Geo synthetics Engineering: in Theory and Practices
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Lecture - 24
Geo synthetics in Pavements

Welcome to NPTEL to video course on Geo synthetics Engineering in Theory and Practice. My name is Professor J. N. Mandal, Department of Civil Engineering, Indian Institute of Technology, Bombay, Mumbai, India, this lecture number 24, this module 5 and lecture 24 Geo synthetics in Pavement.

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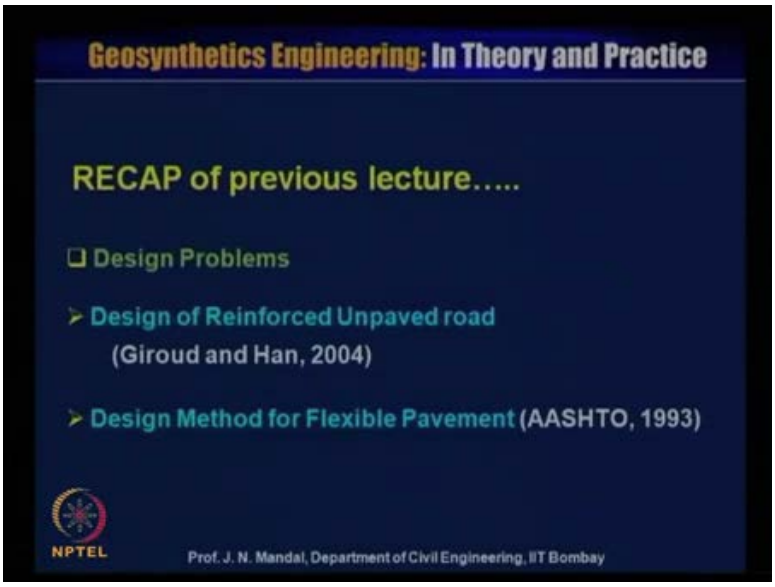

I will now focus recap of previous lecture that is design problem, design of reinforced unpaved road that is Giroud and Han 2004 design method for flexible pavement that is AASHTO 1993.

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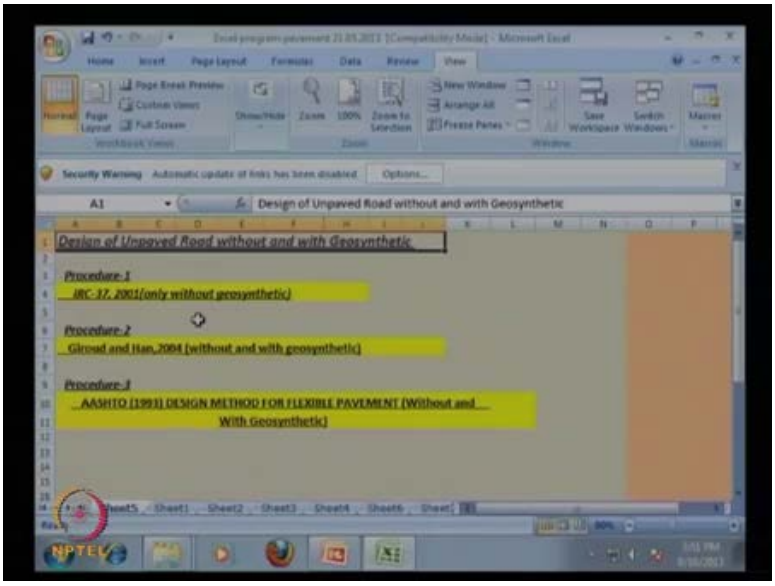

In this lecture I will show you the some excel program how you can calculate the design of unpaved road without and with geo synthetics with 3 procedure, procedure 1 IRC 37 2001 that is only without geo synthetics material. And procedure 2 that is Giroud and Han 2004 without and with geo synthetics material, and procedure 3 that AASHTO 1993 design method for flexible pavement without and with geo synthetics.

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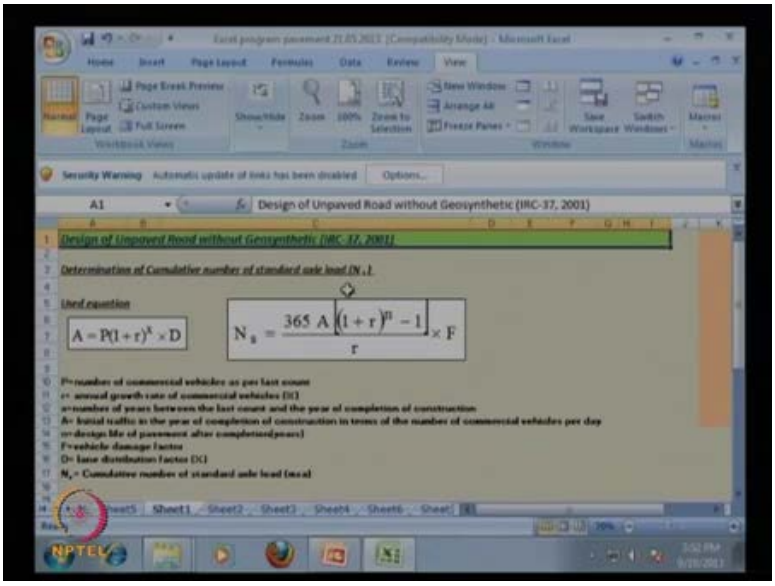

First of all I want to show that IRC 37 2001method that is we know determination of the cumulative number for standard axle load.

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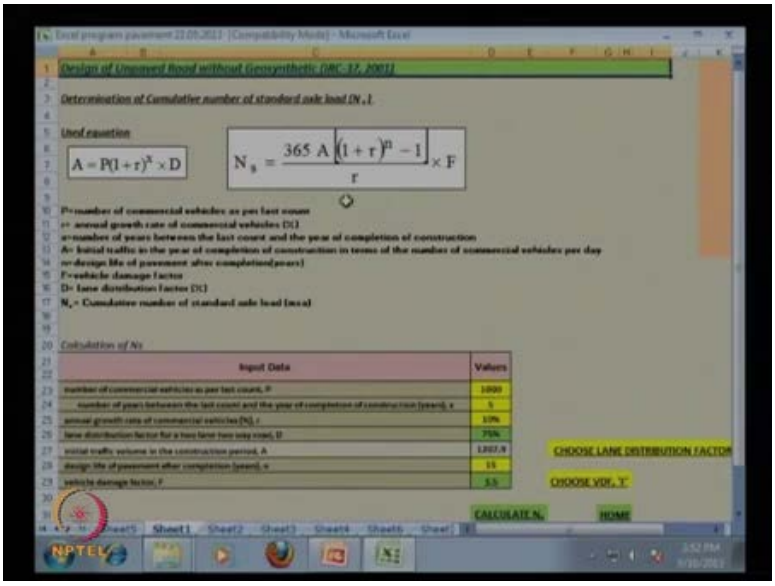

That we use this equation A is equal to P 1 plus r to the power x into D and N s is equal to 365 A 1 r to the power n minus 1 by r into F. So, here we want to calculate what is the A and also we want to calculate what will be the N s, now for A we require P r x and D. So, here it is given that P is equal to 1000 value, and number of years that is 5 here, and the annual growth rate is about 10 percentage, and time distributor factor for 2 length 2 way road which we should calculate. And also initial traffic volume of the construction period A we have to find out, and also we have to calculate the what will be the design life of the pavement after completion of 15 years. And then you have to calculate this vehicle damage factor F.

So, first of all that we want to calculate that lane distribution factor, so lane distribution factor you have considered that two lane single carrying road, and lane distribution factor in terms of the percentage of the total number of the commercial vehicle in both direction is about 75 percentage.

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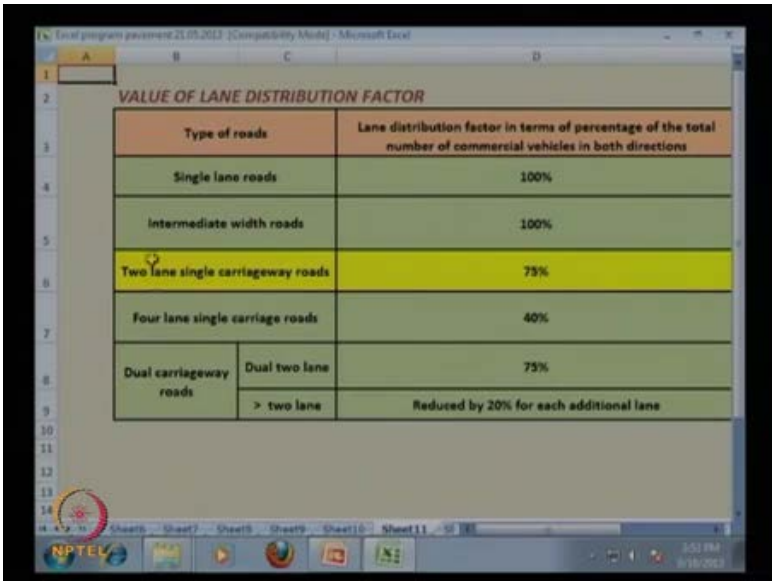

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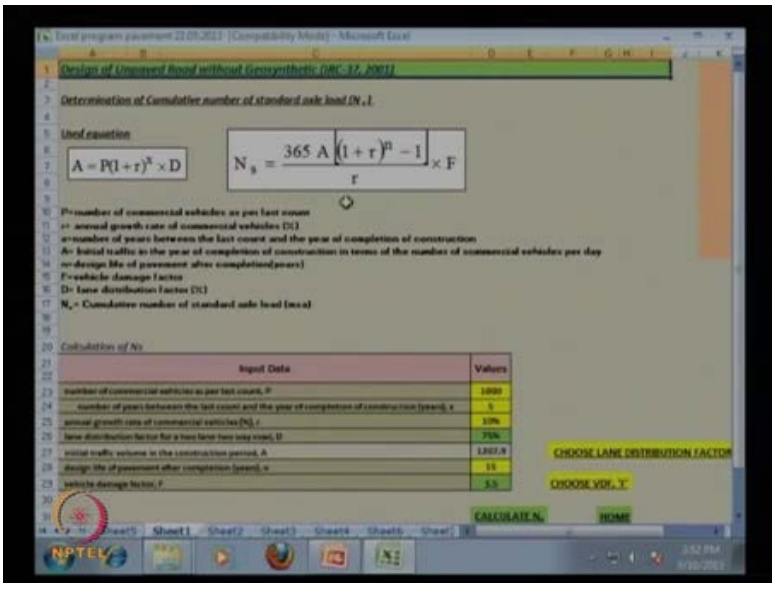

And that is why this is 75 percentage; that means, D is 75 percentage, now you have to calculate vehicle damage factor that is F.

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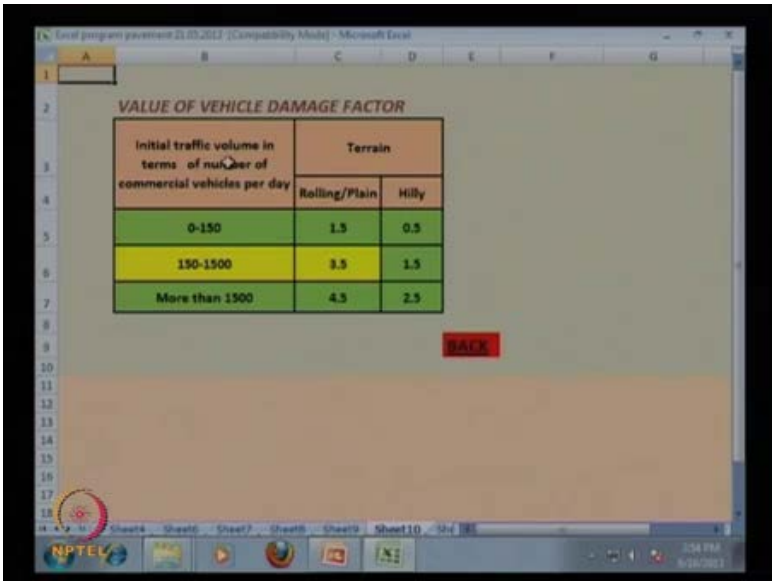

This F can be choose from this table; that means, we know that what will be the initial traffic volume in terms of number of commercial vehicle per day, we are assuming the number of commercial vehicle per day 150 to 1500. And we are considering the terrain whether it is a plain or hilly we have consider the plain terrain, and that is why this vehicle damage factor is 3.5. So, you know that vehicle damage factor that is 3.5.

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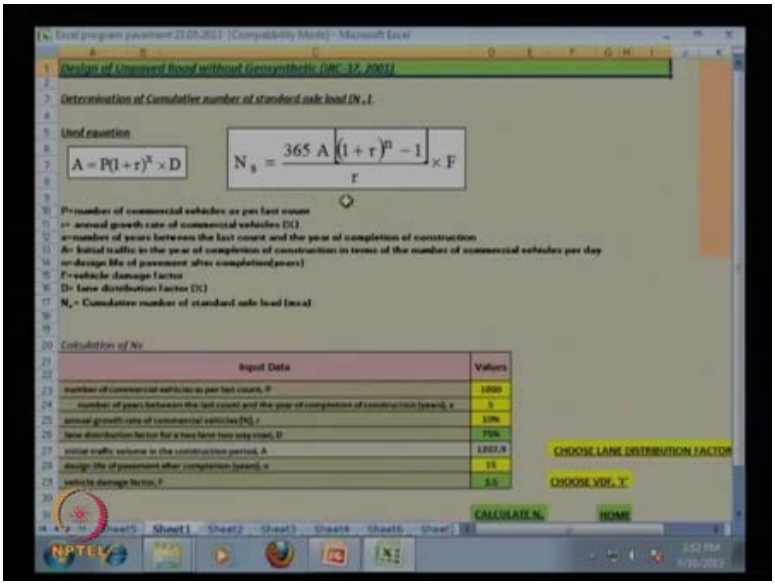

So, we can see here that basic damage factor F is equal to 3.5, so we know here F is equal to 3.5, and we know here D is equal to 75 percentage and r x is a everything is

given. So, we can calculate A we can calculate N of s. So, now, you calculate that N s value.

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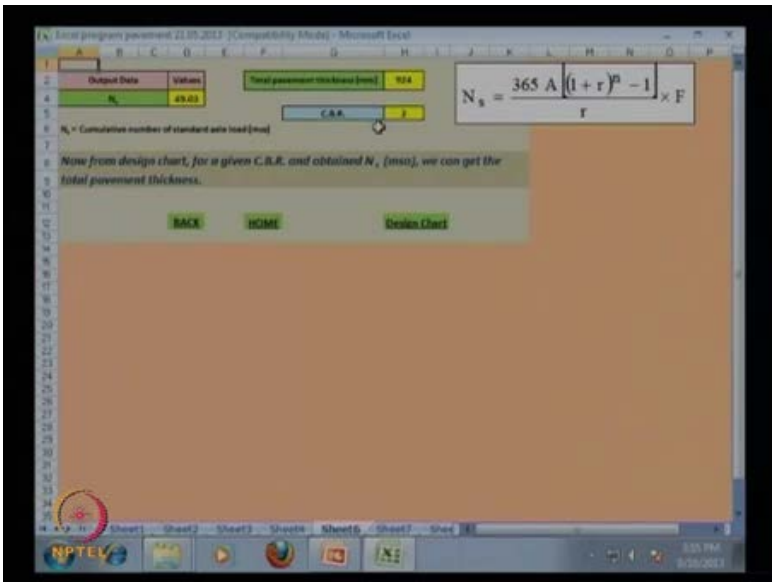

So, here is shown that N s value, so from the output you can see that N s value is 49.03, so you are having this all the values are known N s value is 49.03. And from this you can calculate the what would be the total pavement thickness that will be 924 for the California bearing ratio value is 2. So, N s you know the cumulative number of standard axle load.

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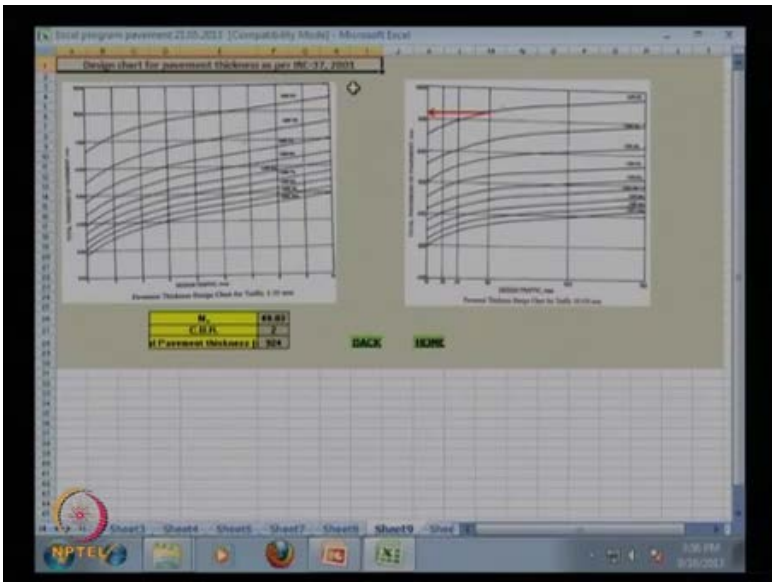

So, this is the design chart, this is for design chart for pavement thickness as per IRC 37 2001, there are 2 charts has been shown 1 is for the design traffic is 1 to 10 m s a, this is the relationship between what will be the design traffic, and what will be the thickness of the pavement for different m s a, and the right hand side is given for 10 to 150 m s a. So, here as our N s value is 49.03, so here you can see this is 49.03, so we know that what is the N s value, and then we moved up.

And then this is the CBR value is equal to 2 this is CBR is equal to 2, so for this 49.03 N s value you move up and then CBR is equal to 2, and then you move horizontal and then you can calculate what will be the thickness of the pavement this will give 924. So, this will give the value of 924, so you can calculate this 924 millimeter of total pavement thickness, this is IRC code specification without geo synthetics material.

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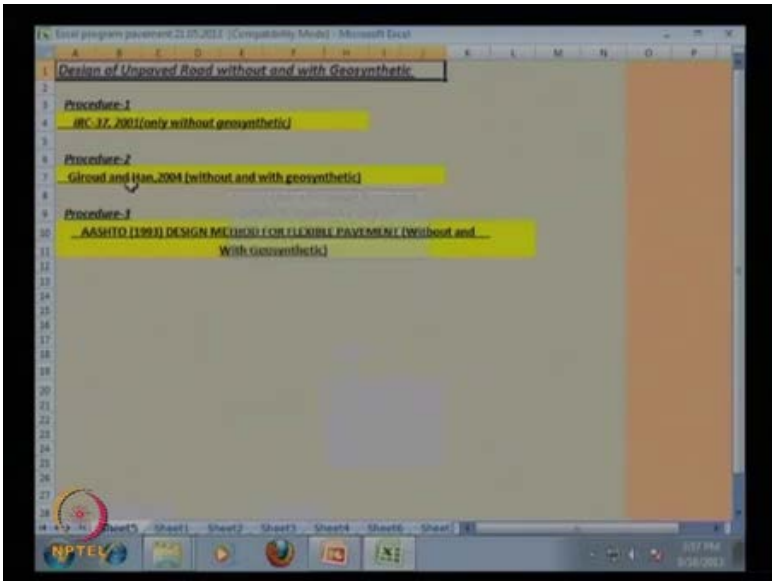

Next procedure 2 that Giroud and Han 2004 without and with geo synthetics material.

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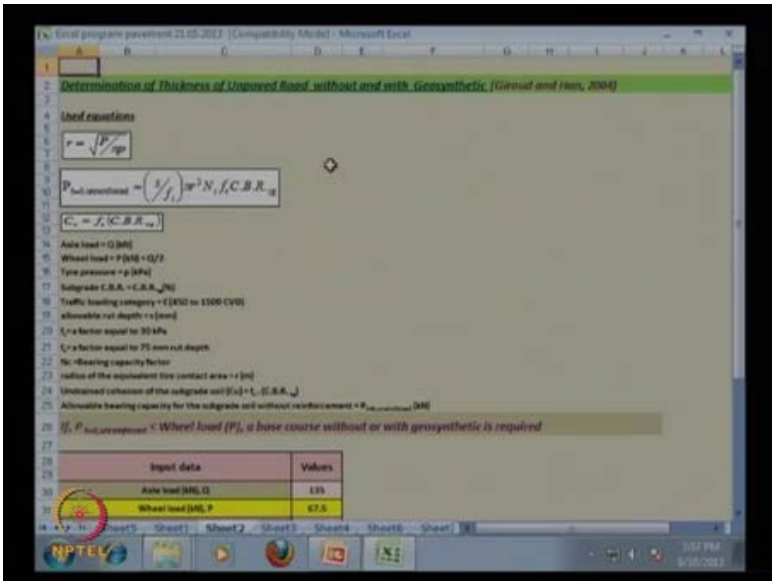

Here you have to determine the thickness for unpaved road without and with geo synthetics, we use this equation r is equal to root over P by pi into p and P h 0 is unreinforced we use this equation and C is equal to this.

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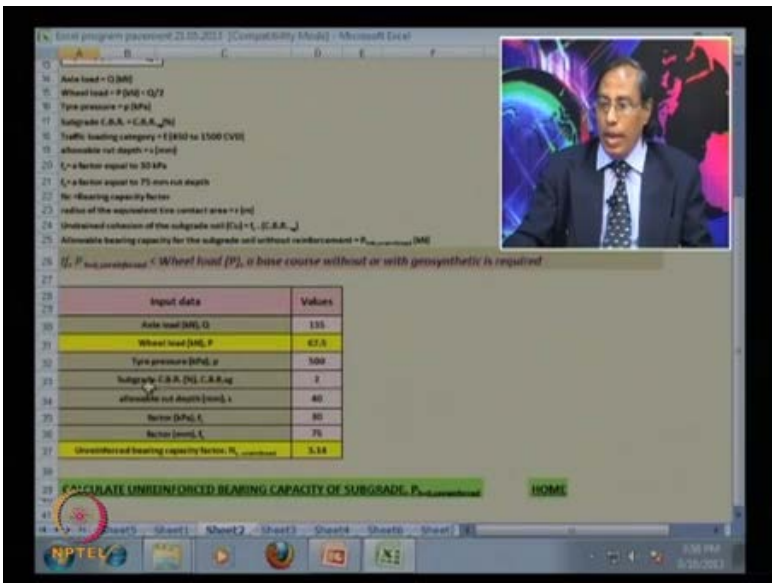

So, here that axle load here we will use this equation and here the axle load is given 135, so wheel load is kilo Newton p half of this axle load that is 67.5. And the tire pressure is given k p a is 500 k p a, sub-grade CBR percentage is given 2, allowable rut depth in millimeter is 40 then factor f s is 30, factor f c is equal to 75. So, for unreinforced

bearing capacity factor is 3.15, so you have to calculate that what will be the unload unreinforced bearing capacity of sub grade soil.

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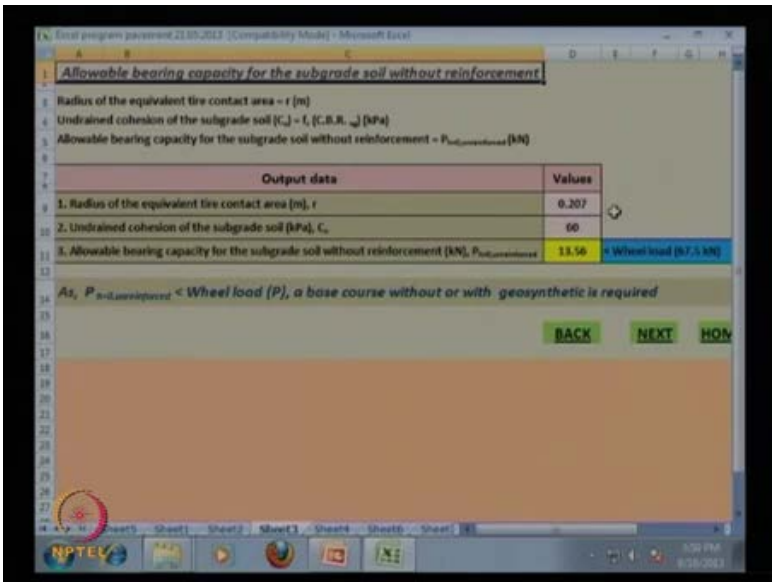

So, you can see that here the output data the radius of equivalent contact r is equal to 0.207 undrained cohesion of sub grade C u is 60. So, allowable bearing capacity of sub grade soil without reinforcement 13.56, so this is less than the wheel load 67.5 kilo Newton as the P h unreinforced is less than the wheel load a best course without and with geo synthetics is required, you can see here that how this is less than 67.5 kilo Newton this is the 67 wheel load 67.5 kilo Newton. So, for it is less than the 67.5 kilo Newton therefore, it is required to introduction of the geo synthetics material for the pavement design.

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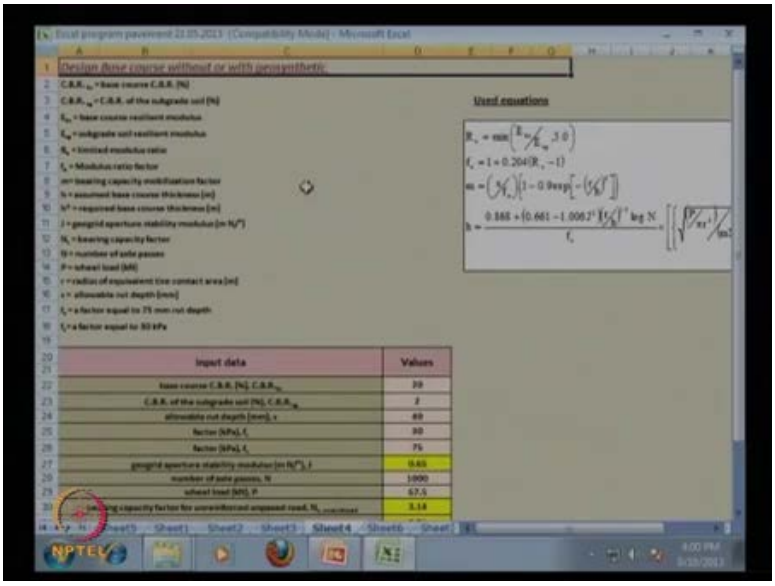

Next design base course without and with geo synthetics, so this is the equation we will use for this design and here base course CBR is 20, CBR of the sub grade soil is 2, allowable rut depth is 40 millimeter, this is factor f c is 30, factor f e in kilopascal is 75. And geo grid aperture stability modulus this is very important that is 0.65 number of the axle passes n is equal to 1000 wheel load p is equal to 67.5, and we consider bearing capacity for unreinforced unpaved road that is 3.14. Bearing capacity factor for geo grid reinforced unpaved road that is 5.71 and bearing capacity factor for geo textile reinforced unpaved road that is 5.14.

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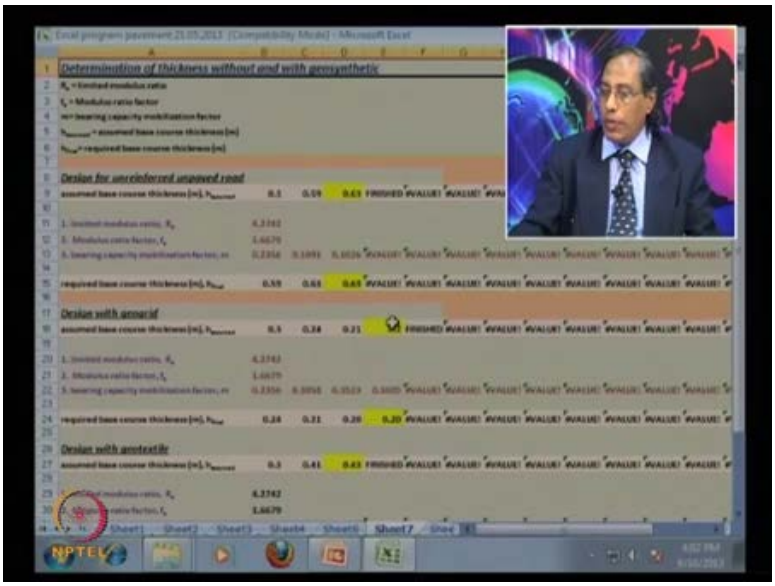

So, then we can now calculate and here you can see that determination of thickness without and with geo synthetics material this program has developed, and then it has the you can see that how the by the iteration, this is how the minimized value has come after that you can almost finish here. So, you can get that initial for the modulus or modular ratio, bearing capacity factor, you can have you can see 0.3 and then 0.5 then 0.63 it is stabilized.

So, for unreinforced case thickness of the pavement is about 0.63 meter, but if we use the geo grid material you can see it is finished that about 0.2 meter. So, what will be the assumed base coat thickness is equal to required base course thickness, this is for geo grid the thickness of the pavement will be the 0.20 meter. Similarly, that if we use the geo textile material and assumed base course thickness, and then ultimately you are having 0.43 and then which is matching with the required base thickness 0.43.

Now, all the three procedure have been then shown here for without geo synthetic material with geo grid material and with geo textile material.

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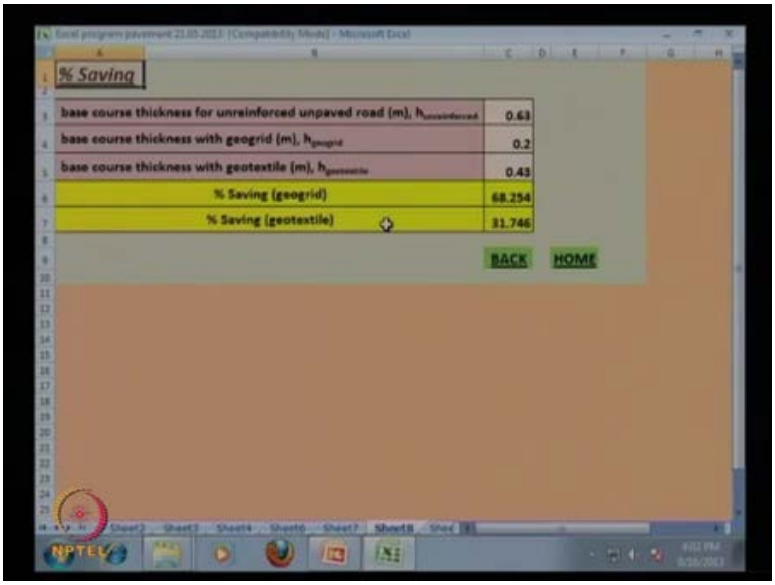

And now you can look that what will be the saving, so base course thickness for unreinforced unpaved road is 0.63 meter, and base course thickness with geo grid material 0.2 meter, and base course thickness with geo textile is 0.48 meter. So, percentage of saving in case of geo grid is about 68.254 whereas, percentage of saving in geo textile is 31.746.

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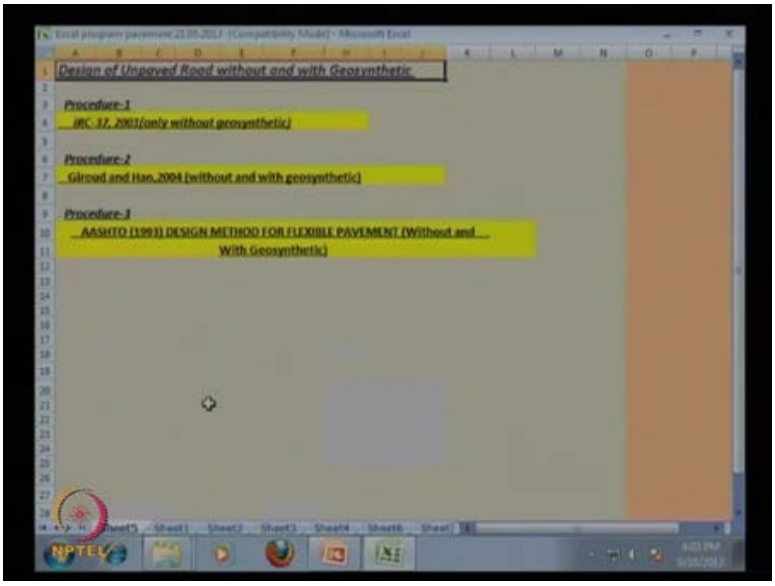

So, we can see that how that geo synthetics can help to reduce the thickness of the pavement. Now, we will address that procedure 3 that is AASHTO design method for the flexible pavement without and with geo synthetics material.

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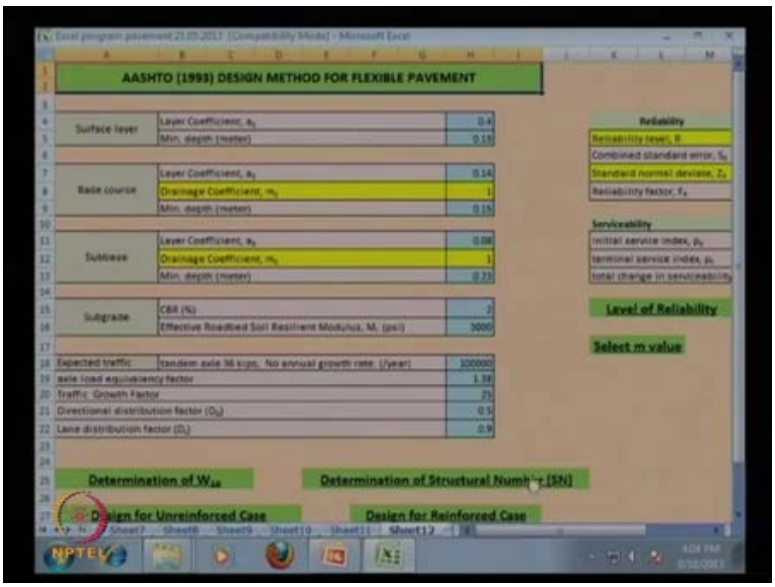

Now, here that is surface course, base course, this is sub base course and this is the sub grade. And here expected tandem 30 kips and number of the annual growth rate per year is 1 lakh, axle load equivalent factor 1.38, direction of different factor D d, we know

what is the lane distribution factor. And you have to calculate that reliability factor, so this is reliability factor is 95 percent.

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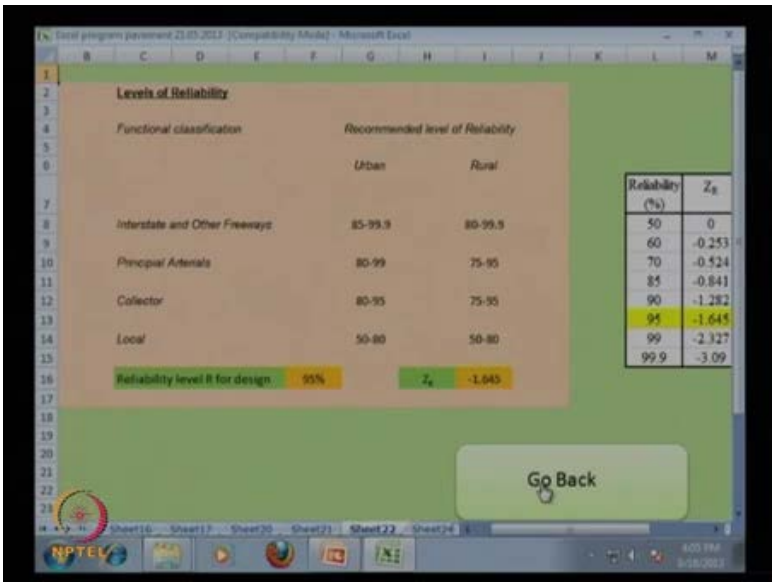

Which you can obtain from this chart it is a level of reliability realibility R for the design is 95 percentage, and correspondingly you can also determine what should be the value of Z R value. So, Z R value this is the reliability, so this is the reliability value and this is the Z R value, here reliability is 95 percentage, so corresponding Z R value is minus 1.645, so you are getting minus 1.645.

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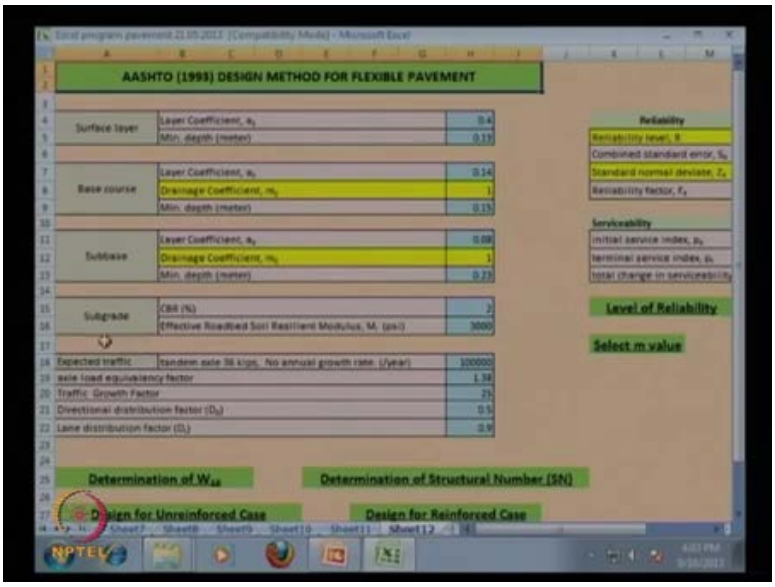

So, here this reliability value is having minus 1.645 for the reliability level of 95 percentage, and Z R are given and from their you can calculate the reliability factor.

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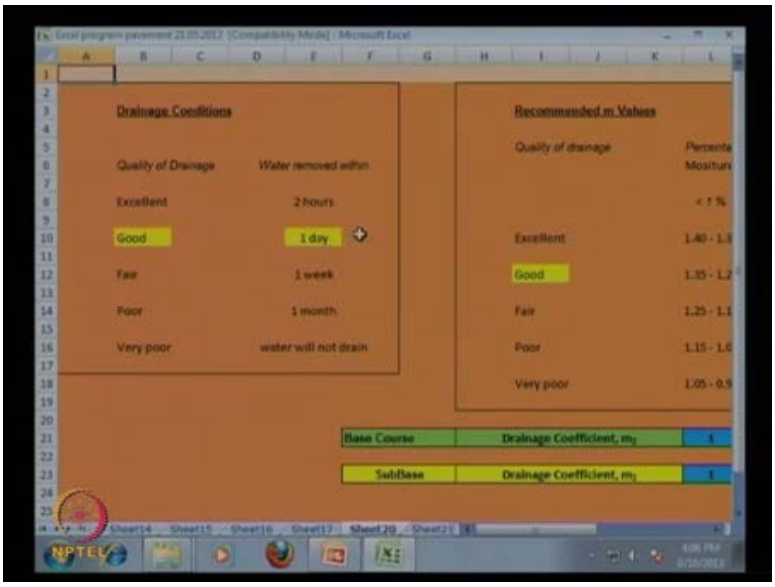

And next that you have to select the value of m value, you can select the m value from here because, we have considered drain is good and it is for 1 day. And this recommended value of m value that it is good, and then also it depend upon the moisture content.

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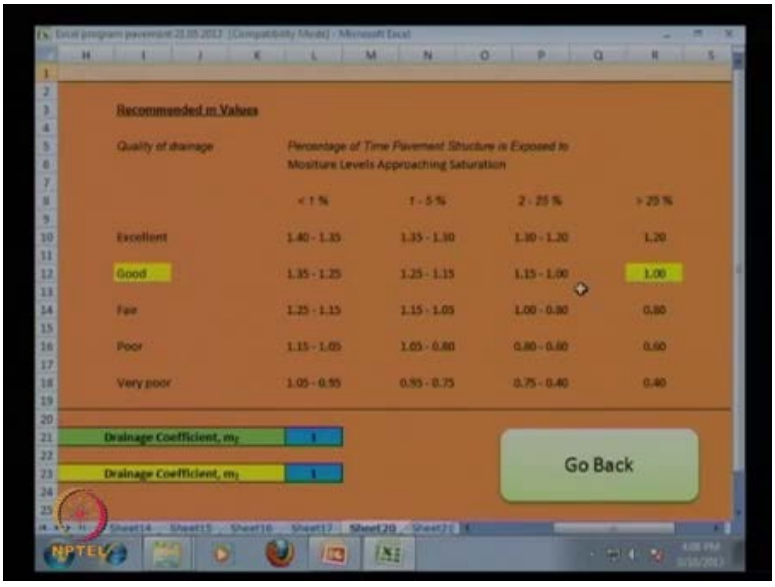

And you are considering that what should be the m 2 and m 3 value, and here because, in base and sub base course is the same material. So, this drainage coefficient m 2 and the m 3 we kept the same that is 1 that is why drainage coefficient m 2 is equal to 1, and drainage coefficient m 3 is equal to 1 this 1 is for the base course, and another is for the sub base course.

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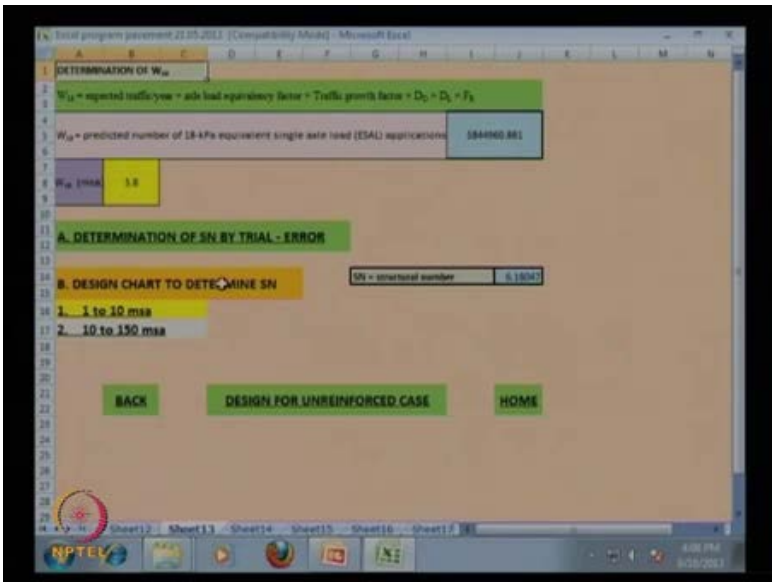

So, you can calculate that what will be the value of m, so next you can calculate the determination of w 18. So, this is the w 18 is expected traffic per year into axle load equivalent factor into traffic growth factor into D D into D L into F R, so from this you can calculate w 18 which is coming 5.8 m s a that is million standard axle. Now, determination of SN by the trial and error method, so you can determine the s n value by trial and error method, so you can obtain that structural number about 6.160.

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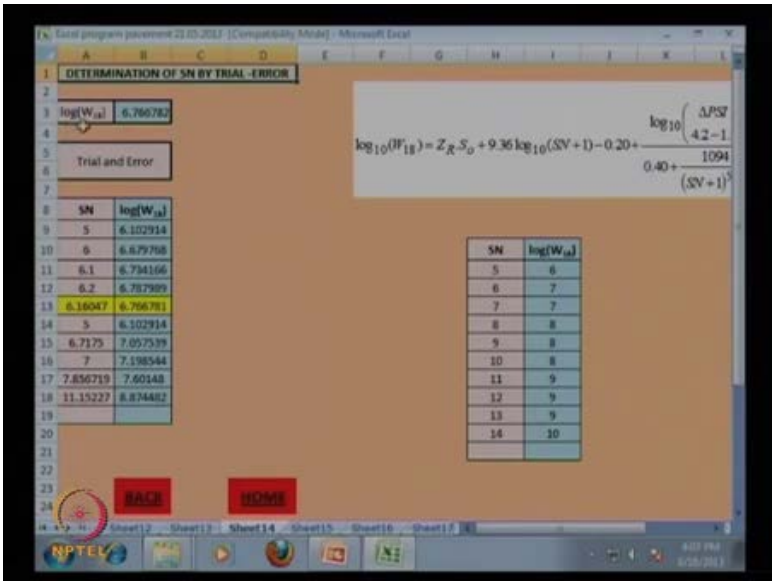

So, you can by go by the trial and error, you can see that you have got that this is W 18 is 6.67 and by the trial and error. So, we can have the structural number value is equal to 6.160, so you have used this equation the right hand side this equation we know the all the value on the left and the right. And then you can calculate that what should be the structural number that is 6.1.

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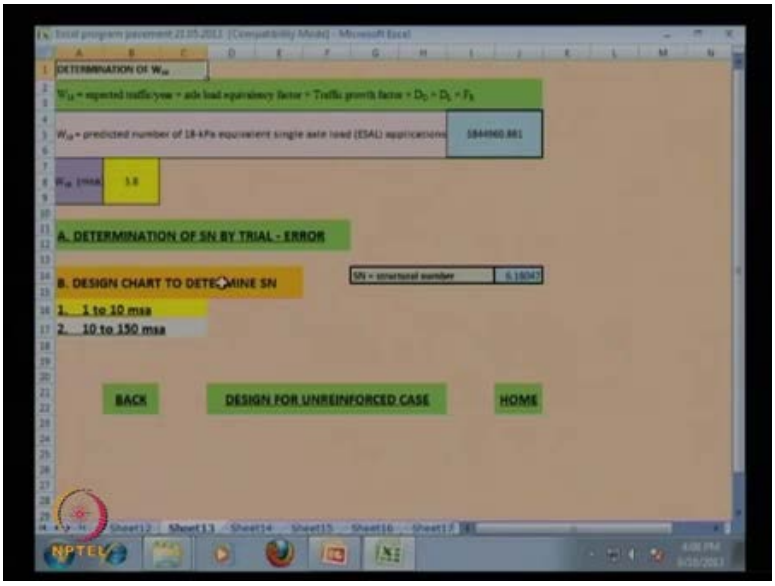

So, you can calculate this structural number knowing that W of 18 or you can use also the design chart. So, this also you can use design chart there are 2 design chart 1 is for 1 to 10 m s a, another is 10 to 150 m s a.

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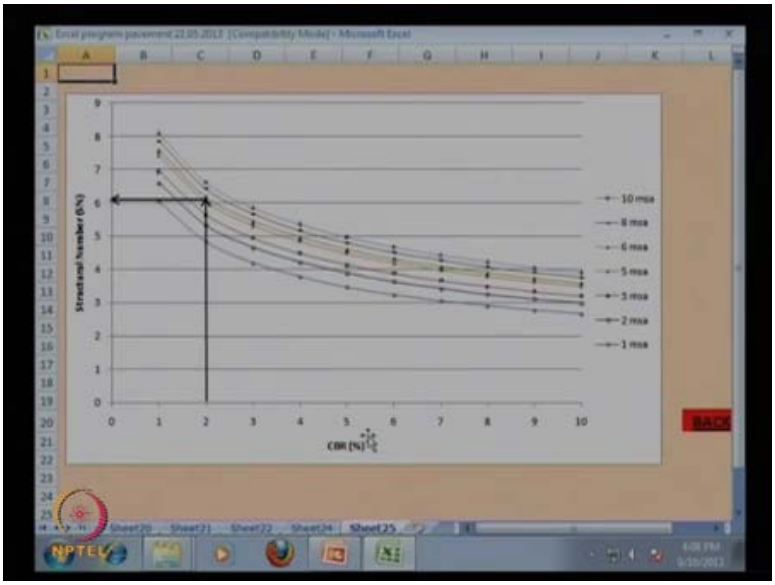

So, you can determine the structural number use this design chart, so this design chart show the relationship between the CBR and the structural number SN for the different m s a 1 to 10 m s a. Here because, this CBR value is 2 and the structural number value lies between 6 to 8 nearer here, so you know the CBR moved up and then you check the structural this m s a value this is about six point something 16, and then you moved the horizontally then you can calculate that what will be the structural number.

So, that you can calculate the structural number knowing the value of this what will be the load, this is 5.8 about m s a. So, this is for 1 to 10 m s a you can also calculate for this 10 to 150 m s a, when you will use from 10 to 150 m s a for different value of CBR and the structural number if it is a more than 10 to 150, so you can add up this chart.

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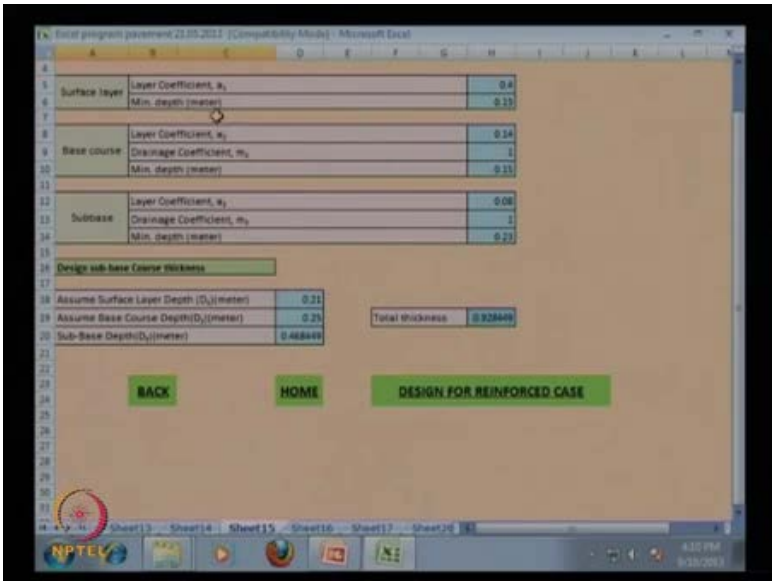

And this is the for design for surface layer course you have taken a 1 and the base course and the sub base course. And you assume the surface layer depth is equal to 0.21, and assume the base course d 2 is 0.25, and sub base course d 3 is equal to 0.468449, so total thickness you can also obtain 0.9284 meter. So, this is in case of the unreinforced what will be the thickness of the pavement.

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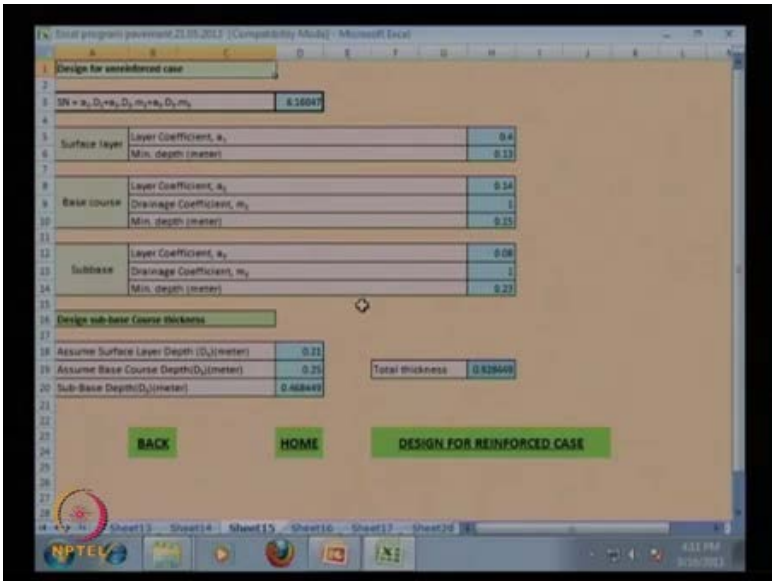

Considering all the structural layer coefficient from this equation SN is equal to a 1 D 1 a 2 D 2 m 2 plus a 2 D 3 m 3. So, you can determine this structural number you can determine what will be the thickness of the pavement.

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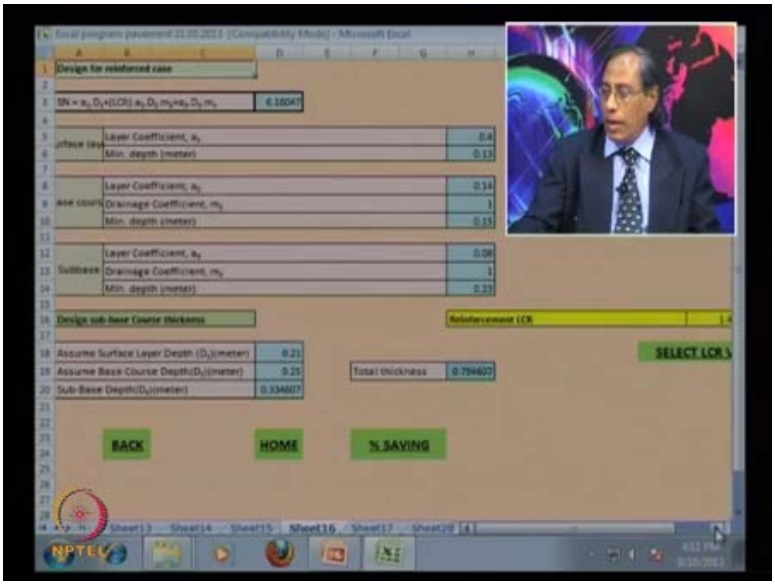

Now, if you move for the reinforcement case, where you have to consider in this equation that SN is equal to a 1 D 1 plus LCR, LCR is equal to Linear Coefficient Ratio into a 2 into D 2 into m 2 plus a 3 into D 3 into m 3. So, if you know that what is the LCR, so you can calculate that also structural number and this LCR you can calculate from this curve.

So, this is the curve which shows that CBR versus layer coefficient ratio LCR for a geo synthetics material, which is a geo composite material, which has a geo grid and nonwoven geo textile and tensile strength is 40 kilo Newton per meter. So, knowing the value of CBR you can calculate the what will be the value of LCR, so here the layer coefficient ratio LCR value is equal to 1.4. So, you can substitute these value that is LCR, so from this figure you can calculate that what will be the LCR value, if LCR value is equal to 1.4 then you substitute this value in this equation 1.4.

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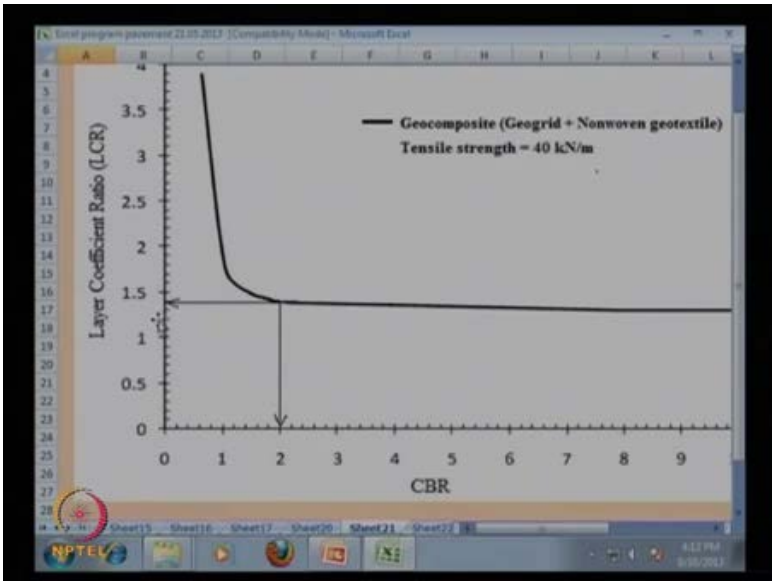

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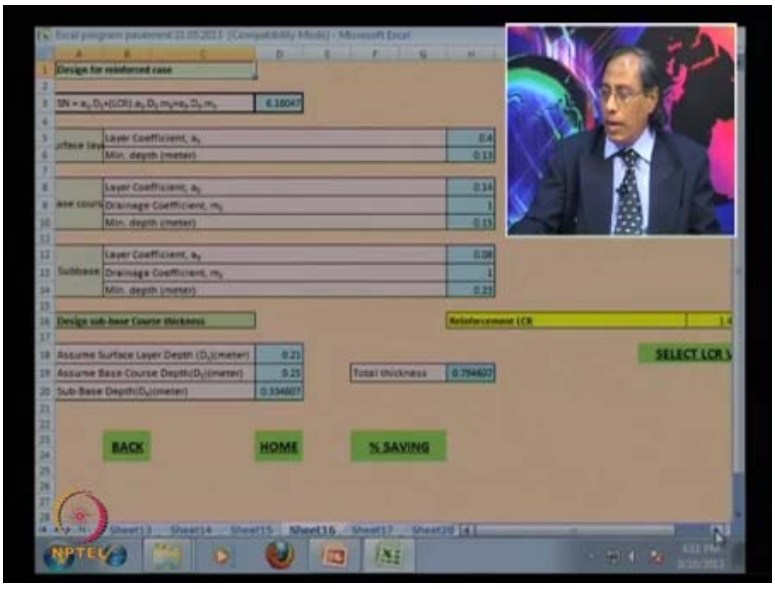

And then you can calculate that what should be the thickness of the pavement. So, here the surface layer course D 2 is equal to 0.21 D 1 D 2 is equal to 0.25 and sub base course D 3 is equal to 0.33 meter, so total thickness is 0.79 meter.

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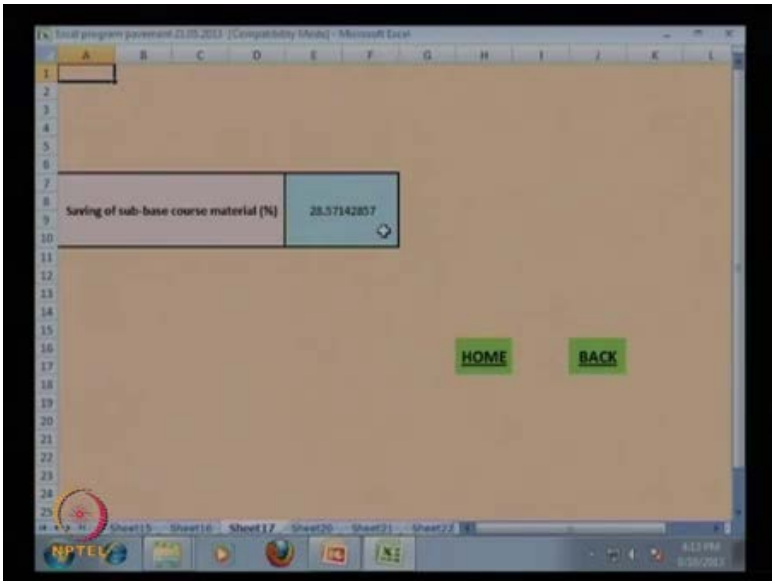

So, then you can see that what will be the percentage of saving, so saving in the sub base course about 28.57 percentage. So, without and with geo synthetics material you have obtain that how you are saving this thickness of the pavement, so you can use this excel program for the determination of the thickness of the unpaved road without and with geo synthetics material.

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So, next development of design method for geo synthetics reinforced flexible airfield pavement.

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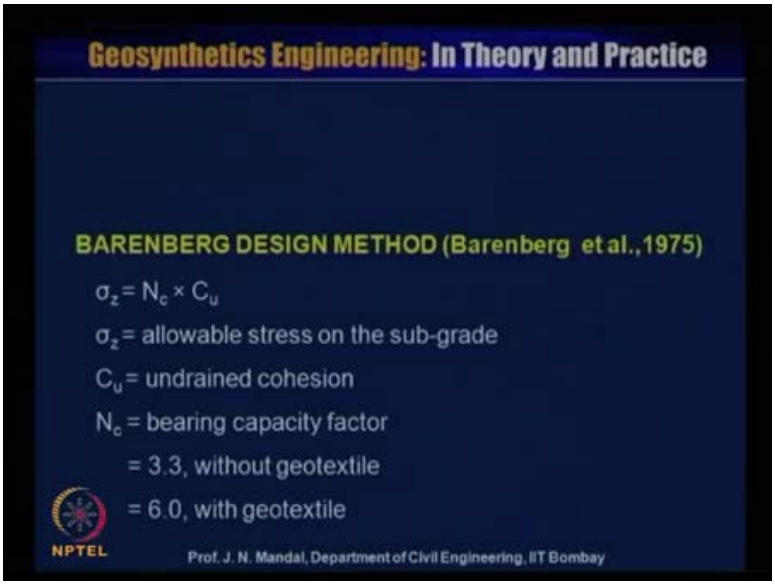

So, barenberg design method barenberg et al 1975, he has given that sigma z is equal to N c into C u for sigma z is allowable stress on the sub-grade, C u is equal to undrained cohesion. And N c is equal to bearing capacity factor that is 3.3 without geo textile and N c is equal to 6.0 with geo textile material; that means, they have performed the field test and from that field test they obtain this value.

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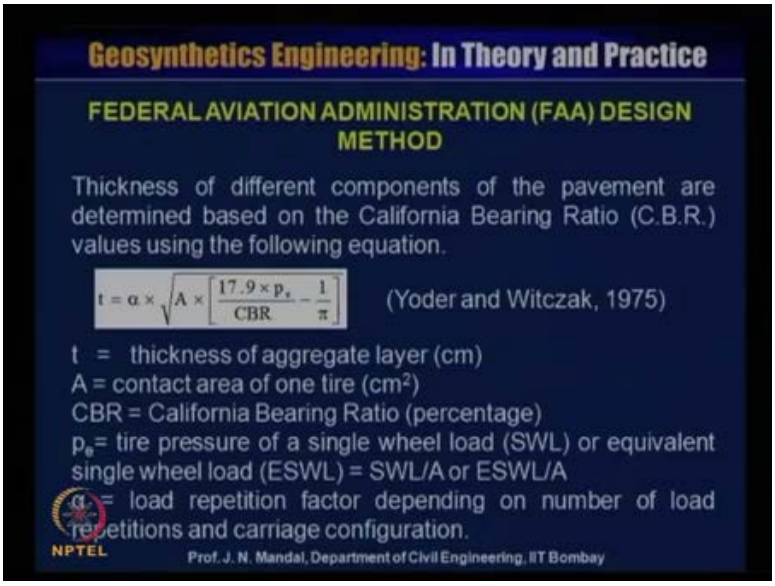

Now, Federal Aviation Administration FAA design method, the thickness of the different component of the pavement are determined based on the California bearing ratio CBR

values using the following equation. That is t is equal to alpha into root of A into 17.9 into p e by CBR minus 1 by pi, this is Yoder and Witczak 1965 for t is equal to thickness of the aggregate layer centimeter.

A contact area of one tire that is centimeter square, CBR California bearing ratio in percentage, P e tire pressure of a single wheel load that SWL or equivalent single wheel load ESWL or that is equal to SWL by the single wheel load divided by contact area of one tire or equivalent single wheel load divided by a that is contact area. And alpha is the load repetition factor depending on the number of the load repetition and carriage configuration.

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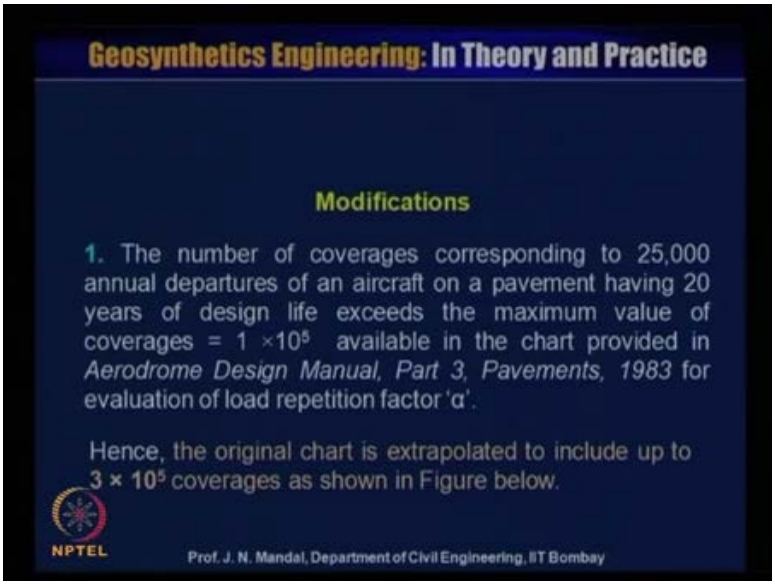

So, some modification has been made this is number of the coverage corresponding to 25,000 annual departure of an aircraft on a pavement having 20 years of design life exceed the maximum value of coverage that is equal to 1 into 10 to the power 5 available in the chart provided in the aerodrome design manual, part 3, pavement 1983 for evaluation of load repetition factor alpha. Hence this original chart is extrapolated to include up to 3 into 10 to the power 5 coverage as shown in the figure. Because, now a days that because, for aircraft weight are increasing, so this is required for more.

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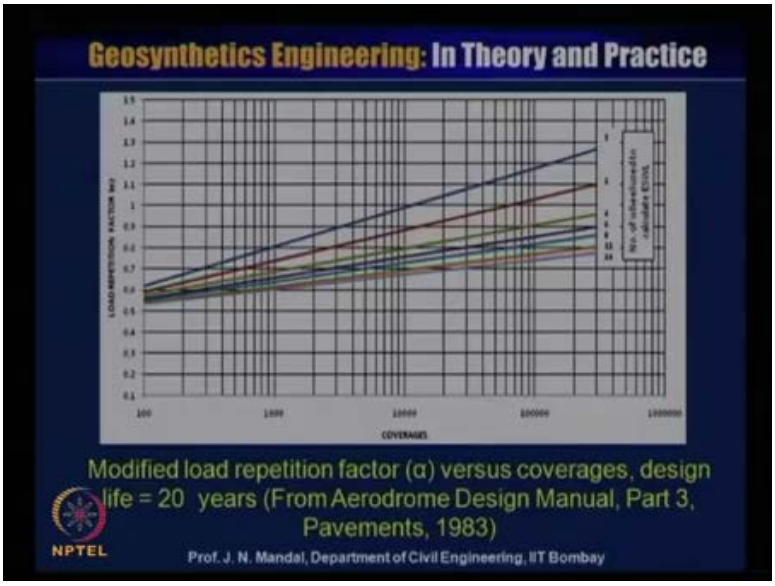

So, initially that whatever it was there that is 1 into 10 to the power 5 and this chart has been extrapolated and include up to you can see that which was 1 and it was up to 3 into 10 to the power 5 it has been extrapolated. Because, for the heavy Boeing etcetera where there will be heavy load, so this is the modified load repetition factor that is alpha versus the coverage this design life for 20 years from the aerodrome design manual part 3 pavement, so this design chart has been modified and we will used for our design.

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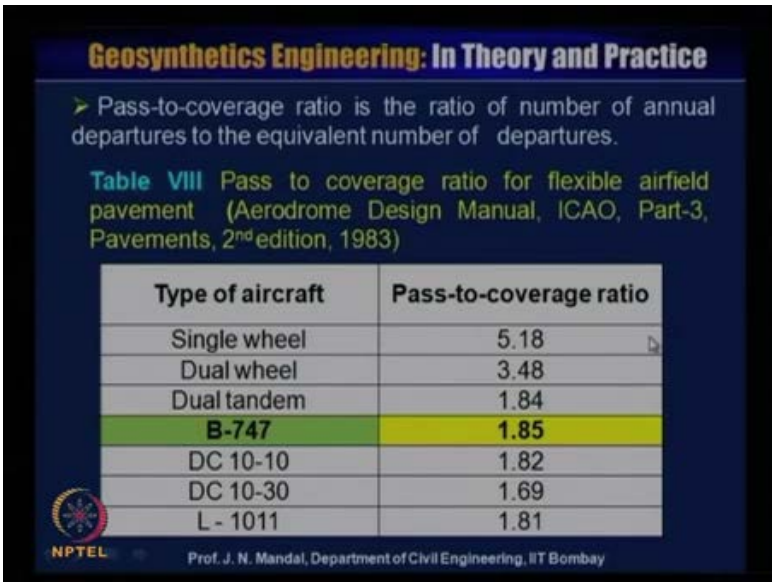

Now, pass to coverage ratio is the ratio of number of the annual departure to the equivalent number of the departure. Now, this table 8 pass to coverage ratio for flexible airfield pavement that is aerodrome design manual, ICAO, part 3, pavement 2'nd edition 1983. Here for the different types of the aircraft you can see the single wheel, dual wheel, dual tandem B 747 Boeing DC 10 10, DC 10 30, L 1011 and this is to pass to coverage ratio. So, this starting from 5.18 to 1.81. so we will consider some cases for design that Boeing 747 which pass to coverage ratio will take 1.85.

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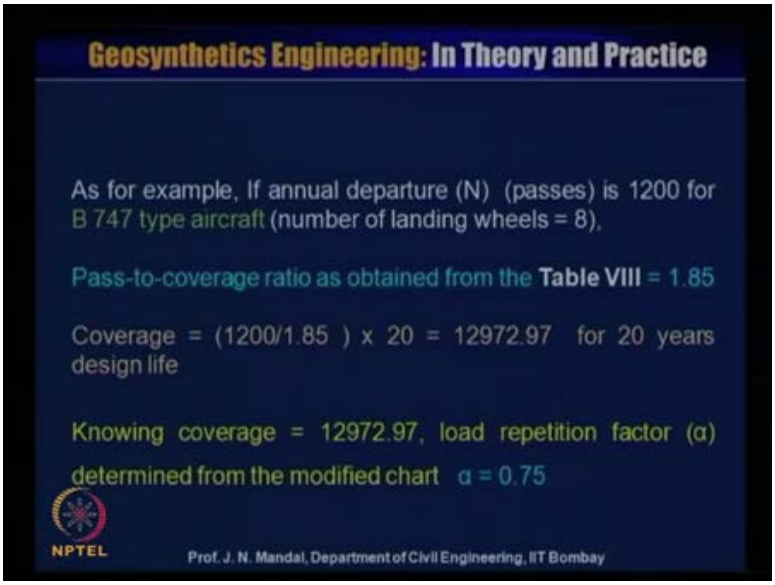

So, as per example if the annual departure N passes is 1200 for B 747 type aircraft the number of the landing wheel is 8. So, pass to coverage ratio as obtained from this earlier table is 1.85 this is for this is pass to coverage ratio 1.85, so coverage will be 1200 because, number of passes 1200 divided by that what is the pass to coverage ratio is 1.85 and this for the 20 years, so this will give you the 12972.97 for 20 years design life. So, knowing the coverage 12972.97 load repetition factor alpha determined from the modified chart that is alpha is equal to 0.75.

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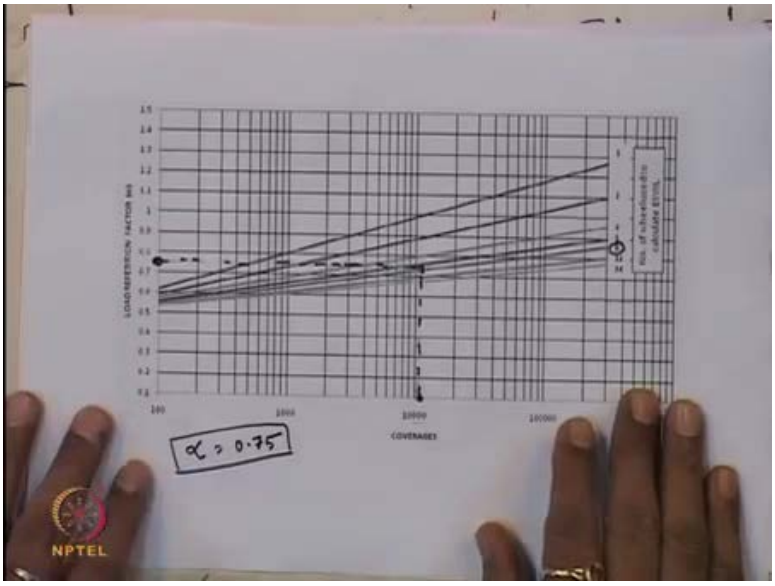

I will show you that here this is the coverage and this the load repetition factor; that means, alpha and this are the number of the wheel used it may be 1, 2, 4, 6, 8, 12 and 24 number of the wheel is used. In this r problem we are assuming that number of wheel is equal to 8, and we know that what should be the coverage that is about 12972, so it is somewhere here that coverage is 12972.97.

And then we know the coverage, value and we know that what will be the number of the wheel. So, number of the wheel is equal to 8, so here number of the weight is equal to 8, so knowing the coverage we know number of the wheel, then you moved horizontally and to the load repetition factor alpha. So, this will give you the load repetition factor alpha, so this alpha value which lies between 0.7 to 0.8, so this will give you about alpha value is equal to that is 0.75. So, you can calculate from this design chart what will be the load repetition factor that is alpha.

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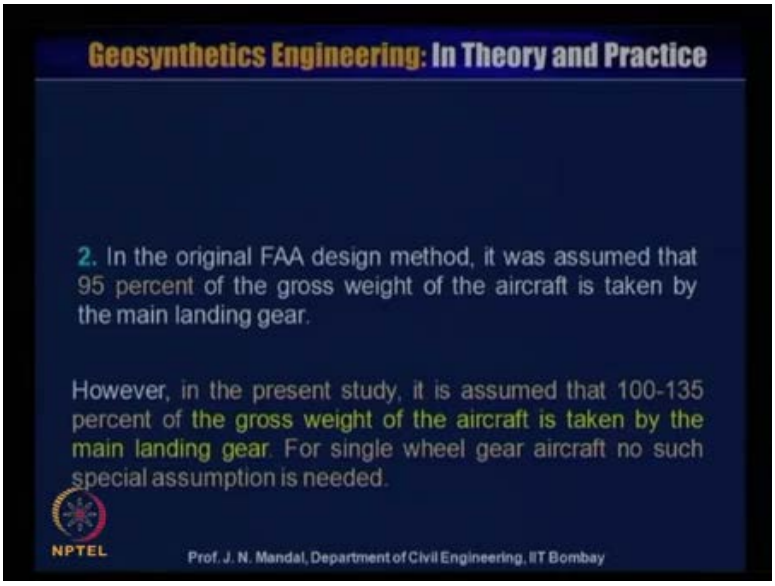

So, we can calculate the load repetition factor, next two in the original FAA design method, it was assumed that 95 percent of gross weight of the aircraft is taken by the main landing gear. However, in the present study, it is assumed that 100 to 135 percentage of the gross weight of the aircraft is taken by the main landing gear, for single wheel gear aircraft no such special assumption is needed.

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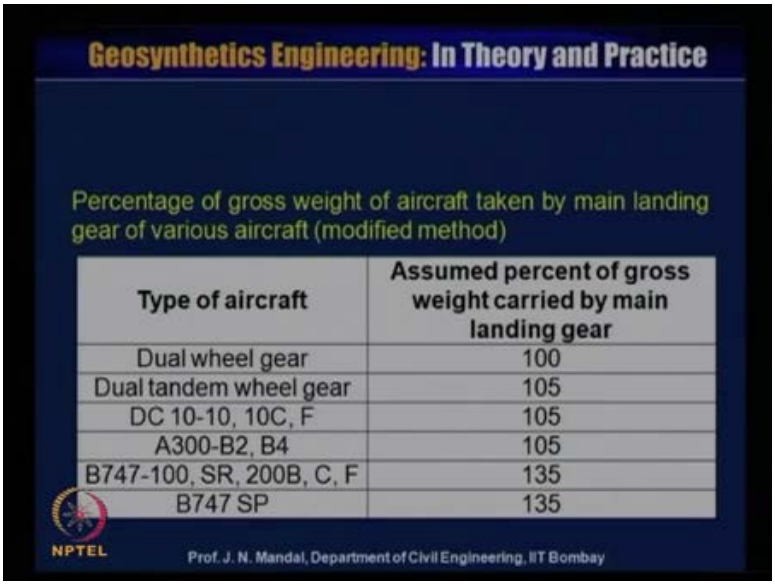

So, this is the percentage of gross weight of the aircraft taken by the main landing gear of various aircraft, this is the modified method you can see here type of the aircraft dual

wheel gear, dual tandem wheel gear, DC 10 10, 10 C, F A 300 B 2, B 4, B 747 100 SR, 200 B, C, F and B 747 SP for this we assume the percentage of the gross weight carried by the main landing it starts from 100 to you can see you can go up to 135. So, this is what it has been modified and because, for the heavy load you have to consider the landing gear is more.

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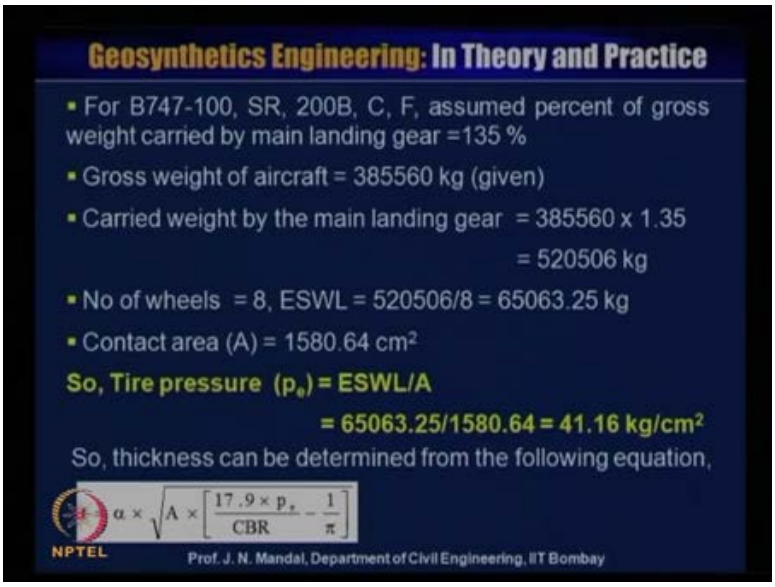

For B 747 100 SR, 200 B, C, F assumed the percentage of gross weight carried by the main landing gear is 135 percentage. So, gross weight of the aircraft is 385560 k g is given, so carried weight by the main landing gear will be 385560 into 1.35 that is 520506 k g. So, number of the wheel is 8, so ESWL will be the 520506 divided by 8 is equal to 65063.25 k g.

And you know the contact area capital A is equal to 1580 into 64 centimeter square, so tire pressure P e is equal to ESWL divided by a that is 65063.25 divided by 1580.64 that is 41.16 k g per centimeter square. So, thickness can be determined from the following equation that is t is equal to alpha root to power A into 17.9 P e divided by CBR minus 1.5, you know that what is alpha value, if alpha value is known to you 0.75, you know that what will be the contact area A which is given.

You know that what will be the P e value, and you know the what will be the CBR value then you can also calculate what will be the thickness of the pavement.

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Now, combination of barenberg design method and the modified FAA method, in this method the thickness of the aggregate layer for various CBR value is determined using the design evaluation given by Yoder and witczak in 1975, considering all the modification. The CBR value can be converted into corresponding undrained cohesion value; that means, C u is equal to 30 into CBR for C u is equal to undrained cohesion value in kilopascal.

If the bearing capacity is provided we can easily determine the CBR values using the above relation and mention barenberg equation. The appropriate bearing capacity factor N c has to be considered for reinforced that is 6.0 and unreinforced case it is 3.3.

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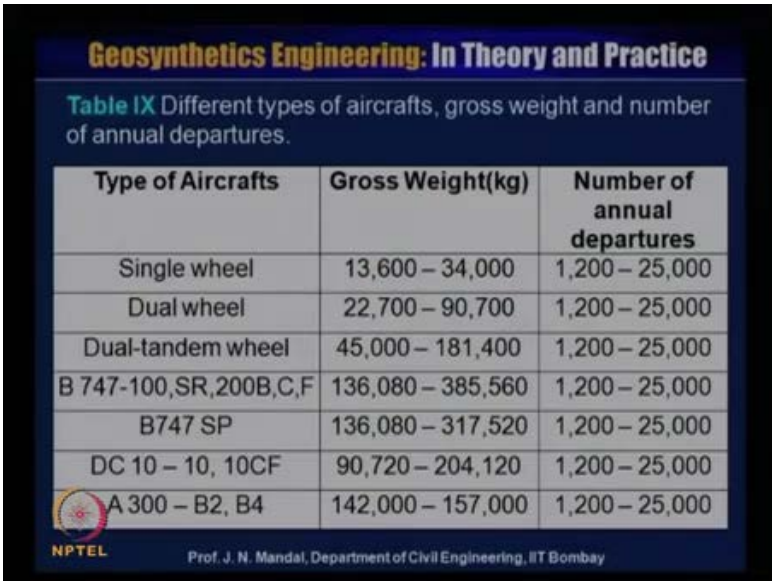

And this is the table different types of the aircraft gross weight and number of the annual departure, this is the you can see the different types of the aircraft is given, and this is the gross weight also it is given which lies between 13,600 to 34,000 k g. Even then you can have 1,42,000's to 1,57,100's of k g gross weight and the number of annual departure also now a days it is 1200 to 25,000 this is the number of annual departure, and gross weight you can see how it is the increasing. So, that is why the design chart modified design chart will be very useful.

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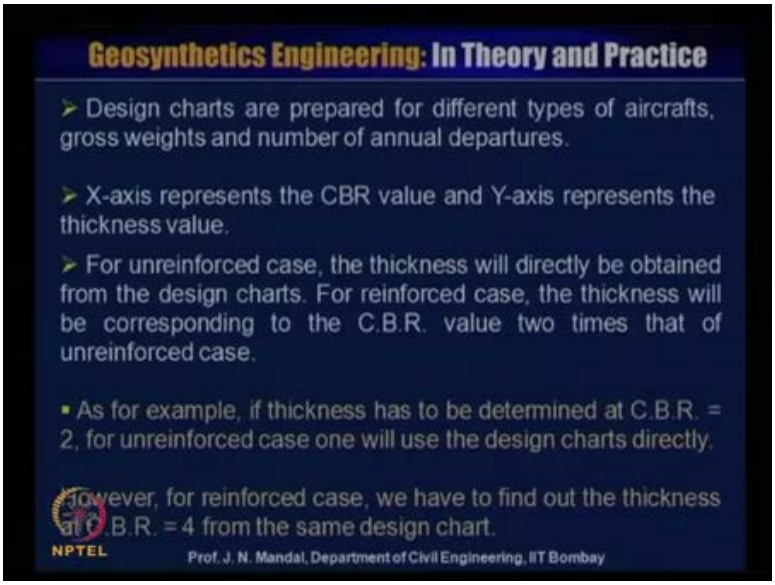

So, design chart are prepared for different types of the aircraft, gross weight number of the annual departure, and x axis represent the CBR value and y axis represent the thickness of the value. For unreinforced case, the thickness will directly be obtained from the design chart, for the reinforced case the thickness will be corresponding to the CBR value two times that of the unreinforced case. As per example, the thickness has to be determined at a CBR is equal to 2 for unreinforced case one will use the design chart directly. However, for the reinforced case and we have to find out the thickness at CBR is equal to 4 from the same design chart.

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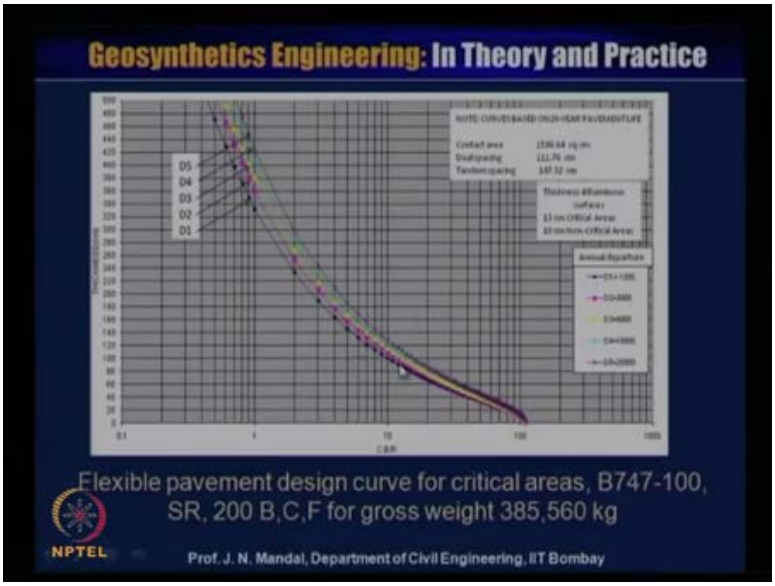

Here you can see that design chart this is for flexible pavement design curve, for the critical areas that is B 747 100 and SR 200 B, C, F for gross weight of 3,85,560 k g and this is the annual of departure, and this is the thickness of the pavement. So, if you know that what will be the annual departure and if you know the CBR value in unreinforced case equal let us say consider the unreinforced case that CBR value is 2.

And the annual departure if you know then you can calculate what will be the thickness of the pavement in unreinforced case. When it is the reinforcement case this it will be the 2 times; that means, 2 will be the 4 and then you know that what will be the departure D 1 or D 2, D 3, D 4, D 5 and then correspondingly you can also calculate that what will be the thickness of the pavement with geo synthetics material.

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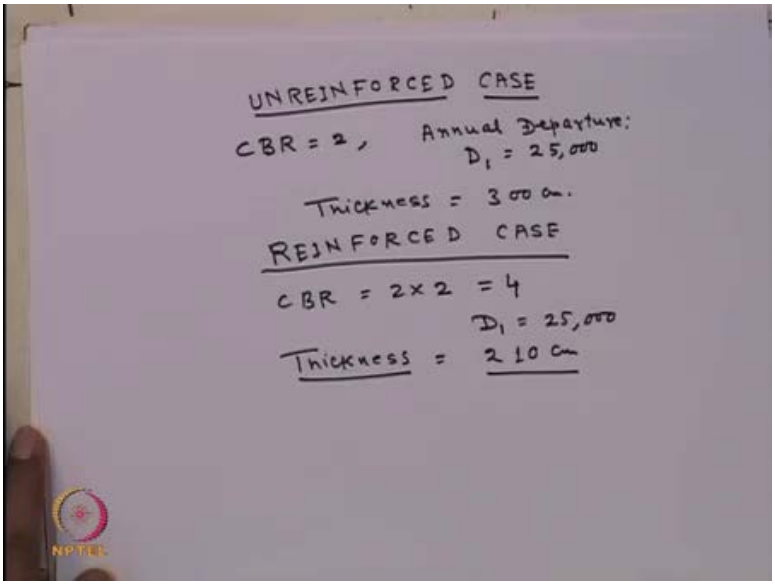

I am showing that how you can use this chart, let us say this is a unreinforced case, and given CBR value is equal to 2 and annual departure let us say annual departure D 1 is equal to 25,000. So, from this design chart knowing the value of CBR if CBR value is equal to 2, and annual departure let us say is equal to 25,000, so you can calculate that what will be the thickness, this thickness will be about your 300 this will be about 300 centimeter, so this thickness about 300 centimeter.

So, thickness of the pavement will be 300 centimeter, but in case of reinforced case, so this CBR will be the double 2 into 2; that means, CBR will be the 4. Let us say annual departure D 1 also equal to shame that is 25,000, so you can calculate the thickness from this design chart. So, that will give you about 210 centimeter this thickness will give 210 centimeter. So, you can have when it is the 4 then you can D and then you can calculate the thickness about 2.0. So; that means, that you are reduction of the thickness due to the introduction of the geo synthetics material about 30 per percentage, so this design chart can be used.

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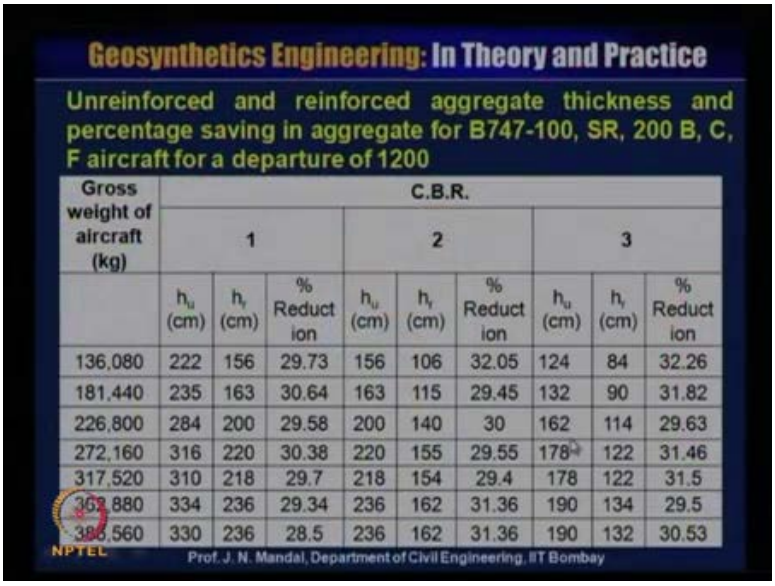

So, this unreinforced and reinforced aggregate thickness, and percentage saving in aggregate for B 747 100, SR, 200 B, C, and F aircraft to a departure of 1200. Here you can see the gross weight different gross weight is given and when CBR value is equal to 1, what will be the thickness for unreinforced case, what will be the thickness for the reinforced case. And you can see percentage of reduction about 28 5 to 29 or 30 percentage is saving, when the CBR value 2 here it is the thickness for pavement for unreinforced case.

And thickness for the reinforced case is 106 to 162 we can see in all cases the thickness of the pavement is reducing due to introduction of geo synthetics material. So, percentage of reduction also is vary from 31 to 32 percentage, when the CBR value is 3 unreinforced case thickness of the pavement lies between 124 to 190. But, in case of the reinforcement thickness of the pavement lies between 84 to 132, so reduction of the thickness is coming about 30 to 32 percentage.

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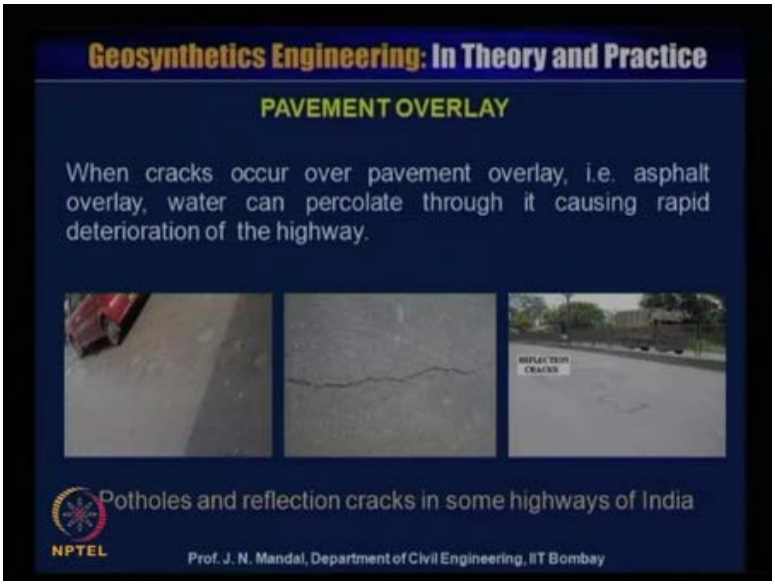

Now, pavement overlay when the crack occur over the pavement overlay that is asphalt overlay, water can percolate through it causing the rapid deterioration of the highway or roadway. You can see that road where there is a pothole, there is a reflection cracking some of the highway of India you can see this is a may be longitudinal cracking, sometimes you can see also the alligator cracking and different types of the pothole. So, here we wanted to address that how the geo synthetics can help to retarded the cracking and what kind of the geo synthetics material we should adopt.

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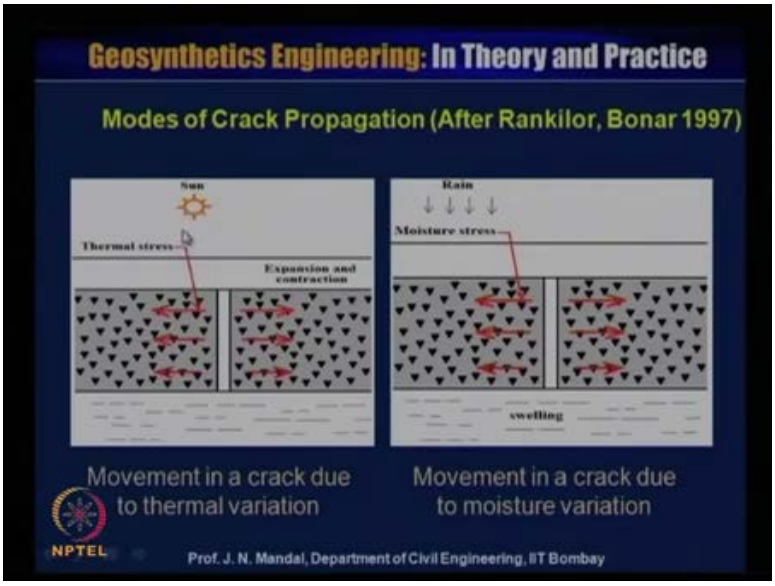

Now, you can see mode of crack propagation after rankilor and Bonar 1997, you can see that this is the temperature sun. So, there is a movement of in a crack due to the thermal variation, so there is a development of thermal stress, and this is expansion and contraction. So, here you see that how the movement in crack due to the thermal variation or due to the rain when there is a rain or there will be a moisture stress, so we can see that movement in a crack due to the moisture variation.

So, first of all you have to think that the cause for the mode of the crack and how it propagate, it may propagate due to the temperature, you may propagate, due to the moisture or rain, and also there is a possibility for any swelling then there is a possibility for cracking. So, the crack may occurs due to the thermal stress also it may occur due the moisture stress.

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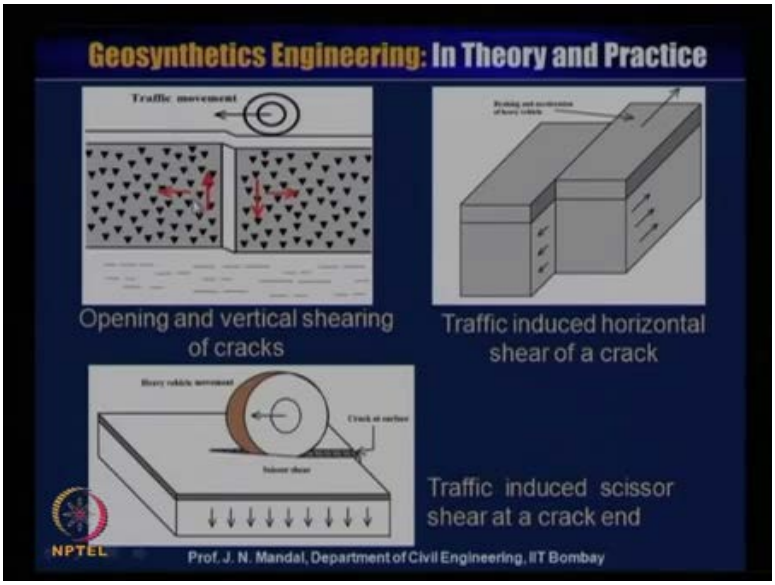

Because, there is a variation of the moisture variation and thermal variation, also that when the opening and vertical you can see opening and there is a also vertical shearing of crack. So, when the traffic move it is goes down it goes up, so there is a formation of the shear and it open, so also larger crack also formed, also traffic induced horizontal shear of a crack. And this is breaking and the acceleration of a heavy vehicle, when there is a break or acceleration of accelerating of a heavy vehicle, then there is a possibility for the traffic induced horizontal shear of a crack will form.

So, you can see that how it is the shear due to the breaking or accelerating of the heavy vehicle. Now, traffic induced that is shear, shear at a crack end it is like a scissor, so this is the crack at the surface and this is scissor shear, so when the heavy vehicle move you can see there is a possibility for the scissor shear and there will be the crack at the surface, so traffic induced scissor shear at the crack end.

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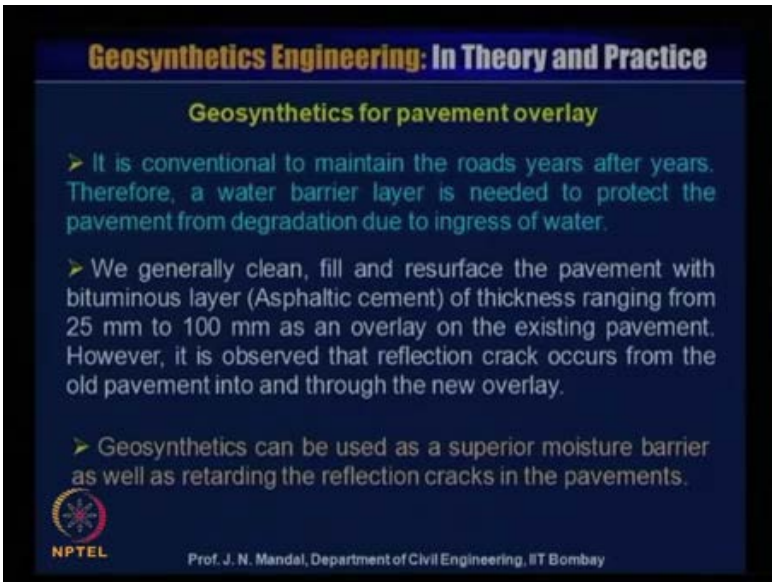

So, you have observe the different types of the cracking pattern, now geo synthetics for pavement overlay. So, it is conventional to maintain the road year after year therefore, a water barrier layer is needed to protect the pavement from degradation due to ingress of water. What we do we generally clean, fill and resurface the pavement with bituminous layer that is asphaltic cement of thickness ranging from 25 millimeter to 100 millimeter as an overlay on the existing pavement. However, it is observed that reflection crack occur from the old pavement into and through the new overlay. So, geo synthetics can be used as a superior moisture barrier as well as retarding the reflection crack in the pavement.

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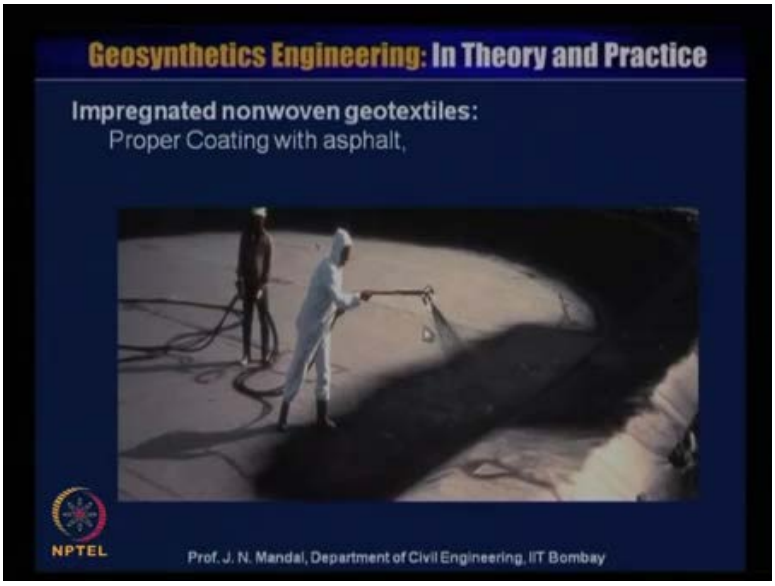

Now, you can see that how the impregnated nonwoven geo textile with the proper coating with the asphalt has been used. So, if there is a formation of the crack you can first of all to clean this and fill up with the coating material, and then you can place the nonwoven geo textile material. And then top of the nonwoven geo textile material you can provide with the asphalt because, the nonwoven geo textile material there is a opening size or apparent opening size of the nonwoven geo textile material. And it should be fill coating with the asphalt then this nonwoven geo textile material will act as a barrier. So, crack will not propagate on the surface of the road this crack can be prevented by the introduction of the geo synthetics material.

So, here you can see that this is the granular base, this is the old pavement and this is the new pavement. And then there is a old pavement crack have formed, and you can see the how the reflection cracking occur without the geo synthetics material, and right hand side you can see that what the geo synthetics material has been introduced, and this is the old pavement and tack coat saturated geo textile here.

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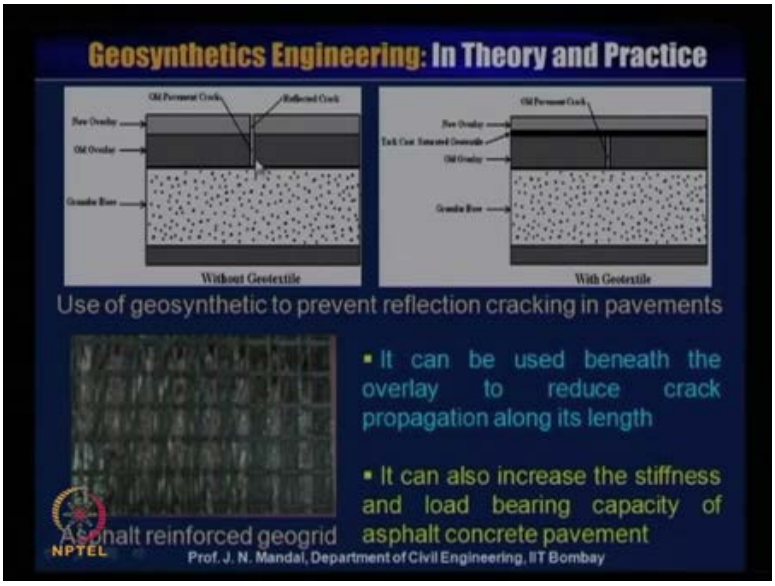

So, when the crack will form it will propagate on the top and then diverted on this direction. So, it is arrested the crack will arrested it will not appear on the top of the surface, so this is the new overlay and this is the old overlay, so use of geo synthetics material can prevent the reflection cracking in the pavement, it can be used beneath the overlay to reduce the crack propagation along it is length.

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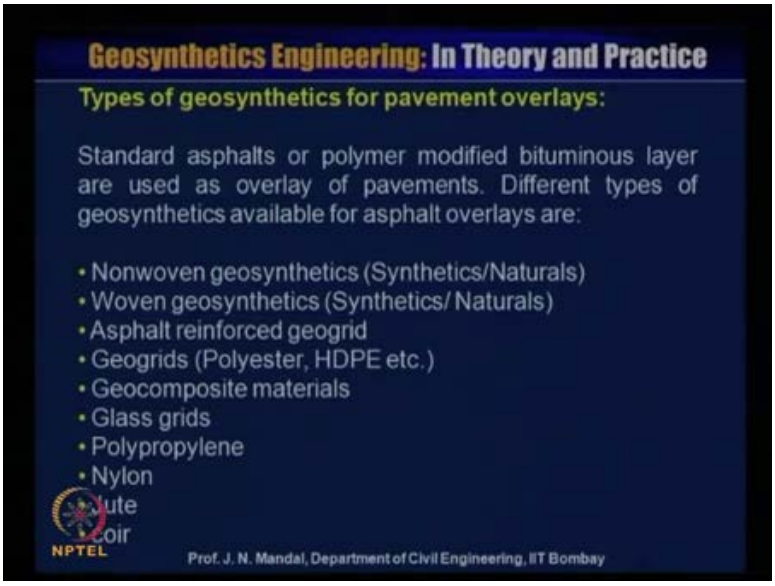

It can also increase the stiffness and load bearing capacity of the asphalt concrete pavement. So, this is one kind of the asphalt reinforced geo grid it is a geo grid material

and also laminated with the geo textile material, and this is the asphalt coated. So, you sometimes you do not need to provide with the asphalt overlay on the top it is also available in the market.

So, type of geo synthetics for pavement overlay, standard asphalt or polymer modified bituminous layer are used as overlay of pavement. Different types of geo synthetics available for asphalt overlay are, nonwoven geo synthetics material that may be the synthetics or natural or woven geo synthetics material that may be synthetics or natural. Asphalt reinforced geo grid or geo grid it may made of polyester or high density polyethylene etcetera. Geo composite material where you can use the geo grid and combination of the geo grid and the geo textile material, whether it is a woven geo textile or nonwoven geo textile material also the glass grid and polypropylene material, nylon, jute and coir.

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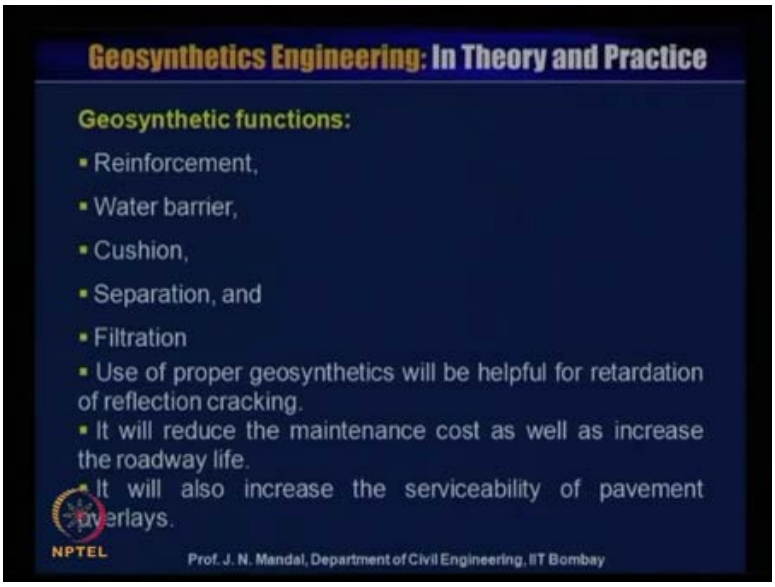

So, main function of the geo synthetics it act as a reinforcement function, and also the water barrier, cushion separation, and filtration. The use of proper geo synthetics will be helpful for the retardation of reflection cracking, it will reduce the maintenance cost as well as increase the roadway life, it will also increase the serviceability of the pavement overlay.

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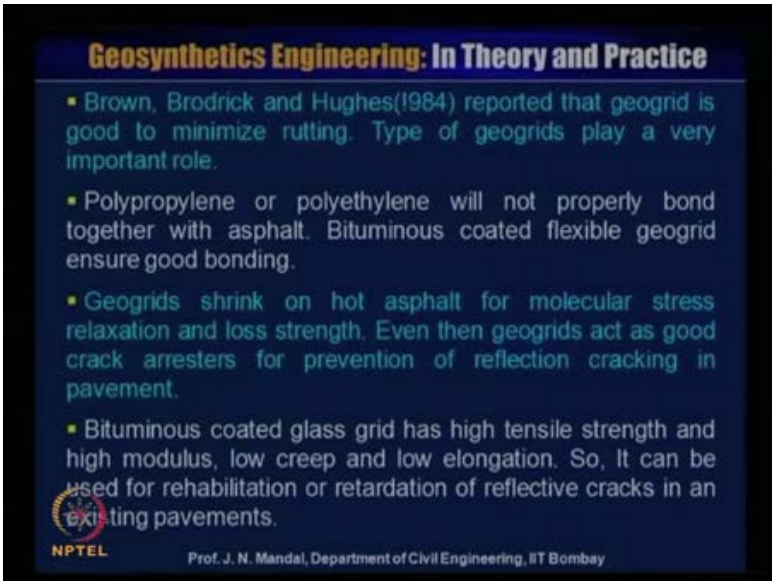

Brown, brodrick and Hughes 1984 reported that geo grid is good to minimize rutting, type of geo grid play a very important role, polypropylene or polyethylene will not properly bond together with the asphalt. So, bituminous coated flexible geo grid ensure good bonding, geo grid shrink on hot asphalt for molecular stress relaxation and loss of strength. Even then geo grid act as good crack arrestor for prevention of reflection cracking in pavement. Bituminous coated glass grid has high tensile strength and high modulus, low creep and low elongation. So, it can be used for rehabilitation or retardation of reflective cracks in an existing pavement.

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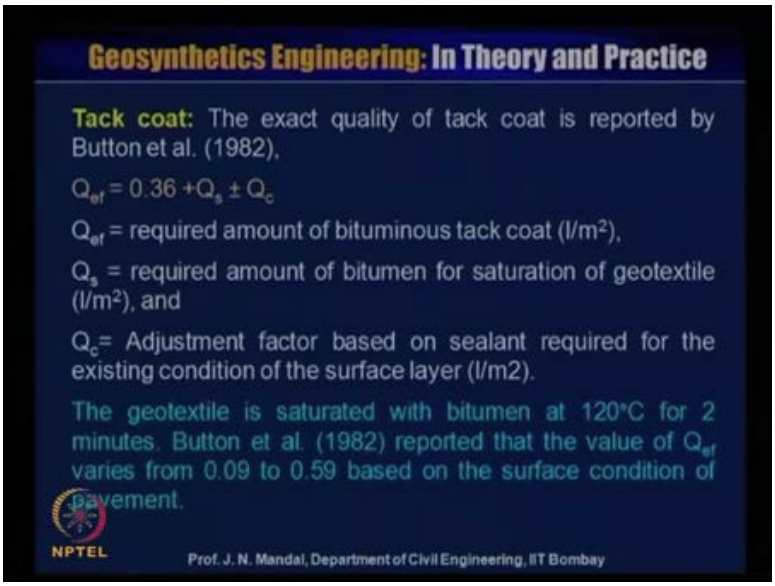

Tack coat, the exact quality of the tack coat is reported by button et al 1982, it is very important that what quantity of tack coat you should use for your design. So, here button given the equation Q e f is equal to 0.36 plus Q s plus minus Q c, for Q e f is the required amount of bituminous tack coat that is liter per meter square Q s is equal to required amount of bitumen for saturation of geo textile liter per meter square. And Q c is adjustment factor based on the sealant required for the existing condition of the surface layer that is liter per meter square. So, it is very important that what amount of bituminous or tack coat is required, the geo textile is saturated with bitumen at 120 degree centigrade for 2 minutes, button et al 1982 reported that value of Q e f varies from 0.09 to 0.59 based on the surface condition of the pavement.

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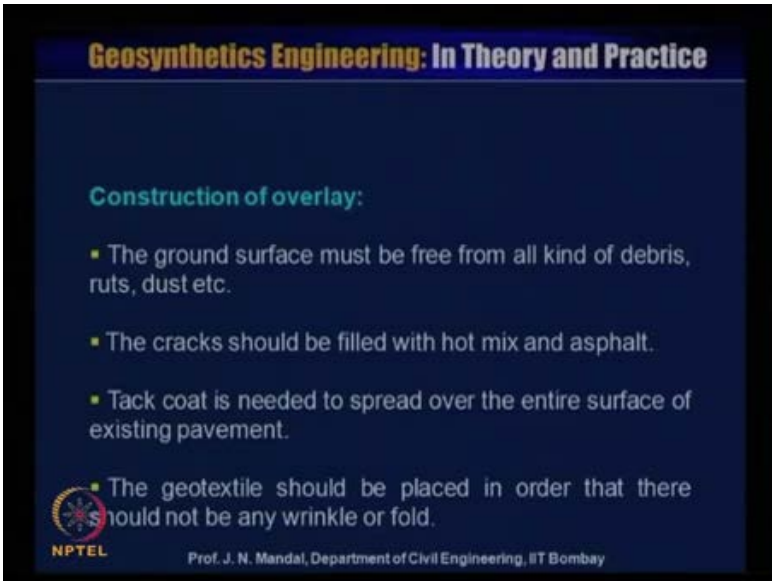

So, it depend upon the surface condition, construction of overlay the ground surface must be free from all kind of debris, rut, dust etcetera. Crack should be filled with hot mix and asphalt, then tack coat is needed to spread over the entire surface of the existing pavement. Then geo textile should be placed in order that there should not be any wrinkle or the fold.

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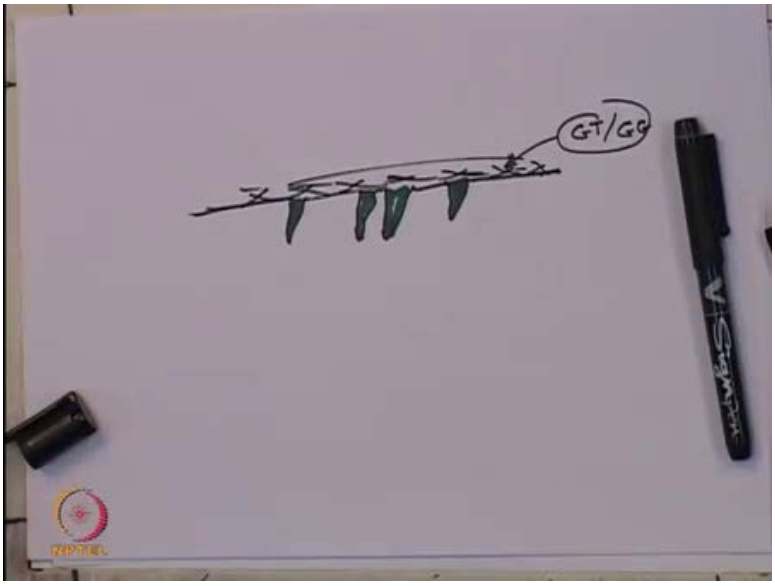

So, you can use if this is the existing road and this you can see there is a formation of the crack, and then this crack is to be filled up with hot mix, it should be clean thoroughly clean it. And then you fill up with the asphalt, you should fill up with the hot mix or the asphalt, and tack coat is needed to spread over the entire surface here, and then you should place this geo textile material on the top of this. So, this is the geo textile material it may be geo grid or geo textile material you have to place, in order that there should not be any wrinkle or the fold on this.

Now, care should be taken, so that there should be any damage of the geo textile material, due to the movement of the any track on the pavement surface. And sometimes you can overlap the geo textile material it should be between 12 centimeter, and the 18 centimeter and one has to be careful about the temperature, the temperature of bitumen should not exceed 135 degree centigrade, 250 degree centigrade. So, after proper curing, so you can provide with the asphalt on the top of this after proper curing then the traffic should be open.

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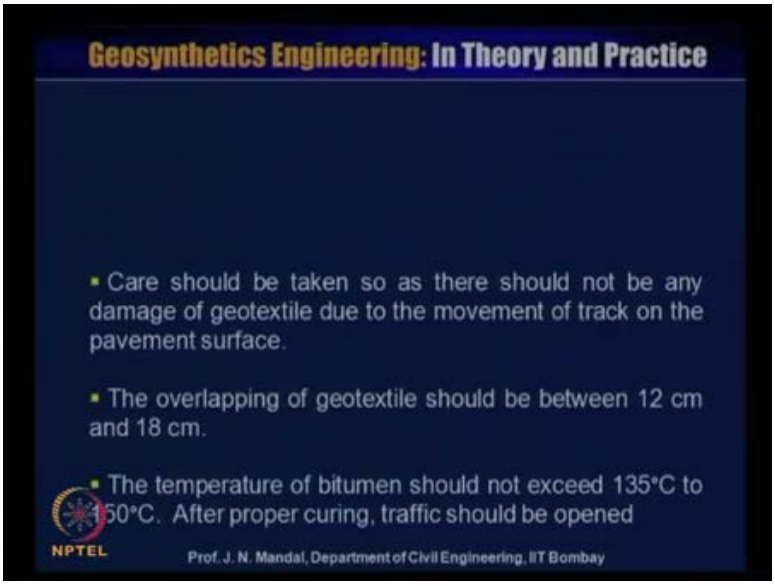

So, if you do the proper kind of the placement of the geo synthetics material, and proper selection of the geo synthetics material then you can retarded the cracking with this I ended up this today's lecture, if any question.

Thank you.