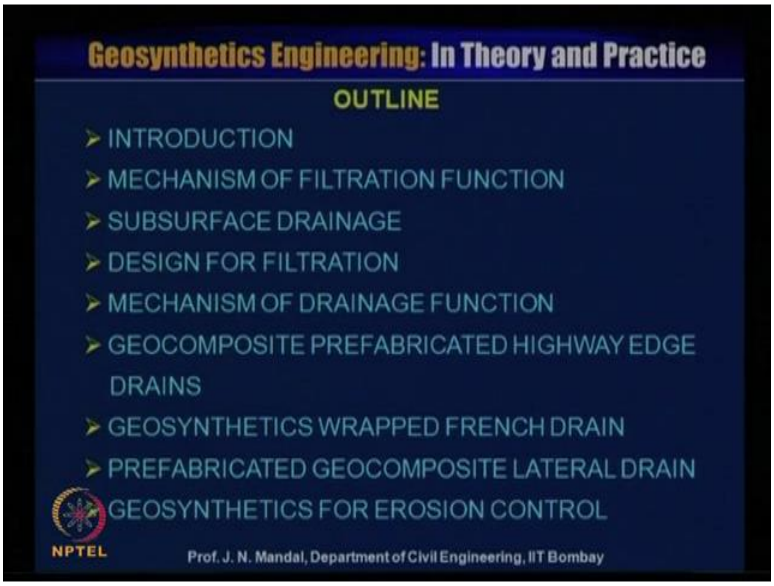
Geosynthetics Engineering: In Theory and Practices
Prof. J. N. Mandal
Department of Civil Engineering
Indian Institute of Technology, Mumbai

Lecture - 15
Geosynthetics for Filtrations Drainages and Erosion Control Systems

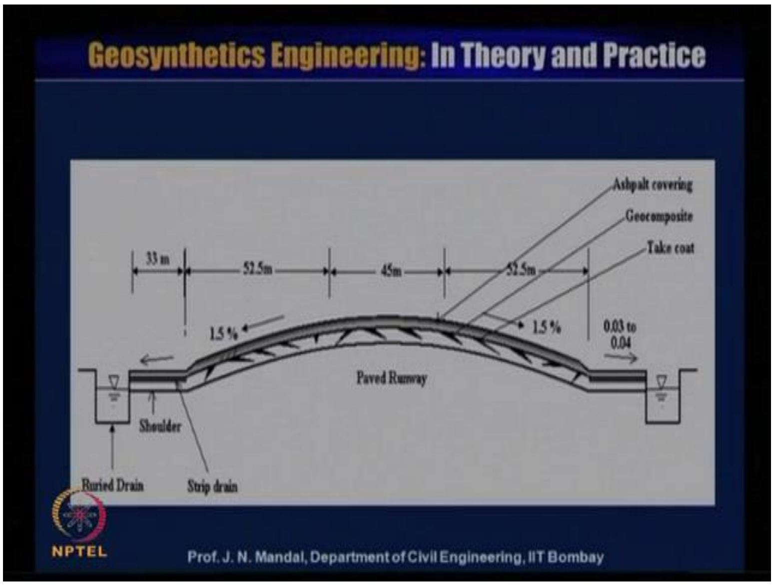
Welcome to lecture 15, my name is Professor J. N. Mandal, department of civil engineering, Indian Institute of Technology, Bombay, Mumbai, India, the name of the course Geosynthetics Engineering in Theory and Practice. This module 4 lecture 15 Geosynthetics for Filtration Drainage and Erosion Control System. This is one of the most important lecture related with the filtration, drainage and erosion control problem. There are many, many problem in infrastructure related with the filtration and drainage as well as erosion control. Many structure collapse due to not proper drainage system or filtration system, so it is very much essential to study in depth about this subject.

(Refer Slide Time: 01:44)



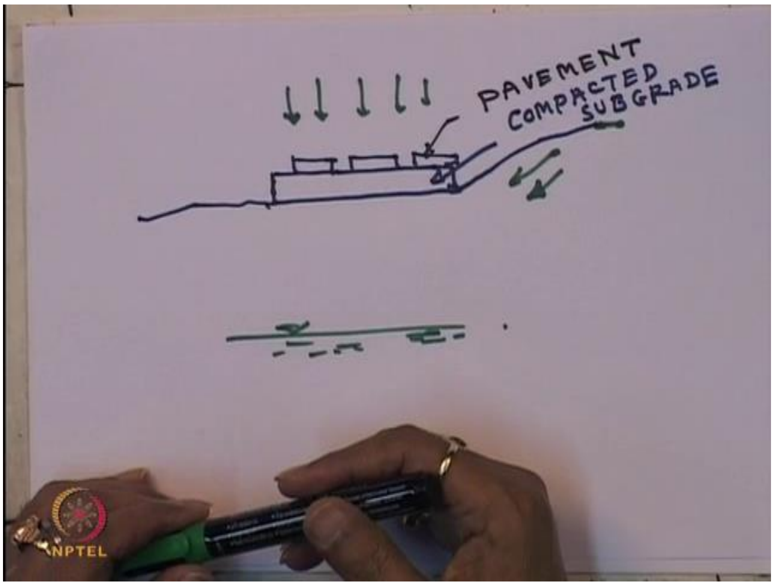
Outline of this course, introduction, mechanism of filtration function, subsurface drainage, design for filtration, mechanism of drainage function, geocomposite prefabricated highway edge drain, geosynthetics wrapped french drain, prefabricated geocomposite lateral drain and geosynthetics for erosion control.

(Refer Slide Time: 02:18)



Look at this picture, this is a paved runway and this is a shoulder and this is the buried drain. And conventional method, we do not provide any geotextile material on the top of the pavement but you can provide with the geocomposite and then asphalt covering on the top. You should provide proper kind of the slope in order that, rain water can drained it out throughout this drainage system. Now, most important that, how the water should percolate through the pavement runway, if there is no geosynthetics material. I am showing you that, some means of moisture movement in a pavement.

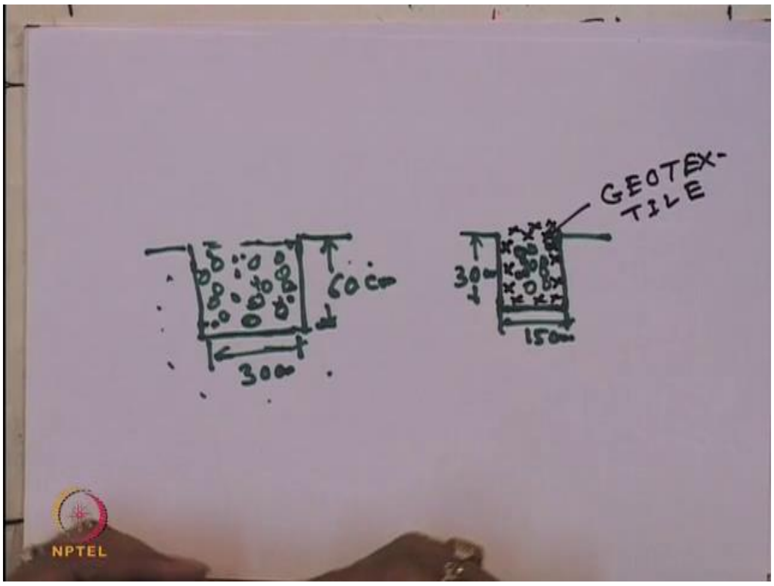
(Refer Slide Time: 03:42)



Let us say, this is compacted subgrade and this is the pavement now rain water, it can pass through this pavement that means, through permeable surface. So, it also sometime the seepage from the high ground water suppose, if it is a high ground water then seepage also from high ground water. There is a vapor movement, if there is any water table so, there will be from water table then also, upper movement of water table or there is a capillary rise.

So, there are various means of moisture movement in the pavement so, moisture can ingrates the crack and soften the subgrade for further deterioration. So, what we can adopt and what we can provide with the proper kind of the drainage and the filtration system and what is the type of conventional system are going on. So, I will show you some drainage system so, what we do that…

(Refer Slide Time: 06:30)

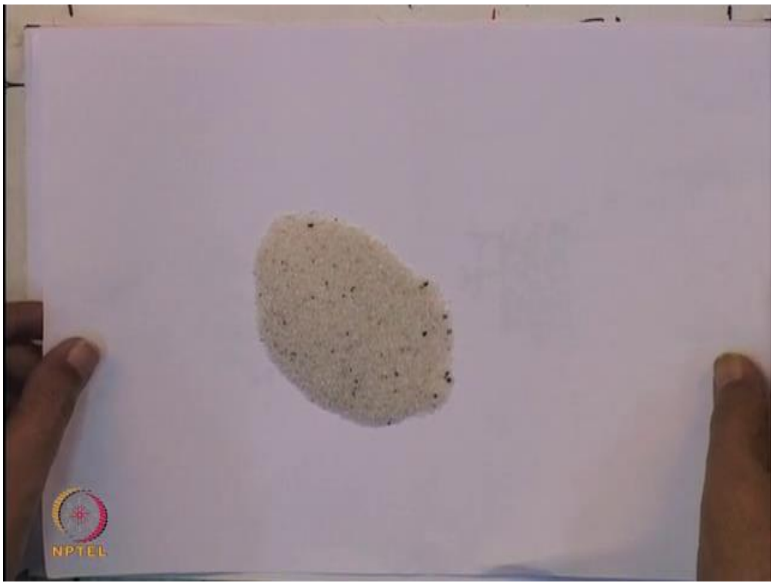


You can see that, roadside we provide with this kind of the drainage system, in the conventional method suppose, if it is a 60 centimeter and if it is a 30 centimeter and then we fill up with the good quality of the aggregate. And after the passage of time, the surrounding it is soil, so after a passage of time, this aggregate choked or clogged and then again, you have to remove the aggregate. Then openly excavate and fill up with the fresh good quality aggregate.

So, this is what is the conventional method what we adopt so, maintenance is one of the greatest problem because it frequently clogged or choked. So, alternative to this system, we can provide let us say, this is 30 centimeter and this is 15 centimeter, so you cannot excavate 30 centimeter and then also we can excavate 15 centimeter. And you can place a layer of geotextile material, this is geotextile material, and then you place the aggregate and then you can wrap with geotextile material, you can wrap it.

So, what will happen? It is like encapsulated with the geotextile material so, there should not be any clogging. So, you have to select the proper kind of the geotextile material, this is geotextile material.

(Refer Slide Time: 09:24)

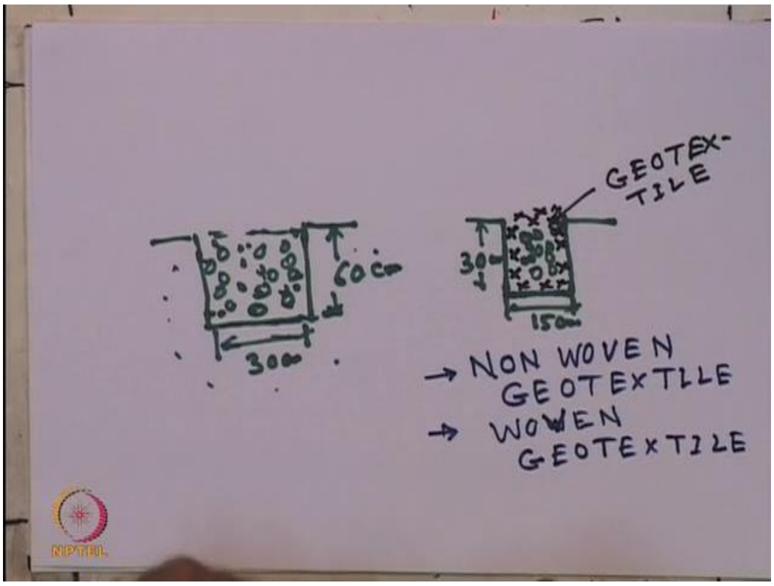


So, most of the cases what we use, you can see sometimes we can use this kind of the sand for the filtration and the drainage that is, conventional what we use it.

(Refer Slide Time: 09:40)

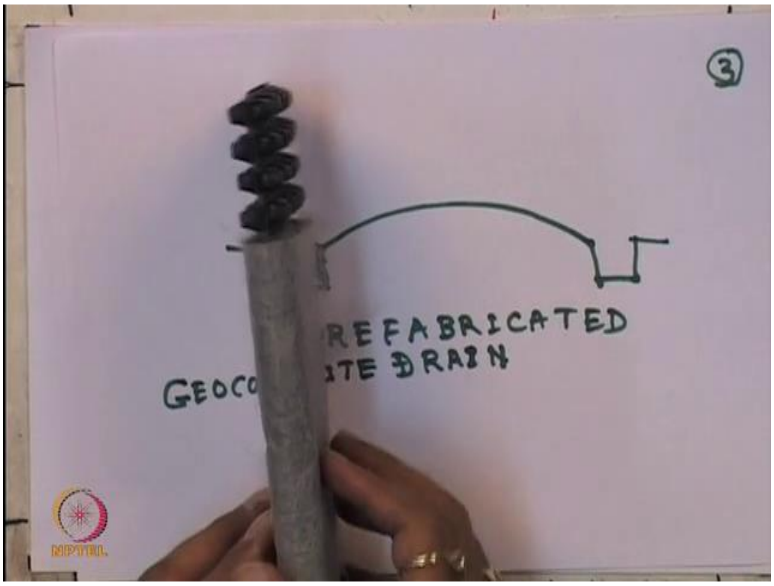
We can also use for more good drainage, we use this kind of aggregate, well graded or open graded good quality aggregate. So, this we sue for the conventional method so, alternative to this system, we can use geotextile.

(Refer Slide Time: 10:04)



It may be non woven geotextile or it may be woven geotextile so, this is the kind of geotextile material and I am saying, I have shown you earlier, this is a kind of non woven geotextile material, this filament is very random. So, you can wrap it, it is very flexible, you can wrap it like this any direction and we fill up with the aggregation. So, we can use this kind of non woven geotextile material or you can use, this is woven geotextile material, whose filament is perpendicular to each other. So, this kind of woven and non woven geotextile can be used.

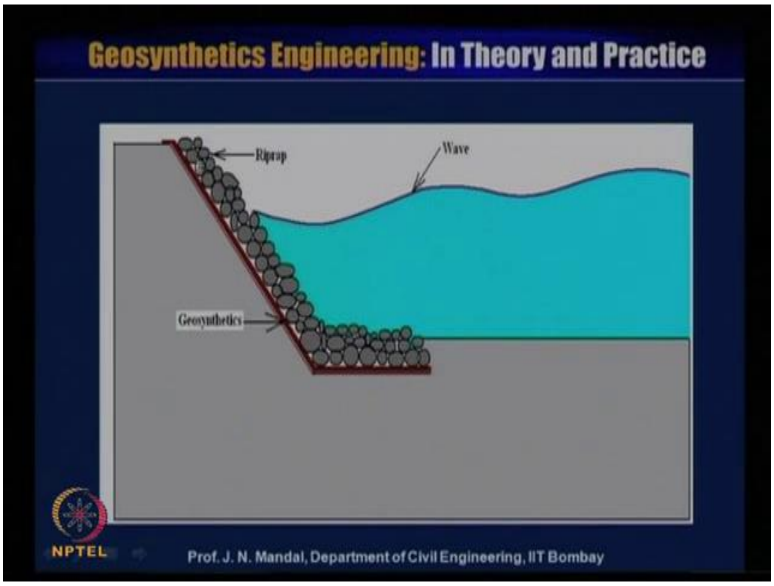
(Refer Slide Time: 11:36)



Apart from this, you can simply for example, this is the road and here is the drainage system so, you can use here this prefabricated drainage. You do not need drainage even then road anything kind of excavation with the machinery. Very less excavation can be done and simultaneously, you can place the material that is, prefabricated drainage. You can say prefabricated geocomposite drain, let us say geocomposite drain so, it is a kind of material like this.

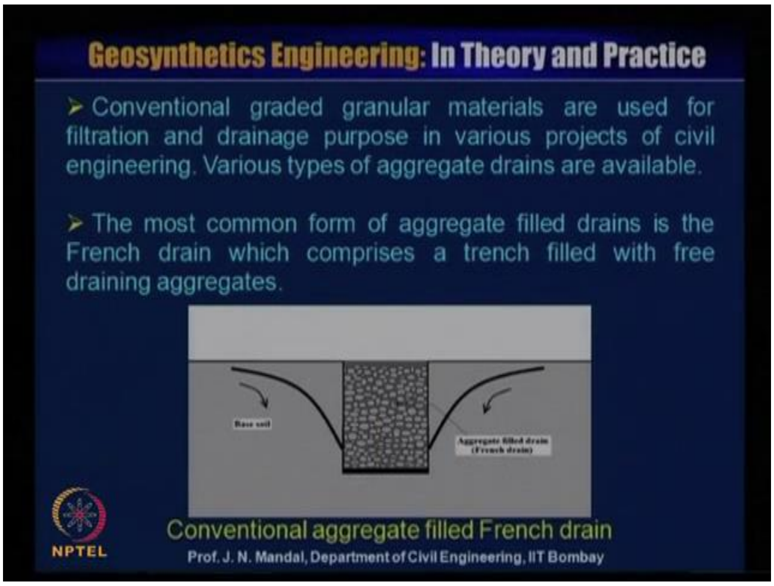
It is prefabricated geocomposite drain, it is a plastic wrapped with the geotextile material, you can simply place both side of the road by the machinery. It has been used exclusively in the Malaysia so, you do not need any kind of the gravel or the sand even then any woven non woven geotextile material, simply you can use this material and it is give very good flow capacity. So, this is what we talk about the filter and the drainage for the road and similarly, we can use the geosynthetic material for the erosion control.

(Refer Slide Time: 13:39)



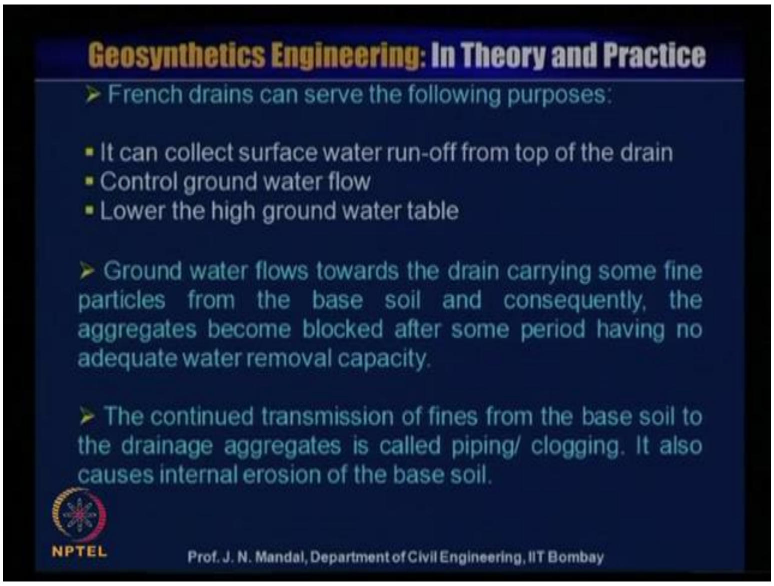
For the erosion control you can see, this is the subgrade and this is the geosynthetic material and this is the riprap or stone is placed on that and this is the wave. Then you have to check up that, what is the tidal wave, whether it is in laminar condition or the turbulent condition so accordingly, you have to design this or erosion control material. So, what I told you about that, conventional graded granular materials are used for filtration and drainage purpose in various project of civil engineering.

(Refer Slide Time: 14:20)



And various types of the aggregate grain are available, the most common form of aggregate filled grain is the French drain, which comprises a trench filled with the free drainage material. You see, this is the French drain and this trench is filled with the free drainage aggregate and this is the base soil and this is the aggregate filled drain so, what this conventional aggregate French drain, we generally use.

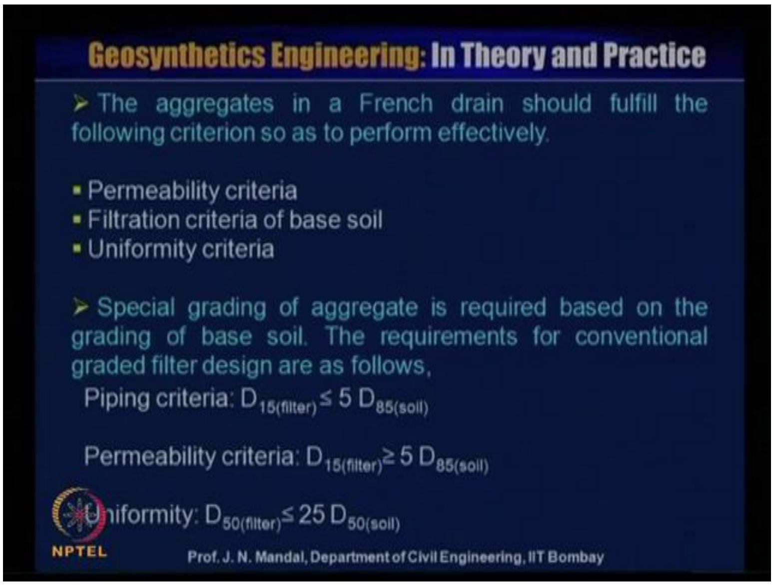
(Refer Slide Time: 15:00)



Now, French drain can serve the falling purpose, it can collect the surface water runoff from top of the drain then control the ground water flow, lower the high ground water table. Ground water flow towards the drain carrying some fine particle from the base soil and consequently, the aggregate become blocked after some period, having no adequate water removable capacity.

Like this, you can see this is the base, the water surface from base, the soil can pass through the aggregate and it blocked. And therefore, there is no adequate water removable capacity, the continued transmission of fine from base soil to the drainage aggregate is called the piping or clogging, it also causes internal erosion of the base soil.

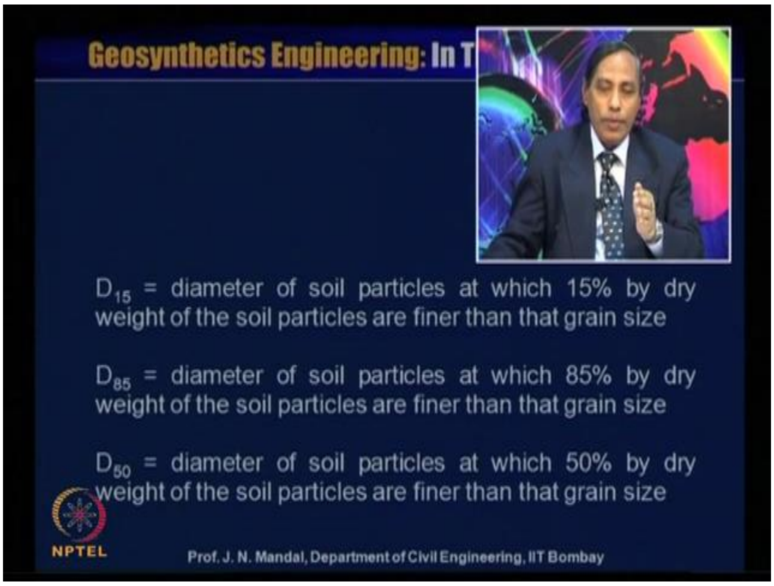
(Refer Slide Time: 16:06)



The aggregate in a French drain should fulfill the following criteria so as to perform effectively one is permeability criteria, second filtration criteria of base soil and third uniformity criteria. This special grading of aggregate is required based on the grading of the base soil, the requirement for conventional graded filter design are as follows. So, there is a piping criteria; that means, D 15 filter should be less than equal to 5 of D 85 soil, permeability criteria D 15 filters will be greater than equal to 5 D 85 soil and uniformity criteria that is, D 15 filter less than equal to 25 D 50 soil.

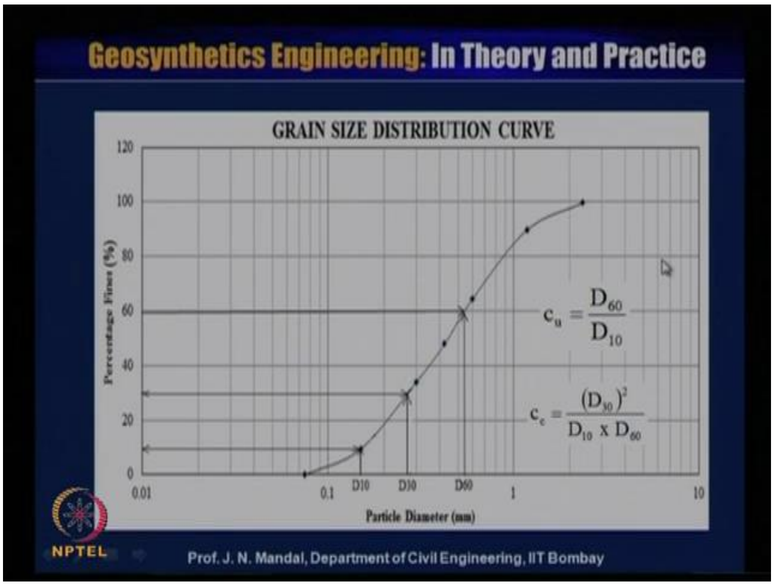
So, in the conventional method, what we design for the piping criteria, permeability criteria and the uniformity criteria now, how can we determine all this parameter.

(Refer Slide Time: 17:15)



So, what is D 15, D 15 is the diameter of the soil particle, at which 15 percent by dry weight of the soil particle are finer than that grain size. D 85 is the diameter of the soil particle, at which 85 percent by dry weight of the soil particle are finer than that grain size. And D 50, diameter of the soil particle at which 50 percent by dry weight of the soil particle are finer than that grain size.

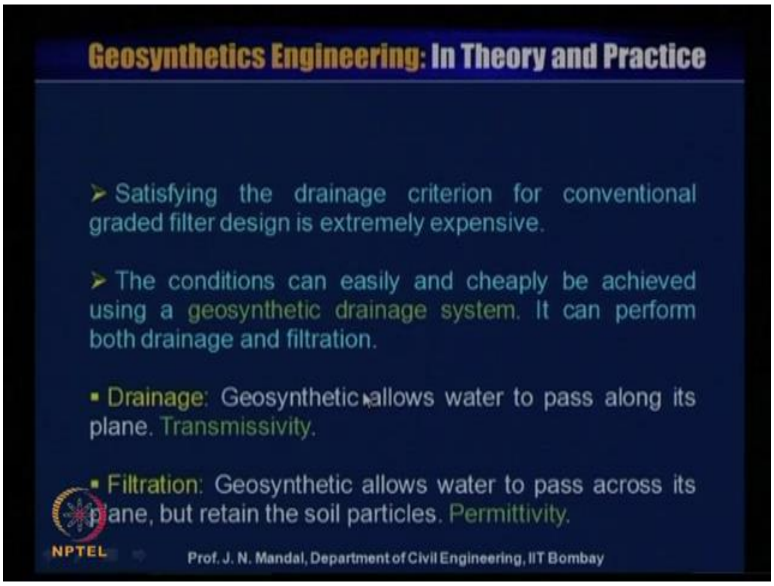
(Refer Slide Time: 17:51)



So, we can see, this is the grain size distribution curve, this is the percentage finer and this is the particle diameter in millimeter. For any filtration, drainage and the erosion control system, one should conduct thoroughly the soil investigation and particularly, the grain size distribution. So, this you can see that, grain size distribution curve and for this grain size distribution curve, you can calculate what should be the D 15, what will be the D 50 and what should be the D 85.

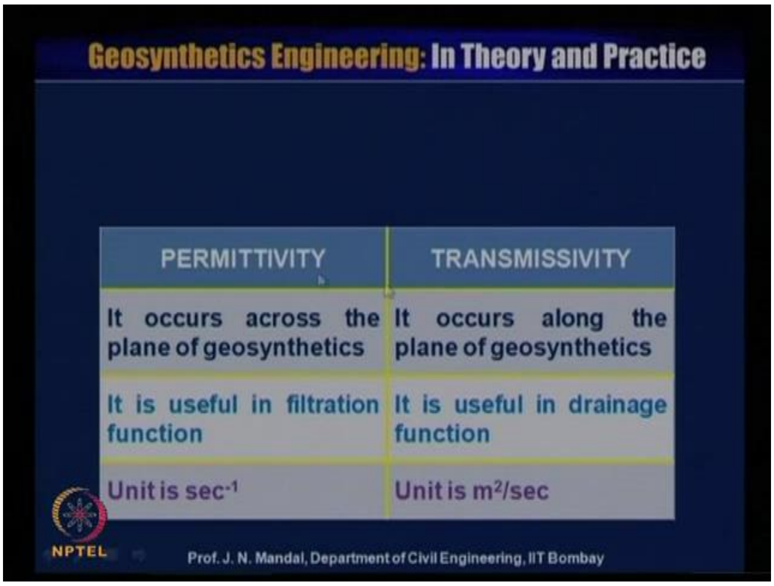
Then, you can check with this criteria, piping criteria, permeability criteria and the uniformity criteria. So, if it is satisfied then it is ok what is called conventional method what we do and in general, for grain size distribution you know, this is the relationship between the percentage finer and particle size distribution. From this curve we generally determine, what is the coefficient of the uniformity C u D 60 by D 10, coefficient of curvature C c, D 30 square divided by D 10 into D 60. From, you can calculate what is D 10, what is D 30 and what is D 50 from this grain size distribution curve.

(Refer Slide Time: 19:30)



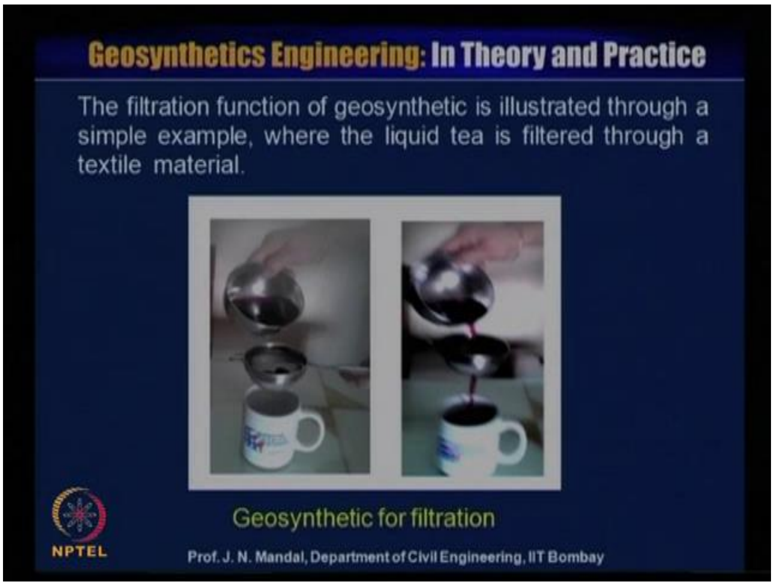
Satisfying the drainage criteria for conventional graded filter design is extremely expensive. The condition can easily and cheaply be achieved using a Geosynthetic drainage system, it can perform both drainage and filtration. What is drainage, what is filtration, drainage means geosynthetics allow water to pass along it is plane it is called the transmissivity. For that filtration, geosynthetics allow water to pass across the plane but retain the soil particle is called permittivity.

(Refer Slide Time: 20:13)



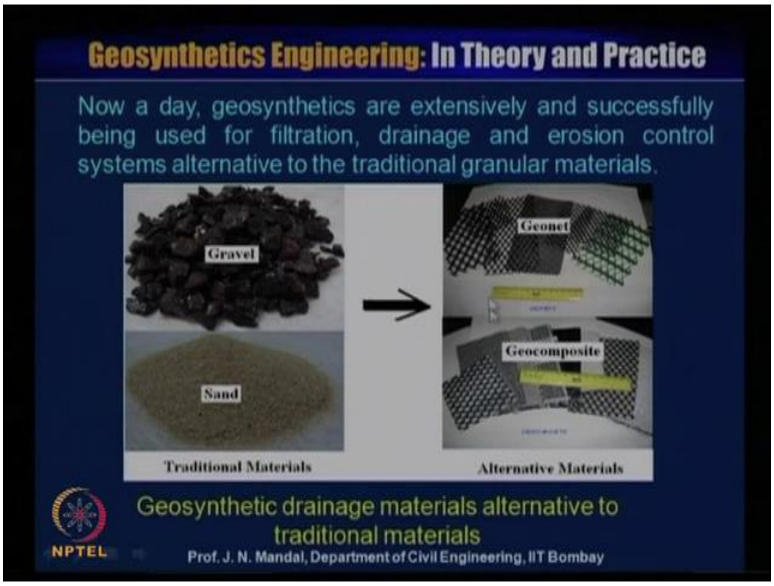
Now, in general, that difference between permittivity and transmissivity, it occurs across the plane of the geosynthetics and it occurs along the plane of the geosynthetics in case of transmissivity. In case of permittivity, it is useful in the filtration function and in case of transmissivity, it is useful in drainage function. And look at the unit of permittivity is per second, unit of transmissivity is meter square per second so, you should remember.

(Refer Slide Time: 20:50)



So, what is the filtration, is very one common example that, geosynthetics for the filtration. This we can see, we take a cup of coffee or tea with the filter material. So, filtration function of geosynthetics is illustrated through a simple example, when the liquid tea is flitered through a textile material so, this is one good example for the filtration.

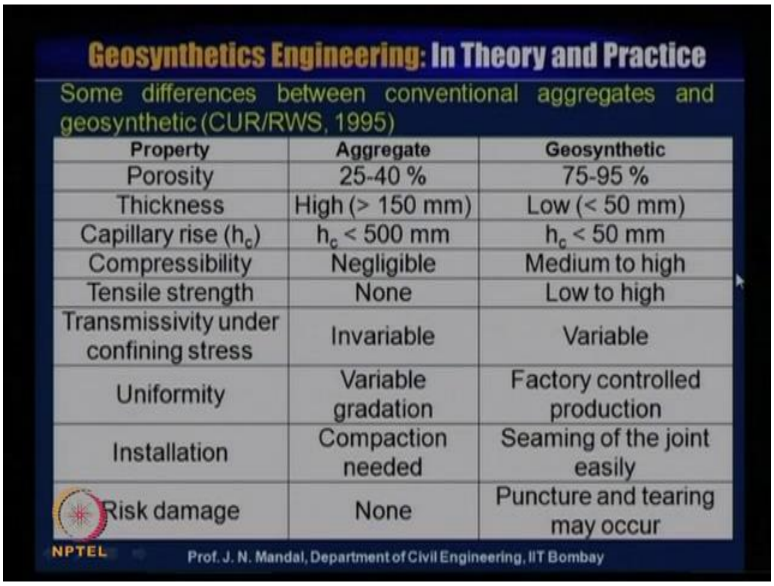
(Refer Slide Time: 21:38)



Now, as I have showed you also, not a geosynthetics are extensively and successfully used for filtration, drainage and erosion control system, alternative to the traditional granular material. So, this I showed you the gravel and sand, these are traditional method and this is the different types of the geosynthetics material. This is geonet, this is geocomposite, it may be woven or non woven geotextile material also, what I showed you.

So, this is alternative system can be used, also in terms of energy, you can shape I also explain in my earlier lecture.

(Refer Slide Time: 22:14)



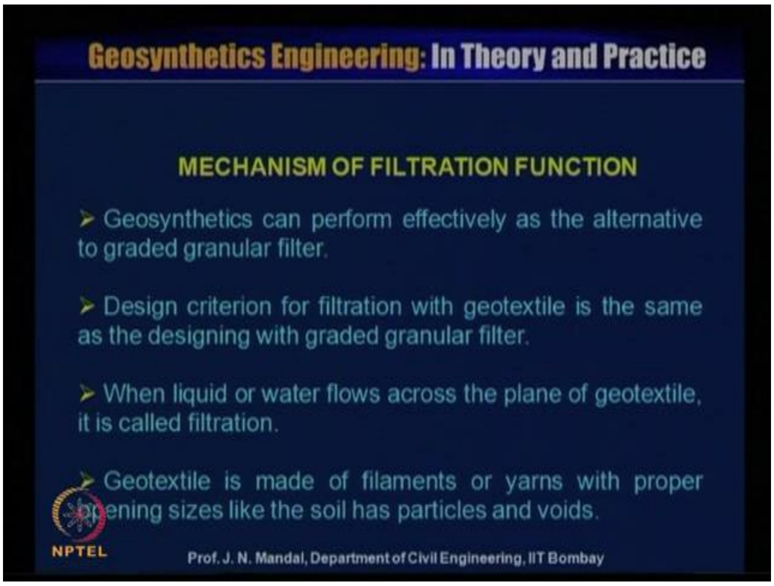
Now here, you can see some difference between the conventional aggregate and geosynthetics and this is given by CUR, RWS 1995, this is edited by Dr. K. Riasky and this is a kind of the code. So, you can see the property, aggregate and geosynthetics, what is the differences between aggregate and the geosynthetics. Look at porosity aggregate 25 to 40 percent whereas, geosynthetics porosity is 75 to 95 percentage. Thickness in case of aggregate is high, it is greater than 150 millimeter and geosynthetics is low less than 50 millimeter.

Capillary rise h c in case of aggregate less than 500 millimeter, in case of geosynthetics h c is less than 50 millimeter. Compressibility in case of aggregate negligible, in case of geosynthetics medium to high, tensile strength in case of aggregate no and in case of geosynthetics it is low to high. Transmissivity under confining stress in case of aggregate invariable but in case of geosynthetics, it is variable. Then uniformity in case of aggregate variable gradation, in case of geosynthetics factory controlled production.

Installation for aggregate you need compaction needed and in case of geosynthetics, seaming of the joint easily, it can be seen. In case of risk damage aggregate is none but in case of geosynthetics, there is a possibility for puncturing and tearing may occur. But, you have to design very carefully in order that, geosynthetics material should not be puncture or tear it off, And generally it is a saying, the CUR is centre for civil engineering research code and this is the ((Refer Time: 24:23)) on the use of the rock in the hydraulics engineering.

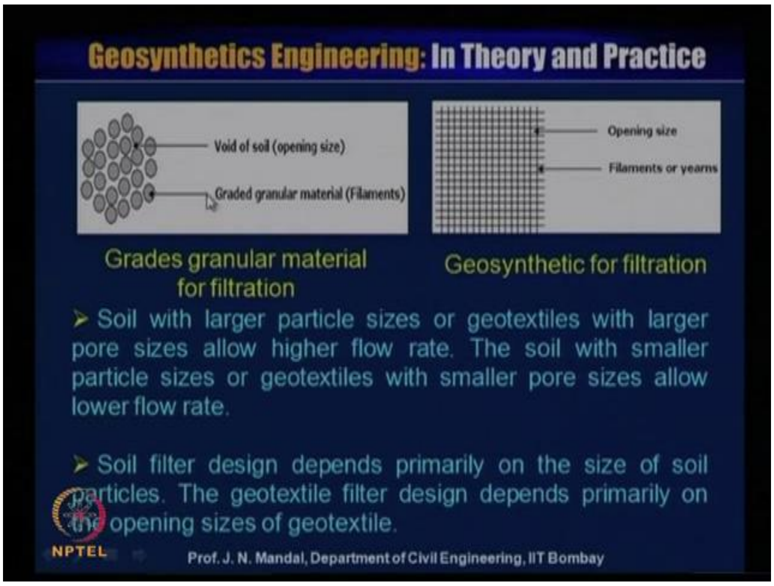
So, you have seen that what is the major difference between the aggregate and the geosynthetics material? So, there is a lot of advantage for the use of geosynthetics material for the filtration, drainage and the erosion control next, what is the mechanism of filtration function.

(Refer Slide Time: 24:52)



So, geosynthetic can perform effectively, either alternative to graded granular filter, design criteria for filtration with geotextile is the same as the design with the grade granular filter. When liquid or water flow across the plane of the geotextile is called filtration, geotextile is made of filament or yarn with proper opening size like the soil has particle and void.

(Refer Slide Time: 25:23)



You can see this picture left hand side, this is graded granular material and this graded granular material, this is like a filament and this is the void of soil, this is like a opening size. So, you can analog this graded granular material filter with the geosynthetics filter if you can see, this is a open geotextile material and it has a opening size or apparent opening size and this has also the filament or yarn. So, filament or yarn like a graded granular material and void ratio of the soil on opening size is like a opening size of the geotextile material.

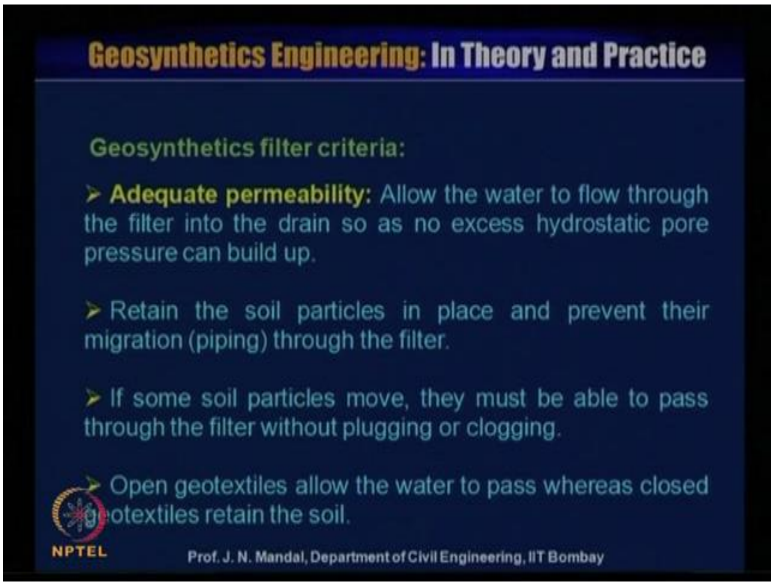
So, soil with large particle size of all geotextile with larger pore size allow higher flow rate, the soil with smaller particle sizes or geotextile with smaller pore size allow large flow rate. Soil filter design depend primarily on the size of the soil particle, the geotextile filter design depend primarily on the opening size of the textile material. As the geotextile material is prefabricated, so you can design as you like it, so this showing some of the picture.

(Refer Slide Time: 26:54)

You can see that, what is the conventional drainage system, you can see this is the drainage, lots of also this plastic bottle and the paper wastage material just lay down, it will be clogging, it is the open. You can see, some also drainage system here, you can see near to the railway drainage system, you can see the railway is passing through, what there is a drainage system, anytime the accident may occur.

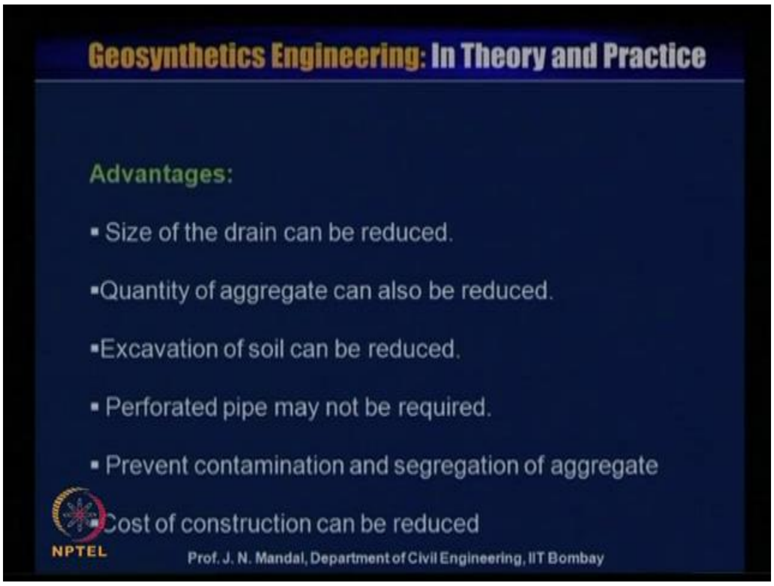
So, this you can see, what kind of severe problems may come if you do not provide proper kind of the drainage system. So, this is the conventional system what is happening so, geosynthetics filter criteria, this is adequate permeability.

(Refer Slide Time: 27:50)



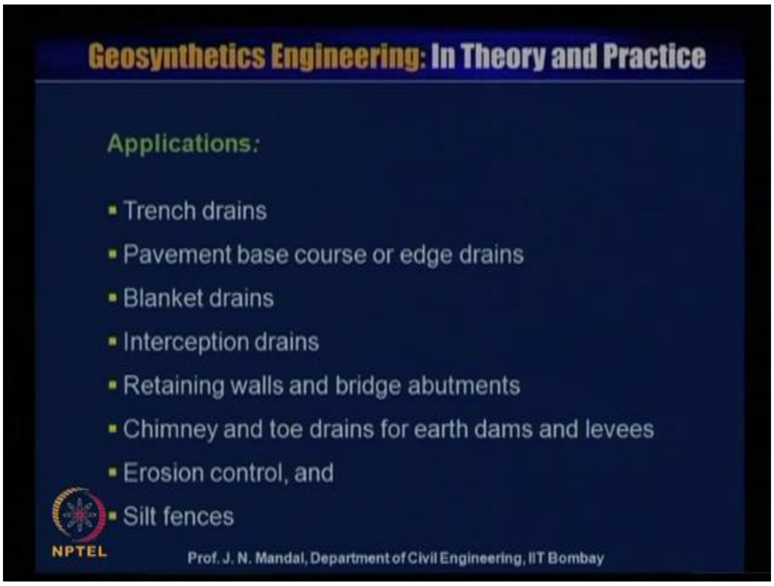
Allow water to flow through the filter into the drain so as, no excess hydrostatic pore pressure can build up. Retain the soil particle in place and prevent their migration that is, piping through the filter. In some soil particle move, they must be able to pass through the filter without plugging or clogging. Open geotextile allow water to pass whereas, the closed geotextile retain the soil.

(Refer Slide Time: 28:23)



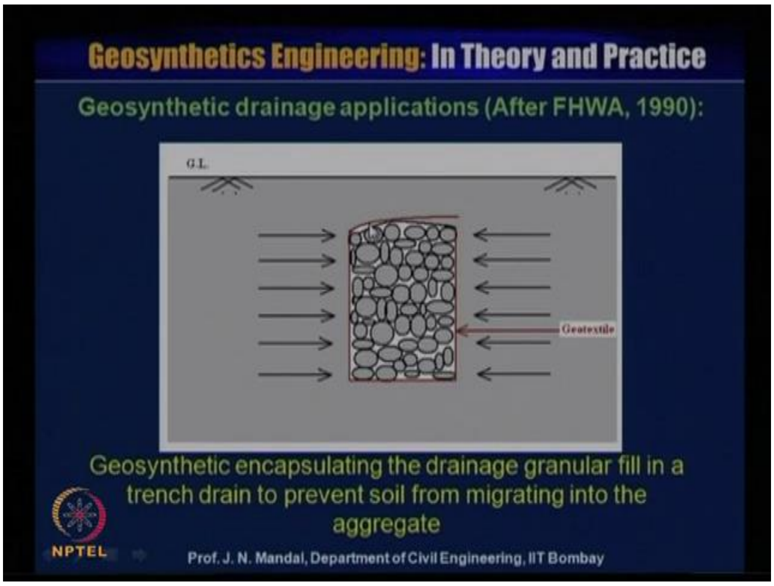
Now, what are the advantage, that size of the drain can be reduced as I told also earlier, quantity of aggregate can also be reduced, because size is reduced. So, automatically quantity of aggregate will be reduced, excavation also soil can be reduced. So, instead of 60 by 30 centimeter, you are excavating 30 by 15 centimeter, perforated pipe may not be required, sometimes in the aggregate you provide with the perforated pipe, it may not be required. Prevent contamination and segregation of aggregate and cost of the construction can be reduced.

(Refer Slide Time: 29:09)



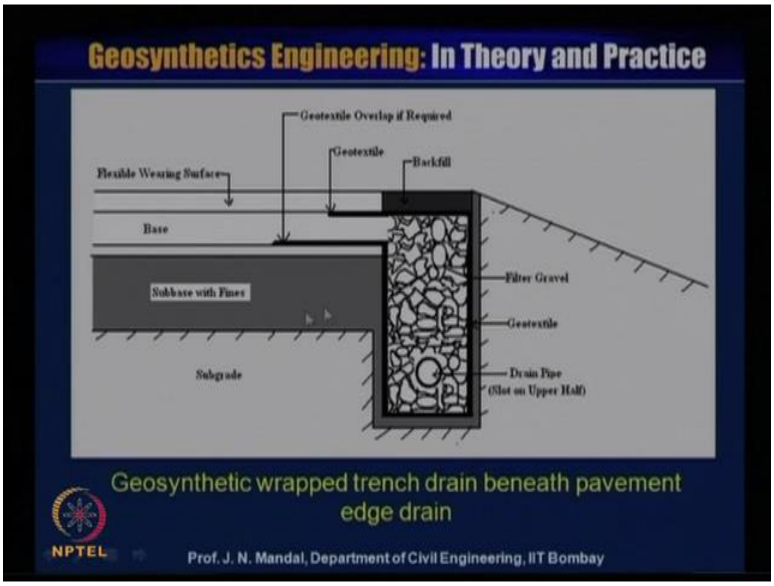
There are many application, it applies in the trench drain, payment base course or edge drain, blanket drain, interception drain, retaining wall and bridge abutment, chimney and toe drain for earth dams and levees, erosion control and silt fence.

(Refer Slide Time: 29:29)



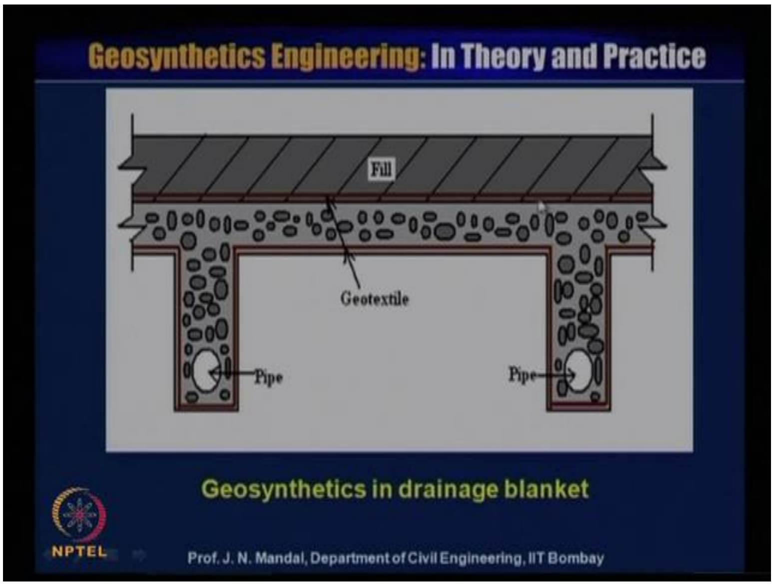
So, you can see here the geosynthetics, this is the geosynthetics, this encapsulating the drainage granular fill in a trench drain to prevent the soil from migrating into the aggregate.

(Refer Slide Time: 29:50)



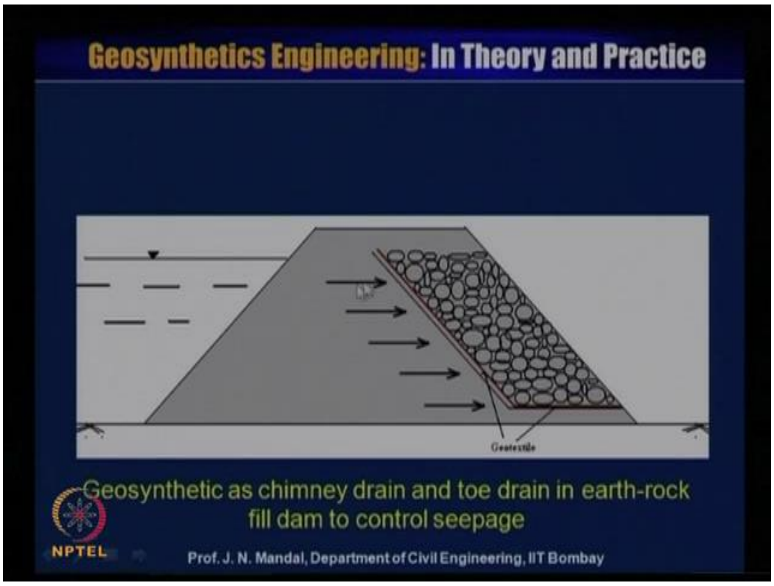
This is FHWA 1995 you can see, this is the road, this is the flexible wearing surface and this is the geotextile material and this is the filter gravel. And sometimes, you provide with the drainage pipe, that is the optional and this is the subgrade soil with fine, this is the subgrade. So, water can just percolate through this drain so here, this geosynthetics material wrap trench drain beneath the pavement edged beam.

(Refer Slide Time: 30:30)



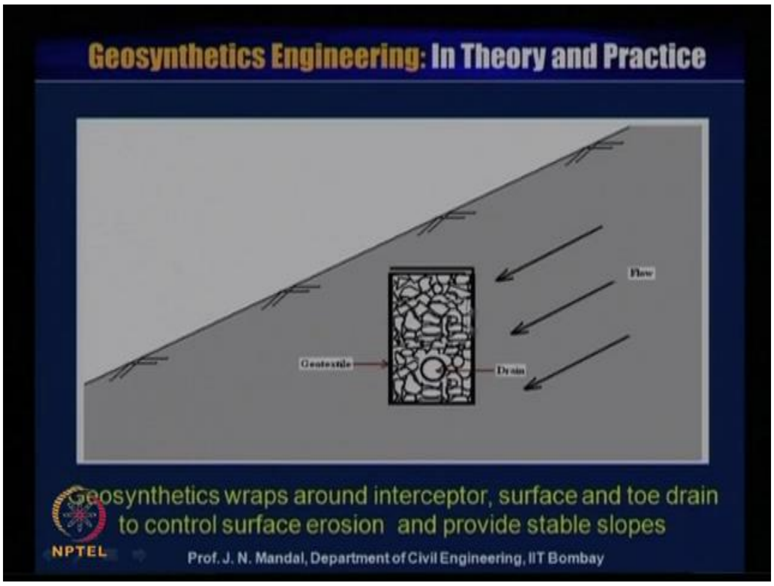
This is another example for geosynthetics in drain blanket, this is the filling material you can see that, how the geosynthetics has been placed like this. This red color, this is Geosynthetic pipe like this and this is the geotextile material, in the force field for drain it out, you can use this kind of also drainage system, so this is the geosynthetics in drainage blanket.

(Refer Slide Time: 30:58)



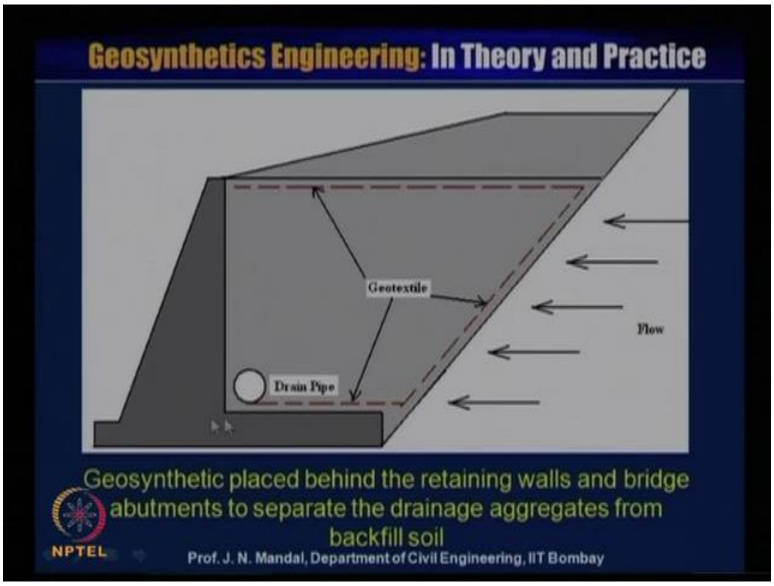
This is geosynthetics as chimney drain and toe drain in a earth rock fill dam so, this is red color is the geosynthetics material. This is either the arched arm and this is chimney drain, this is the earth rock, this is the fill dam to control the seepage, the water can pass through this and this is the aggregate. So, it will not be mix with the aggregate, it is drained it out so why, the geotextile material to control the seepage.

(Refer Slide Time: 31:35)



This is geosynthetics here, the wrap around the interceptor surface and toe drain to control the surface erosion and provide the stable slope. What the stable slope is there, you can see how the water can pass through these, this geotextile material. So, here also you can control the surface erosion by providing the geosynthetic drain.

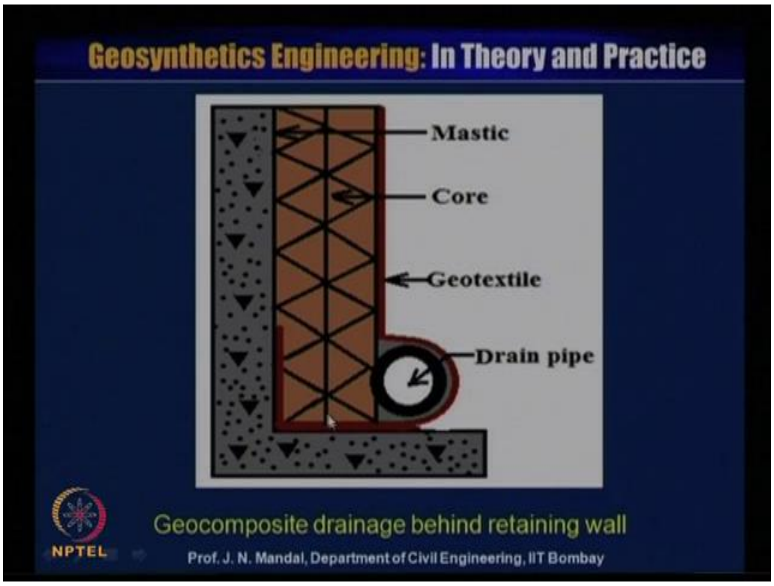
(Refer Slide Time: 32:07)



This is geosynthetics is placed beyond the retaining wall and the bridge abutment to separate the drainage aggregate from the backfill soil. You can see that, this is a backfill soil, this is the drainage pipe, you are providing this red color with the geosynthetics material at the base at the back and also on the top, whatever the water can seepage from here or the rain water from here.

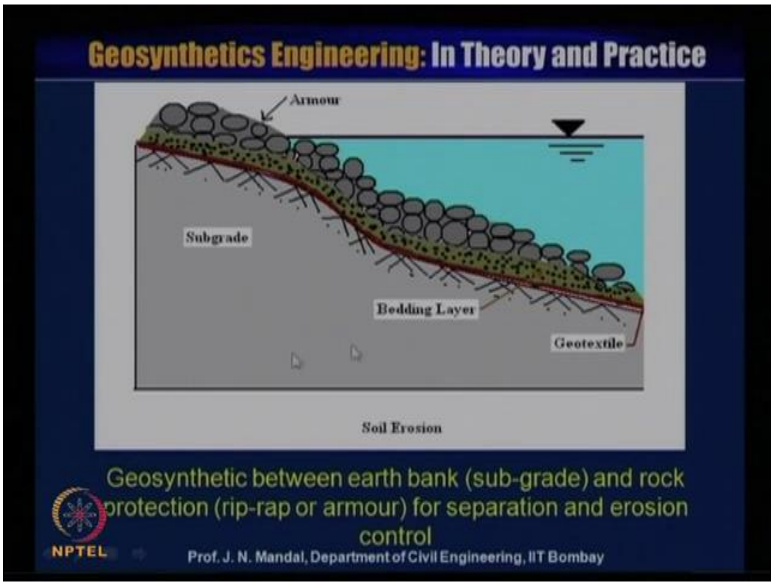
Then ultimately, is passed through the drain pipe one geosynthetics that is why, placed behind the retaining wall. There should not be development of excess hydrostatic pressure, the wall may collapse through prevail to the seepage then you can provide with the geosynthetics material.

(Refer Slide Time: 32:55)



Now, this is what you call, the geocomposite drain behind this retaining wall, this is the retaining wall and this is the geocomposite drain you can provide. There is a drain pipe so, you can provide this kind of this material we can see, this is the core material and this wrapped with the geotextile material, this is geotextile material. So, you can use it on the back of the retaining wall and the water can be drained out through drain pipe.

(Refer Slide Time: 33:40)



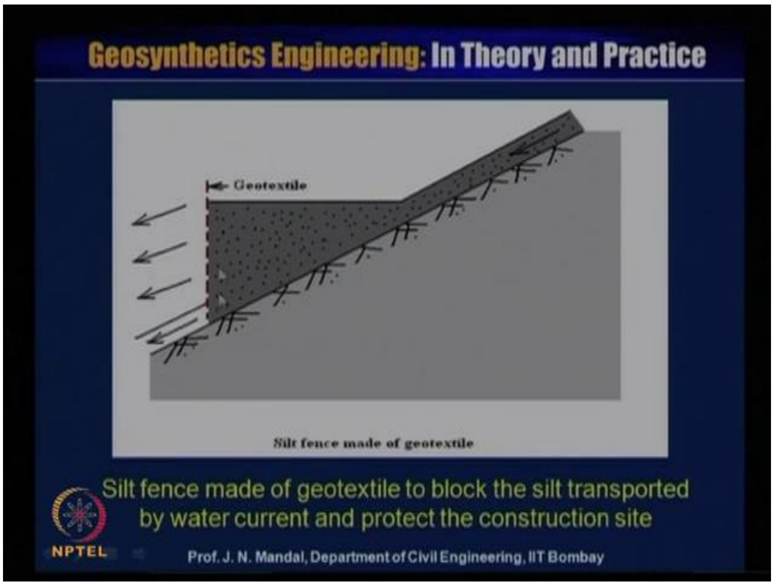
This is for the erosion control, you can see this is the red one is the geotextile material, this is the bedding layer subgrade and there is a sand layer and the armour is on the top.

So, there is a possibility that, this armour material or rock material can penetrate it into the geotextile material, if you directly place it. So, instead of that, you can provide a layer of the sand layer, which will act as a cushion which then after that you can provide with the armour material.

So here, this geotextile material can be replaced for the uniform graded soil or filter so, it will not any punch and then geotextile material is on the safer side. And both the rock, riprap and the even then sometimes you can provide with the precast block over and replace on the geotextile material. Over geotextile material will act as a filtration or drainage and this all the material are the key fabricated. So, it can this cushion or the sand layer, which will protect from the impact damage or also giving the installation, there is a possibility for damage so, it can be controlled.

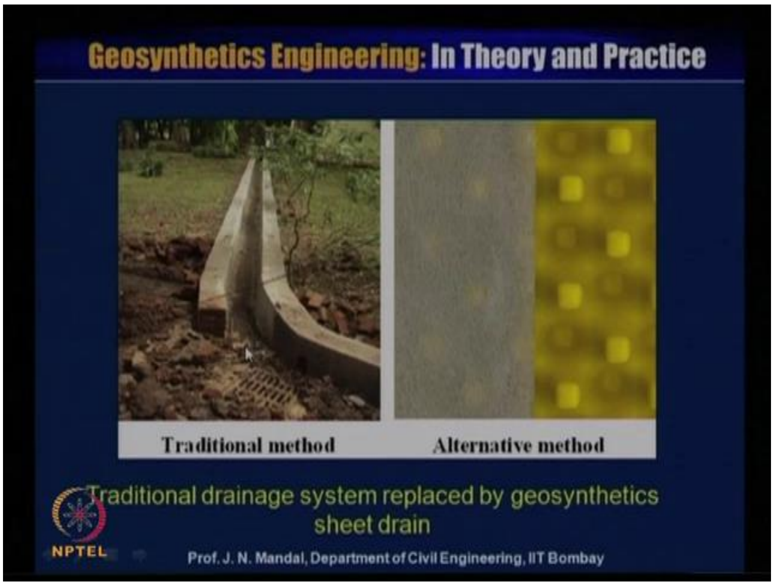
And secondly, there may be a abrasion damage and due to the wave action, if wave action there is a possibility for the abrasion between the aggregate and the geotextile material so, it can be prevented. So, what also you require that, if there is inadequate of permeability so, that is why, you can provide with a proper kind of the geosynthetics material for the erosion control.

(Refer Slide Time: 35:51)



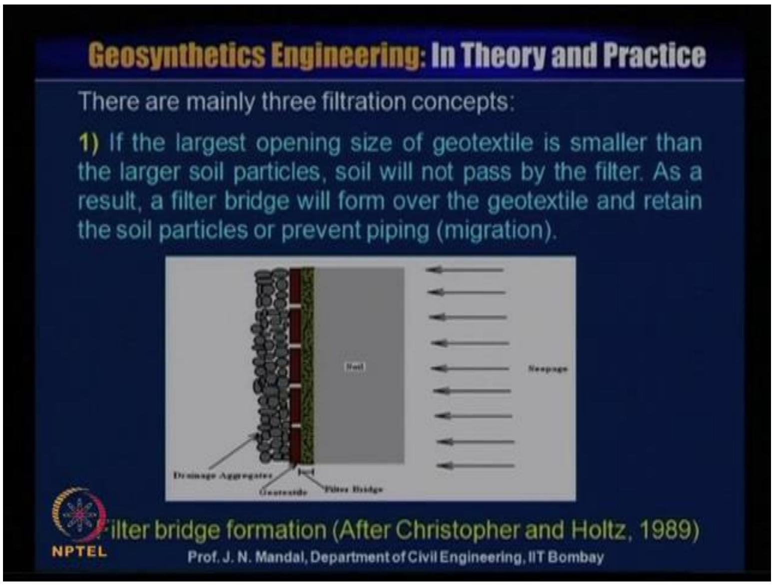
There is another that, silt fence made of geotextile to block the silt transported by the water current and protect the construction site, any construction site is going on here. Then from the slope then there would be the sedimentation and this can be prevented by providing with the lot and the geotextile material as a silt fence. Then the sedimentation can be gradually reduced I will explain later on that, what is the silt fence, how you can make use of the silt fence, how you can design the silt fence.

(Refer Slide Time: 36:31)



Now, this is one you can see that, traditional method drainage system, this is place instead of that, I showed you this kind of the material. It can be replaced by the geosynthetics sheet drain and it can be covered with the soil. So, you do not need to keep it with open or any kind of the contamination and anyone cannot be dumped here, if you can use alternative to the geocomposite material so, it is automatically drained it out.

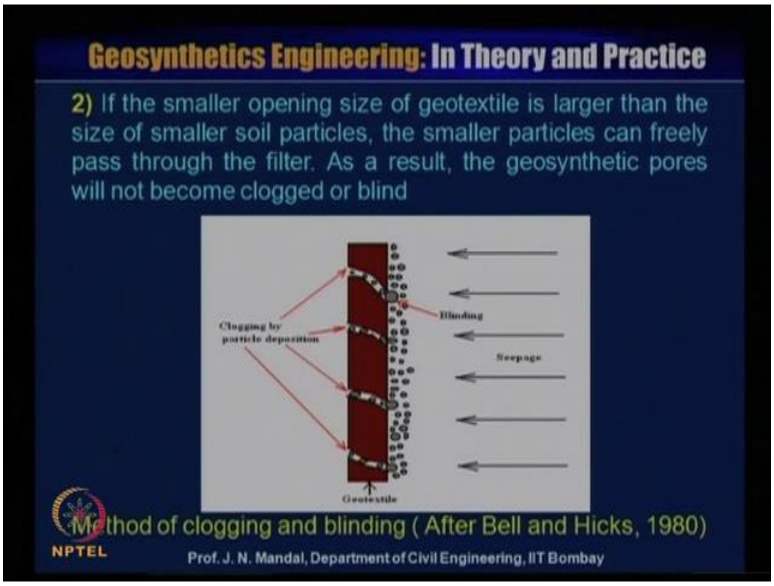
(Refer Slide Time: 37:04)



So now, there are mainly the three filtration concept this is important for us, what is that filtration concept and mechanism. One if the largest opening size of geotextile is smaller than the larger soil particle, soil will not pass by the filter. As a result, a filter bridge will form you can see here, the filter bridge is form, this is a geotextile material and filter bridge will form over the geotextile and retain the soil particle or prevent piping or migration. This is a drainage aggregate seepage on this, this is the soil so, when the largest opening size of the geotextile material is smaller than the largest soil particle, soil will not pass by the filter.

So, a filter bridge will form over the geotextile material and then retain the soil particle or prevent the piping or migration. This is filter bridge formation given by Christopher and Holtz 1989.

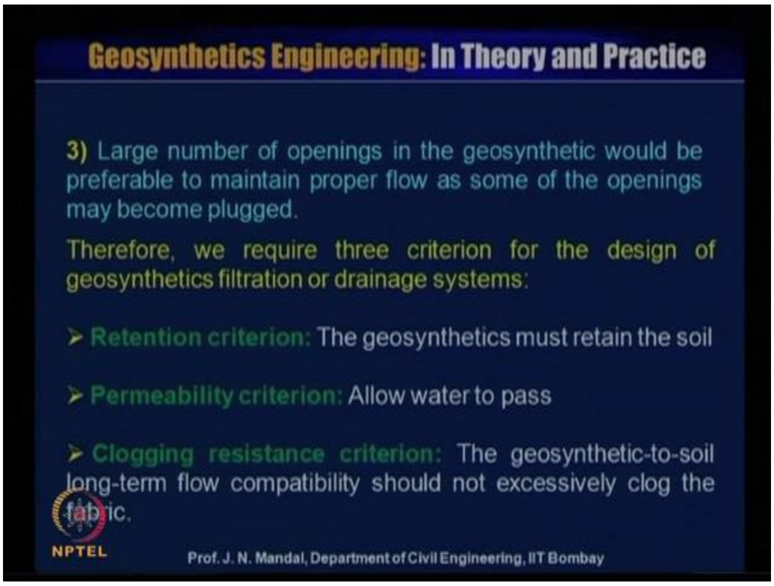
(Refer Slide Time: 38:22)



The second, if the smaller opening size of the geotextile is larger than the size of the smaller soil particle, this smaller particle can freely pass through the filter. As a result, the geosynthetics pore will not become clog or blind you can see here, this is a geotextile material and you can see, how it is blinding and also how it is clogging the particle depores itself due to the seepage.

So, this is the method of clogging and the blinding because here, molar opening size of geosynthetically larger than the size of the smaller soil particle. So, smaller particle can freely pass through the filter as a result, geotextile flow will not become clogged or the blinding so, this is method of clogging blinding given by Bell and Hicks, 1980.

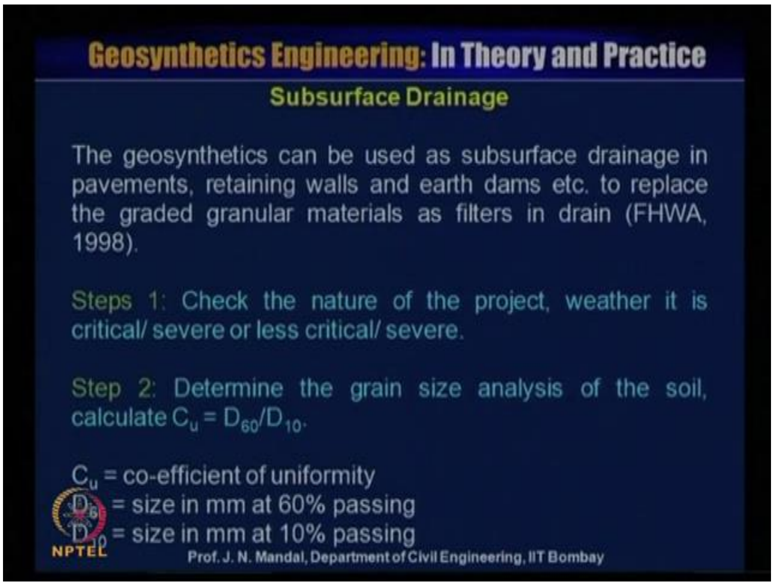
(Refer Slide Time: 39:22)



And third, large number of the opening of geosynthetics would be preferable to maintain open flow, as some of the opening may become plugged. Therefore, we require three criterion for design of geosynthetics filtration and this is important to us. What is this three kind of the criterion? First criteria is the retention criteria that means, geosynthetics must retain the soil, second permeability criterion that allow the water to pass. And third clogging resistance criterion that means, geosynthetics to soil, long term flow compatibility should not excessively clog the fabric or geosynthetics.

So, these three criteria is very important and when you will design the geosynthetics for the filtration drainage and erosion control, it must satisfy all these three criteria. If it satisfy then that kind of the geosynthetics material is suitable for the proper kind of the application in civil engineering now, subsurface drainage.

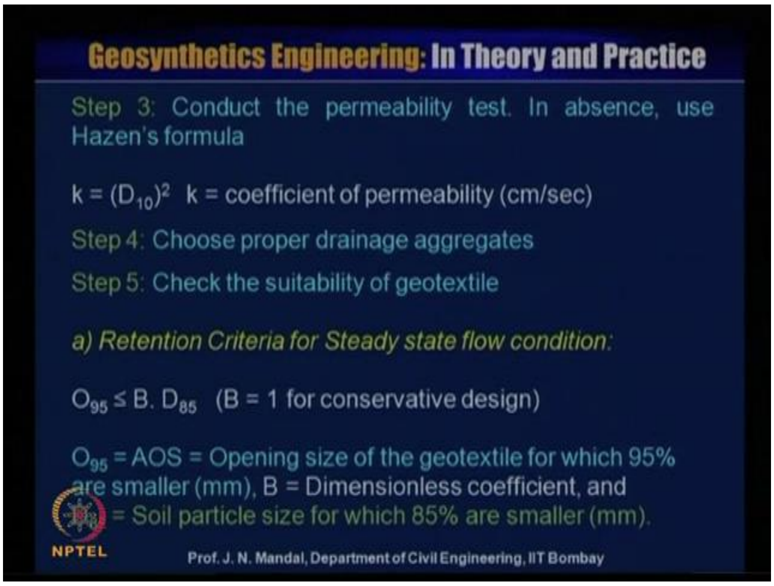
(Refer Slide Time: 40:40)



The geosynthetics can be used as a subsurface drainage in the pavement retaining wall and earth dam, etcetera. To replace the graded granular material as filter in drain, as a FHWA Federal High Way Administration 1998 so here, we are giving the step wise, that what when you design and what you should do. Step 1, change the nature of the project whether it is a critical or severe or less critical or severe. For example, when you are near to the sea shore, there is a wave and then it will be the severe kind of the structure.

So, it will be a critical so, first of all you should know, whether it is a critical or it is a less critical so, that you have to define, depending upon the type of the project. And step 2 as I said that, you should thoroughly find out that, what will be the grain size distribution and from the grain size distribution, we can calculate what will be the severe. That is, D 60 by D 10, C the coefficient of uniformity, D 60 is the size in millimeter at 60 percent passing, D 10 size in millimeter for 10 percent passing.

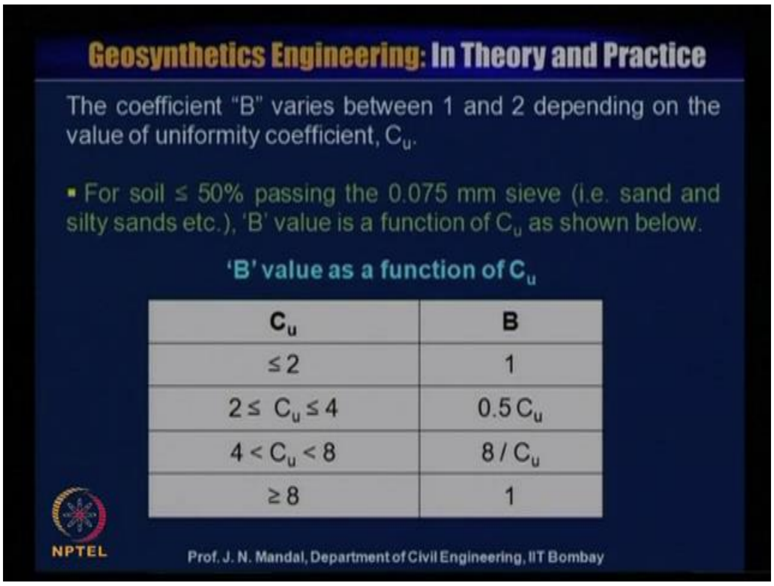
(Refer Slide Time: 42:05)



So, from grain size distribution curve, you can determine this parameter now step 3, conduct the permeability test, in absence you can use the Hazen's formula. That you know k is equal to D 10 square or k is the coefficient of permeability, centimeter per second. Step 4 choose proper drainage aggregate, step 5 check suitability of the geotextile material. Now, retention criteria for steady state flow condition, for steady state flow condition, O 95 should be less than equal to B into D 85, for D is equal to 1 for conservative design.

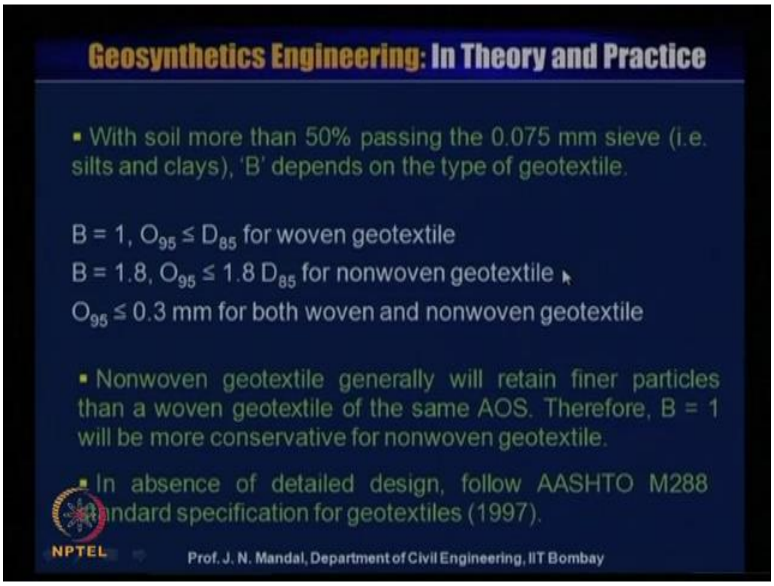
And O 95 is very very important to us, O 95 is apparent opening size or opening size of the geotextile, for which 95 percent are smaller in millimeter and B is a dimensionless coefficient and D 85 soil particle size for which 85 percentage are smaller in millimeter. So, from the grain size distribution curve, you can determine the D 85 and B as I said, it is 1 for conventional design. So then you can determine, whether O 95 is less than equal to B into D 85 or not.

(Refer Slide Time: 43:43)



Like this coefficient, B varies between 1 and 2 depending on the value of uniformity coefficient C u. So, for the soil less than equal to 50 percent passing, the 0.075 millimeter sheet that is, sand and silty sand, etcetera B value is a function of C. You can see this table that, how B value as a function of C u, when C u less than equal to 2, B is 1. C u greater than equal to less than equal to 4, B value is 0.5 C u, when C u greater than 4 less than 8 then B value is 8 by C u. When C u is greater than equal to 8, B value is 1 so, based on this C u, you can select what should be the B value.

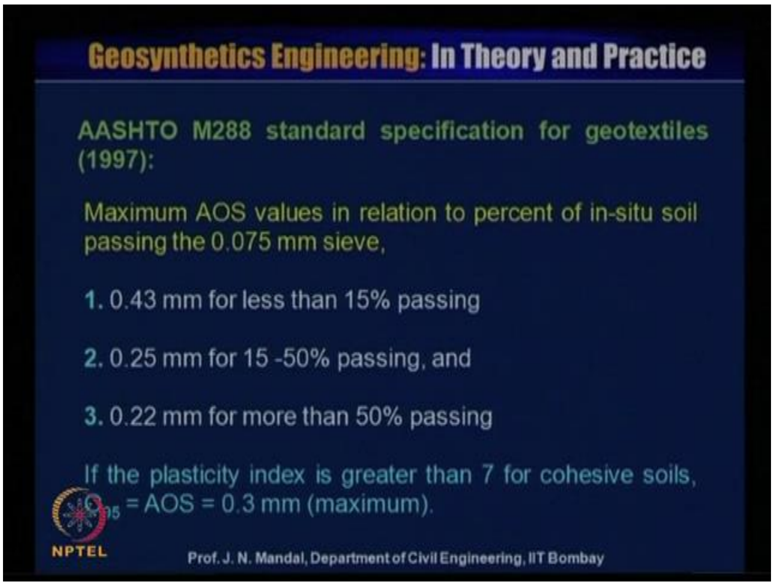
(Refer Slide Time: 44:34)



Now, second that, with the soil more than 50 percent passing, the 0.075 sieve that is, silty and clay and B depend upon the type of geotextile. When B is equal to 1, O 95 less than equal to D 85 for woven geotextile, B is equal to 1.8, O 95 less than equal to 1.8 D 85 for non woven geotextile and O 95 less than equal to 0.3 millimeter for both woven and non woven geotextile material.

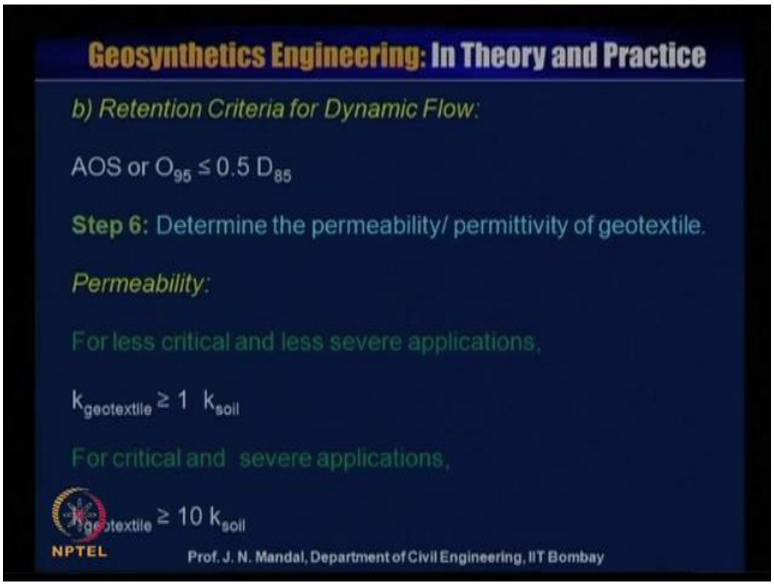
Now, non woven geotextile generally, will retain after the particle then woven geotextile material of the same apparent opening size. Therefore, B is equal to 1 will be more conservative for non woven geotextile, in absence of detail design, you can follow the AASHTO M288 standard specification for geotextile 1997.

(Refer Slide Time: 45:37)



Now, this is AASHTO M288 standard specification for geotextile 1997, maximum apparent opening size value in relation to percent of in situ soil passing the 0.075 millimeter sheet 1, 0.43 millimeter for less than 15 percent passing, number 2, 0.25 millimeter for 15 to 50 percentage passing and number 3, 0.22 millimeter for more than 50 percent passing. If the plasticity index is greater than 7 for cohesive soil, O 95 that is apparent opening size will be equal to 0.3 millimeter maximum, this is as per AASHTO specification.

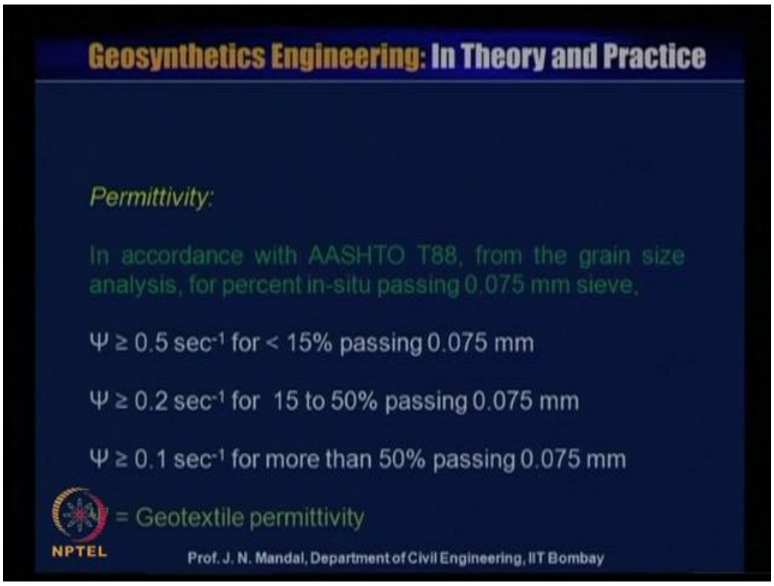
(Refer Slide Time: 46:25)



Now, for the retention criteria for dynamic load, if it is a dynamic load then apparent opening size or the O 95 is less than equal to 0.5 into D 85. Step 6, determine the permeability or permittivity of geotextile, now permeability for less critical and less severe application, the coefficient of permeability of geotextile should be greater than equal to coefficient of permeability of soil. But, for critical and severe application, coefficient of permeability of soil should be greater than equal to 10 times the coefficient of permeability of the soil.

So, that you remember, what should be the coefficient of permeability of the geotextile when there is a less critical, that will be greater than or equal to 1 into k of soil. And if it is the severe or critical then there is k geotextile should be greater than equal to 10 times the coefficient of permeability of the soil.

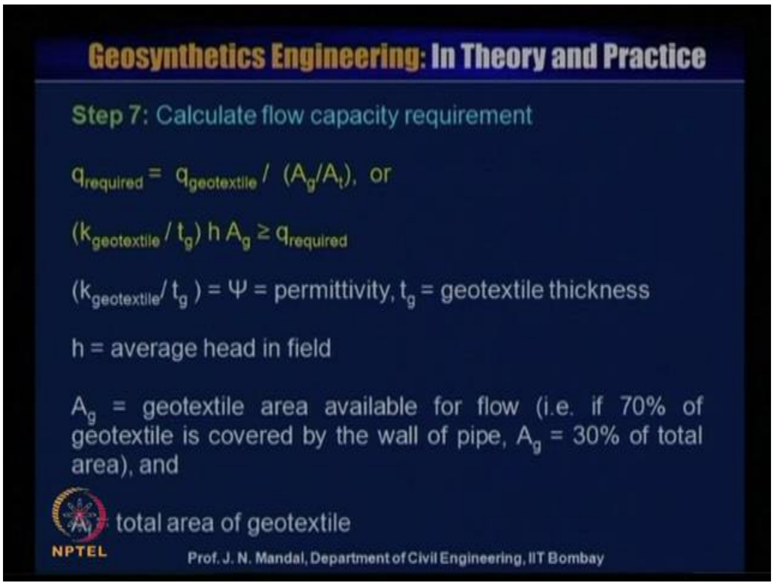
(Refer Slide Time: 47:38)



Now, permittivity in accordance with the AASHTO T88, form the grain size analysis, the for percentage in situ passing 0.075 millimeter sieve, the psi value should be greater than equal to 0.5 percent again when for 15 percent passing through 0.075 millimeter, when psi greater than equal to 0.2 per second for 15 to 50 percent passing 0.075 millimeter and psi greater than equal to 0.1 per second for more than 50 percent passing 0.075 millimeter where, psi is equal to geotextile permittivity.

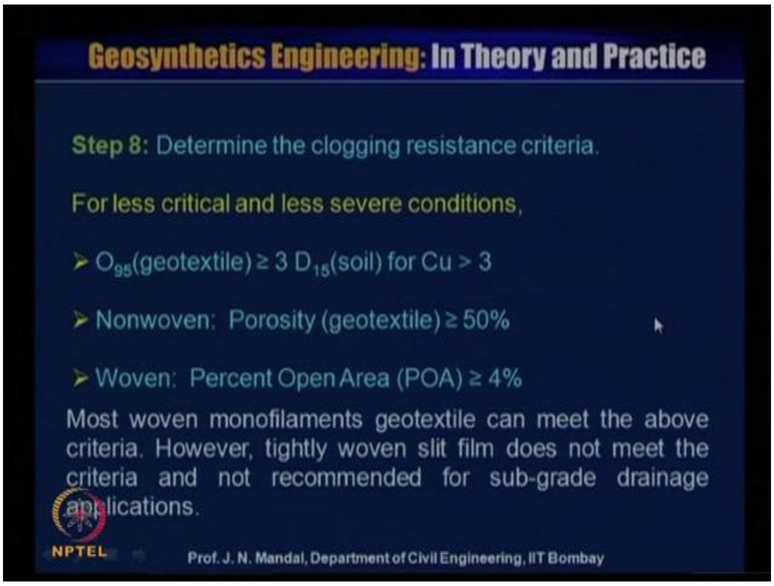
So, you will be knowing what percentage of the passing, whether it is less than 50 percent passing through 0.075 from the grain size distribution curve. And also, you will be knowing whether it is 15 to 50 percent so accordingly, you can select this permittivity value for the geotextile material.

(Refer Slide Time: 48:41)



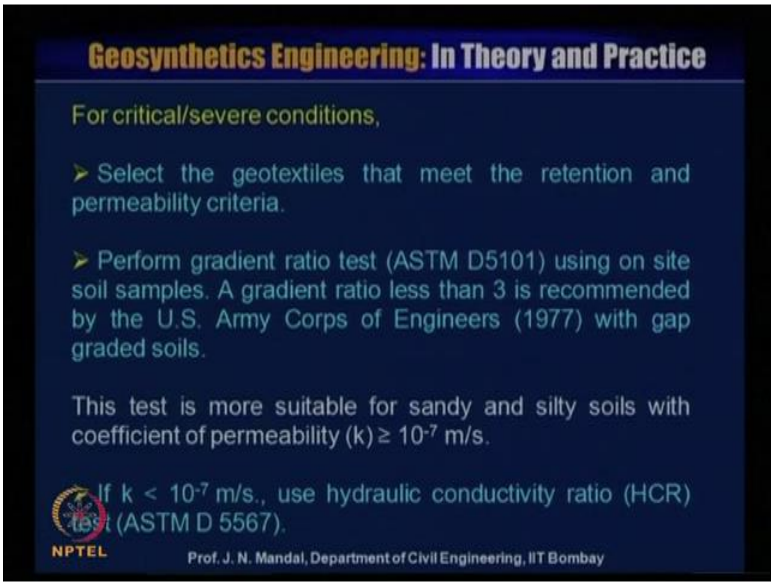
Step 7 then calculate the flow capacity requirement, q required will be equal to q geotextile divided by A g into A t or k geotextile by T g into h into A g should be greater than equal to q required. So, k geotextile by T g is equal to psi that means, permittivity and T g is equal to geotextile thickness, h is average head in the field and this A g is geotextile area available for flow. That is, if 70 percent of the geotextile is covered by the wall or pipe, A g will be equal to 30 percent of the total area and here, A t is the total area of geotextile.

(Refer Slide Time: 49:36)



Now, step 8 determine the clogging resistance criteria, for less critical less severe conditions, O 95 of geotextile should be greater than or equal to 3 D 15 soil for C u greater than 3. If the non woven then porosity of geotextile will be greater than equal to 50 percent, if it is a woven then percent open area POA should be greater than equal to 4 percent. Most oven monofilament geotextile can meet the above criteria however, tightly woven slit film does not meet the criteria and not recommended for subgrade drainage application.

(Refer Slide Time: 50:24)



For critical or severe condition, select the geotextile that meet the less retention and the permeability criteria. Perform gradation ratio test, as far ASTM D5107 using on site soil sample. A gradient ratio less than 3 is recommended by the US army corps of engineers 1977, with gap graded soil. The test is more suitable for sandy and the silty soil with the coefficient of permeability k greater than equal to 10 to the power minus 7 meter per second, if k less than 10 to the power minus 7 meter per second, use the hydraulic conductivity ratio that is, HCR test as per ASTM D5567. So, with this, I ended up this today’s lecture, any question.

Thanks for listening.