil engineering application like retaining wall, pavement, erosion control and silt fence etcetera. In a conventional rigid concrete retaining wall, water can pass through the vertical drainage layer to the under drain system or weep holes and consequently, development of the hydrostatic pressure behind the retaining wall can be reduced. However, drainage sand layer can become clogged after a passage of time causing the wall to collapse due to the generation of high hydrostatic pressure.

The problem can be overcome by providing geo synthetics behind the reinforced concrete wall or using gabion wall consisting of wire basket filled with the stone of 100 millimeter size.

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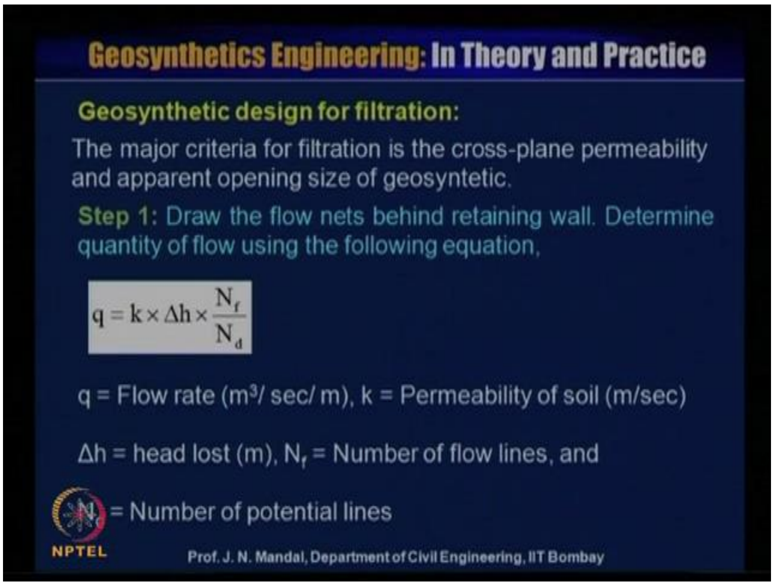

Geo synthetics design for the filtration the major criteria for the filtration is the cross-plane permeability and apparent opening size of geo synthetics. So, what are the step, step 1, first of all you draw the flow net behind the retaining wall, to determine the quantity of flow using the following equation, you know that q is equal to k into delta h into N f by N d.

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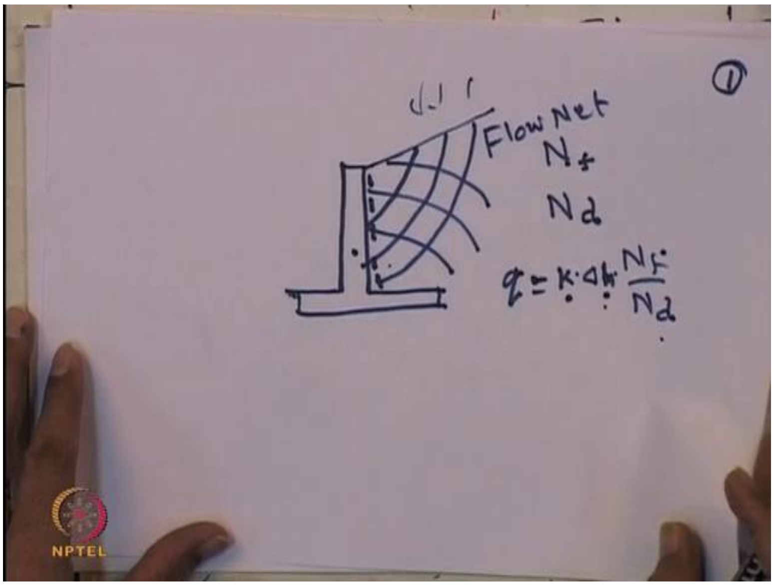

For example, that if it is a wall so you do not know what quantity of water can flow pass through this, you are providing this geo textile material here. So, you can draw the flow line, you can draw the equipotential line. So, you can count, what is the number of the flow line, what will be the number of the equipotential line.

So, from the flow line and the equipotential line, you can calculate what should be the q value; that means, you know q is equal to k into delta of h into N f divided by N of d, you do not know the what will be the, if the rain water comes from these then first of all you should know in that locality. What should be the quantity of flow water passes through this geo synthetics material, where here q is equal to flow rate that is meter cube per second meter, k is coefficient of permeability of the soil meter per second. And this delta h is equal to head loss in meter N f is the number of flow line and N d is the number of the potential line.

So, you can calculate from this flow net, this is flow net diagram, from this flow net diagram. So, you can calculate what should be the quantity of water can pass through that film.

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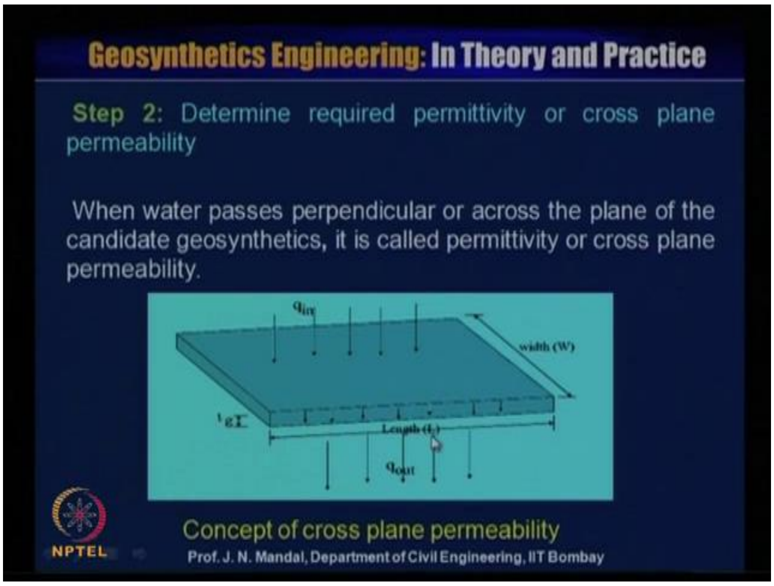

Now, second you have to determine the required permittivity or cross-plane permeability, because you know that when water passes perpendicular or across the plane of the candidate geo synthetics, it is called permittivity or cross-plane permeability. You can see this figure shown concept of cross-plane permeability which we have discussed earlier.

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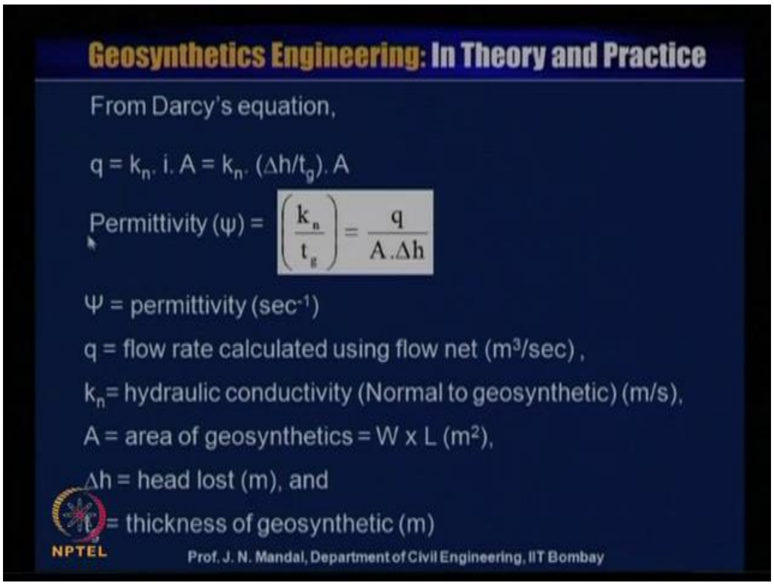

So, from this you can calculate the permittivity with this equation that is permittivity is equal to k n by t g q by A into delta h which we have already discussed and A is equal to area of geo synthetics which is W into L.

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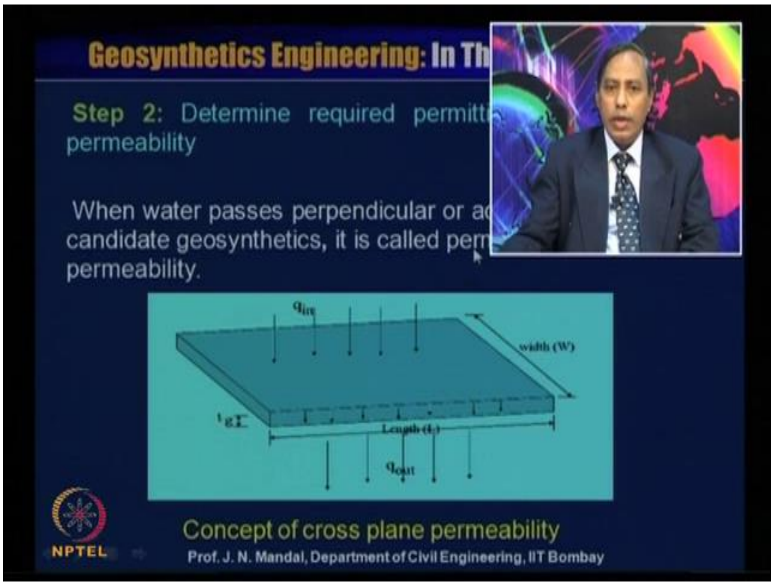

A is area of geo synthetics that is W and into that L, this is L, this is W.

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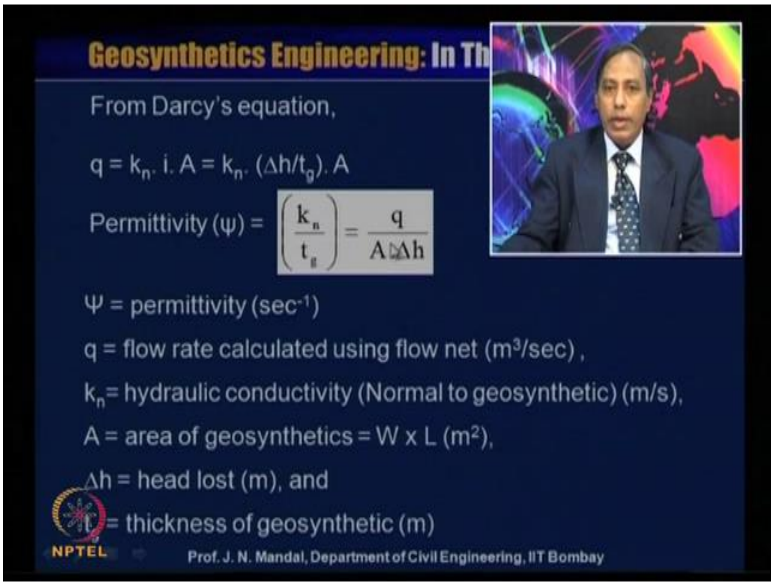

So, you can remember this equation permittivity that is psi is equal to k n by t g is equal to q by A into delta h we have derived earlier.

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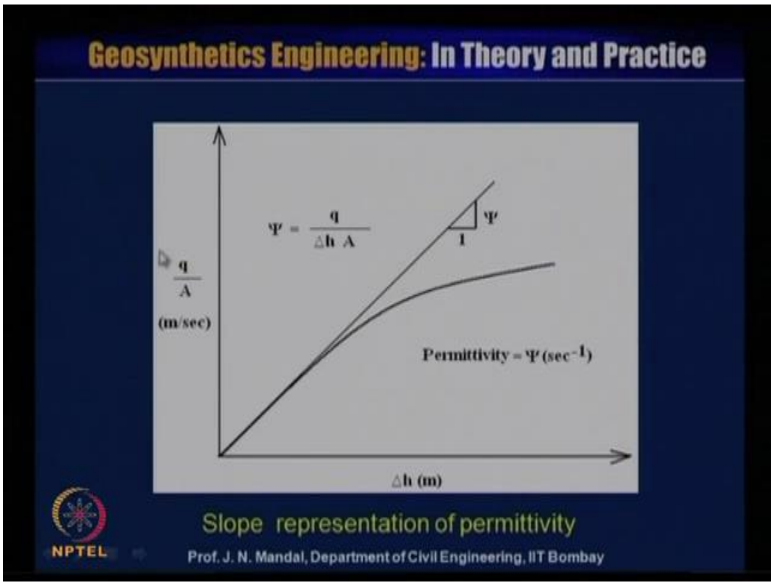

And from that you can slope representation of the permittivity, which you have covered.

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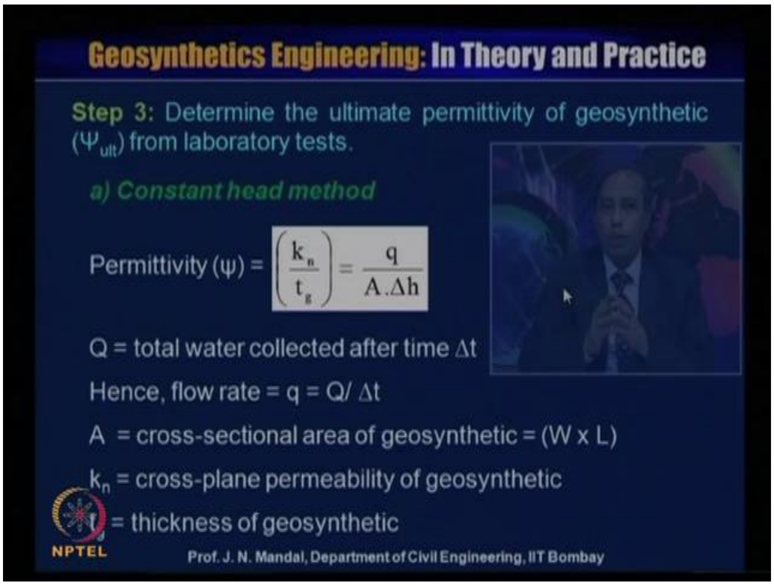

Now, steps 3 determine the ultimate permittivity of geo synthetics, that is pi, psi ultimate from the laboratory test, this is from the laboratory test. So, this is constant head method you can determine permittivity psi is equal to k n by t g q by A into delta h. So, this is from laboratory, you can calculate which we have derived earlier.

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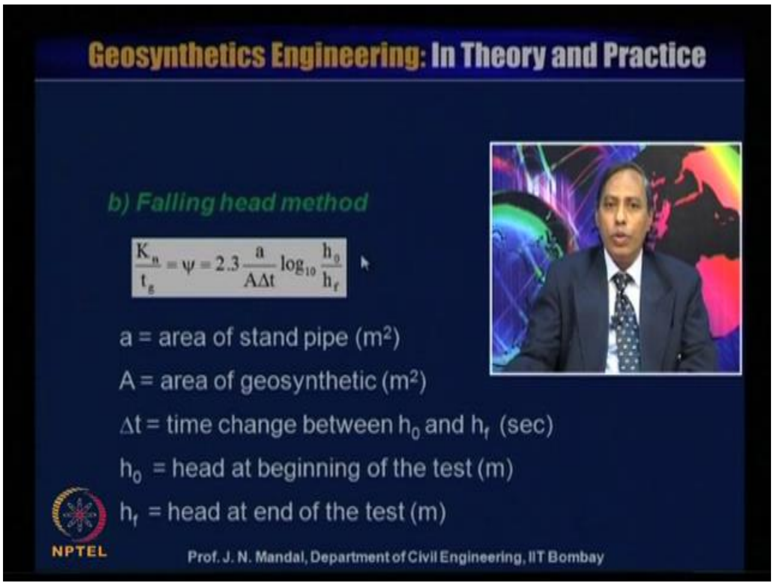

Also by falling head method, this is also laboratory test from that also you can determine permittivity psi that is K n by t g is equal to psi is equal to 2.3 a small a divided by a capital A into delta t log 10 h 0 by h f a small a is the area of the stand pipe capital A is equal to area of the geo textile and delta t is time change between h 0 to h f this also we have already covered.

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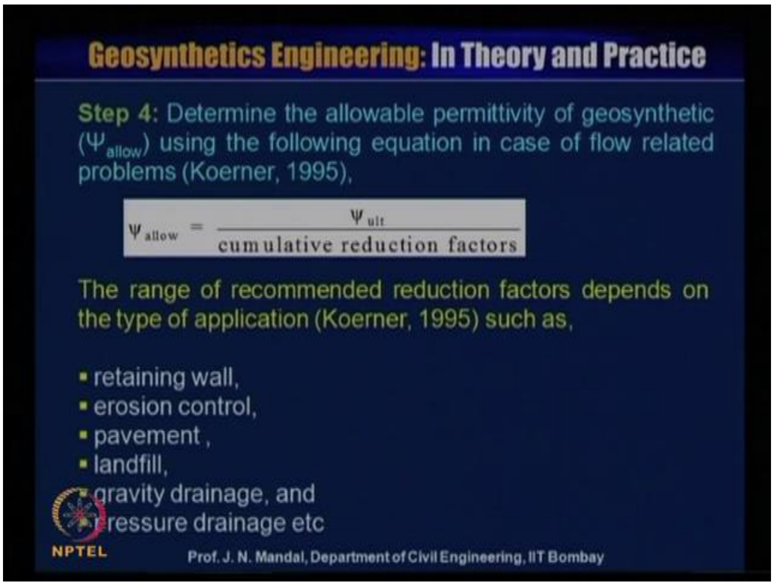

Now, step 4 determine the allowable permittivity of geo synthetic psi allowable using the following equation in case of flow related problem koerner 1995, because you know what will be the ultimate permittivity. So, you have to calculate the allowable permittivity that is psi allowable. So, psi allowable is equal to psi ultimate value divided by cumulative reduction factor.

Now, this cumulative reduction factor depend upon the time type of application, if it is a applicable for the retaining wall, then all the cumulative reduction factor, like that you reduction factor for the creep, reduction factor for installation damage, reduction factor for biological degradation, reduction factor for clogging, reduction factor for the blinding all these factor we have to be taken into consideration, for the design then you have to find out what should be the cumulative reduction factor.

Now, these retaining for the retaining wall, cumulative reduction factors are different for the erosion control, pavement, landfill, gravity drainage and the pressure is drain. So, you have to adapt that reduction factor, and you know what will be the ultimate value, and then you can calculate what will be the allowable permittivity value.

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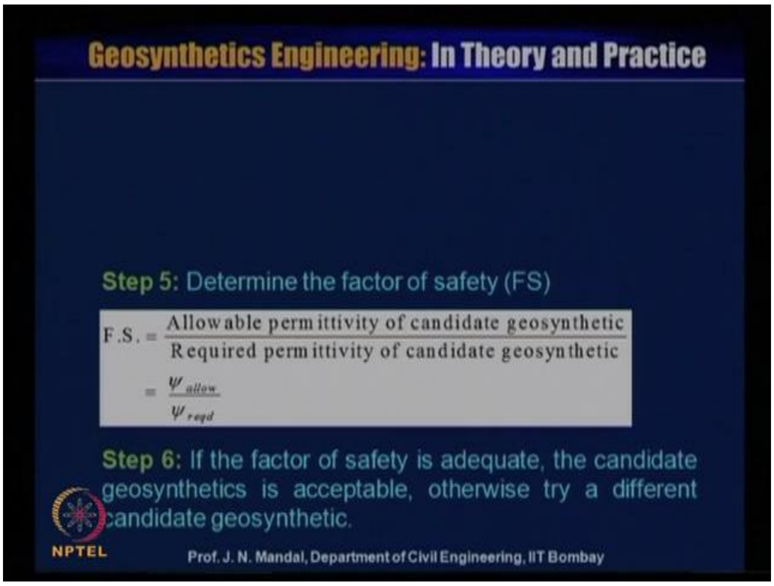

Now, step 5 you have to determine the factor of safety, factor of safety will be equal to allowable permittivity of candidate geo synthetics divided by required permittivity of candidate geo synthetics, you know what is allowable permittivity of the candidate geo synthetic, and you know what will be the requirement permittivity of candidate geo synthetic, then you check the what will be the factor of safety. Step 6, if the factor of safety is adequate, the candidate geo synthetics is acceptable, otherwise you try a different candidate geo synthetics material.

So, sometimes if the one layer of geo synthetics is not sufficient, you have to provide 2 layer, 3 layer, 4 layer. So, instead of that you can go for the geo composite material, geo net material instead of the, number of the, layer of the single geo synthetics material.

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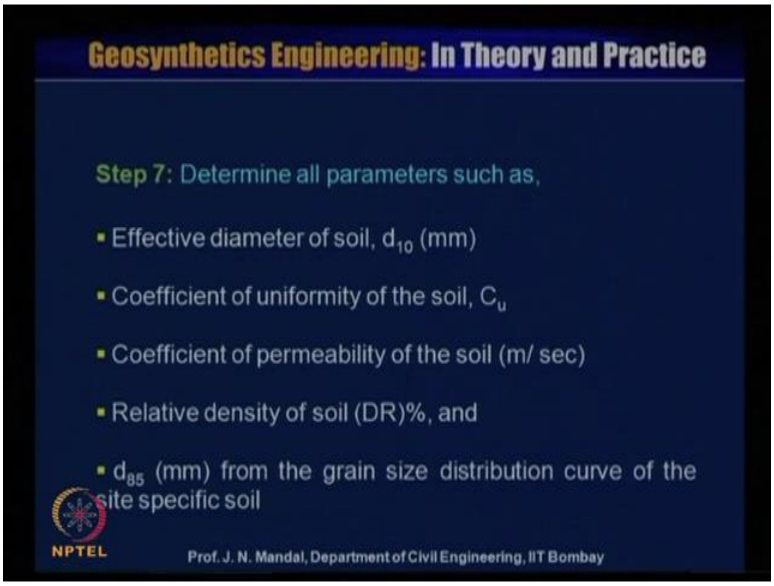

Step 7, determine all parameter such as, effective diameter of the soil d 10 in millimeter, coefficient of uniformity of the soil C u, coefficient of permeability of the soil that is in meter per second, relative density of the soil, that is DR in percentage and d 85 that is in millimeter from grain size distribution curve of the site specific soil. So, from the grain size distribution curve you can determine all this parameter.

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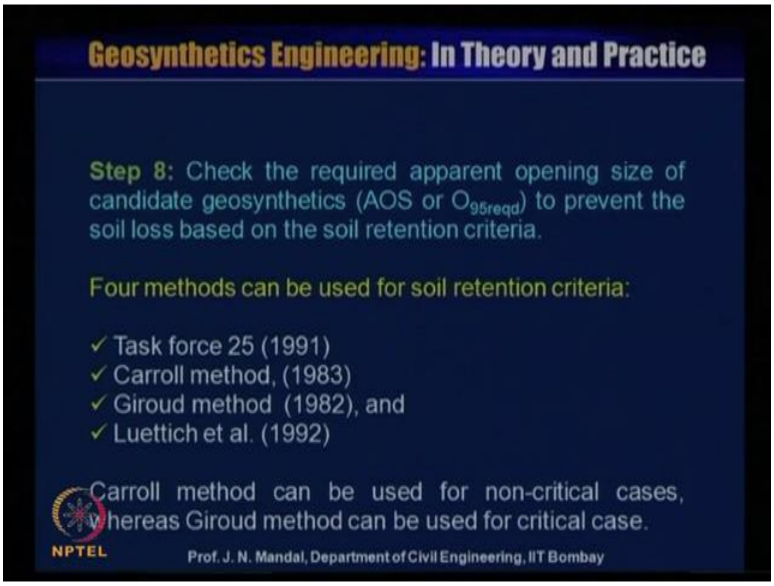

Step 8, check the required apparent opening size of the candidate geo synthetics; that means, AOS or O 95 required, to prevent the soil loss based on the soil retention criteria.

Now, there are 4 method can be used for soil retention criteria, one task force 25 1991, Carroll method 1983, giroud method 1982 and luettich et al 1992, Carroll method can be used for non critical cases whereas, giroud method can be used for critical case.

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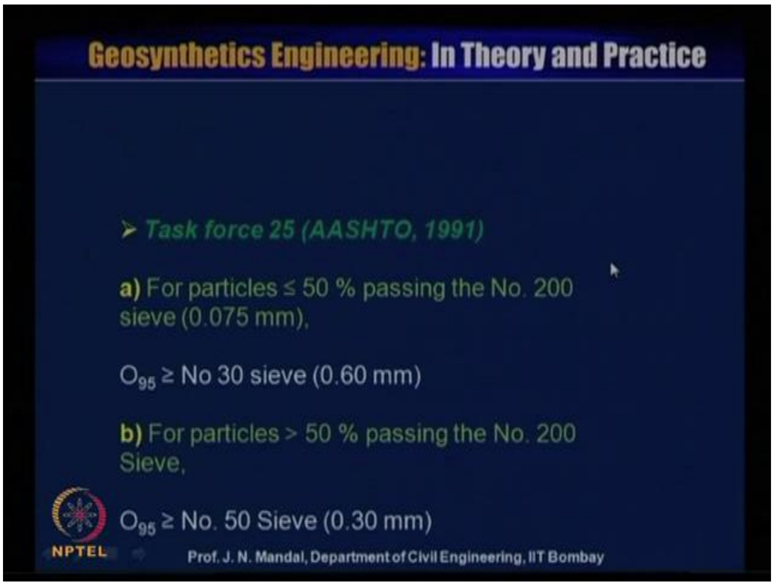

So, what is the task force, AASHTO 1991, a for particle less than equal to 50 percent passing the number 200 sieve that is 0.075 millimeter, O 95 should be greater than number 30 sieve, that is 0.60 millimeter, b for particle greater than 50 percent of passing the number 200 sieve, then O 95 greater than equal to number 50 sieve that is 0.30 millimeter, this is very important.

So, when you can sieve from the grain size distribution curve, where are the particle less than 50 percent, passing the number 200 sieve or the particle greater than 50 percent, passing the 200 sieve based on that from the task force 25 you can determine what is O 95, if it is a less than 50 percent then O 95 is 0.60 millimeter what you require, if it is a greater than 50 percent then O 95 should be 0.30 millimeter. So, this is task given by the task force.

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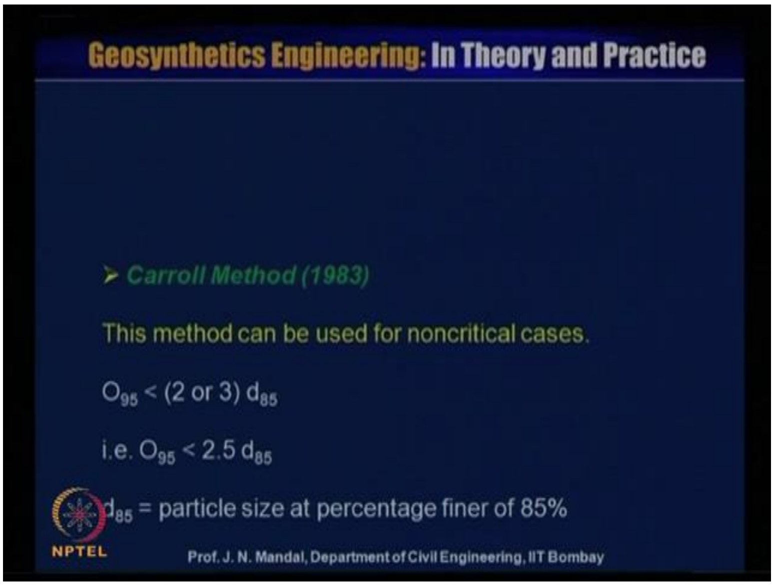

Now, in Carroll method 1983, this method can be used for noncritical case, this is O 95 less than 2 or 3 of d 85 that is O 95 less than 2.5 into d 85, d 85 is the particle size at percentage finer of 85 percentage. So, if you know 85 percentage. So, you can directly determine, what will be the apparent opening size or O 95 by the Carroll method.

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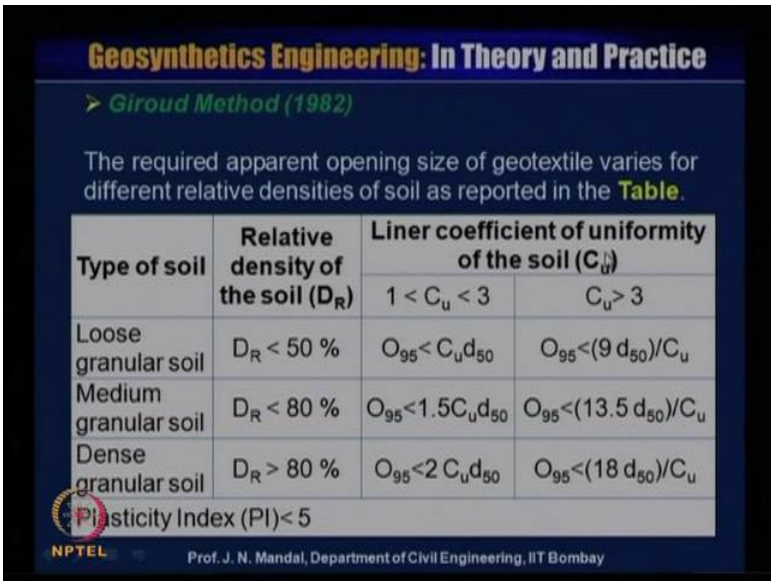

Now, this is giroud method 1982. So, the required apparent opening size of the geo textile varies from the different relative density of soil, you can see if it is a type of soil, relative density of the soil D R and this is the linear coefficient of uniformity of the soil

C u. So, from the grain size distribution curve, you can determine what is C u? Now, if it is a type of soil loose granular soil relative density D R less than 50 percent and C u value is greater than 1 less than 3 then O 95 should be less than C u into d 50.

So, from the grain size distribution curve, first of all you check that what will be the value of C u, whether C u greater than 1 less than 3 then you substitute this value C u and then from the grain size distribution curve you know what is d 50. So, then you will be knowing what will be the O 95. Now, if the C u value is greater than 3 then O 95 should be less than 9 d 50 divided by C u, next if it is a medium granular soil where relative density less than 80 percent and C u greater than 1 and less than 3 then O 95 should be less than 1.5 C u into d 50 and if C u greater than 3 then O 95 should be less than 13.5 d 50 divided by C u.

If it is a dense granular soil; that means, relative density greater than 80 percent and C u greater than 1 less than 3, so O 95 should be less than 2 into C u into d 50 and if C u greater than 3. So, O 95 should be less than 18 into d 50 into C u and plasticity index is less lesser than 5. So, you know the grain size distribution curve and from the grain size distribution curve you can determine what is C u, you can determine what is d 50.

So, if you know that C u value and also the relative density value, then from this table you can calculate, that what is O 95 our target is O 95 what is apparent opening size of the geo textile or the equivalent opening size of the geo textile. So, from this giroud chart also you can calculate the O 95.

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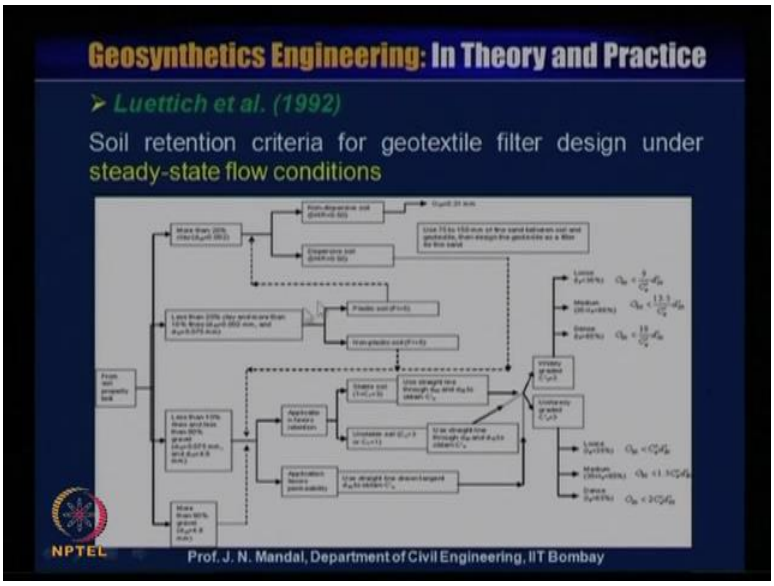

So, this is the luettich et al 1992, soil retention criteria geo textile filter design under steady state flow condition. So, this is only I am just explaining this part, if that depend upon the value of the C u whether it is a well graded or less well graded then you can see this value of the C u accordingly then depending upon the density of the soil, then there is a also relationship between the C u and the d, different value of d value.

So, whether it is a loose or medium or dense. So, accordingly like that, giroud method. So, you can also determine what should be the O 95 value and if this is C u value is less than 3, then also it is a loose condition medium or the high density or relative density, then accordingly you can also calculate that what will be the O 95, it is almost that similar like, that giroud chart. So, you can adapt this chart luettich chart for the steady state flow condition.

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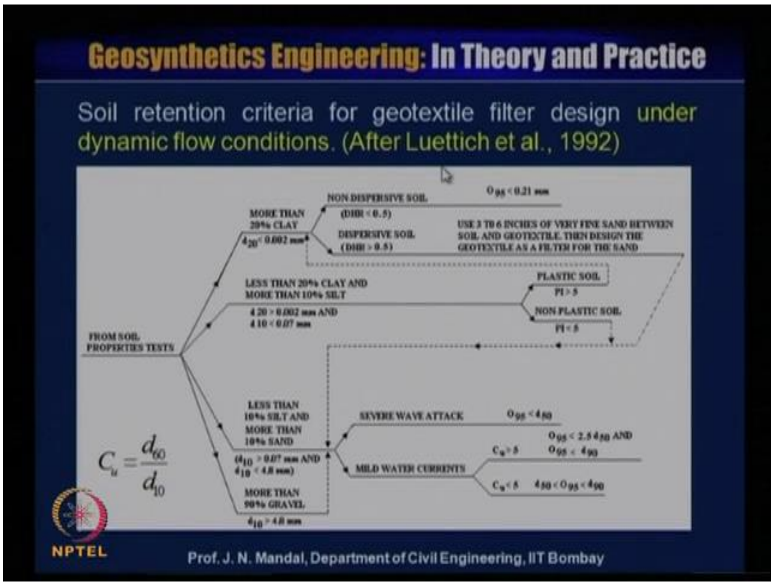

He also established also another for the, another curve and this curve for dynamic flow condition, you can see this also he has mentioned the dynamic flow condition. So, this dynamic flow condition, also you can calculate that what will be the O 95 whether, it is a severe wave attack then O 95 should be less than d of 50 if it is a mild water current, then you can see C u greater than 5 and O 95 less than 2.5 into d 50 and O 95 less than equal to d 90.

And if the C u less than 5 then d 50, O 95 greater than d 50 or less than d 90 and also it depend upon severe condition whether it is the less than, the 10 percent of the silt and more than 10 percent of the sand and also d 10 should be greater than 0.07 millimeter and d 10 less than 4.8 millimeter and for the more than 90 percent of the gravel d 10 greater than 4.8 and as you know that, you can calculate the C u d 60 by d 10.

So, for the soil retention criteria or geo textile filter design, under dynamic flow condition this is given after luettich et al 1992. So, here when the 2 chart, one for the steady state flow condition, another for the dynamic flow condition.

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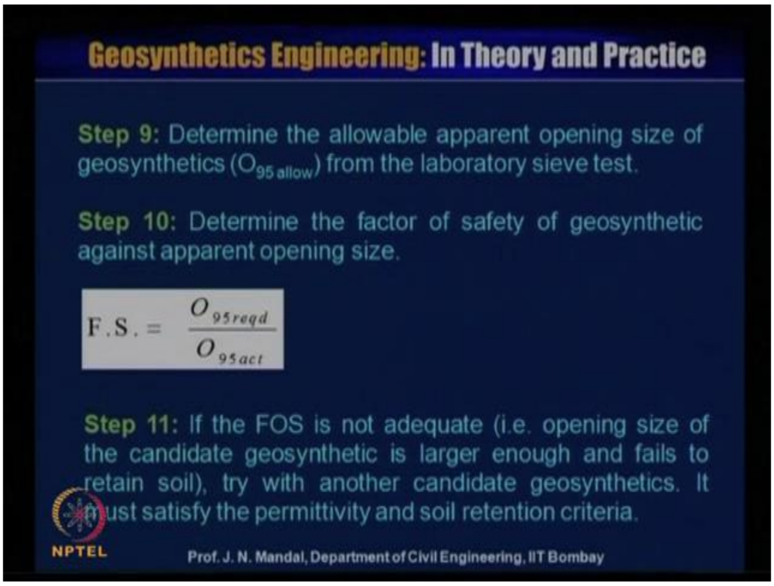

Now, step 9 determine the allowable apparent opening size of the geo textile, from the laboratory sieve test. So, from the laboratory test sieve you can determine what is O 95, then step 10 determine the factor of safety geo synthetics against apparent opening size; that means, factor of safety will be equal to O 95 required and O 95 actual, then step 11 if the factor of safety is not adequate; that means, opening size of the candidate geo synthetics is larger enough and fail to retain the soil. We can try with the another candidate of geo synthetics material. It must satisfy the permittivity and the soil retention criteria.

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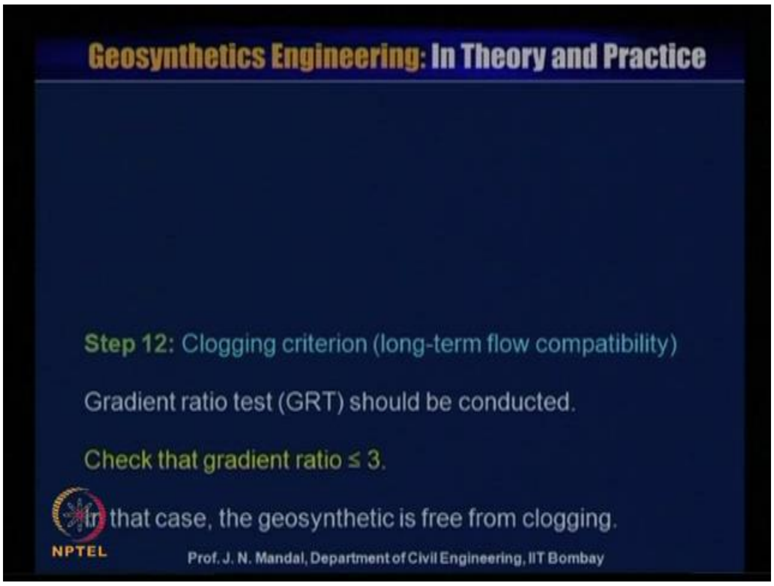

Step 12 clogging criteria; that means, long term flow compatibility. So, this is you go for Gradient Ratio Test or GRT should be conducted and check the gradient ratio value less than equal to 3, in that case the geo synthetics is free from clogging.

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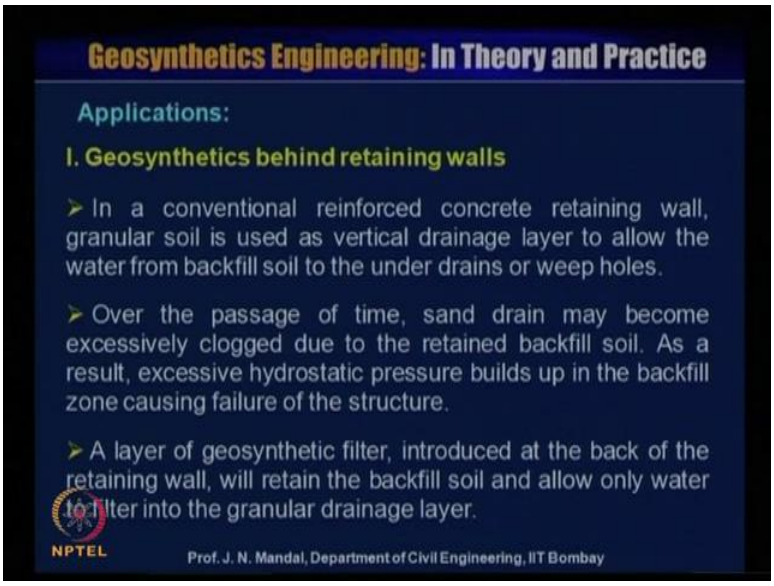

Now, some application geo synthetics behind the retaining wall. In a conventional reinforced concrete retaining wall, granular soil is used as a vertical drainage layer to allow the water from back fill soil to under drain or weep or hole. Over the passage of time, sand drain may become excessively clogged due to the retained backfill soil. As a result, excessive hydrostatic pressure build up in the back fill zone causing the failure of the structure. A layer of geo synthetics filter, introduced at the back of the retaining wall, will retain the back fill soil and allow only water to filter into the granular drainage layer.

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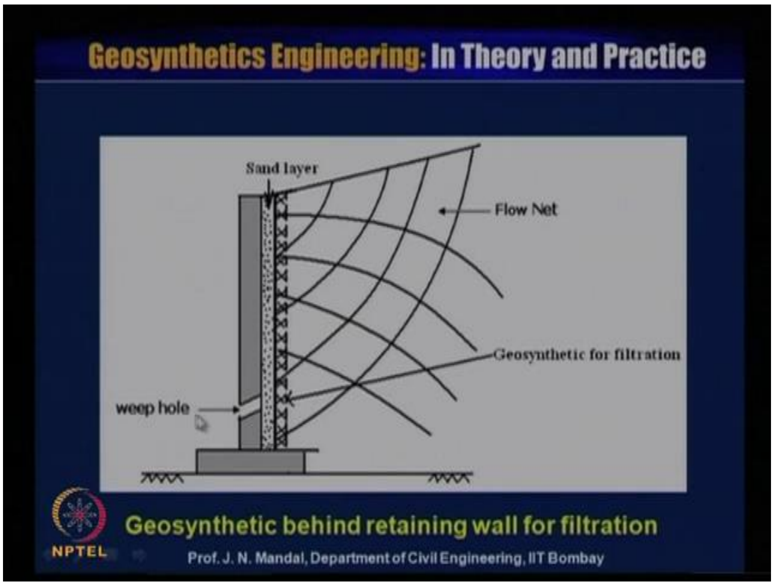

Now, you can see that, this is the geo synthetics material, is placed behind the retaining wall for the filtration, this is the sand layer and there is a weep hole and you can see that, you can draw the flow net this is equipotential and the flow line and the geo synthetics here, is act as a filtration, the water can pass through the geo textile material and then sand in and then through the weep hole the water can drained it out.

So, here it has been shown that how the geo synthetics has been used, behind the retaining wall and we will explain later how to design that, if these altitude how we can also reduce the hydrostatic pressure here.

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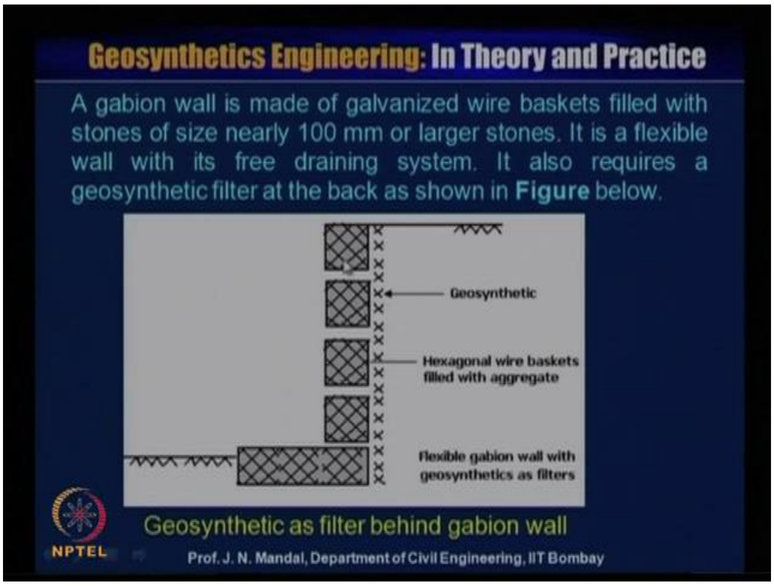

This is one gabion wall is made of galvanized wire basket filled with the stone of size 100 millimeter or larger stone. It is flexible wall with it is free draining system. It can also require geo synthetic filter at the back, you can see here, this geo synthetic material has been placed if you do not place this geo synthetics material, then soil will be clogged into the gabion because gabion is filled with the gravel. So, it will be clog, it will choke.

So, that was the reason that you should provide with one layer of geo textile material, at the back of the gabion wall, though the gabion itself is very good filtration or drainage material, the water can pass through easily, but when you are placing with the soil on the back, then the soil may clog on to this wall. So, therefore, it is required to provide a layer of geo synthetics material and this is the flexible gabion wall with geo synthetics as a filter. And this gabion wall which is a hexagonal wire basket filled with the aggregate. So, you can see that how, the geo synthetics is also placed at the back of the gabion wall.

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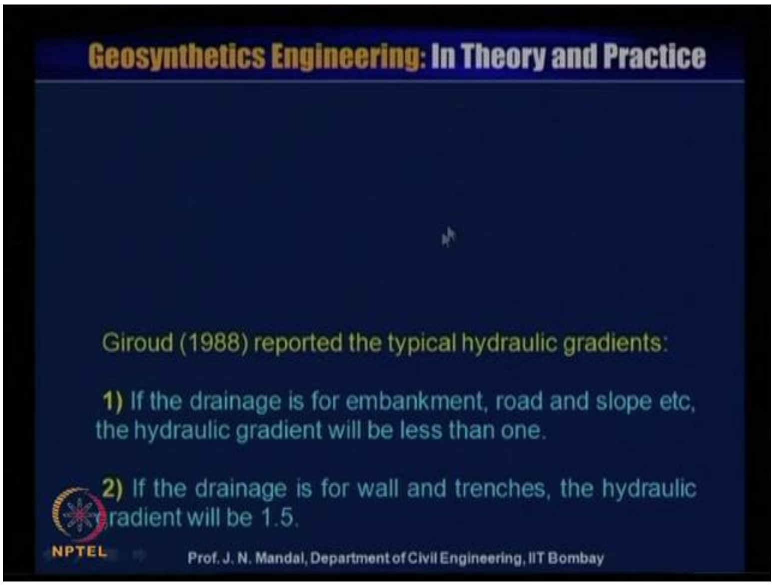

Now, giroud 1988 reported the typical hydraulic gradient, if the drainage is for embankment, road and slope etcetera, the hydraulic gradient will be less than one, if the drainage is for wall and trenches, the hydraulic gradient will be 1.5.

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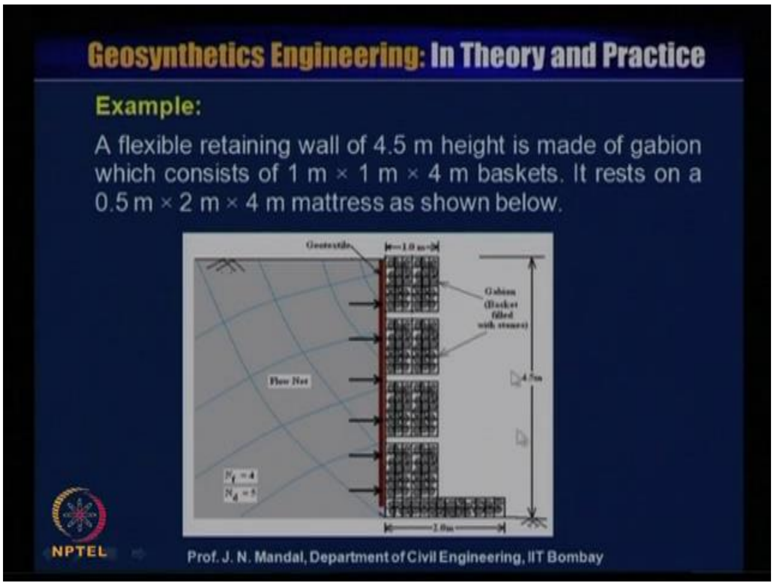

Now, I will present an example a flexible retaining wall of 4.5 meter height is made of gabion which consist of 1 meter by 1 meter into 4 meter basket. It rest on a 0.5 meter by 2 meter into 4 meter mattresses as shown, here and the back of the gabion retaining wall a layer of geo textile is placed and water should percolate through the geo textile, through that gabion box and this gabion box is a basket filled with the stone. So, when we will design, then we should know what should be the quantity of water passes, through the gabion.

So, we you have to draw the number of the flow line. So, this you can see number of flow line has been drawn and number of equipotential line, let us say the number of flow line N f is 4 and number of equipotential line N d is equal to 5.

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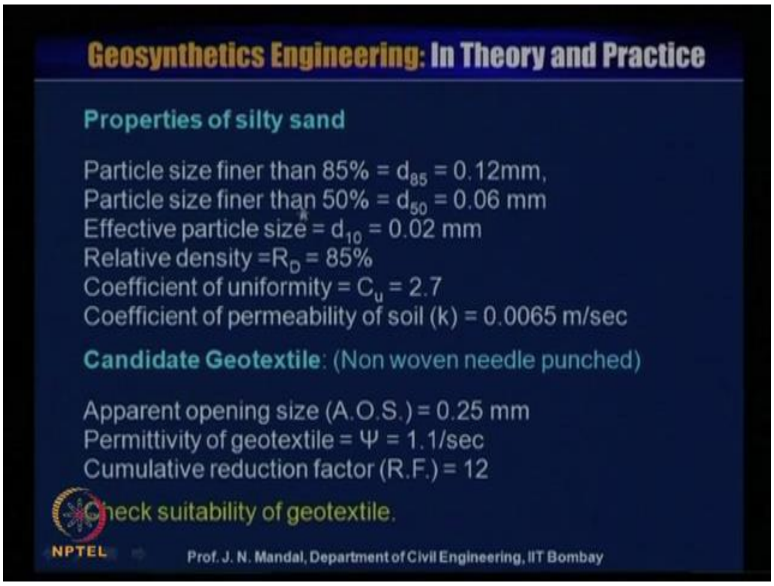

And properties of the silty sand is given particle size of the finer than 85 percent d 85 0.12 millimeter, particle size finer than 50 percent is equal to d 50 is equal to 0.06 millimeter, effective particle size d 10 is equal to 0.02 millimeter, relative density R d is 85 percentage, coefficient of uniformity C u is equal to 2.7, coefficient of permeability of the soil k is equal to 0.0065 meter per second.

Candidate geo textile, we are considering here, the nonwoven needle punched geo textile and properties of the nonwoven needle punched geo textile Apparent Opening Size AOS is 0.25 millimeter, permittivity of geo textile psi is equal to 1.1 per second and cumulative reduction factor RF is equal to 12. So, we have to check that whether this nonwoven needle punched geo textile material is suitable or not.

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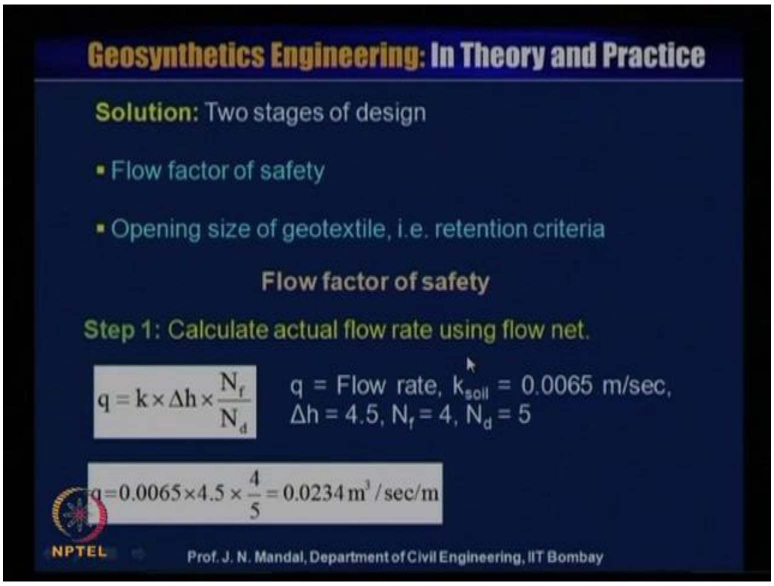

Now, solution when you will solve this kind of the problem, there are two stages of design, one is flow factor of safety, the other is the retention criteria; that means, what should be the opening size of geo textile and what will be the ultimately flow factor of safety. So, step one we will calculate what will be the actual flow rate, as I mentioned you earlier that you draw the flow net diagram and calculate the N f and N d.

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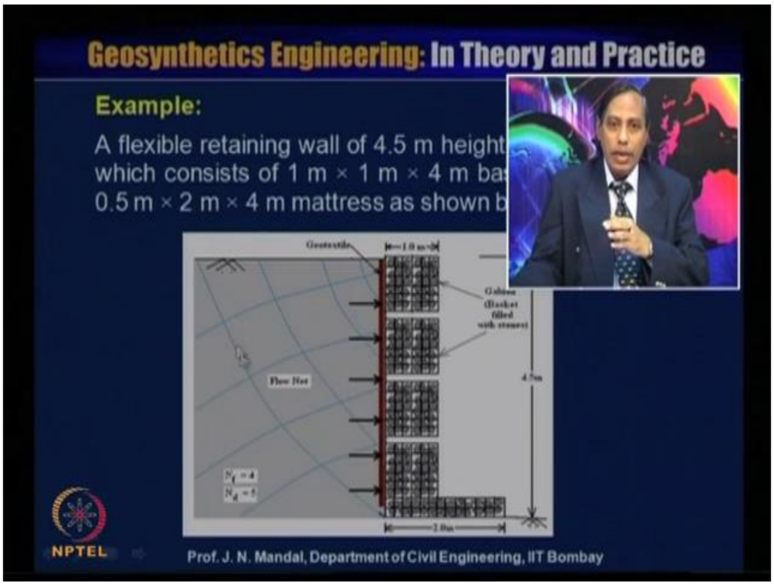

Here, this is the flow net diagram and we calculated what will be the number of flow line here 4 and number of equipotential line 5.

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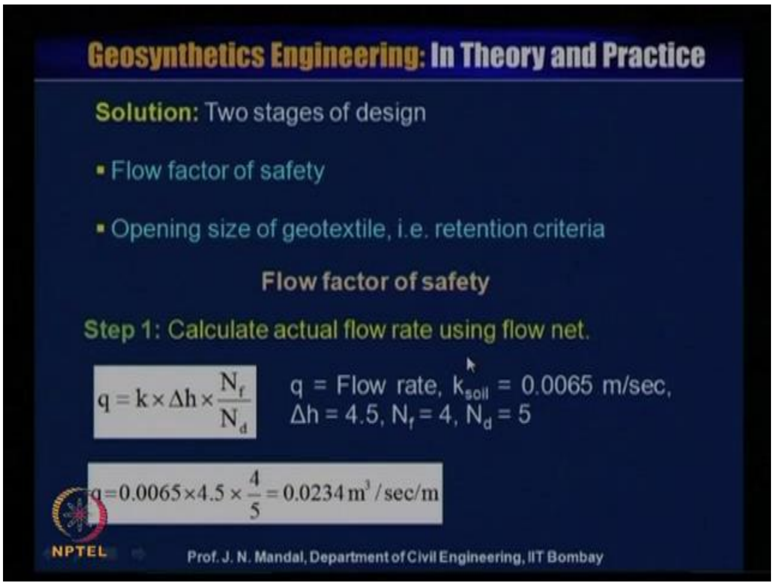

So, we know N f N d k value is given k soil is given 0.0065 meter per second and delta h is 4.5, N f we know 4, N d 5. So, if we substitute these value that q will be 0, k is equal to 0.0065 into delta h is equal to 4.5, N f is equal to 4 and N d is equal to 5. So, ultimately q will be the 0.0234 meter cube per second per meter.

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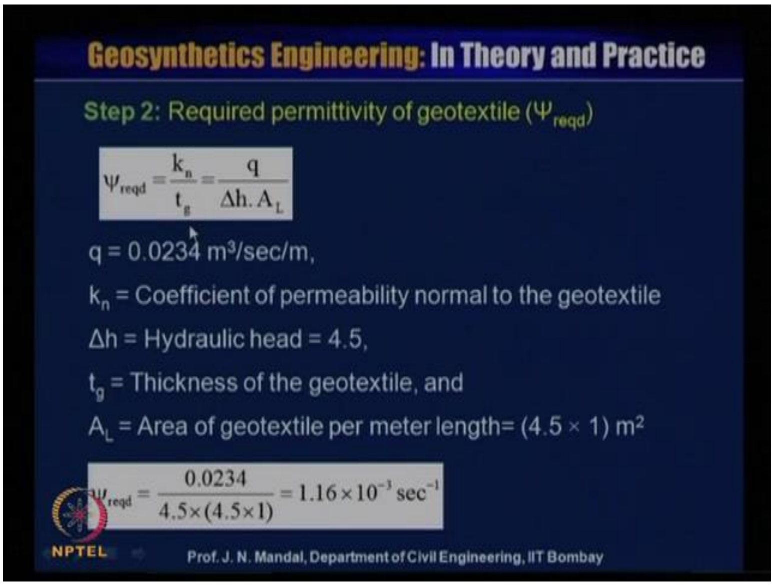

Now step 2, what is required permittivity of geo textile which is psi required. So, psi required you know this equation k n by t g q by delta h into A L and here is flow q already we have calculated earlier 0.0234 meter cube per second per minute, and k n is coefficient of permeability normal to this geo textile and delta h is equal to hydraulic gradient that is 4.5, t g is equal to thickness of the geo textile and A L is thickness, A L is area of geo textile per meter length; that means that is 4.5 into 1 that is 4.5 into 1 meter square.

So, now if you substitute this value, then you can calculate what is psi required, psi required is equal to q is known 0.02345 and delta h is 4.5 and area of geo textile per meter length 4.5 into 1. So, if you calculate you can determine that, what should be the required permittivity of the geo textile that is psi required is 1.16 into 10 to the power minus 3 per second.

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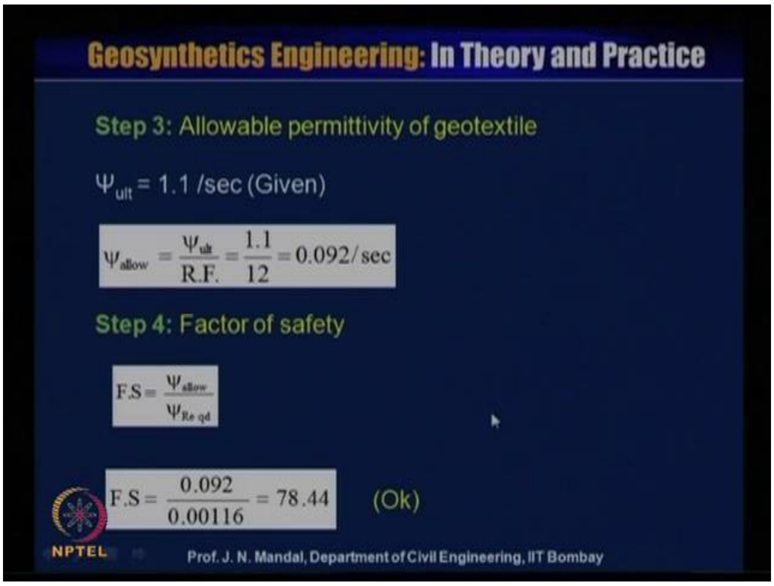

step 3, allowable permittivity of geo textile. So, this is psi ultimate is given, in the problem 1.1 per second. So, what will be the allowable geo textile permittivity. So, allowable geo textile permittivity will be, the ratio of ultimate geo textile permittivity and the reduction factor. So, we have consider here, the reduction factor is 12. So, we can write 1.1 by 12 is 0.092 per second.

Now, step 4 you have to calculate what is factor of safety, that is factor of safety will be equal to psi allowable by psi required. So, psi allowable is 0.092 psi required which we have calculated earlier psi required is this 1.16 into 10 to the power minus 3; that means, 0.00116 that is equal to 78.44. So, this is ok.

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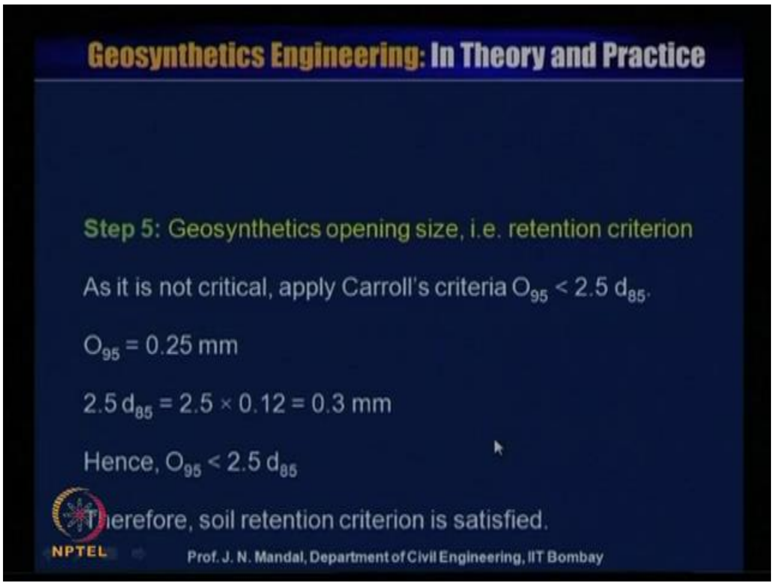

So, this is one that flow related criteria now, step 5 that we have to be taken care for the opening size of the geo synthetics material; that means, what should be the retention criteria. So, these criteria also should satisfy. So, as it is not a critical apply the Carroll's criteria, that Carroll's had given that apparent opening size of the geo textile O 95 should be less than 2.5 into d 85 . Now, O 95 is given 0.25 millimeter, so 2.5 into d 85. So, d 85 also given that is 0.12. So, 2 into d 85 means 2.5 into 0.12 is 0.3 millimeter.

And O 95 you can see 0.25 millimeter that should be less than 2.5 into d 85, so 2. d 85 is having 0.3 millimeter. So, this is less than this therefore, soil retention criteria also satisfied. So, we have designed the gabion geo textile when you will use in the back of the wall, gabion wall. Now, geo synthetics filter around under drain in a highway, when generally the crushed stone or you can say uniform or the graded soil, filtered around the perforated pipe under drain is used.

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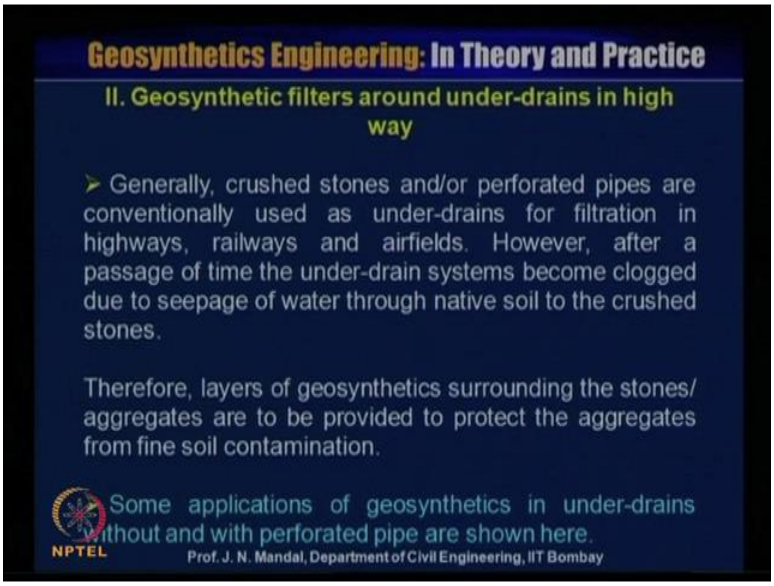

Generally the crushed stone and or perforated pipe are conventionally used as under drain for filtration in highway, railway and airfield. However, after a passage of time the under drain system become clogged due to the seepage of water through native soil to the crushed stone. Therefore, layer of geo synthetics surround the stone or aggregate are to be provided to protect the aggregate from soil contamination. Some application of geo synthetics in under drain without and with perforated pipe also are shown here.

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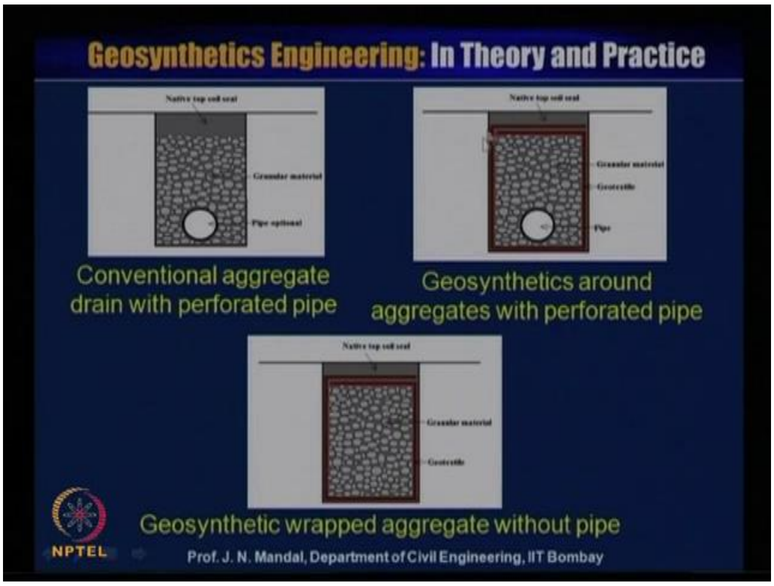

You can see here, this is the conventional aggregate drain with perforated pipe, you can see this you excavate filled up with the aggregate and this is the pipe that is optional and then on the top of this it is the native soil. So, there is a possibility for clogging or choking, because the native soil is directly come in contact with the aggregate. So, after a passage of time it will choke.

Therefore, it is preferable that you should provide a geo synthetics, this red color geo synthetics around the aggregate with perforated pipe, that is optional you can provide the perforated pipe or you it is not necessary to provide the perforated pipe here, geo synthetics around aggregate with perforated pipe and here, geo synthetics wrap around aggregate without pipe, that pipe is optional.

So, when you are providing this pipe, when you are providing the geo synthetics material, then the soil will not clogged, because this geo synthetics material act as a separation and the same time it act as a good drainage and the filtration material.

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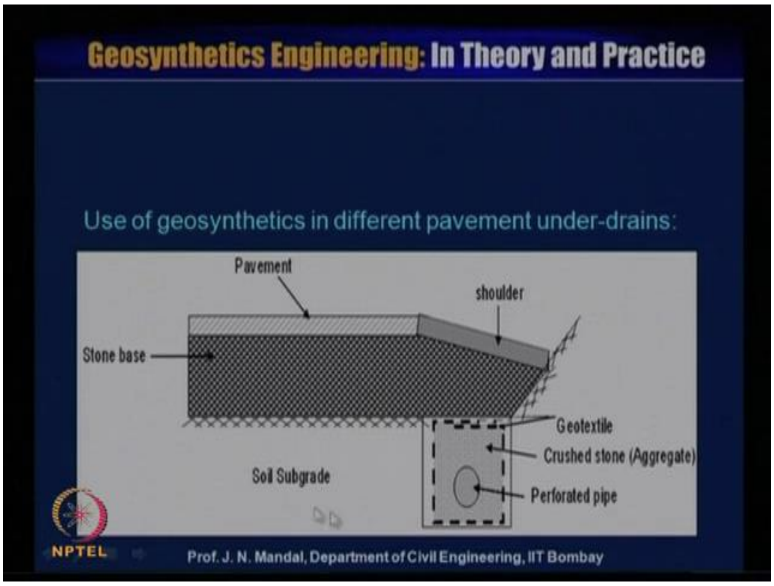

Now, some use of geo synthetics in pavement under drain, this is the soil sub grade and this is the stone base, this is the pavement, this portion is the shoulder and this is the drainage part, you can see we can provide with the crushed stone or aggregate and this is wrapped with the geo textile material and this is perforated pipe and this perforated pipe is optional. So, whenever rain water will percolate, through the pavement to the stone base and then it passes through this drain. So, there should not be any clogging.

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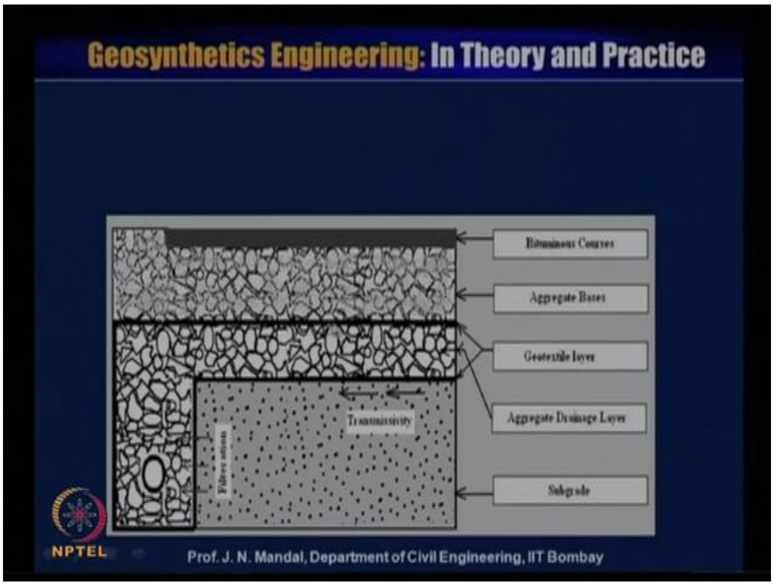

This also, this another system where you can use for the pavement, this is the bitumen course, this is the aggregate base and this is the geo textile layer, you can see that geo textile layer is placed like this, like this and like this. And aggregate drainage layer is placed and here is a pipe, that is the optional here, geo synthetics material act as a two function, one that water can flow along this plane of the geo textile material, which we call the transmissivity and one that water can pass across this plane of the geo textile material, which is called the filtration or which we call also transmissivity.

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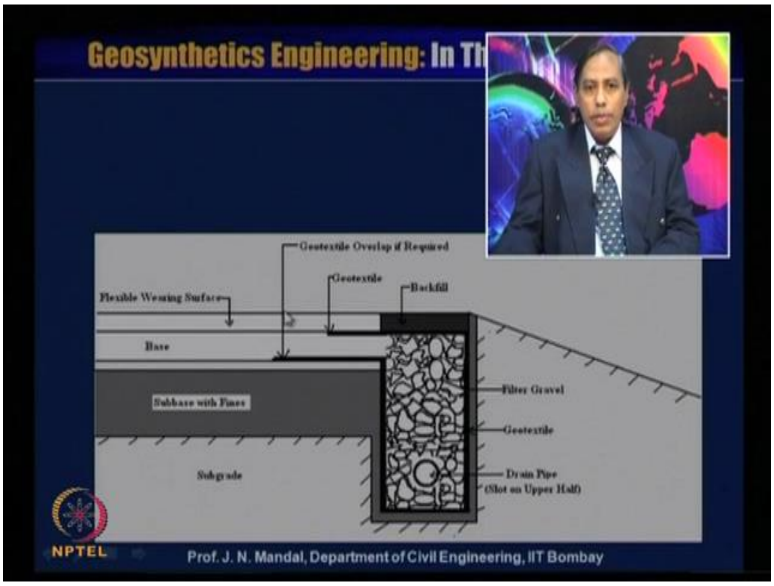

Now, this is also similar type, you can see this is a flexible wearing surface is here, geo textile overlay if it is required and this is the back fill and this is the filter gravel material, this is geo textile material, this is the drain pipe and these slot is on the upper half and this is the sub grade and this is the sub grade with the fine. So, when water also can percolate through this, also you can provide this kind of the drainage system.

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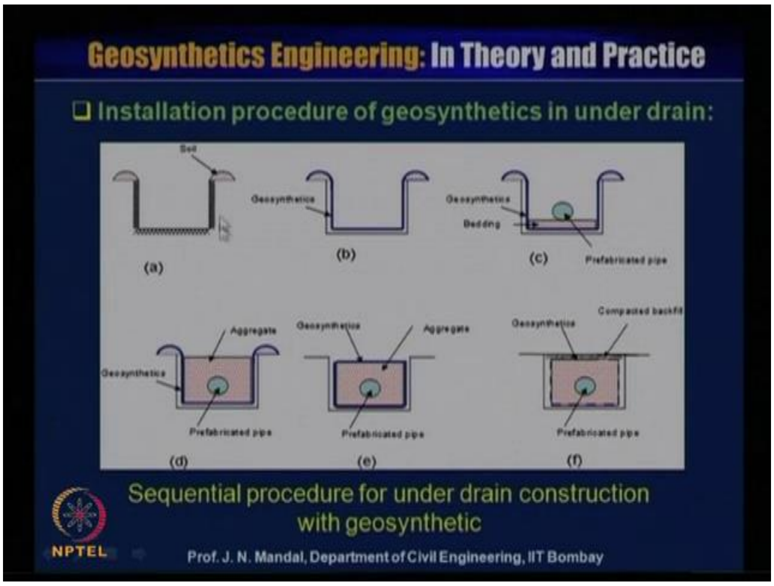

Now, in case of drainage how to install the geo synthetics material, so you installation procedure of geo synthetics in under drain.

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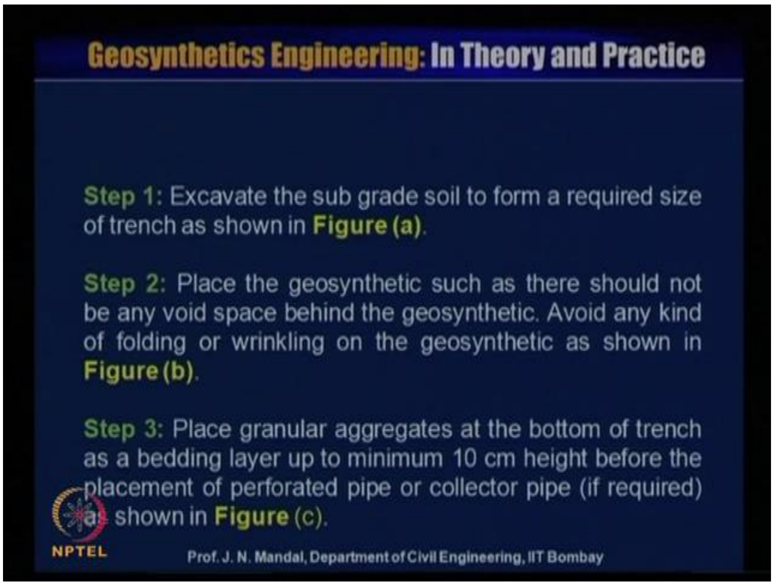

This is first that you require excavate the sub grade soil to form a required size of a trench as shown.

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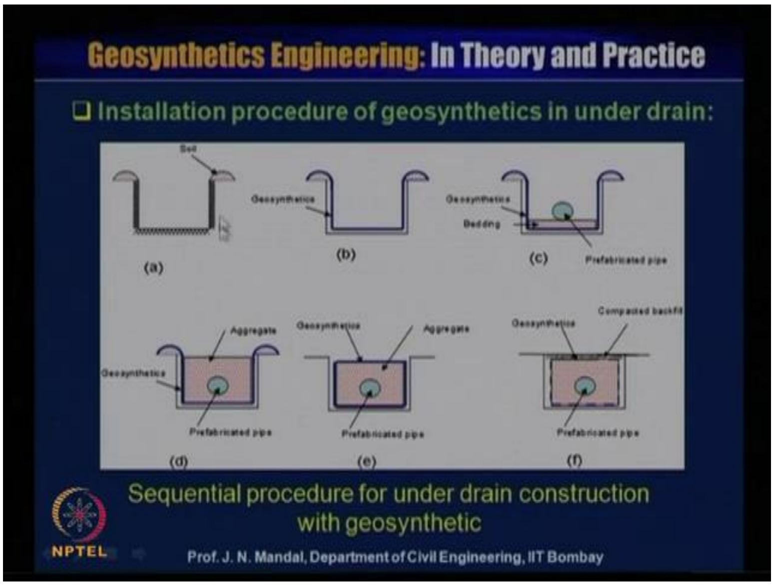

You excavate and form a required type of the soil, I will just show you the sequential procedure for under drain construction with geo synthetics material.

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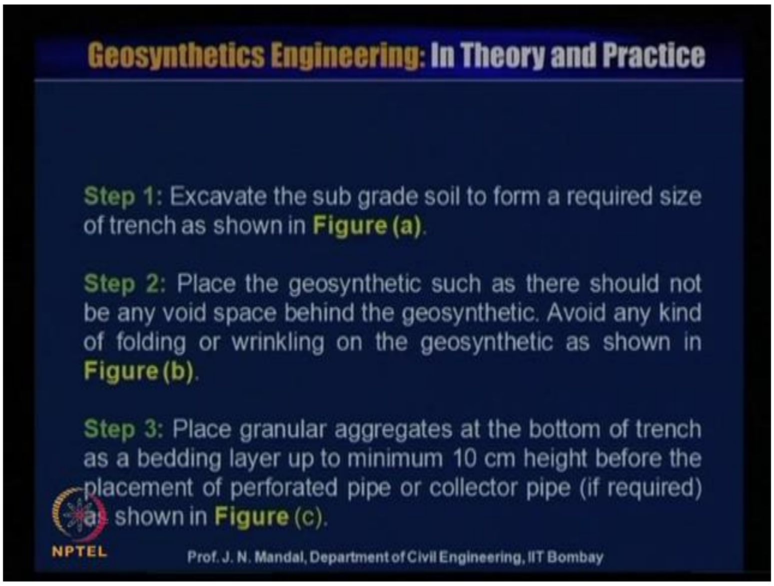

So, next you can place the geo synthetics such as, there should not be any void space behind the geo synthetics. Avoid any kind of folding or wrinkling on the geo synthetics.

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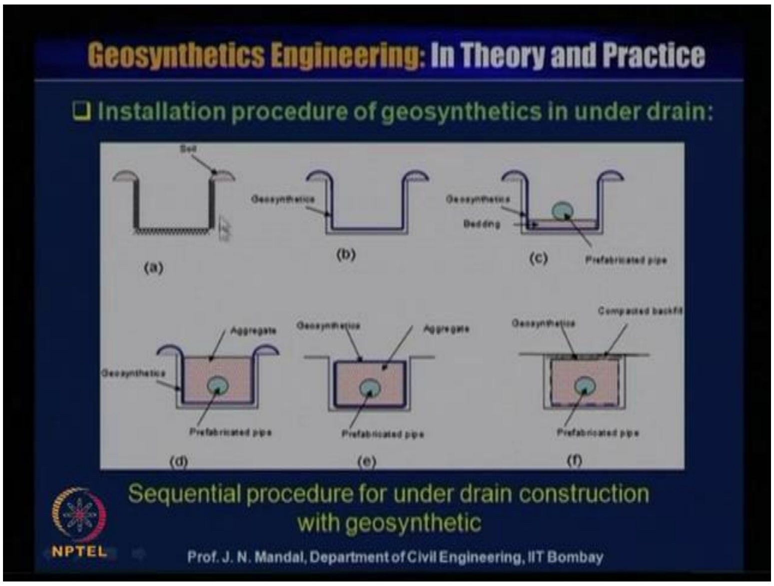

So, you are placing this geo synthetics material like that. So, there should not be any wrinkling, there should not be development into void.

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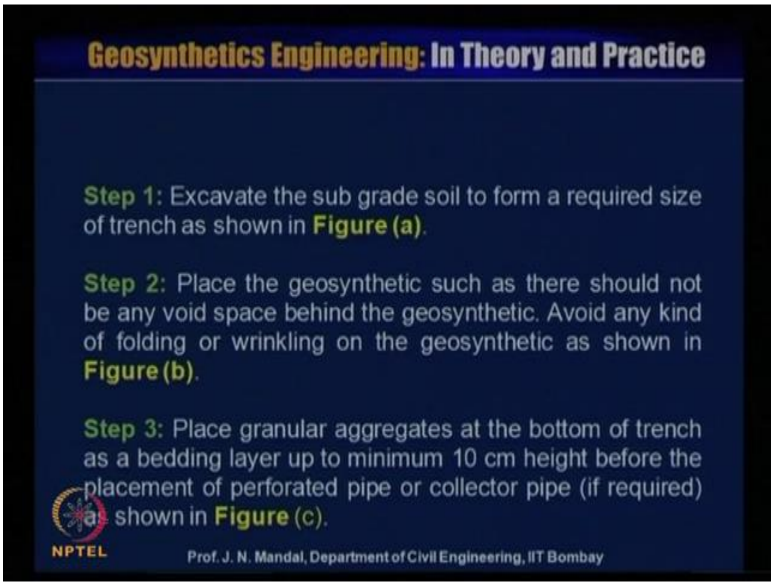

And next step 3, you place the granular aggregate at the bottom of the trench as a bedding layer up to minimum 10 centimeter height before the placement of perforated pipe or collected pipe if required.

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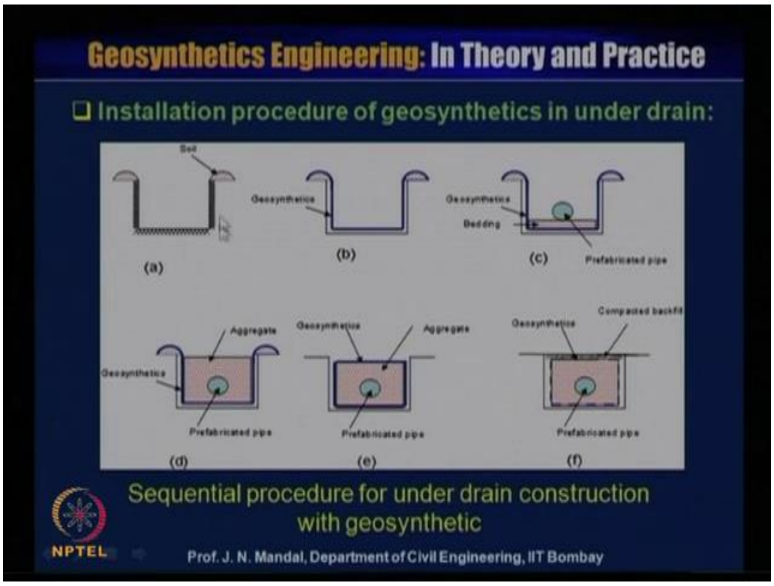

So, here you can see that, this is the bedding layer 10 centimeter and then this is the prefabricated perforated pipe.

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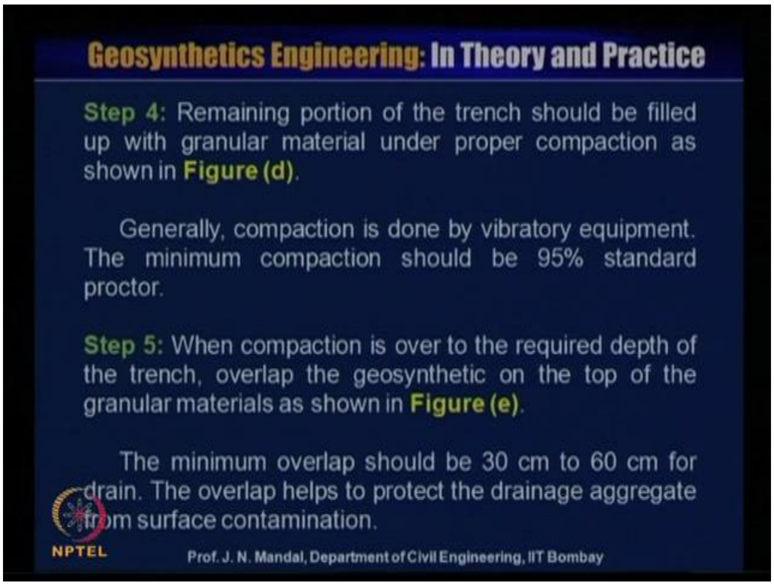

Then step 4, remaining portion of the trench should be filled with granular material under proper compaction.

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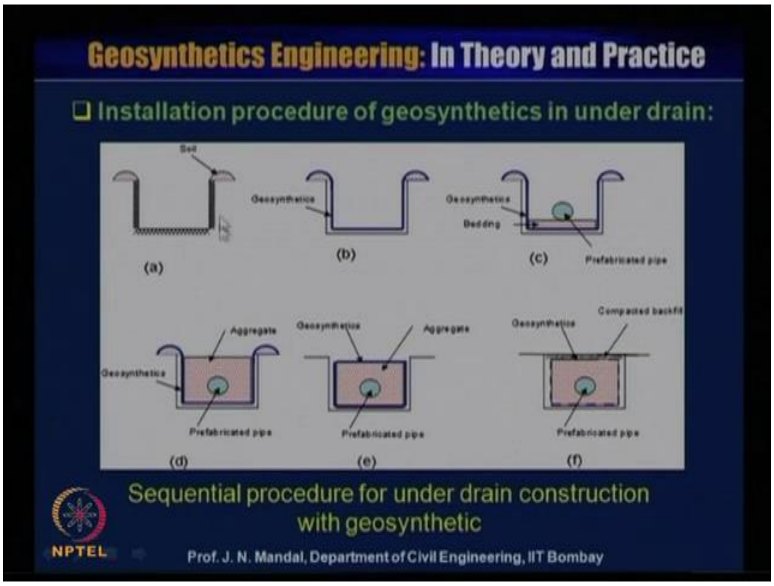

So, this is remaining portion you have to fill up with the granular material to the required depth. So, this aggregate is filled up here. Now, step 5 generally that compaction is done by the vibratory equipment. The minimum compaction should be 95 percent standard proctor. Step 5, when compaction is over to the required depth of the trench, overlap the geo synthetics on the top of the granular material and the minimum overlap should be 30 centimeter to 60 centimeter for drain. The overlap help to protect the drainage aggregate from surface contamination.

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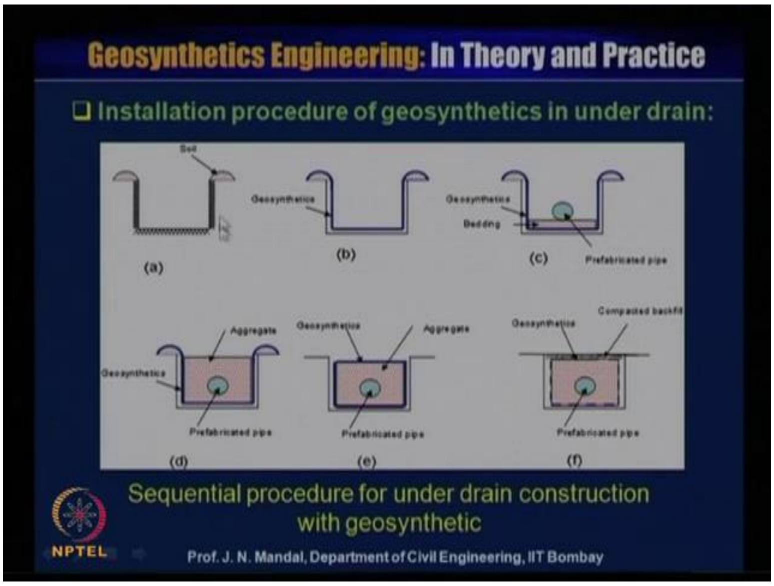

You can see here, this is geo synthetics material is wrapped on the top here.

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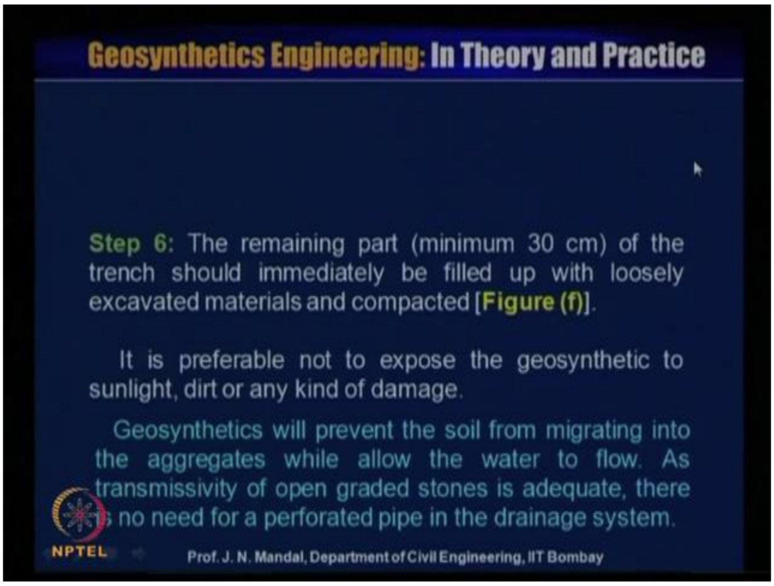

And then the remaining part minimum 30 centimeter of the trench should immediately be filled with loosely excavated material and compacted.

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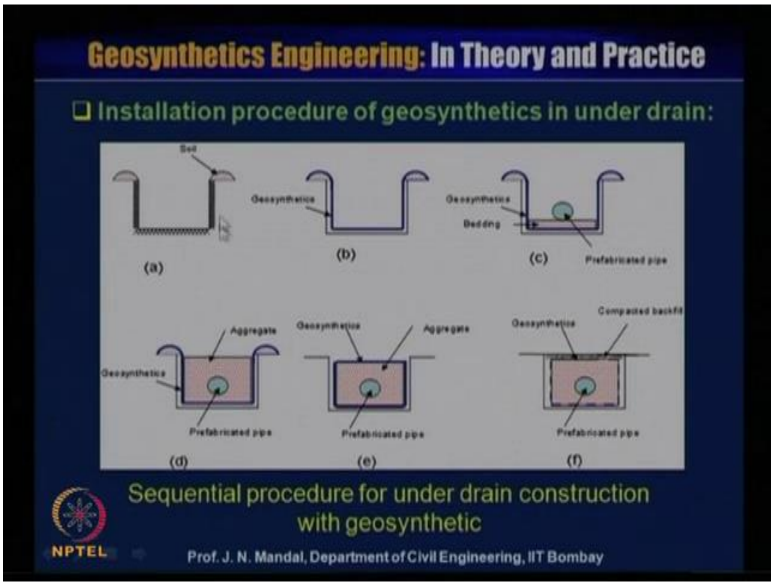

So, here this loosely soil this is on the top you had to the loosely soil is to be the filled it up.

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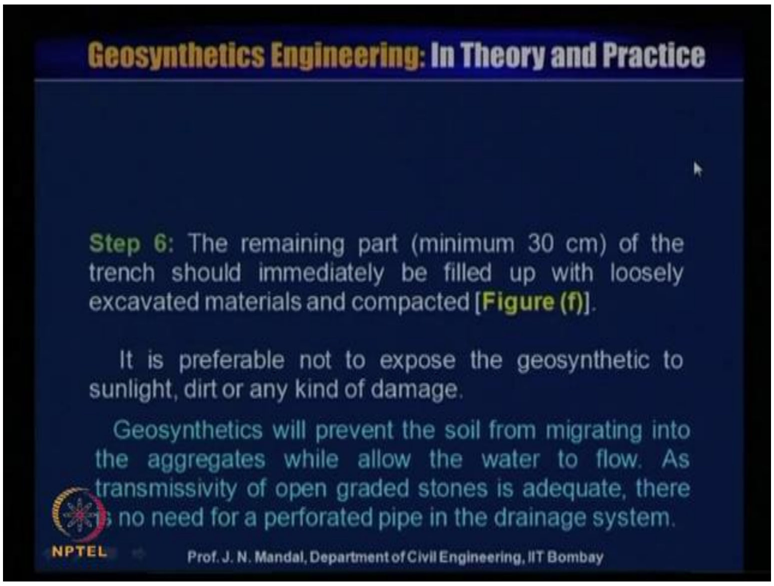

So, it is preferable not to expose the geo synthetics to sunlight, dirt or any kind of drainage. Geo synthetics will prevent the soil from migrating into the aggregate while allow the water to flow. As transmissivity of open graded stone is adequate, there is no need for a perforated pipe in the drainage system.

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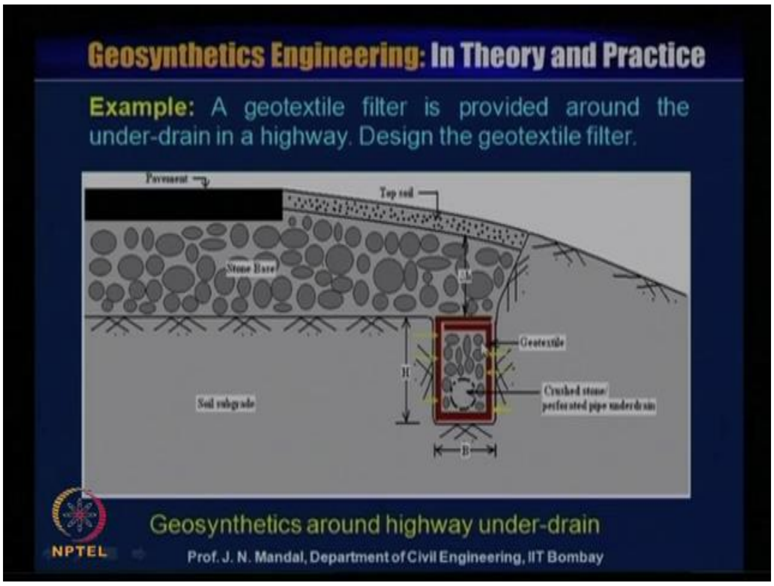

Now, I am showing second example, a geo textile filter is provided around the under drain in a highway. So, this is the sub grade, this is the stone base, this is the pavement, this is the top soil and this is the drain, this is width b, this is height of the drain h and this red is geo textile material and this is the crushed stone and perforated pipe under drain that is optional and this is delta h. So, this is geo synthetics material around highway under drain.

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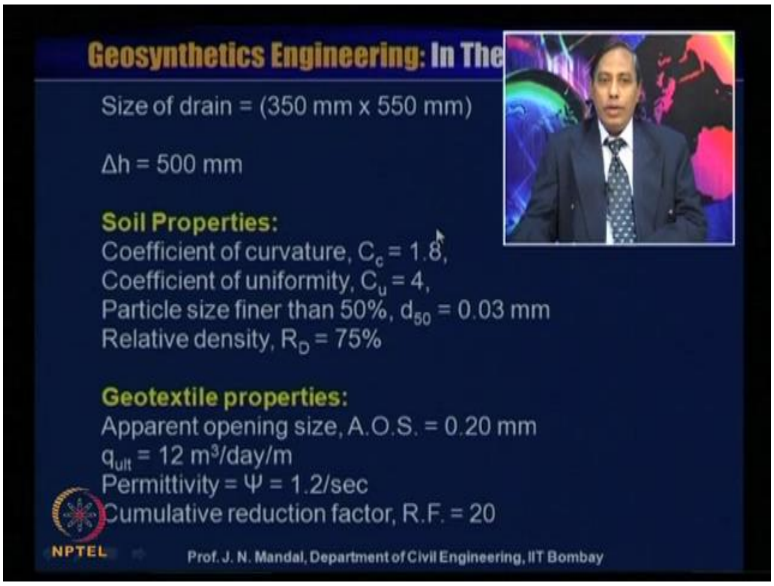

Now, size of the drain is 350 millimeter by 550 millimeter, that mean this b 350 millimeter and height h 550 millimeter and delta h is 500 millimeter; that means, this delta h is 500 millimeter. Now, we should know that what should be the soil property. So, coefficient of curvature C c is 1.8, coefficient of uniformity C u is 4, particle size finer than 50 percent d 50 0.03 millimeter, relative density R d is equal to 75 percentage these are the soil property.

And geo textile property is given Apparent Opening Size AOS is 0.20 millimeter and ultimate flow q ultimate is equal to 12 meter cube per day per meter, permittivity value psi is given 1.2 per second and cumulative Reduction Factor RF is equal to 20.

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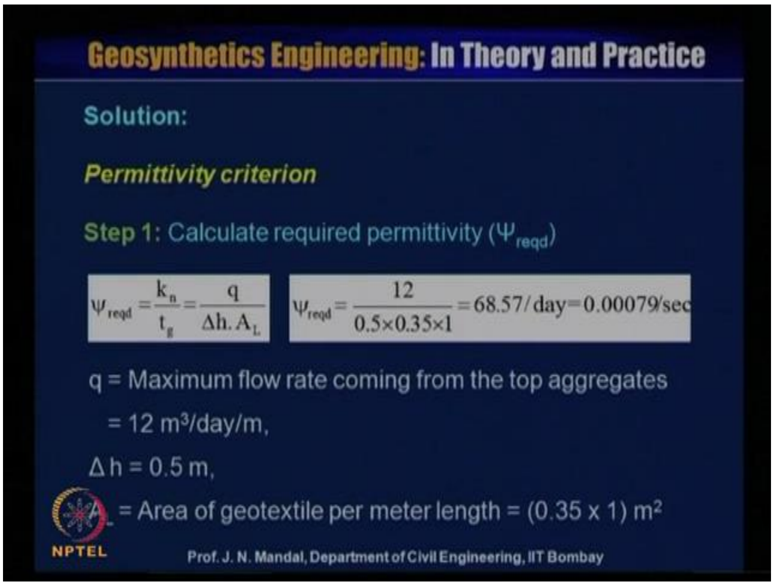

So, now solution you have to fulfill the permittivity criteria. So, step 1, calculate the required permittivity; that means, permittivity psi required, psi required is equal to k n by t g that is q by delta h into A L we know the equation, q value is given 12, delta h value is given 0.5 and A L is equal to 0.35 into 1 because A L is equal to 0.35 into 1.

And then you calculate the what is required permittivity that is 68.57 per day or is equal to 0.00079 per second and q is maximum flow rate coming from the top aggregate, that we take 12 meter cube per day meter, as you know delta h already I have mentioned 0.5, area also geo textile length is this meter square.

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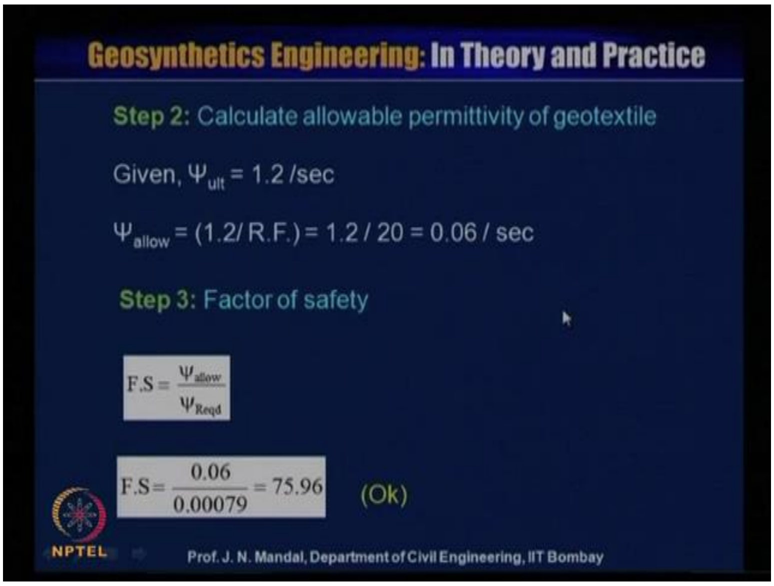

Step 2, calculate the allowable permittivity of geo textile and that is given psi ultimate 1.2 per second. So, psi allowable will be 1.2 divided by reduction factor and reduction factor given 20. So, this will be equal to 1.2 by 20 is 0.06 per second. Then step 3, factor of safety. So, factor of safety is the ratio of psi allowable by psi required. So, factor of safety is psi allowable 0.06 and psi required, we have calculated earlier 0.00079. So, psi is equal to 0.00079. So, this factor of safety is 75.96 is it is quite on the hard side of the factor of the safety.

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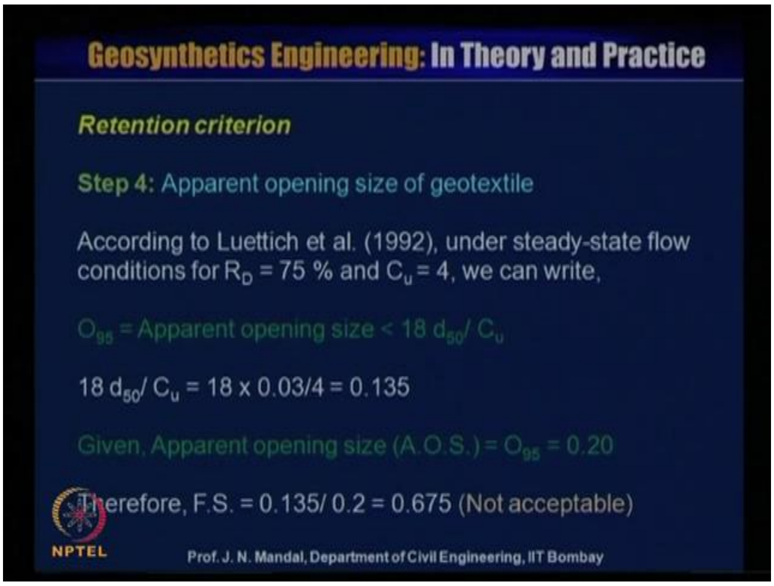

Now, you have to check the retention criteria; that means, step 5 you have to calculate what will be the apparent opening size of the geo textile material or O 95. So, according to the luettich et al. 1992 table under the steady state flow condition, I already been described in a my previous lecture and from that table. So, for the relative density 75 percent and C u is equal to the 4. So, we can write, this equation you can have this equation; that means, O 95 should be less than 18 into d 50 by C u.

So, what is 18 d 50 by C u. So, 18 d 50 means is 0.03 and C u is equal to 4 and d 50 value also it is d 50 value also it is given this is 0.03 millimeter. So, this you substitute this value 0.03 this divided by C u, C u is equal to the 4 this is 4. So, you can write 18 into 0.03 divided by 4 that is C u is equal to 0.135. Now, given the apparent opening size of the geo textile O 95 is 0.20.

So, therefore, factor of safety 0.135 by 0.2; that means, this factor of safety is 0.675. So, in terms of the retention criteria it is not satisfied because this value is too low, this is the only 0.675 therefore, it is not acceptable, you can see the retention criteria is not satisfying but flow related criteria it is satisfying. So, you have to check that, what kind of the geo textile material should use. So, you can take another geo textile material and also to check that what should be the apparent opening size of the geo textile material.

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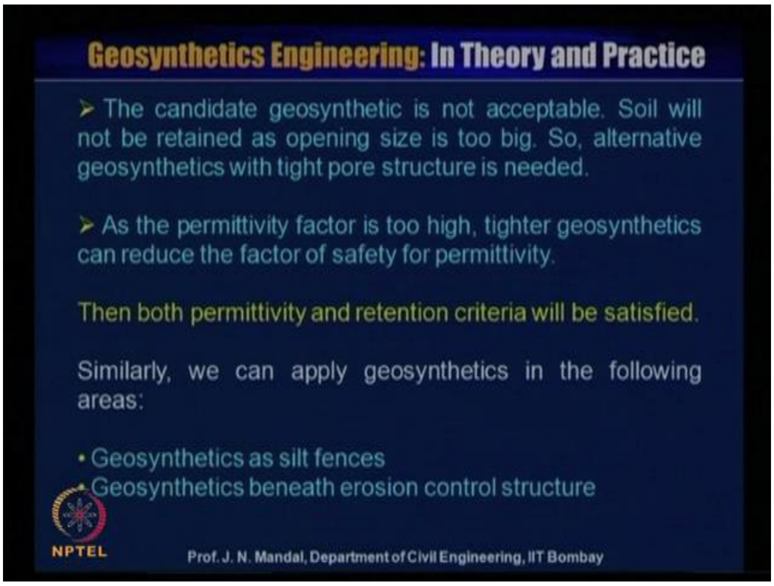

Now, candidate geo synthetics is not acceptable. Soil will not be retained as opening size is too big. So, alternative geo synthetics with tight pore structure is needed. As the permittivity factor is too high tight, geo synthetics can reduce the factor of safety for permittivity, then both permittivity and retention criteria will be satisfied. Similarly, we can apply geo synthetics in the following area that is geo synthetics as silt fences and geo synthetics beneath the erosion control structure.

So, you have to be very careful that, whether the both the criteria that is permittivity criteria and at the same time the apparent opening size of the geo textile material and correlated criteria is satisfying or not, if it is satisfied then it is, if it does not satisfy then you have to adopt some alternative material, which can satisfy the criteria I end it up this lecture today.

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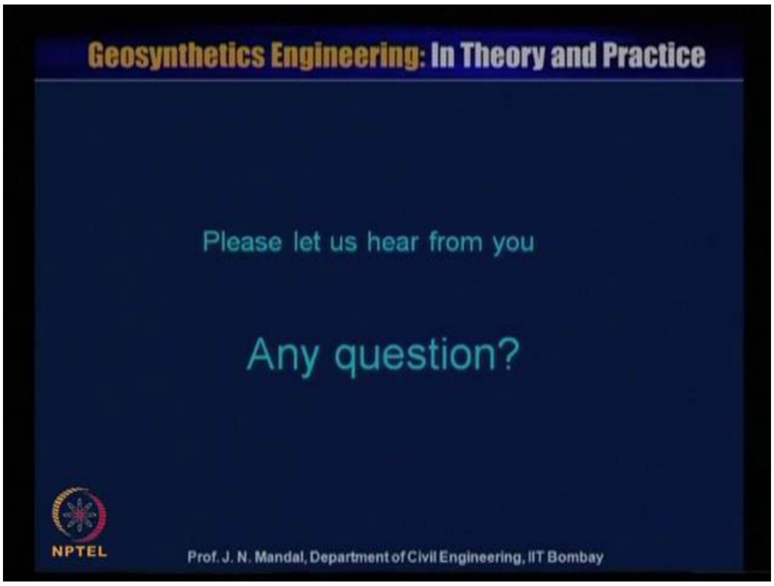

Please let us hear from you any question.

Thanks for listening.