Geosynthetics Engineering: In Theory and Practices
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Module - 04
Geosynthetics for Filtrations Drainages and Erosion Control Systems
Lecture – 18

Welcome to lecture 18. 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 is module 4 lecture 18 Geosynthetics for filtration drainage and erosion control system. Now I will focus the recap of the previous lecture, Geosynthetics silt fences and silt curtains, mechanism of drainage function, design step for drainage, application of Geosynthetics drainage that is geosynthetics gravity drainage and geosynthetics pressure drainage, capillary migration break, design of drainage with geonets, geocomposite drainage and landfill cover.

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Now, I will show that how the geocomposite drain are used at the back of the retaining wall and this geocomposite drain are prefabricated.

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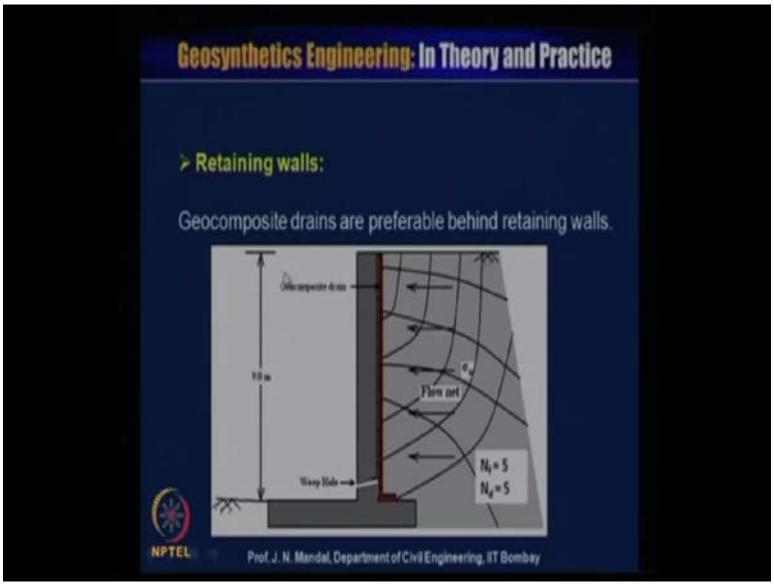

So, here it is a 9 meter height wall and water is flow and passing through this geocomposite drain. It is like a material like this that geocomposite drain which can be provided at the back of the retaining wall water can pass through this material and also there is a lateral force which is acting on this wall.

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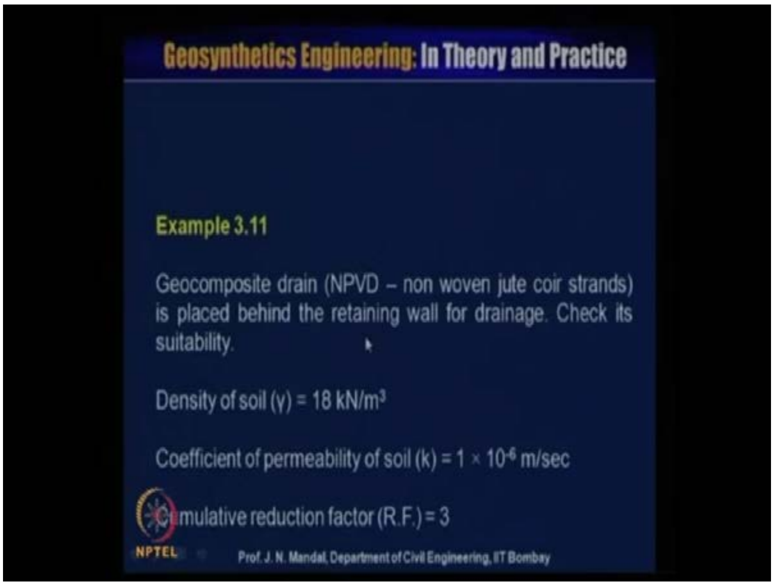

So, here I am giving 1 example, this is geocomposite drain this is nonwoven jute coir grade n p v d is placed, behind the retaining wall for drainage and check it stability. Generally, it should be the polymer material because we have performed strain test also for the natural prefabricated geocomposite drain and that is why, that is we are providing this. But, most of the cases, we provide with the polymer material, polymer geocomposite material as I showed you.

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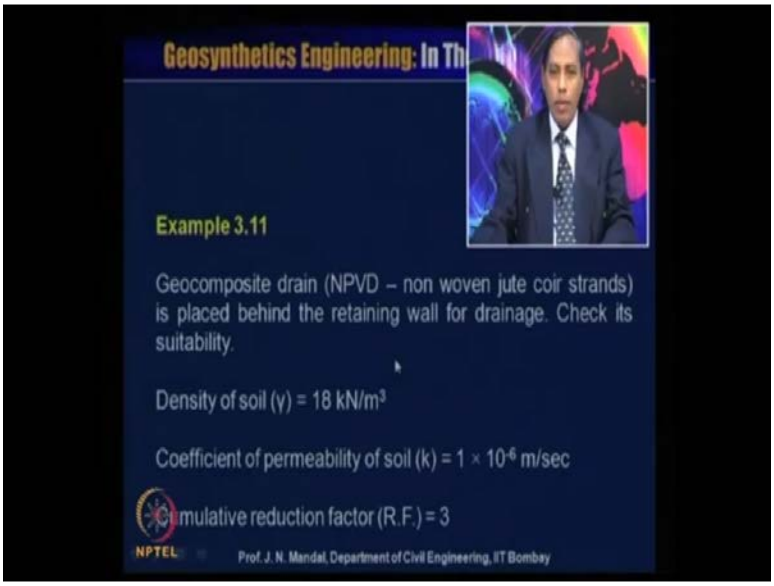

But, for our example, we have considered the nonwoven jute coir stand as a geocomposite material because we have performed some test and we have some result and we want to show you that, how it can be used by providing at the back of the wall. Now density of the soil is given 18 Kilonewton per meter cube coefficient of permeability of soil k is equal to 1 into 10 to the power minus 6 meter per second and cumulative reduction factor r f is equal to 3.

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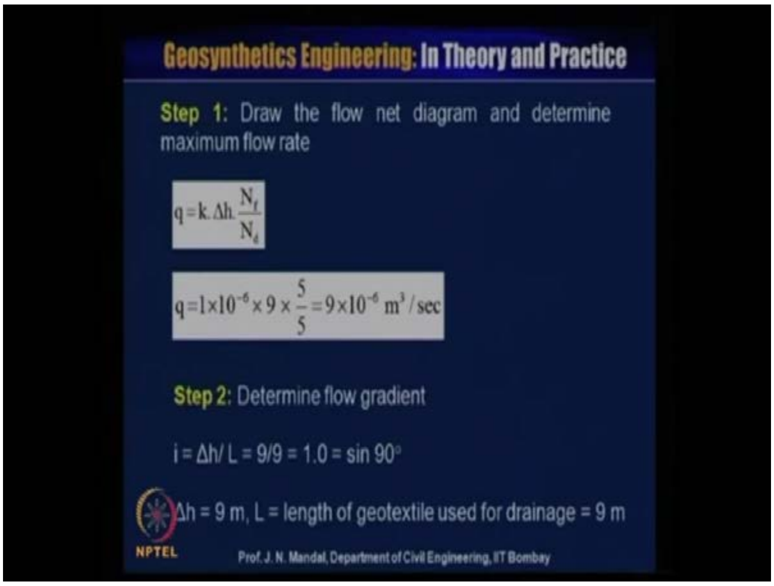

Now step 1, draw the flow net diagram and determine the maximum flow rate. So, where q is equal to k into delta h n f by n d and q is equal to k is 1 into 10 to the power minus 6 this is k coefficient of permeability of the soil is 1 into 10 to the power minus 6 meter per second and then delta h delta h is 9 delta h is height of the wall is 9 meter and then you draw the number of the flow line and the equipotential line and then you count from the flow net, what will be the number of flow line? What will be the number of the potential line? Here is number of the flow lines is 5 and number of the potential line is 5. So, we put n f by n d is equal to 5. So, if you calculate you can have q is equal to 9 into 10 to the power minus 6 meter cube per second.

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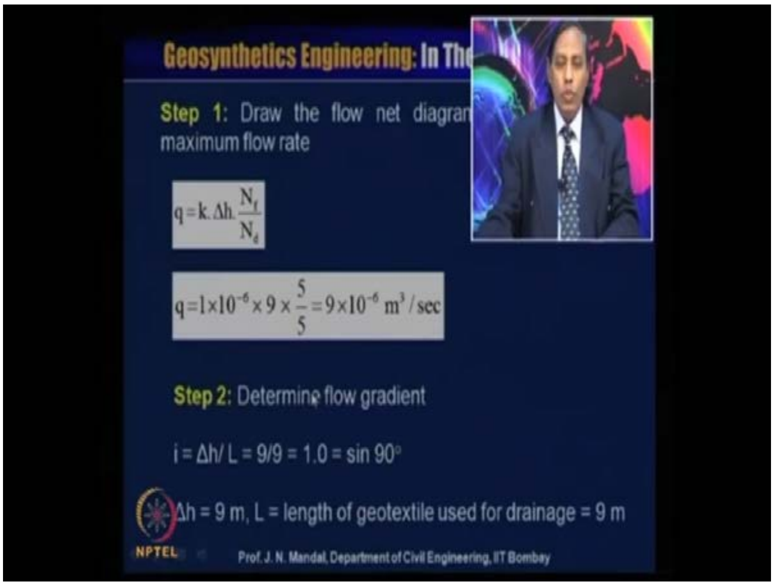

Step 2: Determine flow gradient here i is equal to delta h by l is equal to 9 by 9 is equal to 1 or you can say i also is equal to sin 90 degree, which is the same for delta h is equal to 9 meter l is equal to length of the geotextile used for drainage also 9 meter. It is like this is the wall its height is 9 and also this drainage is l is 9 and delta is also 9. So, ratio will be 1. So, i will be the 1.

Step 3: Determines the required transmissivity. So, we know the equation transmissivity theta required is equal to k p into t g is equal to q divided by i into w. So, theta required is equal to q you know 9 into 10 to the power minus 6. We know the q that is 9 into 10 to the power minus 6 here meter cube per second. So, q is equal to 9 into 10 to the power minus 6 divided by I into w. So, that is i 1 w 1. So, theta required will be equal to 9 into 10 to the power minus 6 meter square per second.

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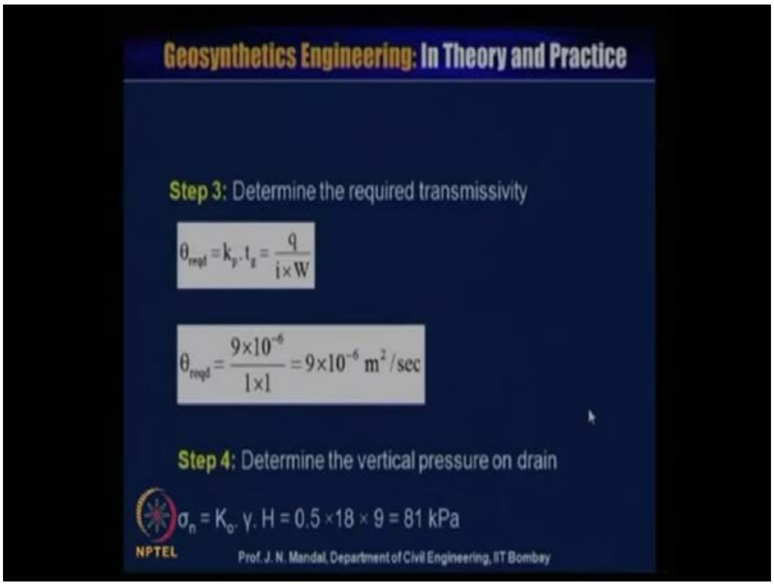

Now, step 4, is determine the vertical pressure on the drain you have to find out what should be the vertical pressure is acting on the wall. Now, here sigma n is equal to k 0 gamma into h. So, k 0 you consider 0.5 gamma is 18 and h is 9 meter. So, 0, 5, 18 into 9 means 81 kilopascal that means, we wanted to address that how the normal pressure is acting here, that is sigma of n and that sigma n is equal to k 0 into gamma into h any pressure sigma in gamma into h. So, whole pressure will be the lateral pressure will be the k 0 into gamma this is unit weight of soil into height h. That mean 9 meter. So, we can calculate the sigma n is equal to 0.5, 18 into 9, 81 kilopascal.

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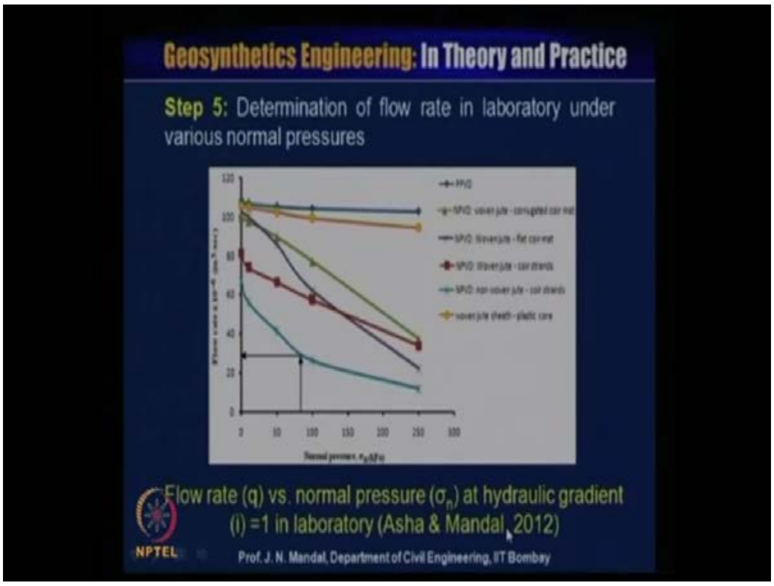

So, this is the step 5: Determination of flow rate in the laboratory under various normal pressure. So, here you can see that relationship between the flow rate that is 10 to the power minus 6 meter cube per second and this is under normal pressure sigma n this is kilopascal. So, this test also has been performed under various normal pressure. It may be 50, 100, 150, 200, 250 and so on. So, you can calculate that what should be the flow rate. So for any particular normal pressure you can directly determine what should be the flow rate of that sample.

So, here many different types of the sample have been performed because in our example only, we have taken n p v d natural prefabricated drain and that is why you're considering only this blue color curve. You can see that flow rate is decreasing decreasing with the increasing the normal pressure and then almost little bit constant. So, even then sometimes you have to go for the very very high pressure. So, because you have observed that our vertical pressure on the drain is 81 kilo pascal.

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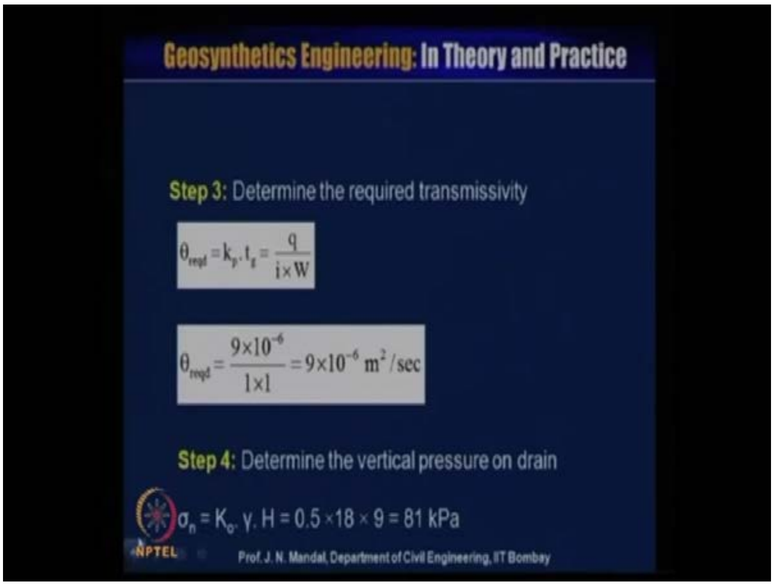

So, we are considering this prefabricated vertical drain for the use of the back of the wall. So, for this we are we will calculate what will be the flow rate. We know what will be the pressure. So pressure is 81 and for this prefabricated drain then, what will be the flow rate. So, we are calculating the flow rate from this curve. So, here this curve has drawn all under the hydraulic gradient of 1 and you should remember, it should be over the Darcy's law it should be in the linear condition generally.

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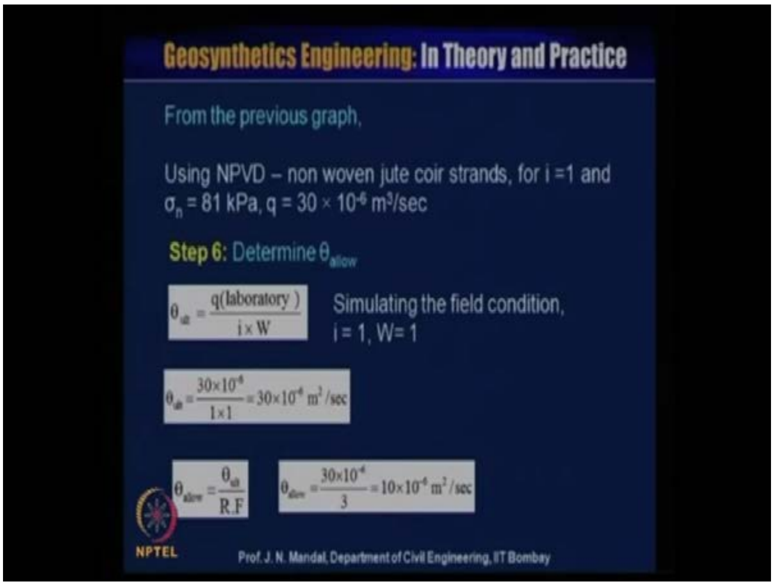

So, from the previous curve, using the natural prefabricated drain or nonwoven jute coir strand for i is equal to 1and sigma n is 81 kilopascal q is 30 into 10 to the power minus 6 meter cube per second for this 81 and corresponding flow rate is in between 20 and 40 then this is 30 into 10 to the power minus 6 meter cube per second. Step 6: Determines theta allowable. So, theta we know the ultimate is equal to q laboratory divided by i into w to simulating the field condition i is equal to 1 and w is equal to 1.

So theta ultimate will be equal to 30 into 10 to the power minus 6 divided by 1 into 1 is equal to 30 into 10 to the power minus 6 meter square per second. Now, theta allowable is equal to theta ultimate divided by reduction factor. So, we consider reduction factor 3. So, theta allowable is equal to 30 into 10 to the power minus 6 by 3 is 10 into 10 to the power minus 6 meter square per second.

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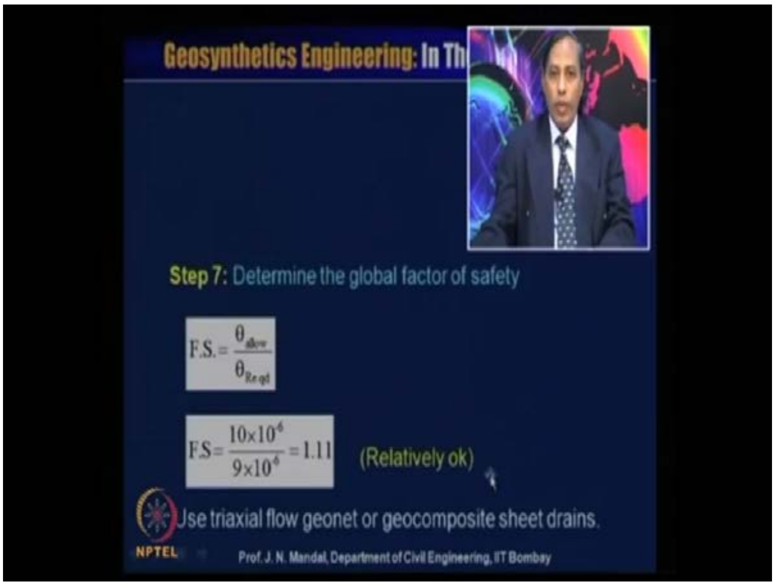

Now, step 7: Determines the global factor of safety. So, factor of safety is equal to theta allowable by theta required. So, we know what is theta allowable like 10 into 10 to the power minus 6 and theta required is 9 into 10 to the power minus 6. So, you can have the global factor of safety 1.11. This is relatively low but, it is sometimes it depend upon type of the structure or otherwise you can use triaxial triaxial flow geonet that is green color green color geotextile flow net or the geocomposite sheet drain. So, that can be used. So, we can use that woven or nonwoven geotextile material or you can use the geonet also you can use the triaxial flow geonet. If the flow is more.

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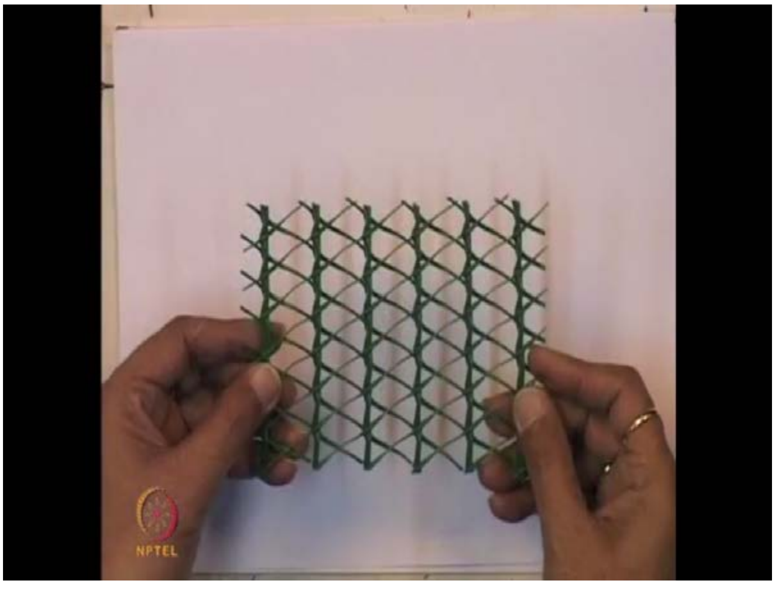

So, I am just showing you that 1 that triaxial flow net you can see this is the triaxial flow geonet. So, you can use triaxial flow geonet or you can use any geocomposite sheet drain that means you can use any geocomposite sheet drain like this also you can use. So, depending upon the type of the flow, you can use this prefabricated material.

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Now, the geocomposite sheet drain or the geomat or geospace, so there are different types of the geocomposite sheet.

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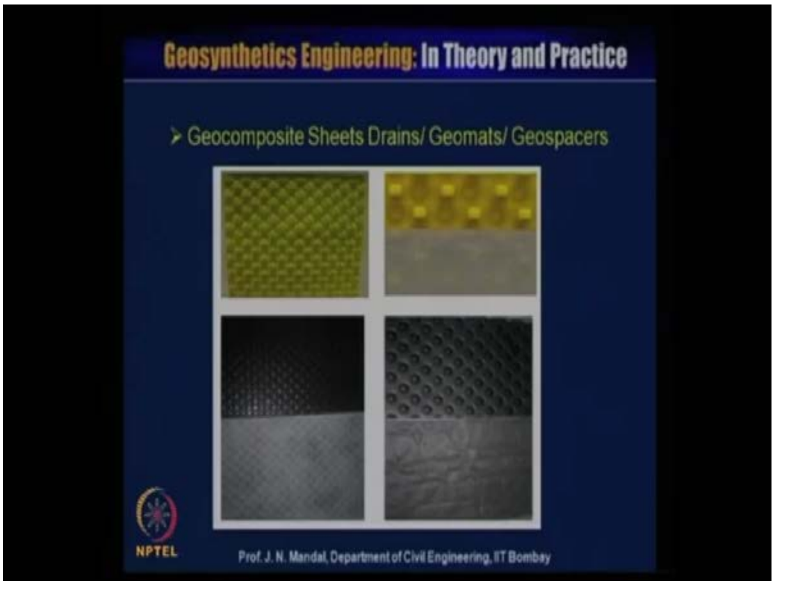

So, you can have some of the geocomposite sheet. It is like this you can have like this also.

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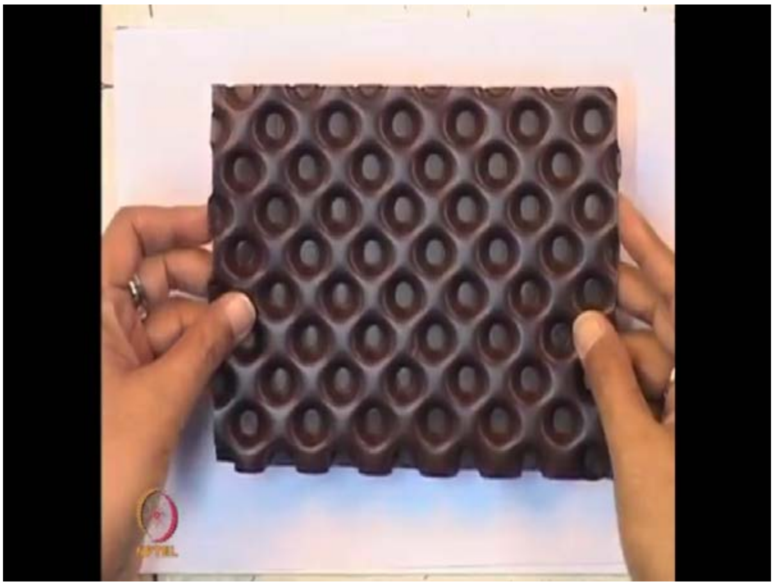

Sometime you can say it is a geocomposite sheet also, you can have this this kind of also sheet you can have different types of the geocomposite sheet or geomat or the geospacer sometimes that it is covered with the nonwoven geotextile material. So, that you can have variety of geocomposite material. The prefabricated geocomposite sheet drain can be used as excellent drainage material. In high flow rate related area you can use behind the reinforced soil retaining wall, you can use behind seeping soil slopes, you can use beneath sports fields, you can use beneath geomembrane liner, beneath surcharge fill beneath floor slab.

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So, here we have performed some compressive strength of the geocomposite sheet drain so there are different types of the sheet drain.

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You can have this kind of the sheet drain you can see this type of the sheet drain this type of the sheet drain you can have it you can see that there is difference of configuration and you can see like a cap type of this is one kind you can have the more larger type also you can see this is the cap is larger than this you can have this kind of also geocomposite sheet drain.

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You can have also with laminated with some also geotextile material you can see this side is the plastic this other side laminated with the geotextile material also.

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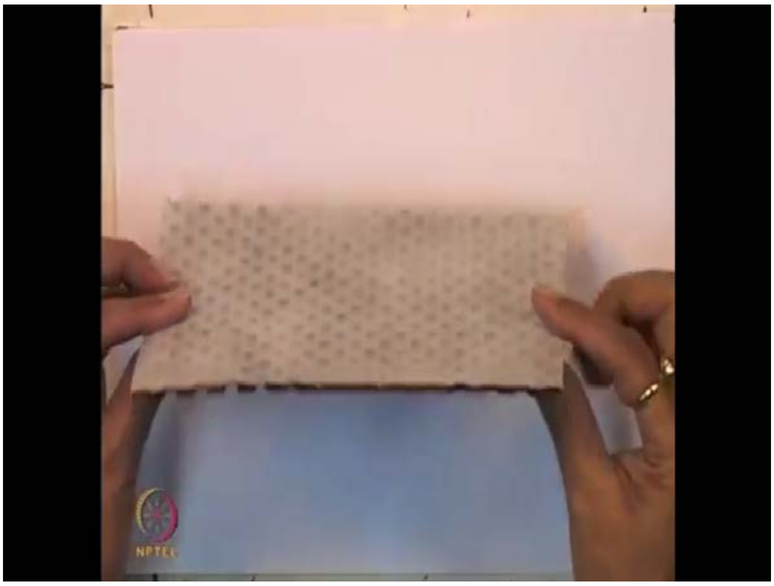

You can have this kind of also the sheet you can have this kind of also the sheet.

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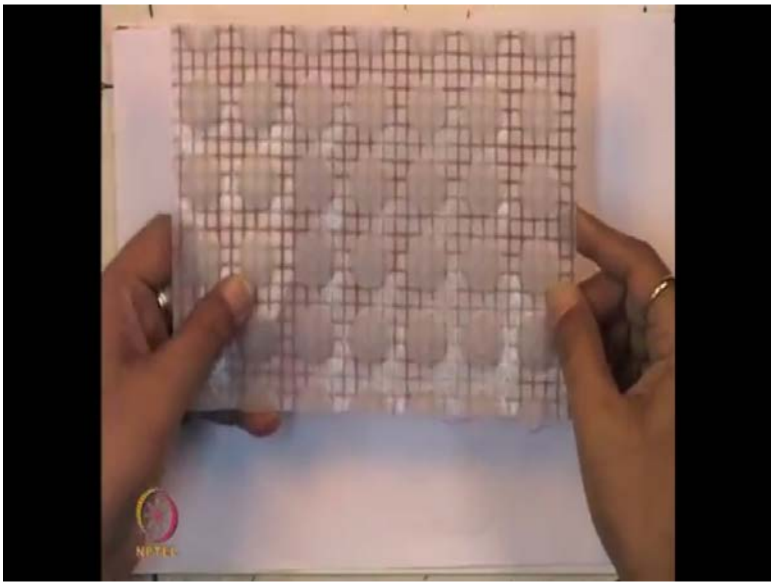

There are variety of geocomposite sheet are there this is also laminated with also this geotextile in one side and other side.

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So, these are the different types of the material and this compressive strength of geocomposite sheet drain have been performed. So, here you can see that how the geocomposite material has been kept and then you are applying the load to determine the compressive strength.

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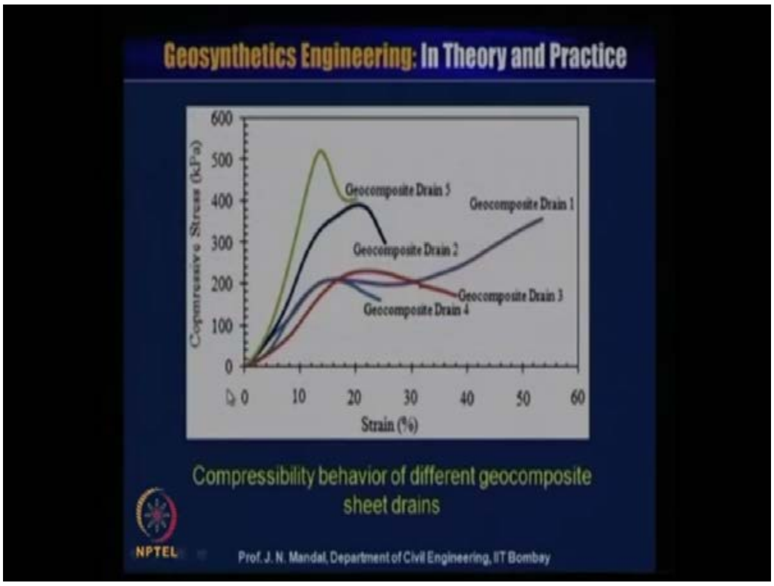

So, we have performed and then we obtain from the test result here is shown the compressibility behavior of the different geocomposite material.

So, this relationship between the compressive stress kilopascal to the strain you can see the different material is different strain and also different compressive stress value, one you should know what will be the compressive stress of this material.

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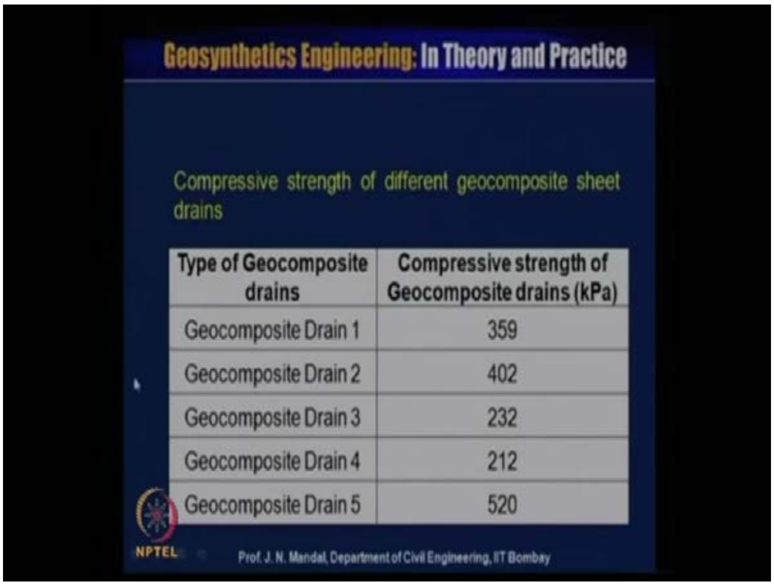

Showing the next slide within the form of table you can say that geocomposite drain one whose compressive strength about 350 kilopascal another geocomposite drain 402 other is 232, 212 and 520 kilopascal. The one end you should know what will be the compressive strength of the different geocomposite sheet material at the same time for the same material you should know what will be the flow rate of that material. I am not showing here what will be the flow rate of that material of this kind of the material.

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So, geocomposite prefabricated highway edge drain. So, what we do that most of the time what I have explained you earlier that you excavate from the trench and then place the either the woven and nonwoven geotextile material and then fill up with the aggregate and wrap it and use it as a drainage material, for the both side of the road which can be the clogging fill, apart from that it will be much more convenient that if you can use this geocomposite material.

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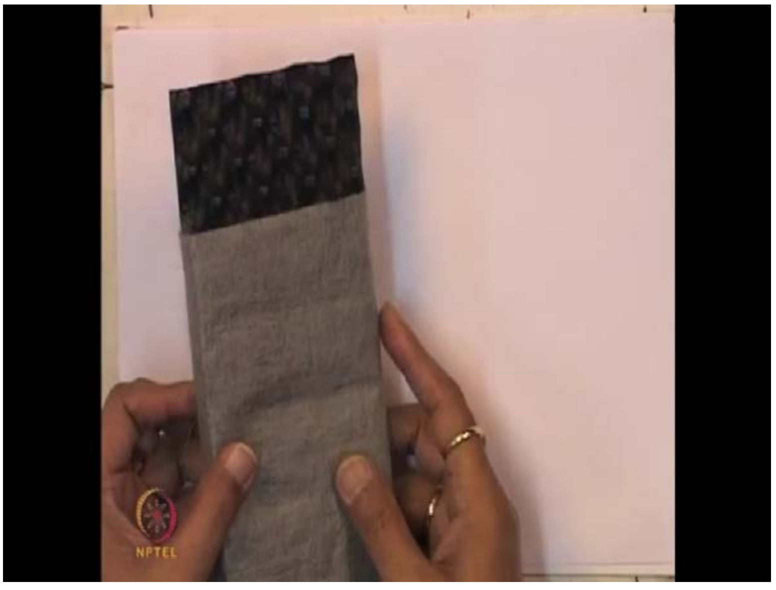

So, this geocomposite material is like this. so, this can be placed on the highway edge so this will act as edge drain both side of the road you can provide with this kind of the drainage material.

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So, it is like this if this is the highway, so you can place this material here. This is geocomposite material or sheet. This is geocomposite material is sheet. So, both side you can provide with the geocomposite material. So, water can also percolate through this kind of the material. So you have as you do with the conventional this type and even then you can reduce the area and use this geotextile material and aggregate here. So, you do not need it instead of this, you can adopt this kind of the system with this geocomposite we can say geocomposite in a highway as a edge drain and this also reported by the dempsey in 1988.

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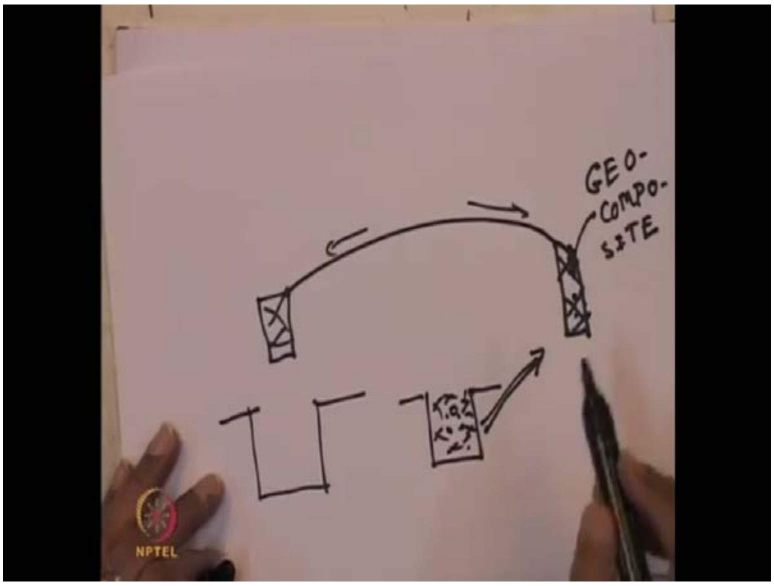

So, here you can see that how the application of prefabricated geocomposite highway edge drain this after koerner 2005 this is prefabricated geocomposite highway edge drain here is the subgrade soil here is a subbase course here is a base course here is a wearing course and here is a shoulder so here is the wheel load so whatever the water it can percolate through this geocomposite material and then it is going down so this kind of the system has been used exclusively in the Malaysia where you know the rainfall intensity is more.

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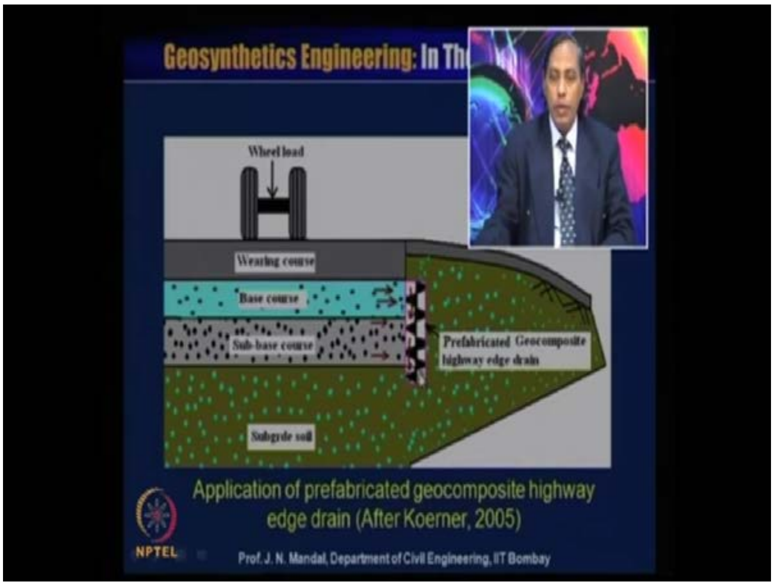

So, I am giving 1 example, suppose maximum required flow rate for highway edge drain you know q required is 800 liter per hour and from the laboratory test the ultimate flow rate through the geocomposite edge drain let us say q ultimate is equal to 5000 liter per hour and assume cumulative reduction factor r f is equal to three we have to check the global factor of safety.

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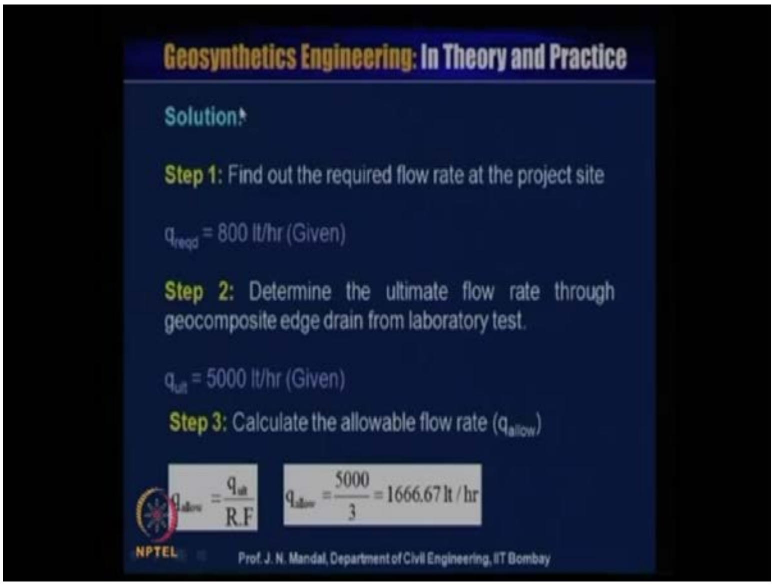

It is very simple solution step one you find out what will be the required flow rate at the project site. So, q required is 800 liter per hour it is given. Step 2. Determine the ultimate flow rate through geocomposite edge drain from laboratory test that is q ultimate is equal to 5000 liter per hour also given. Step 3calculate the allowable flow rate q allowable. So, q allowable is equal to q ultimate divided by reduction factor here reduction factor is 3.

So, q allowable will be equal to 5000 divided by 3 is 1666.67 liter per hour. Then step 4 check the flow factor of safety f s that means f s is equal to q allowable divided by q required that means f s will be equal to 1666.67 divided by 800 q required. We have calculated earlier q required is 800 is given and this we have calculated so a factor of safety is 1666.67 by 800 is 2.08 though this is the low however acceptable for noncritical condition next. We will address geosynthetics wrapped French drain.

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So, here you can see that here is the drain this is another drain and this red is the geotextile material expressed like this and then it is overlapped like this. This is another also trench and this is the geotextile like this and the inside is aggregate. So, this is the stone or aggregate and this grade is geotextile material and this height is about z and distance between the 2 drain is small d. so, this is called geotextile wrapped French drain.

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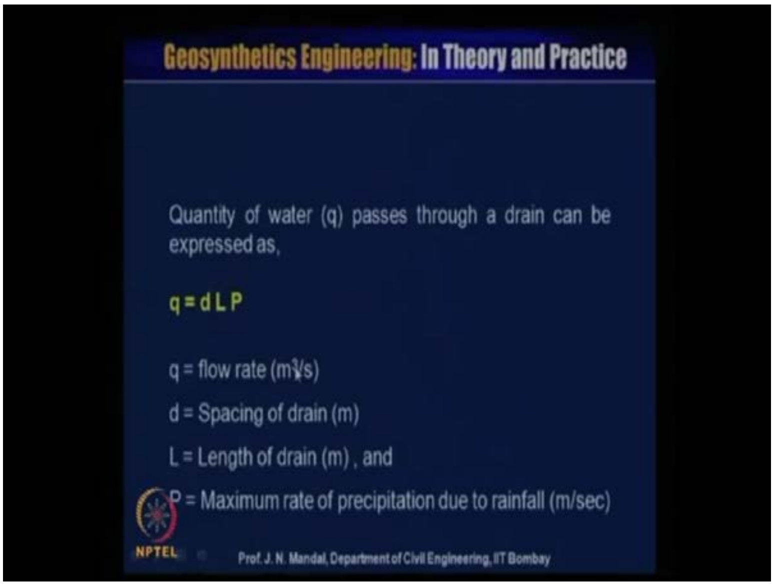

Now first of all, we have to find out what will be the quantity of water small q passes through the drain which can be expressed as q is equal to d l p where q is equal to flow rate meter cube per second d is spacing of the drain is meter as I showed you this is the d the spacing of the drain this is the drain this is 1 drain this is another drain. So, this is the spacing between the 2 drain is d so, d spacing of the drain and l is equal to length of the drainage. So, you know what will be the length of the drainage and p is equal to maximum rate of precipitation due to the rainfall meter per second this is important. So, whenever you will design then you should know what should be the maximum rate of precipitation in that region due to the rainfall. So, that is very important.

So, if you know what should be the spacing of the drain what will be the length of the drain and what will be the precipitation due to the rainfall then you can calculate that what will be the quantity of water passes through a drain and that particular area that is you can calculate q is equal to d into l into p that means you can calculate flow rate. Now, the quantity of water passes through the drain q can also be expressed as this that is q is equal to w h s l p r p divided by s d where w h s is the highway width including the shoulder.

So, you have considering including the shoulder part also here in meter that is why w h s l is equal to length of the drain and p is equal to maximum rate of precipitation due to the rainfall and r p is equal to rainfall penetration rainfall penetration r p is equal to rainfall penetration that is in percentage and p is maximum rate of precipitation due to the rainfall and s d is the number of shoulder drain.

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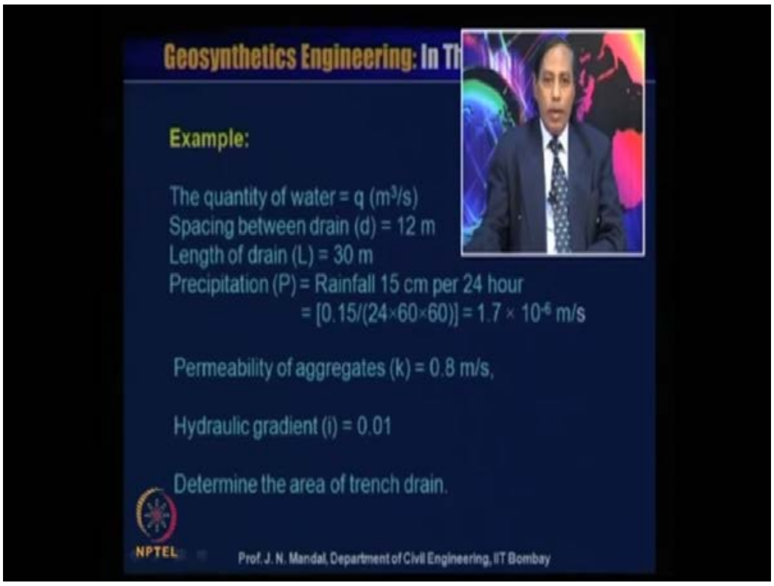

For an example, the quantity of water is equal to q meter cube per second spacing between the drain d is equal to 12 meter length of the drain l is equal to 30 meter precipitation p that is rainfall 15 centimeter per 24 hour that means 15 centimeter per 15 centimeter in terms of meter 0.15 this per 24hour mean 24 into 60 into 60 in second that means if you calculate, you can calculate the what will be the precipitation p is equal to 1.7 into 10 to the power minus 6 meter per second and permeability of the aggregate k is equal to 0.8 meter per second hydraulic gradient i is 0.01 you have to determine the area of trench drain what should be area of trench drain.

So, solution you know the equation q is equal to d into l into p d is 12. l is 30 and p is 1.7 into 10 to the power minus 6 we have calculated p is equal to 1.7 into 10 to the power minus 6. So, q will be equal to 0.000625 meter cube per second again. We know q is equal to k into i a. so, from this equation Darcy's law you can calculate a a is equal to q by k i into i k is given 0.8 meter per second I also given that is 0.01. So, we substitute this value k and i into this equation. So, you can have a will be equal to this. This is q is this 0.000625 this divided by k k is 0.8into I, i is equal to 0.01. So, you are having 0.77 meter square.

So, you can make the area of the trench 0.77 meter into 1 meter. So, you can find out what will be the trench area what we are looking for now. This is another example, that it is required to design subsurface shoulder drain for a highway. This is highway as shown here, you can see here the red is the geotextile material and inside that open graded aggregate and this is the perforated pipe that is optional and width of the trench is w and length of the trench is l and from here to the shoulder the depth is about 8 and this is the stone aggregate, this is the soil subgrade and this is all permeable sub base.

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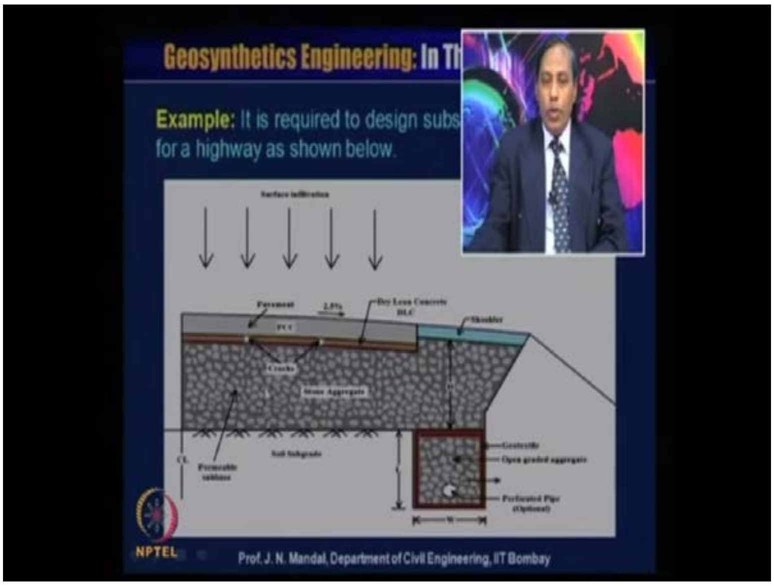

So, we provide sometime that here that is dry lean concrete, dry lean concrete and then one the top of that we provided the p c c that is pavement and this is slope is 2.5 percentage and then it is the shoulder. Now, when the rainfall over the surface infiltration then due to the temperature or moisture content sometimes you can observe there is a formation of the crack in the dry lean concrete that is called d l c. So, when there is a formation of the crack then water which pass through this dry lean concrete to the aggregate and then to the trench here.

So, if you do not provide with geosynthetics material, then it will be clog. So, that is why that we will provide with the geotextile material to form the trench and it will act as a very good subsurface shoulder drain for the highway. So, highway side drain is let us say 50 meter long that means l is 50 meter long with 2 shoulder drain which is s d intensity of rainfall p is 15 centimeter per 24 hour.

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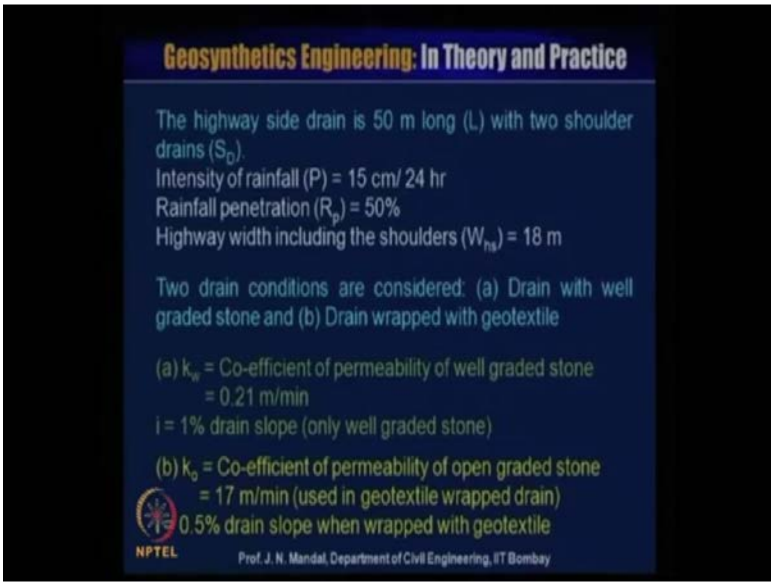

Rainfall penetration r p is 50 percentage highway width including the shoulder w h s is equal to 18 meter 2 drain condition are considered 1 drain with well graded stone and b drain wrapped with geotextile and in case of the a that k w is coefficient of permeability of well graded stone that is 0.21 meter per minute and the i is 1 percent that means drain slope only well graded stone and b that means drain wrapped with geotextile and in this case k 0 is coefficient of permeability of open graded stone is equal to 17 meter per minute used in the geotextile wrapped drain and i is equal to 0.5 percentage drain slope when wrapped with geotextile.

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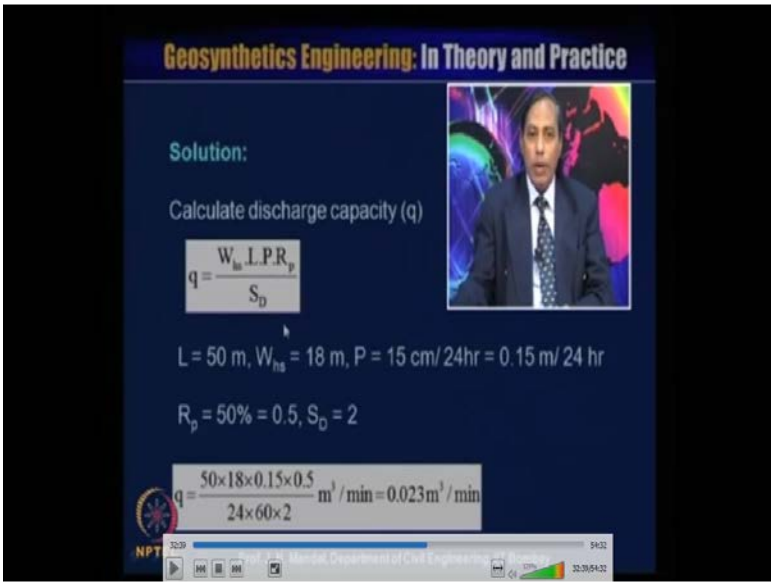

So, this is the problem and now we will go for the solution. So, first of all you have to calculate what should be the discharge capacity q. So, you can apply this equation q is equal to w h s l p e r p divided by s d l is given 50 meter w h s is given 18 meter p is given 15 centimeter per 24 hour that means this will be 15 meter per 24 hour r p is given 50 percentage that is 0.5 and s d is 2. 2 shoulder drain that is why this s d is 2.

So, then you substitute these value into this equation that mean q is equal to l is that is l is 50. So, we are putting this 50 and then p is also the 15 that is 0.15 and r of p is 50 percent that is also 0.5 this divided by s d this divided by s d s d is equal to 2 and because this we have made in terms of the minutes, so that is why 24 into the 60. So, so you can calculate q, q is equal to 0.023 meter cube per minute.

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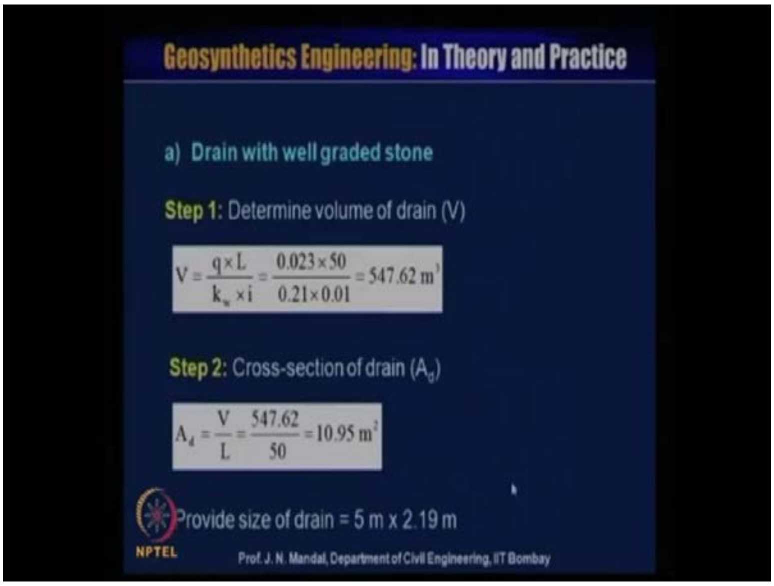

Now, case a, drain with well graded stone step 1 determine the volume of the drain. So, volume is equal to q into l by k w into i q is 0.023 l is 50 meter and k w is 0.21 that is coefficient of permeability of the well graded aggregate and i that is slope is 0.01. So, you can have volume is equal to547.62 meter cube.

Step 2: Cross section of the drain that is a d. so, a d will be equal to volume divided by length. So, volume is 547.62 divided by length is 50. So, a d will give 10.95 meter square.

So, you know that what should be the area of the drain. So, that is 10.95 meter square. So, you can provide the size of the drain 5 meter into 2.19 meter. So, you required 5 meter by 2.19 meter of the size of the drain. You can see that, what is the size of the trench drain, when there is no geotextile material only you are providing with the well graded stone. Now, b is the drain wrapped with the geotextile material step 1 determine the volume of the drain that is v, v is equal to q into l by k 0 into i q is 0.023 l is 50 and k 0 is open graded aggregate has been used that is 17 and i is equal to slope is 0.005. So, this volume is 13.5 meter cube.

Step 2 cross section of the drain a d. So, cross section of the drain a d is equal to v by l v is 13.5 divided by l is 50 meter. So, this will is equal to 0.27 meter square. So, provide the size of the drain 0.27 meter into 0.27 meter you can see that how the area can be deistically reduced due to the introduction of the geotextile material.

So, you have to calculate that what will be the total area of geotextile for the French drain. So, total area will be 4 into 0.27 into length is 50 plus 0.27 into 50. So, I can say that because it is a like a trench is like this. So, when you place the geotextile material like this, this is the aggregate is there and this is all along this length. So, this length which is 50 meter and this size of the drain. Let us say 0.27 point by 0.27.

So, you have to cover this side this side this side and also this side and also you have to give another overlap. So, along this length that is why this is the 4 side you have to give plus you have to give another overlap on the top overlap on the top that means this 0.27 along this length 50 meter. So, that is why this total area of the geotextile for French drain required about 4 into 0.27 into 50 meter length plus 0.27 wrapped into 50 that means 67.5 meter square next horizontal drainage blanket combination with French drain.

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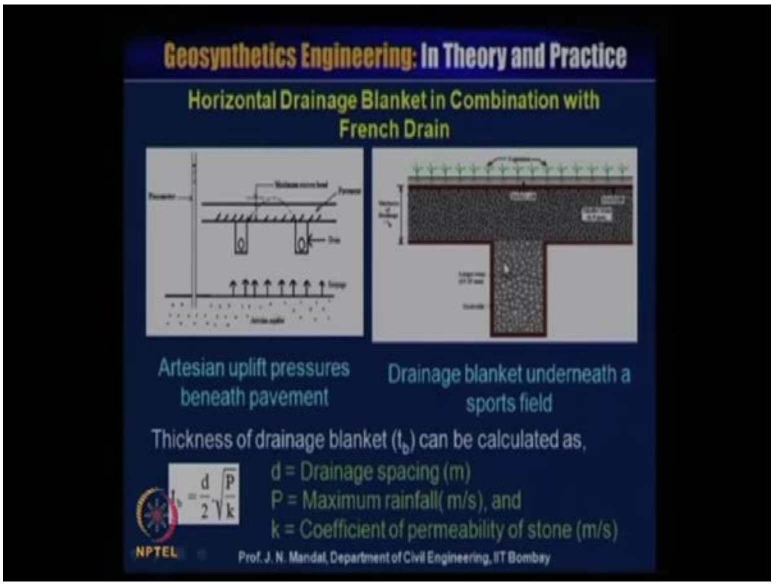

So, you can see this is the French drain and this is the drainage blanket underneath the sports field. If there is any sports field for you can use the geotextile material or the geocomposite material and on the top of this forced wheel you can you can see the vegetation or grass can grow and this is the thickness of the drain this is the blanket drain thickness of the blanket drain and here is the geotextile material and this is the aggregate size may be 19 to 25 millimeter and this is the thickness of the blanket.

Now, this is the drainage blanket underneath the sports field. Now, what happen actually we can look at the left hand side figure here is a artesian aquifer then water seepage upward and here is the drainage. So, artesian uplift pressure beneath the pavement here is a maximum excess head. If the pavement are here you can see pavement are here and due to the artesian uplift pressure beneath the pavement you can say that water level goes on increasing and this goes behind the pavement. So, water will be stagnant here we can see here the piezometry here. So, due to the artesian uplift pressure beneath the pavement. So, that will be the problem then how the horizontal drainage blanket with the French drain can solve this problem.

Now, you have to calculate what should be the thickness of the drainage blanket because the water level goes up here, this is the maximum excess head. So, accordingly you are to select the thickness of the drainage blanket that is t of b which we need to calculate in order that maximum excess head should not appear on the top of the pavement. So, there will be no water moved on the top of the pavement. So, you require proper kind of the geosynthetics engineering system.

Now, we have to calculate what will be the thickness of drainage blanket that is t b. So, t b can be expressed with this equation t b is equal to d by 2 root of p by k for d is equal to drainage spacing that is between the 2 drainage spacing meter and p is equal to maximum rainfall meter per second and k is the coefficient of permeability of stone meter per second. So, if we know then you can calculate that what should be the thickness of the pavement.

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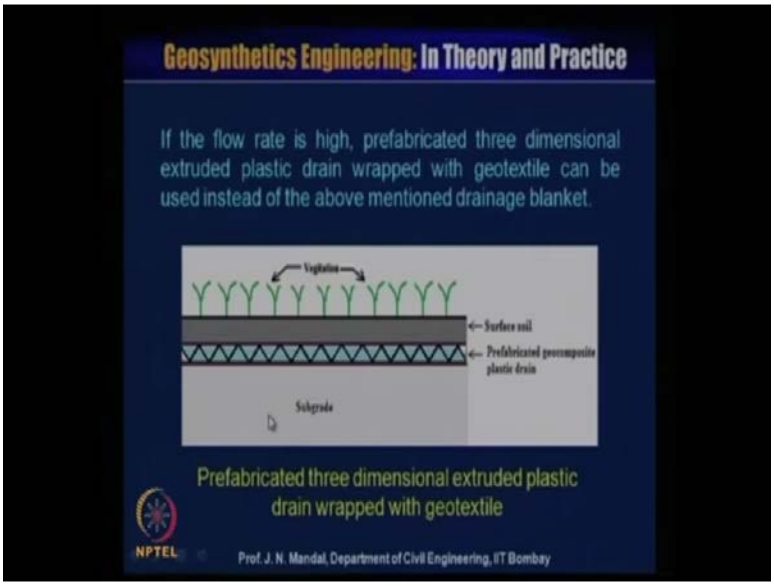

Now, you can see here that prefabricated 3 dimensional extruded plastic drain wrapped with the geotextile material is placed this is the subgrade you place this and this is the surface soil here. The vegetation has grown if the flow rate is high the prefabricated 3 dimensional extruded plastic drain wrapped with geotextile can be instead of that whatever the above mentioned drain blanket has been used. It is used instead of you do not need. So, you require only that one layer of prefabricated geocomposite plastic drain.

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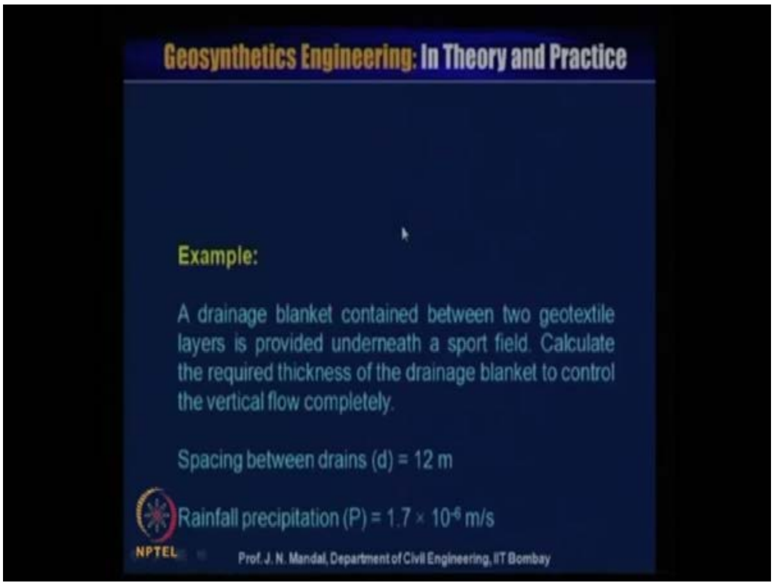

So, we are giving 1 example that a drainage blanket contained between the 2 geotextile layer is provided underneath a sports field. Calculate the required thickness of the drainage blanket to control the vertical flow completely. Now, here spacing between the drain d is equal to 12 meter rainfall precipitation p is equal to 1.7 into 10 to the power minus 6 meter per second. Now, the solution, assume that course sand is used for the drainage blanket. So, k is equal to 0.01 meter per second course sand.

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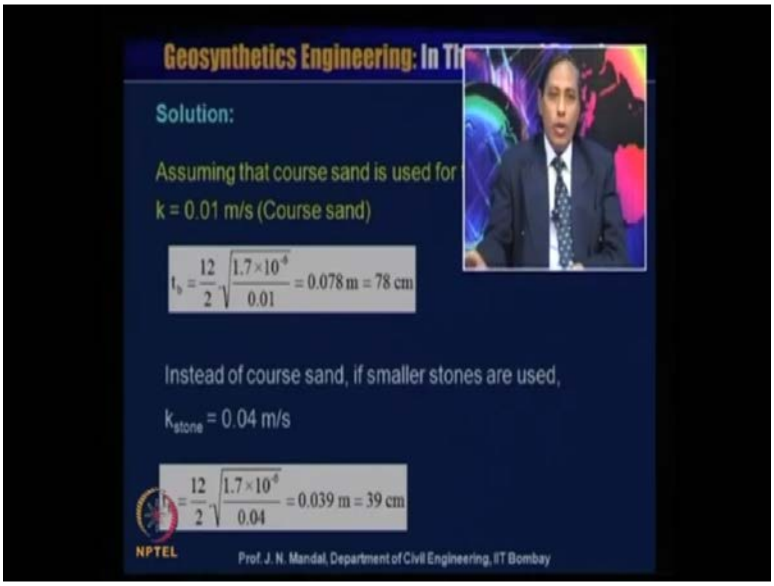

So, then we calculate that what should be the t b, t b will be equal to using this earlier equation you know that equation t b d by 2 root over p by k. So, d by 2 root over p by k. So, it is d by 212 by 2 root over p by k is 1.7 into 10 to the power minus 6 this divided by 0.01 this will give t b is 0.078 or 78 centimeter. If we use instead of course, sand if the smaller stone are used whose coefficient of permeability is 0.04 meter per second.

So, you can calculate what will be the thickness of the blanket t b is equal to 12 by 2 into root of 1.7 into 10 to the power minus 6 divided by this k is 0.04. So, this will give t b value 0.039 meter or 39 centimeter. You can see that if you use course sand what will be the thickness 78 centimeter. Whereas, if you use the smaller stone you can see that thickness has reduced to 39 centimeter. Now, first of all you have to also calculate that what will be the drawdown ground water level due to installation of geotextile wrapped French drain.

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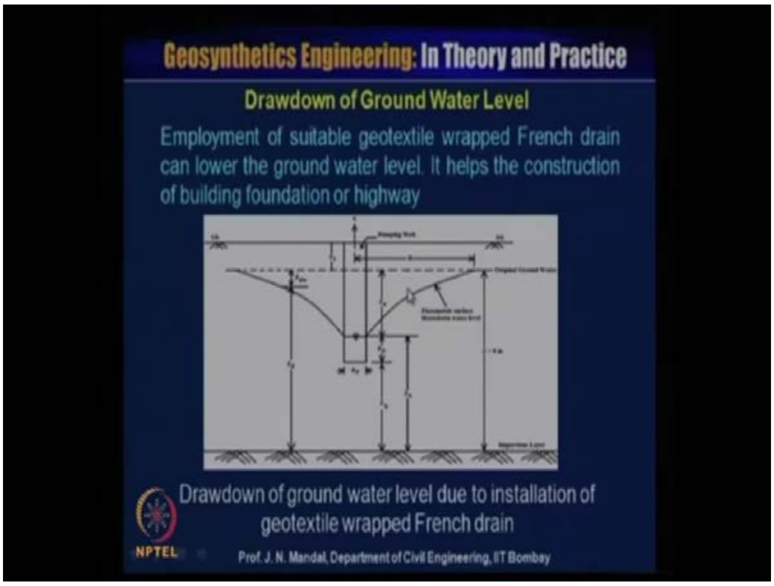

So, here employment of suitable geotextile wrapped French drain can lower the ground water level. It help the construction of the building foundation or the highway. Here you know that drawdown curve ground water level due to installation of wrapped French drain. So, here I’ve just showing you this is the ground level and this is the pumping well that is q and this is the piezometric surface drawdown water level and this is original ground level here original ground level and this is the piezometric surface drawdown and this is the impervious layer here. Now, here r is equal to the radial distance of the original ground water level from the drain center this is r and z this z.

So, z is depth of the ground water above impervious layer that is z is given 8 meter and z d that means residual head on the drawdown curve this is drawdown curve this is the residual z d and z d w is the reduction in water level on the drawdown curve and z of w here z of w is the depth of the water in pumping well. When you are pumping then water level comes in equilibrium at that stage and then the piezometric surface drawdown curve occur.

So, here this is the z w. So, z w is the depth of the water in the pumping well and z of b here from here to here. So, z of b is the distance between the drain bottom and impervious layer that is z b and z 0 is here to here that means z 0 is the distance of water level in the drain from impervious layer and this is d w d w is the width of the drain and i is the slope of the drain and let us say that k is equal to coefficient of permeability of the soil and z of t here z of t is the distance of original ground water level from the ground surface this is z 2. So, you know that in this figure what is z d w what is z d d w z w z b z 0 z r and z t and we consider that that length of the drain along this the length of the along this the length of the drain which is y this is length of the drain is y and coefficient of permeability of the soil is k of s.

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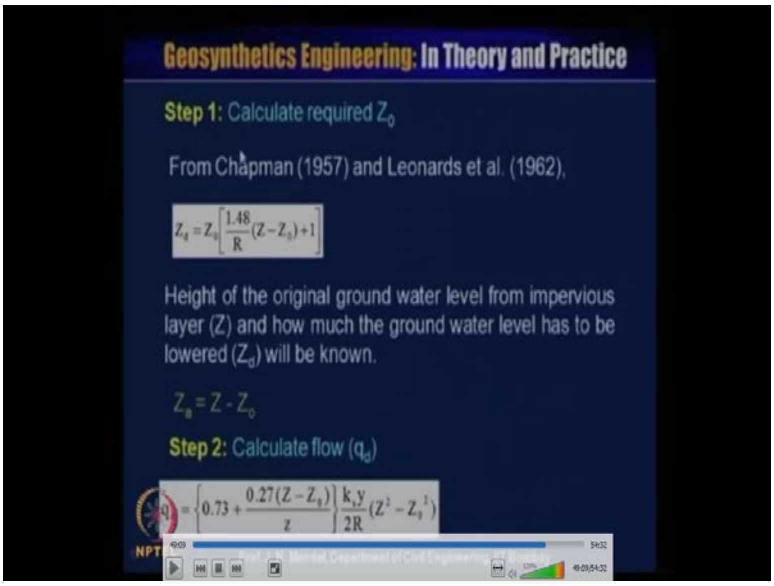

Now, step 1: I am showing some theory to calculate the required z 0 from the chapman 1957 and Leonards et al 1962. So, you can calculate z d is equal to z 0 this is flower bracket 1.48 by r then z minus z 0 plus 1. So, height of the original ground water level from impervious layer z and how much the ground water level has to be lowered z d will be known that means that if we look this figure here it is the z of a this is z of a how much ground water level has to be lowered this is z of a. So, z of a is equal to this is z this is z and this is z 0. So, z of a will be equal to z minus z 0 so that is why we have calculated the z of a will be equal to z minus z of 0.

Now, step 2 calculates the flow that is q d. So, q d you adopt this equation q d is equal to 0.73 plus 0.27 z minus z 0 divided by z and then k s into y divided by 2 r into z square minus z 0 square. So, you know what is z what is z 0 already I have explained here and you know the what will be the coefficient of permeability k s you know the what will be the length of drain this is y. So then from this you can calculate what will be the flow rate. Now step 3 calculates z w in terms of d w. So, you know the Darcy's equation q d is equal to k w into i into a k w into i into a is equal to that is d w into z w where k w is the coefficient of the permeability of well graded aggregate from this equation you can calculate z w that means z w is equal to q d divided by k w i into d w.

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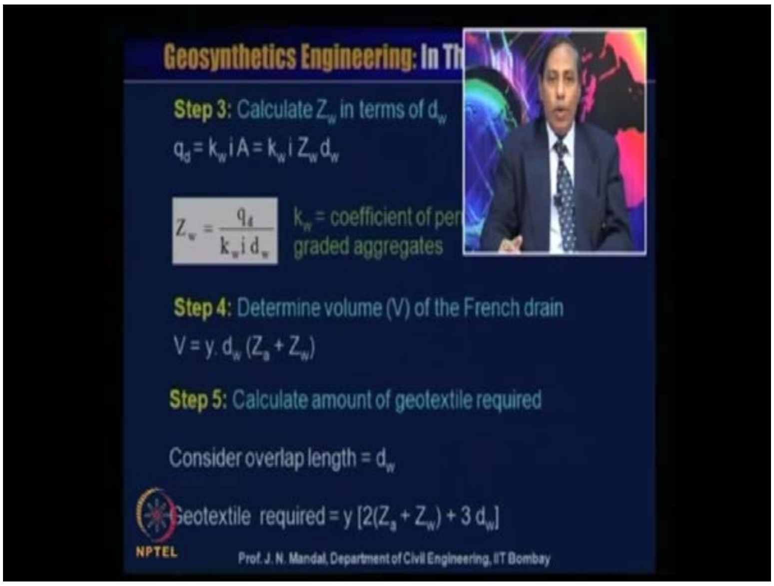

Now, step 4 determine volume v of French drain that means v is equal to y into d w into z a plus z w. So, y is equal to length of the drainage and d w is the width of the drainage and z a plus z w as defined earlier. So, you can calculate that what will be the volume of the French drain

Step 5: Calculate amount of geotextile required. Now consider the overlap length d w. So, geotextile required length is y and 2 into z a plus z w plus 3 of d w. So, it is like this so it is the it is the trench and it length y is about 50 meter whatever it is this is y. So, this is the d w this is d w this is d w and here the trench is this.

So, this is d w and this distance is z w and this distance is z a. So, we have to provide with the geotextile material into this drainage with this length will be z a plus z w and this length is y. So, y into 2 times of z a plus z w because this side and also this side 2 into z a plus this z w plus 3 d w because we are giving here bottom 1 and top 1 and then overlapped one so it will be the 3 d w. So, geotextile require will be y along the length 2 into z a plus z w plus 3 d w so you will be knowing what will be the what will be the required geotextile material for the trench drain so, by ended up this today's lecture.

Any question?

Thank you very much.