Geo synthetics Engineering: In Theory and Practices
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Module - 1
Lecture - 5
Introduction to Reinforced Earth

Dear student warm welcome to NPTEL phase 2 program 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 module number 1, lecture number 5 Introduction to Reinforced Earth.

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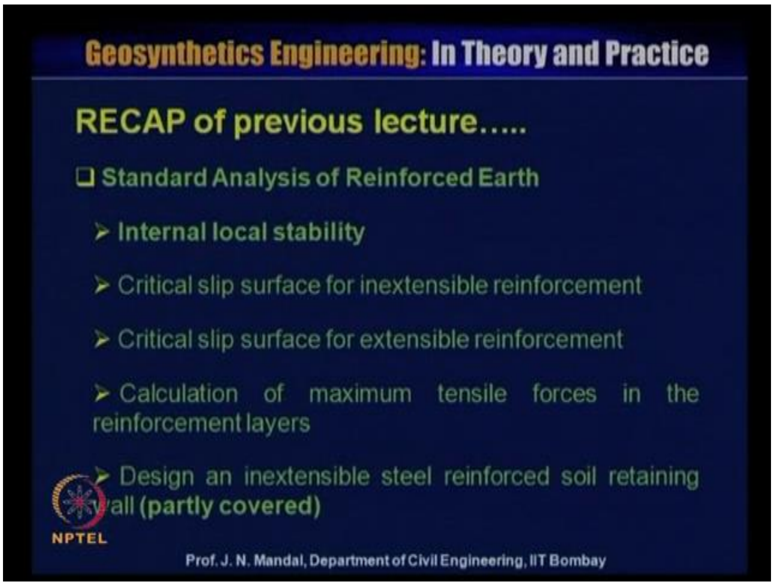

I will now address the recap of the previous lecture, what we have covered, so far, standard analysis of reinforced earth internal local stability, critical slip surface of inextensible reinforcement. That means, metallic reinforcement, critical slip surface of extensible reinforcement; that means, polymer reinforcement a geo grid. Then calculation of maximum tensile forces in the reinforcement layer, we have also partly covered on design and inextensible steel reinforced soil retaining wall.

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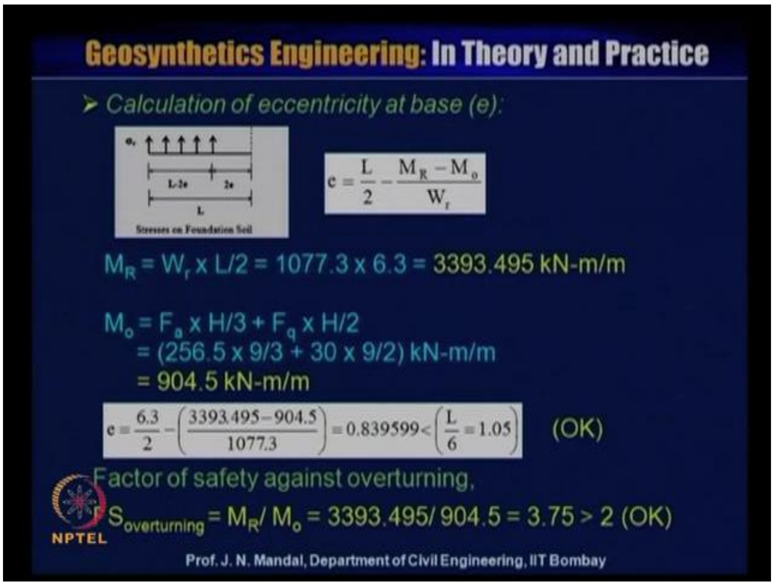

So, far we have partly shown the failure mechanism of reinforced earth wall, the potential failure mechanism of reinforced earth wall, one is the sliding, which I have covered and the sliding, it is like this.

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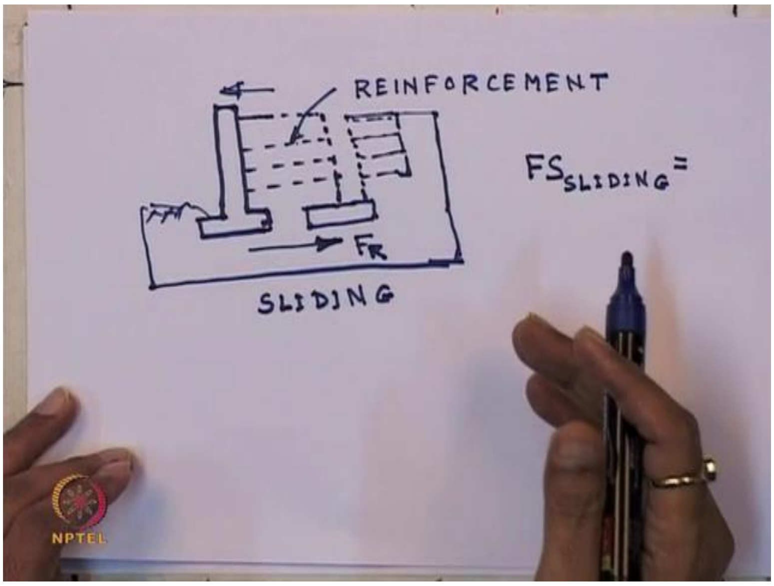

If this is the ((Refer Time: 02:41)) wall and this is the reinforcement. So, initially we calculate, what will be factor of safety due to sliding. So, this the sliding, this is one of the potential external failure mechanism of reinforced earth wall and this is the reinforcement. So, reinforced structure may slide on this direction so that is why you require something force on this direction to resist it. So, it may be designated as F of R.

So, earlier we have calculate this what are the factor of safety due to sliding. So, this we have already covered that, what will be the factor of safety against this sliding. Apart from this sliding failure, there are also potential failure due to the overturning and as well as due to the bearing capacity. So, what will happen in case of overturning, now we will go to the problem for the overturning.

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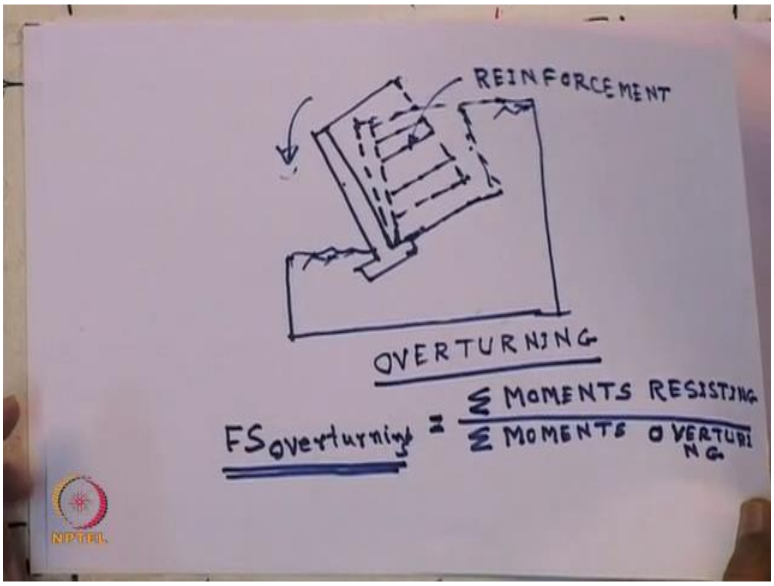

This is the reinforcement, this is the wall so here is the reinforcement. Now, this all may overturn so this is overturning now, this overturning due to the overturning this reinforced earth wall may collapse. So, we have to calculate, what will be the factor of safety against overturning, we have considered the reinforced soil retaining wall with a uniform structure, this is the external overturning stability of a reinforced earth retaining wall with the uniform structure loading.

So, we have to calculate, what will be the factor of safety due to the overturning. So, factor of safety due to overturning can be defined as summation of moment resisting, this divided by moment summation of moment overturning. So, you have to calculate this factor of safety, that is the ratio of summation of moment resisting and ratio of summation of moment overturning and apart from this failure, we have the bearing capacity failure, that mean some kind of the foundation problem. So, ((Refer Time: 09:31)) in case of the bearing capacity problem.

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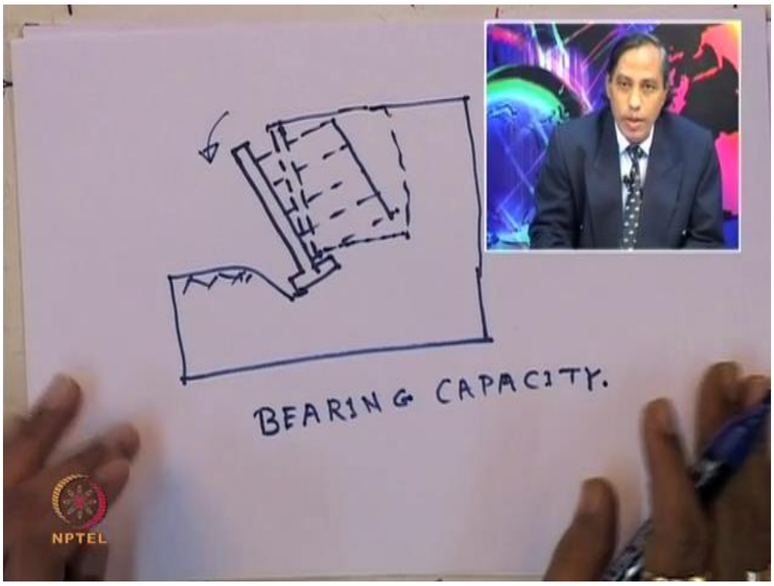

So, if this is the wall and this is the reinforcement number of layer of the reinforcement. So, this is bearing capacity. So, foundation may fail due to the bearing capacity. So, you have to calculate that, what should be the factor of safety against this bearing capacity. Apart from the bearing capacity failure, there is also potential rotational of strip surface failure, but we are not considering in this problem, the rotational strip surface failure.

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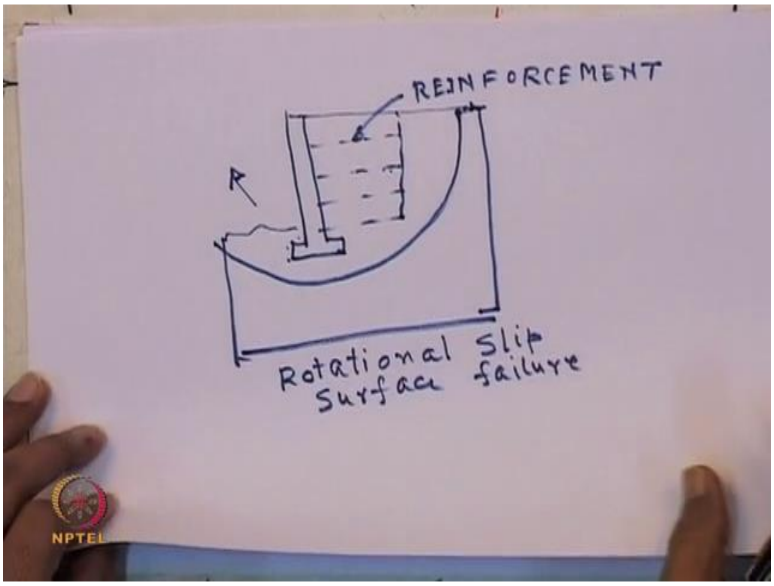

So, I am just showing that one of the picture draw this reinforced soil wall and this is the reinforcement, this is the reinforcement and structure may collapse, like this. So; that means, this is called the rotational slip surface failure or it call also the global stability or deep sheeted stability. So, when the failure surface pass beyond the reinforced material, you can see the reinforcement material, but this slip surface passes beyond the reinforcing material. So, there is a possibility for the global failure or rotation slip surface failure, this just I am showing one of the failure may occur.

So, we will initially talk about the overturning, over turning failure. So, what should be the factor of safety against the over turning.

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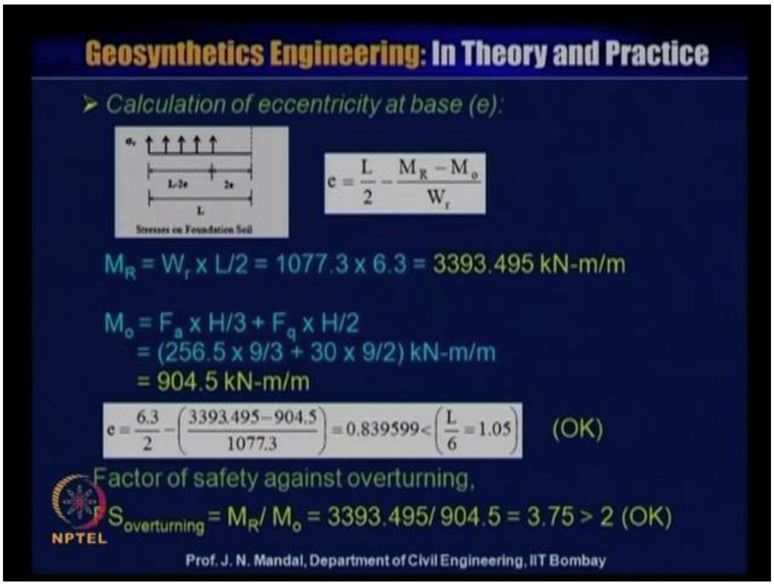

To understand this overturning failure, we have to consider the what should be the eccentricity; that means, you have to calculate the eccentricity, at the base of the foundation. So, I just show you some picture regarding, the potential failure mechanism of external stability failure, due to some surcharge loading, we show that how the structure can fail due to the sliding and we have calculated the, what will be the factor of the safety due to sliding.

Now, we will address that what should be the failure due to the overturning; that means, what should be the factor of the safety due to the overturning, that is what should be the ratio of the moment resistant to the moment overturning. Now, when we will show that overturning, we have to calculate that what should be the eccentricity. So, this is at the base of the foundation and length of the reinforcement is L and L minus 2 is which will be the acting zone and this is the stresses on the foundation soil and there is also the vertical stress which is defined as sigma of v, you have to calculate what should be the eccentricity.

So, eccentricity e is equal to l by 2 minus M R minus M o divided by W of r. Now, what is M R, M R is the resisting moment; that means, that is equal to W r into L by 2.

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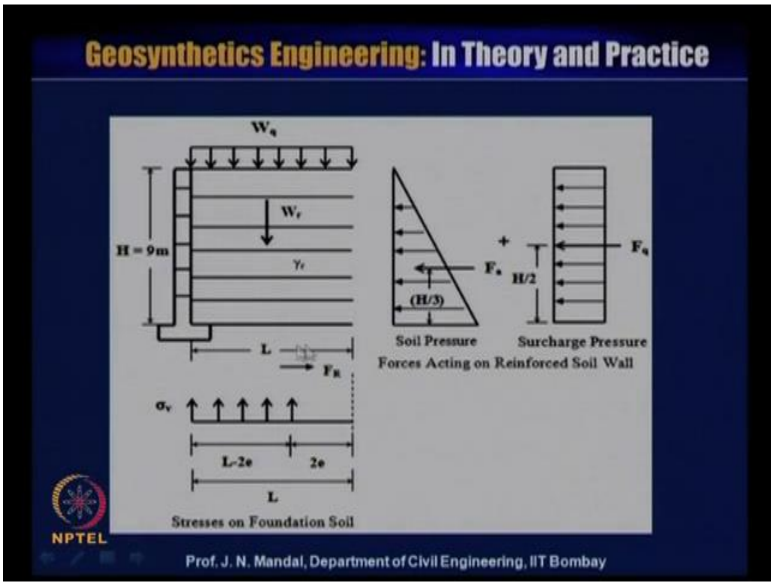

So, it is like this, if this is the wall and this is the length of the reinforcement is L and W r is weight which is acting vertically downward, if we take a moment at the toe of the wall. So, this moment will be W r into L by 2 this W r is acting at the middle of the reinforcement.

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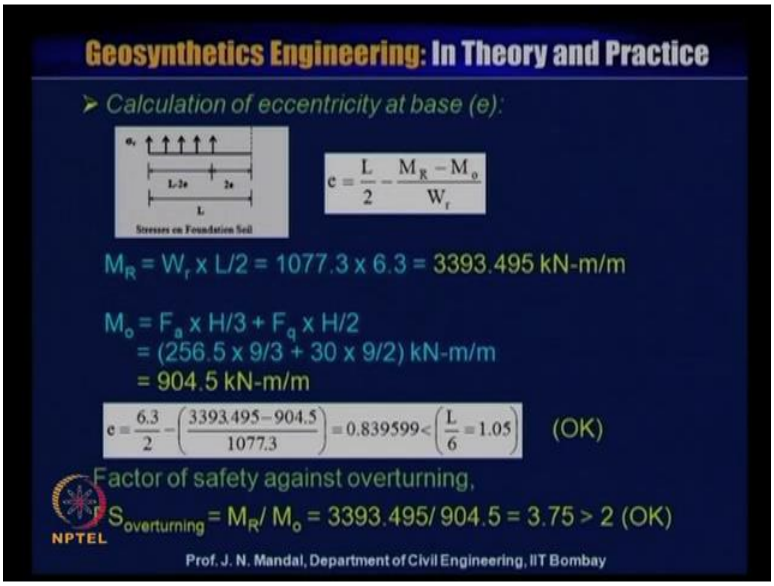

So, this is W r into L of 2 which is shown M R is equal to W r into L by 2. So, we have earlier calculate that what will be the W of r, we have already calculated we know the length, we know the height, we know the gamma. So, we can calculate what will be the W of r.

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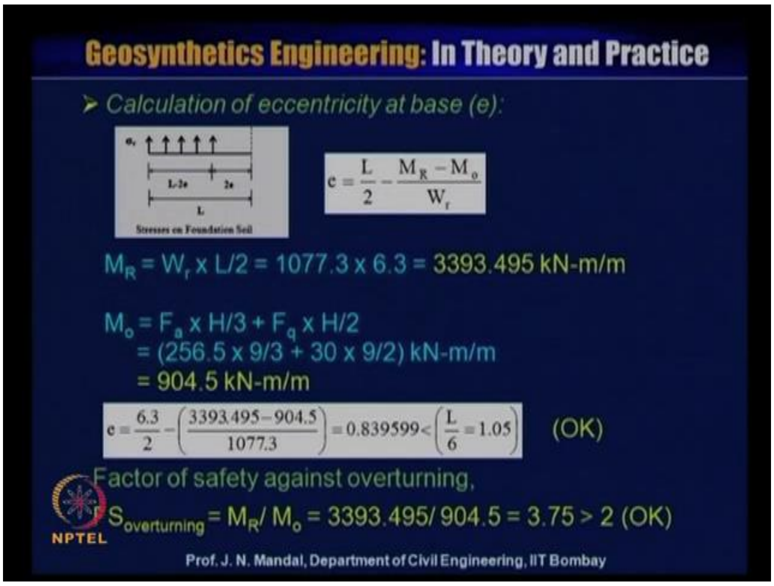

So, with calculation I have shown earlier 1077.3 and this into L by 2 that is 6.3 and that is coming resisting moment 3393.495 kilo Newton meter per meter. Now, we will calculate these overturning moment M o, that mean what are the forces are acting on the wall. So, there is a F a and there is F q, F a is the forces due to the soil pressure, F q the forces due to the surcharge load.

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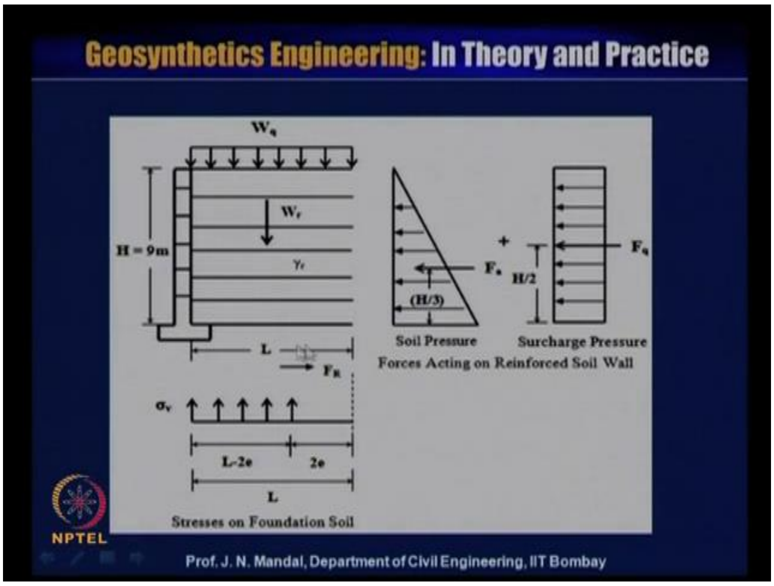

So, here this is the F a, this is the soil pressure these are all the forces acting on the reinforced soil wall. So, this is the forces is F a, which is acting at a distance of H by 3. So, moment will be F a into H by 3.

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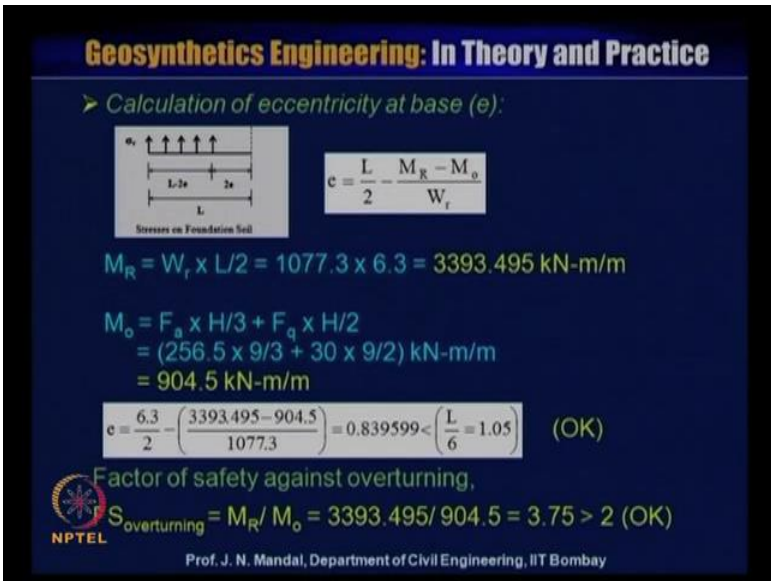

So, that is why it is shown that F a into H by 3.

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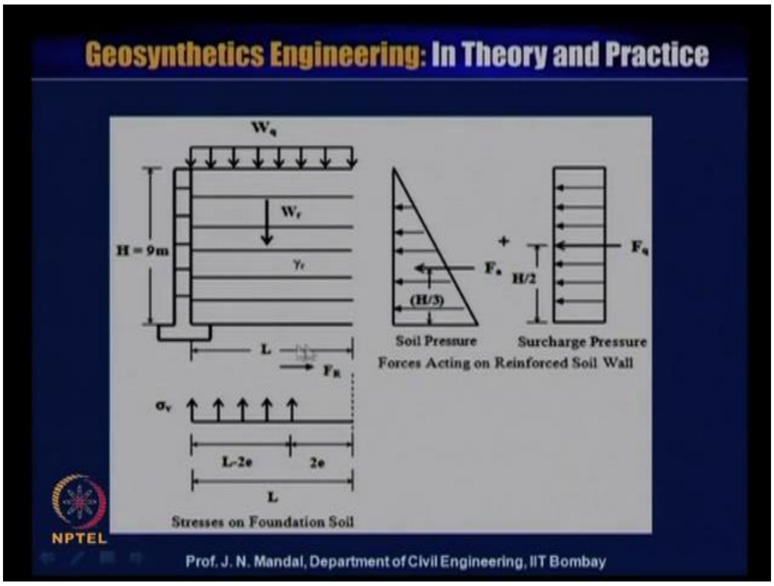

You know that it is acting at the one third at the height of the wall and plus the force due to the surcharge load, that is W q which is the force is represented here, as F q that is surcharge pressure. Now, this surcharge pressure is acting at the middle of the wall; that means, height of the wall is H then this height will be H by 2. So, this moment will be F q into H by 2. So, total moment will be, this into F a into this distance H by 3 plus F q into H by 2.

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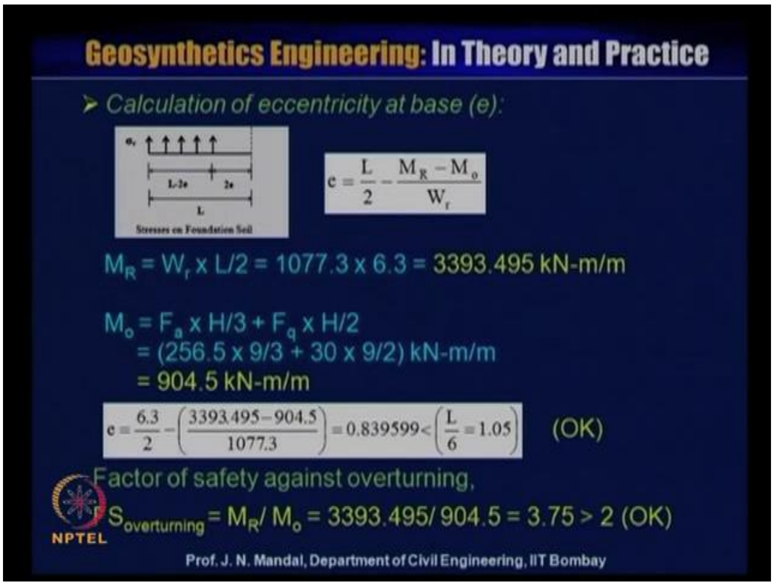

So, this moment M o will be F a into H by 3 plus F q into H by 2. So, F a we have already calculated, this is 256.5 into H by 3 is 9 by 3 height of the wall is 9 meter and F q we calculated earlier 30 and H is 9. So, 9 by 2. So, if we calculate, we can obtain 904.5 kilo Newton meter per meter. So, we have calculated this M R as well as, M 0. Now, you have to calculate eccentricity e. So, this eccentricity if you know that, eccentricity we will be we can calculate what is L minus 2 e we know the length, but we do not know the value of eccentricity.

So, eccentricity can be expressed as L by 2 minus M R minus M 0 by W r. So, L is 6.3 divided by 2 minus minus M R, M R is you have already calculated this is 3393.495 3393.495 minus M 0, M 0 is 904.5. So, 904.5 this divided by this weight W r which we have calculated earlier. So, W r is equal to 1077.3. So, if we calculate this we can have 0.839. So, which is less than L by 6 that is 1.05. So, there will be no development of tension, at the base of the foundation soil, then it is now, ultimately we have to calculate what will be the factor of safety against overturning.

So, factor of safety against overturning is equal to M R by M 0. So, M R is known 3393.495 divided by M 0 is known 904.5. So, 904.5 this is give 3.75 and it should satisfy the criteria that it should be greater than 2. So, it is greater than 2; that means, it is.

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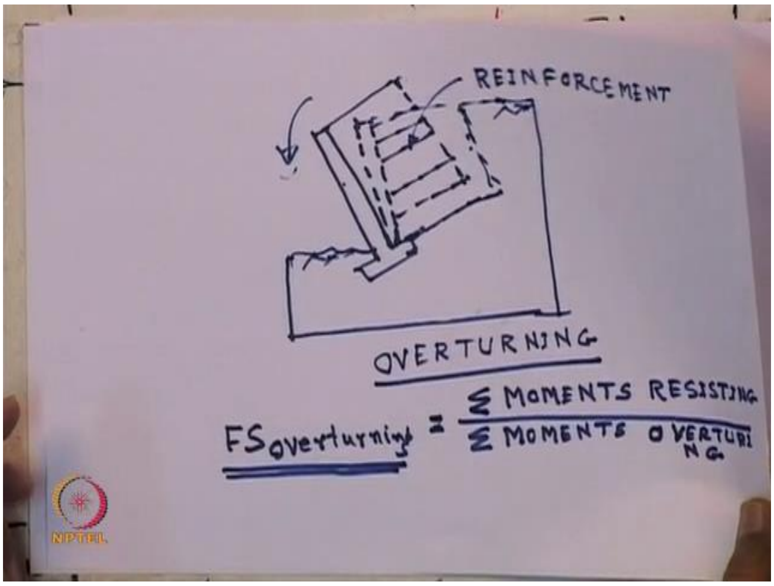

So, far we check up with this factor of safety against this overturning; that means, we told this moment resistance by moment overturning and it is greater than 2. So, it satisfy the criteria.

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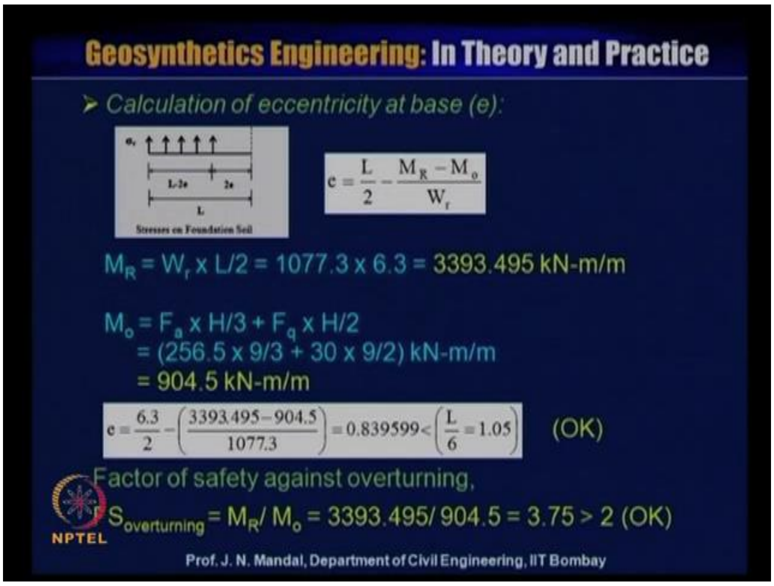

So, it is design the shape, in terms of the overturning. Next we will talk about this bearing capacity, what will be the factor of safety against this bearing capacity.

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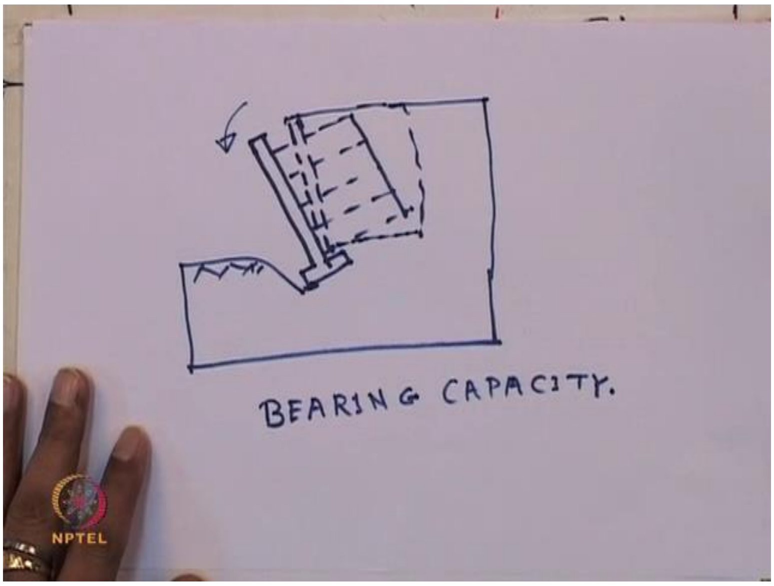

So, we will discuss this problem that how we can calculate these bearing capacity at the foundation, whether the shape or not.

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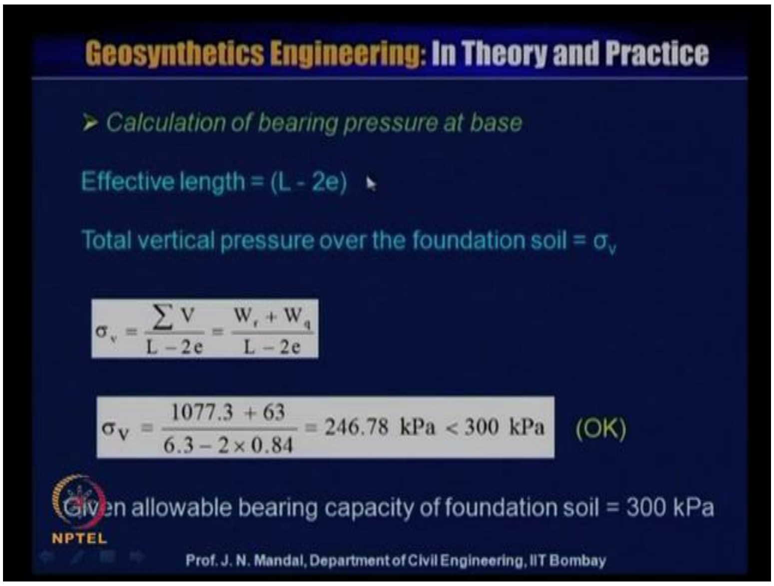

So, this bearing capacity, in this bearing capacity calculation we should know what should be the effective length. So, effective length is L minus 2 e.

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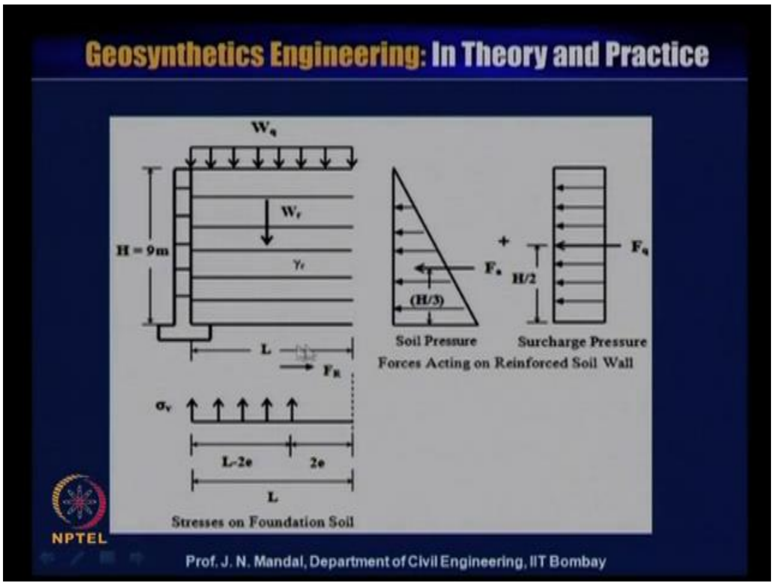

So, we can see here, this is the effective length, this is the stress on the foundation soil. So, this is the layer of distribution, this layer of distribution is recommended for the stress on the foundation soil. So, this is the active zone, this L minus 2 e.

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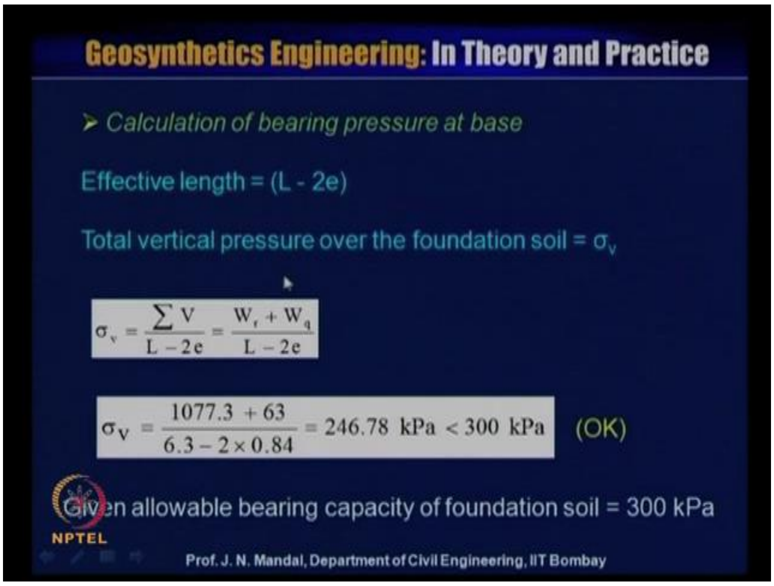

So, that is why the effective length will be L minus 2 e, what will be the vertical pressure, over the foundation soil that is you have to calculate sigma v. So, this is the sigma of v, this is vertical stress which we have to calculate and which you have to calculate within this acting zone that is L minus 2 e only this zone is acting as far near of distribution. So, total vertical pressure over the foundation soil is the designated at sigma v. So, sigma v will be equal to summation of V divided by L minus 2 e this is acting zone.

So, summation of V mean that is this summation of V that is due to the weight and due to the surcharge. So, we can write that summation the that is weight W r and it is surcharge W of q and this is L minus 2 e. So, we can write sigma V W r we calculated 1077.3 plus W q we calculated 63 and this L is 6.3 minus 2 into e, e we calculated 0.84. So, sigma V will be equal to 246.78 kilopascal, which is less than 300 kilopascal which is given. So, it is. So, given the allowable bearing capacity of the foundation soil is 300 kilopascal. So, it is less than the 246.78; that means, it is...

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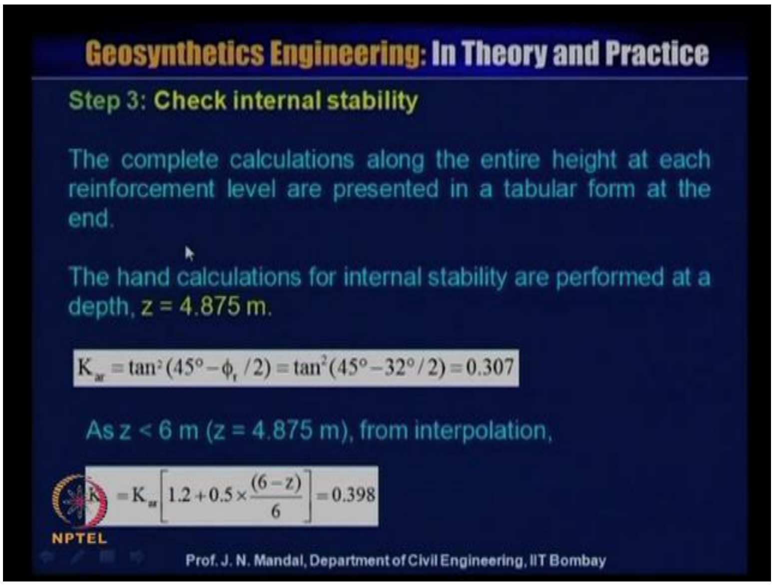

So, far we talk about the external stability of reinforced earth retaining wall now, we will discuss the internal stability. So, for this internal stability, the complete calculation along the entire height at each reinforcement level are presented in a tabular form at the end, but here I am just showing one hand calculation for the internal stability I have performed at a depth z is equal to 4.875 meter, you can assume any of the depth, but I have consider one typical value of depth that is z is equal to 4.875 meter.

So, calculate this internal stability. So, you have to calculate what is the K of a r coefficient of active participation K r is equal to tan square 45 degree minus phi r by 2 and phi r value is 32 degree is given. So, it will be tan square 45 minus 32 by 2 is equal to 0.307. Now, here we look that z is less than 6 meter, though we consider z is equal to 4.875 meter. So, from the interpolation we can calculate this K r is equal to K a r 1.2 0.5 6 minus z by 6 that will be equal to 0.398, I show you how we have calculated K r is equal to 0.398.

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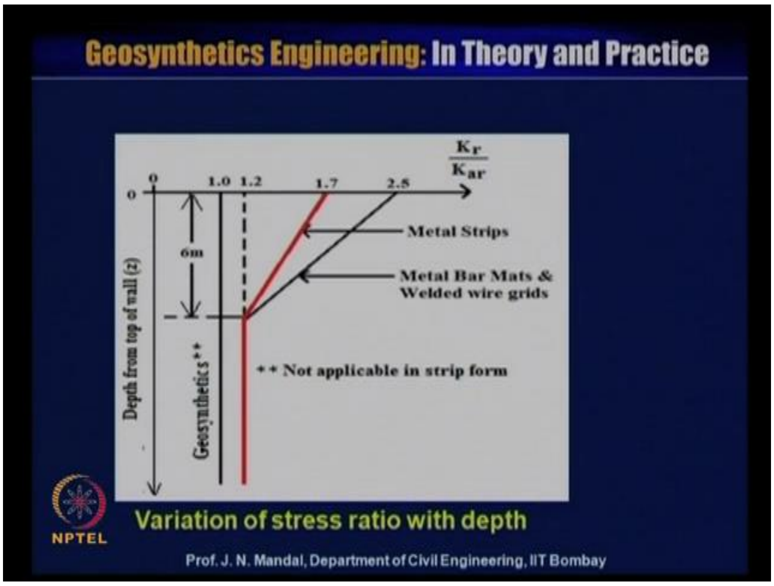

Now, from this figure, so we have to calculate this is the metal strip we have used and we know that K r by K r is 1.2 to 2.6 we have to calculate for this zone 1.7 this is a metallic strip rate current zone and this you know that after the 6 meter depth is remain constant, this is the depth 6 meter depth will remain constant. So, we can see that 1.2 and 1.7. So, in between at any depth you have to find out and then you can calculate that what is K r by K r is lying.

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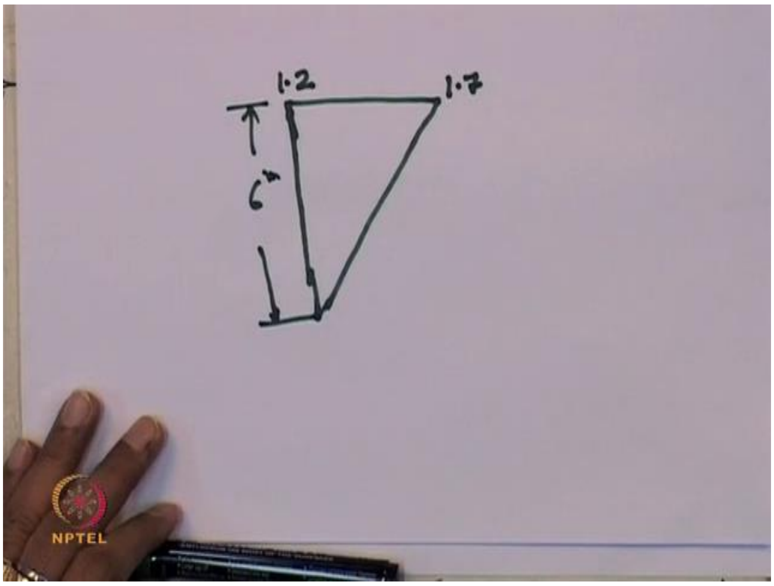

So, if we consider like and that you have seen that, this is let us say 1.7 and this is 1.2

and this is about 6 meter.

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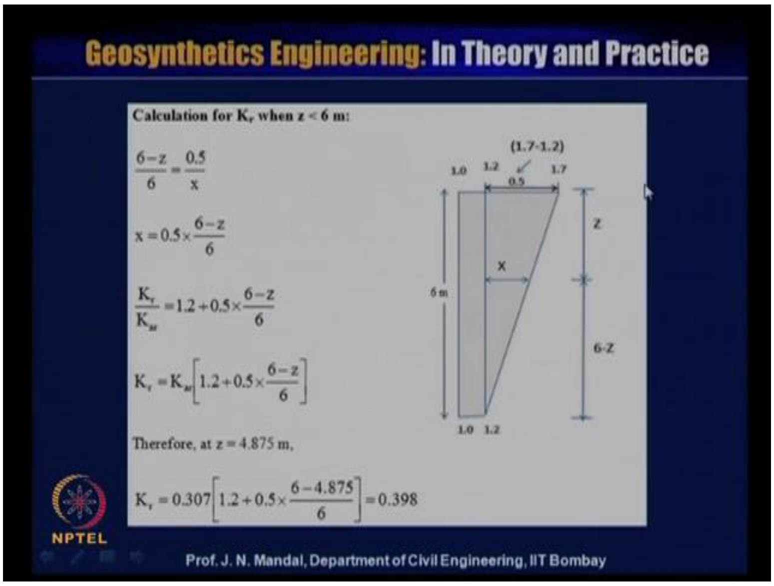

So, what I wanted to show here, that this is 1.7 and this is 1.2 and this depth is 6 meter and this is x and so this portion will be 1.7 minus 1.2; that means, this will be 0.5 and this at a depth of z this is x. So, the remaining portion will be 6 minus z because this is the 6 meter. So, this is 6 minus z, so from this triangle. So, we can to calculate what should be the value of K r for the z less than 6 meter, here z is less than 6 meter.

So, this from this triangle both, you can calculate 6 minus z divided by 6 is equal to this is 0.5 this divided by x. So, from this equation, you can calculate x is equal to 0.5 6 minus z y by 6. Now, this is K r by K r will be equal to 1.2 plus x; that means, 0.56 minus z by 6.

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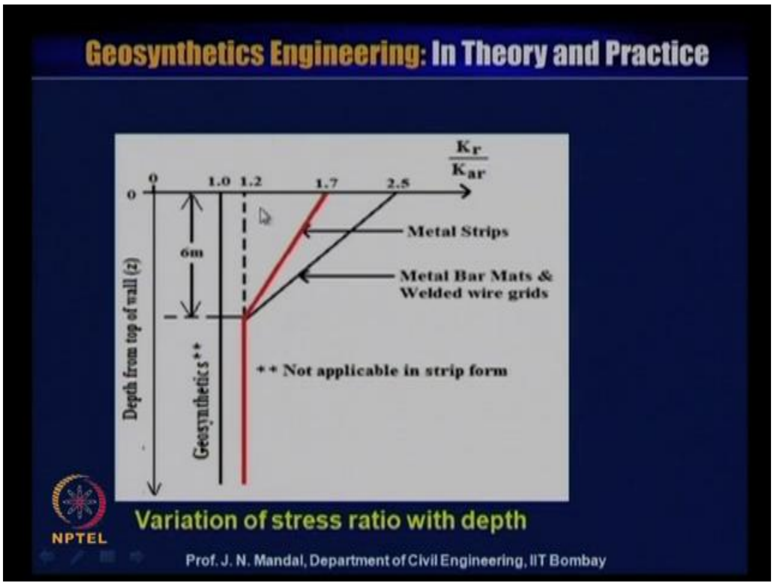

You can see here, this is 1.2 plus this is K r by K r.

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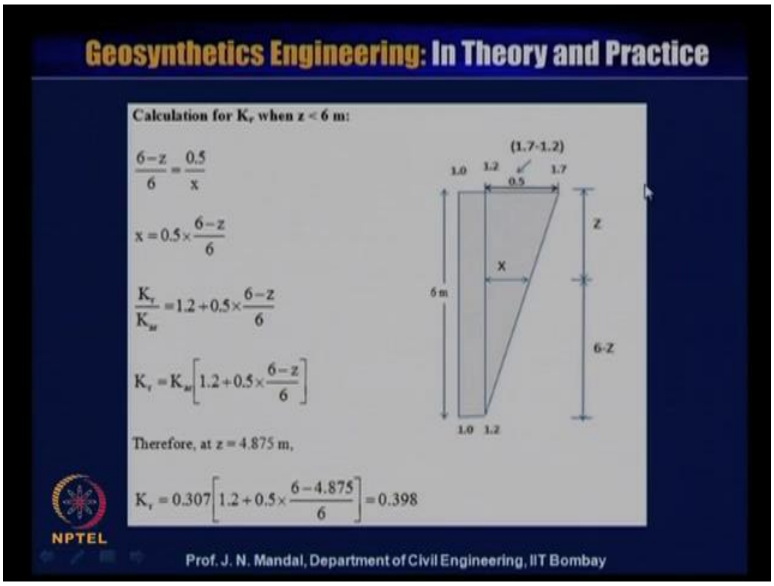

So, this will be 1.2 plus 0.5 into 6 minus z by 6. So, K r will be equal to K r 1.2 plus 0.5 into 6 minus z by 6. So, we have to calculate what will be the K r at z is equal to 4.875 meter. So, you have to substitute the value of the z is 4.875 here. So, you can calculate K r is equal to you have calculated K r is 0.307 this is 1.2 plus 0.5 into 6 minus at a depth 4.875 meter divided by 6. So, we calculate K r is equal to 0.398.

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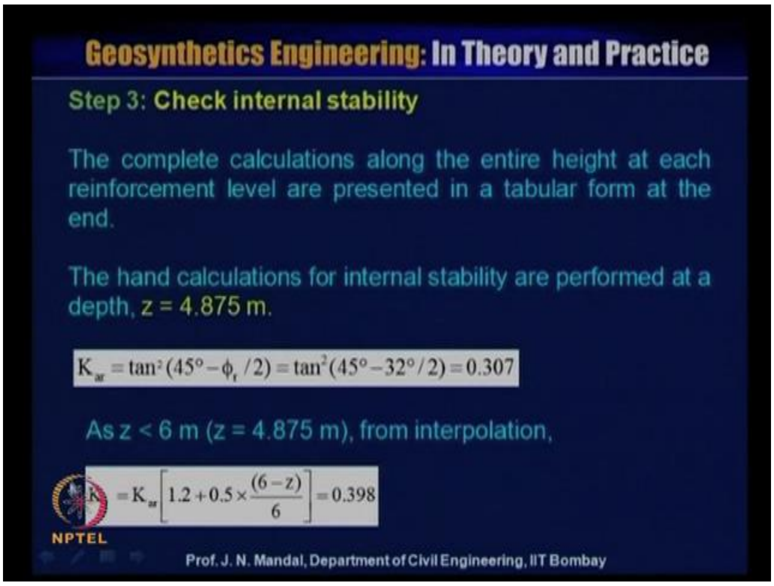

So, from this that is why this when z is less than 6 meter, z is equal to 0.87 meter from the interpolation, we calculate K r is equal to 0.398. So, you know that how to calculate this K r from this diagram.

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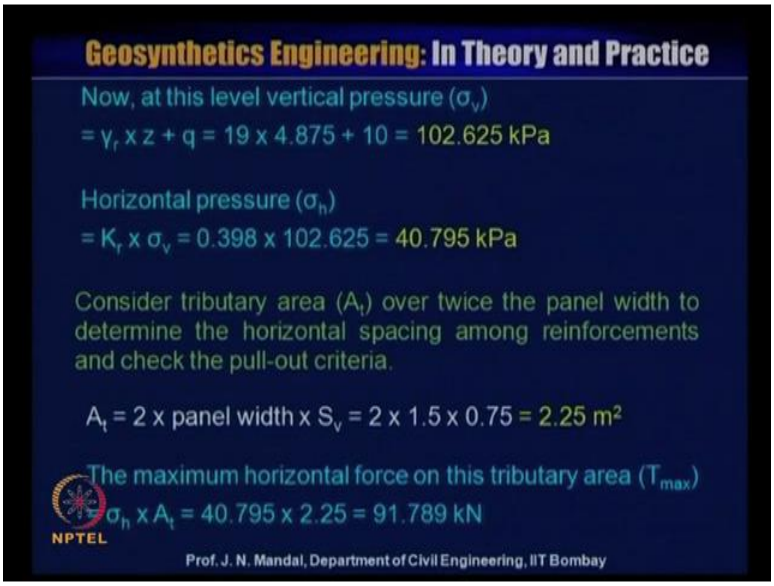

Now, at this level you have to calculate the vertical pressure, that is sigma of v. So, sigma v is what will be the gamma r into z plus q is the surcharge load, density is 19 and depth you know 4.875 and plus surcharge is 10. So, vertical pressure sigma v is equal to 102.625 kilopascal. So, if you know that vertical pressure, you can also calculate that horizontal pressure sigma h because you know sigma h is equal to K r into sigma v that is vertical pressure.

So, K r you have calculated 0.398 into sigma v 102.625. So, horizontal pressure will be 40 into 795 kilopascal. Now, you consider the tributary area A t over the twice the panel with to determine the horizontal spacing among reinforcement. So, tributary area A t can be defined as 2 into panel width into S v and panel width we have consider 1.5 meter. So, 2 into 1.5 and spacing we have considered 0.75. So, therefore, A t that tributary area will be the 2 into 1.5 into 0.75 that will give 2.25 meter square.

Now, you know maximum horizontal forces on the tributary area, that is T maximum will be equal to horizontal force sigma h into A t; that means, what will be the tributary area. So, sigma h is 40.795 into area A t is 2.25 that is 91.789 kilo Newton.

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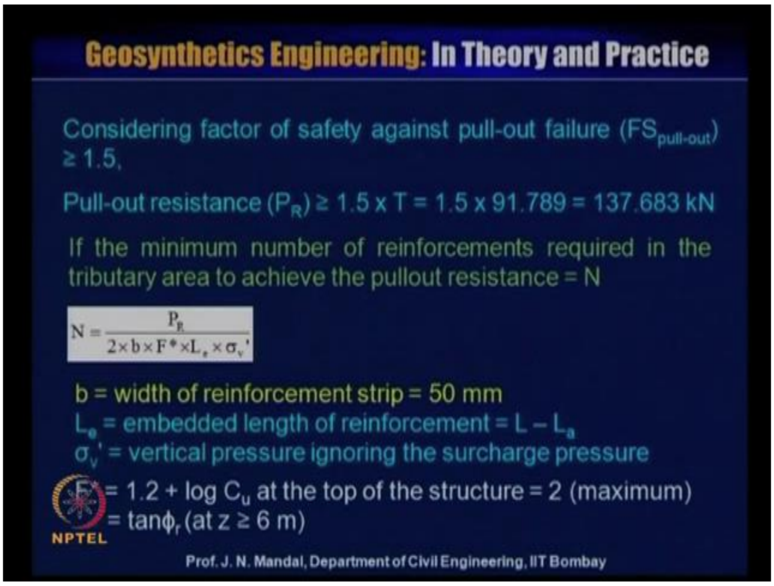

So, you have to consider that factor of safety, against pull-out failure that is F S pullout it should be greater than equal to 1.5 for all internal stability you have to check what will be the factor of safety against pullout. So, pull out resistance which is designated as P R which should be greater than equal to 1.5 into T, T we have calculated 91.789. So, that will be equal to 1.5 into 91.789; that means, 137.683 kilo Newton. Now, if we consider the minimum number of the reinforcement required in the tributary area, to achieve the pullout resistance that is N.

So, N will be equal to P R divided by 2 into b into f star into L e into sigma v dash for v is the width of the reinforcement strip and that is 50 millimeter, L e is the embedded length of the reinforcement; that means, L minus L of a and sigma v is the vertical pressure ignoring the surcharge pressure. You can calculate the f star and that depend upon the, what will be the value of coefficient of uniformity, of the soil that is C of u say f star can be calculated by the equation f star is equal to 1.2 plus log C u at the top of the structure or equal to 2 the maximum or f star is equal to tan phi r at depth z greater than equal to 6 meter.

So, when you want to calculate the f star and that depend upon the what will be the soil characteristic at that locality and that depend upon that c value; that means, what will be the coefficient of uniformity of the soil and that maximum value you can take that two value and if the depth is greater than 6 meter. So, you can take f star is equal to tan of phi r.

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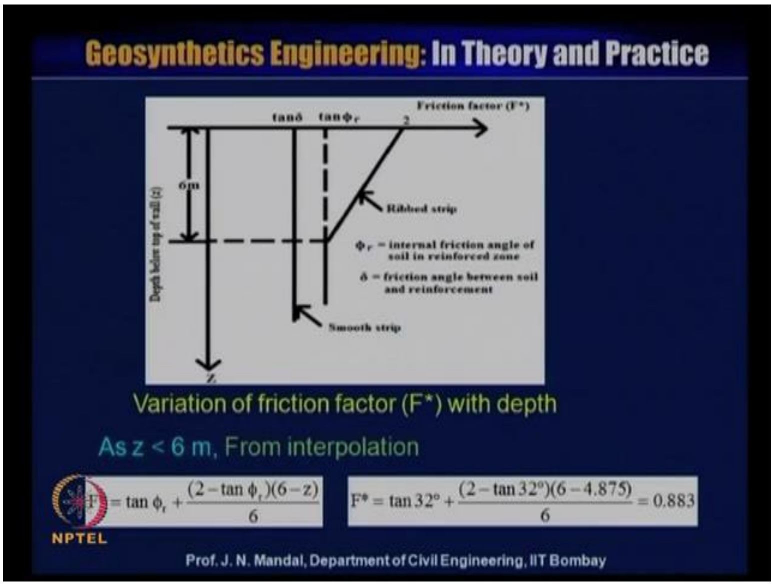

So, next slide we show that what will be the variation of friction factor F star with the depth. So, you can see here, this is the depth of the wall and this is the friction factor and this is tan phi r, this is than delta and this is the strip and what phi r is internal friction angle of soil in the reinforced zone and delta is the friction angle between soil and the reinforcement. Now, if this figure is show that variation of friction factor F star with the depth.

Now, in our problem we find that depth z is less than 6 meter. So, therefore, we have to calculate F star by from interpolation. So, this F star can be calculated as f z is less than 6 meter.

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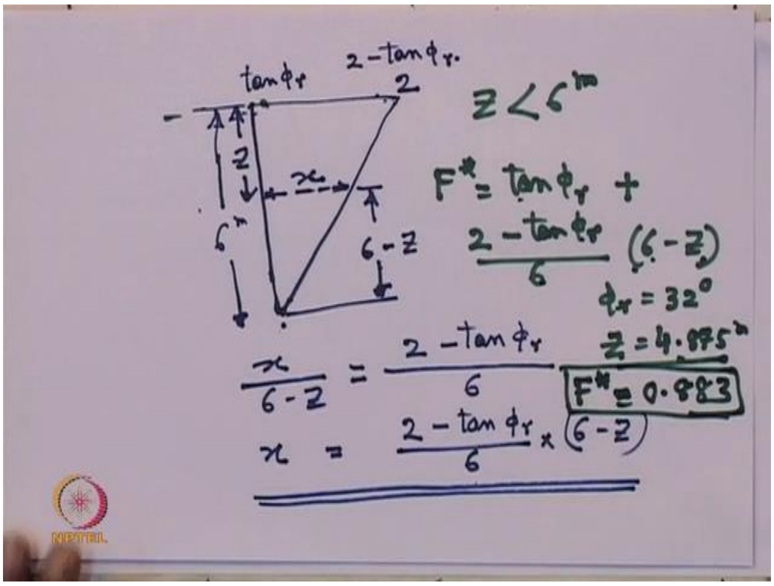

So, you can see that this depth, this is 6 meter and in this here, it is 2 here, it is tan of phi r and at any depth let us say, this is x. So, we are considering at a depth that is z. So, this will be equal to 6 minus z and this difference, will be equal to 2 minus tan of phi r. So, from this triangle, we can write that x divided by 6 minus z is equal to 2 minus tan phi r this divided by 6. So, you can write x this divided by 6 minus z, 6 minus z is equal to 2 minus tan phi r, than means 2 minus tan of phi r this divided by 6.

So, we can calculate that x, x will be equal to 2 minus tan of phi r divided by 6 into 6 minus z. So, we can have this relationship that is x is equal to 2 minus tan phi r by 6 into 6 minus z. So, we can now, calculate that when the z is less than 6 meter. So, you can also show here, that F of star and remember that z is less than 6 meter and from this interpretation you can write F of star is equal to tan of phi r that mean, you can consider from a r 0 it will be the tan of phi r and plus 2 minus tan of phi r by 6 into 6 minus z.

So, we know that, what will be the value of phi r, phi r is equal to 30 of 2 degree and z we know, that we want to calculate at a depth of z is 4.875. So, at this depth we want to calculate, what will be the F star. So, we are substituting this value phi r then tan 32 degree plus 2 minus tan phi r is 32 degree divided by 6 into 6 minus z, z is equal to 4.875

meter, which is less than 6 meter. So, from this equation, you can calculate that what should be the F star value. So, this F star value will be equal to 0.883. So, this we are having 0.883. So, we are having this value of F star.

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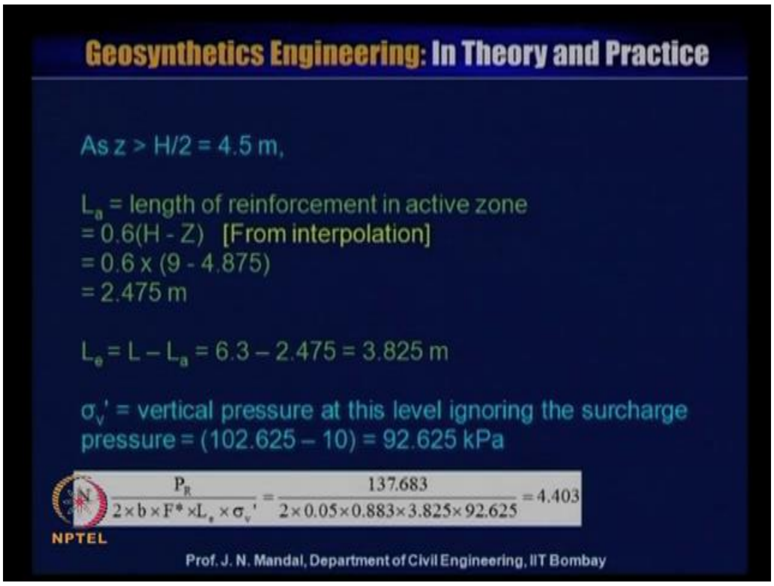

Now, as the depth is greater than H by 2 or is equal to 4.5 meter. So, you have to calculate what will be the length of the reinforcement in the active zone. So, you have to calculate the length of the reinforcement in the active zone. So, length of the reinforcement in the active zone is 0.6 H minus Z this also you can calculate from the interpolation; that means, 0.6 into 9 is the height of the wall minus z at depth of 4.875 is equal to 2.475 meter. So, we can calculate 2 into 0.475 meter. So, now, you have to calculate this length of the reinforcement in the active zone. So, length L e is equal to L minus L of a.

So, you calculate it what will be the length of the reinforcement active zone; that means, L of a is 2.475. So, L a is 2.475 and L is 6.3. So, this minus, this will give 3.825 meter. So, sigma v dash that is vertical pressure at the level ignoring the surcharge pressure, will be equal to 102.625 minus 10. So, this will give 92.625 kilopascal. So, this N equal to P r divided by 2 b F star into L e into sigma v dash. So, we have calculated P r earlier, that is 137.683 2 into v width of the metallic strip 0.05 F star we calculated 0.883 L e we calculated 3.825 into sigma v dash which we have calculated 92.625. So, N is equal to 4.403.

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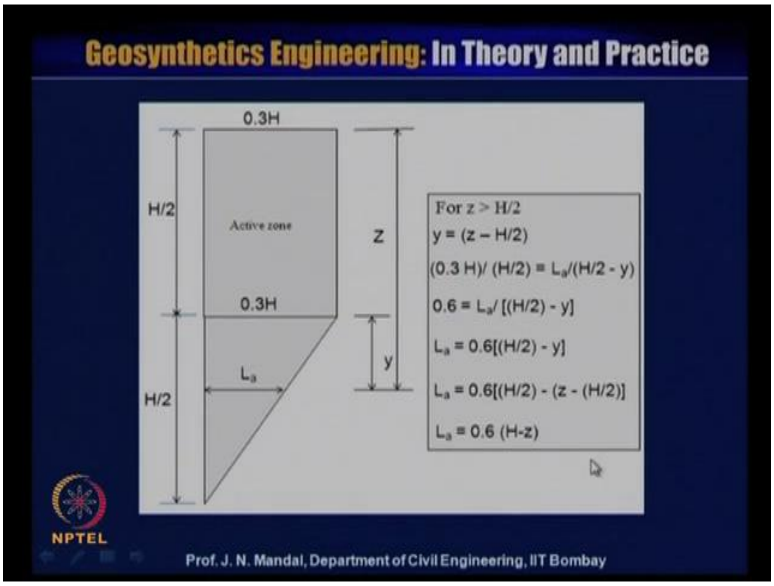

So, we have to consider this N as a round figure and of course, here I just wanted to mention that.

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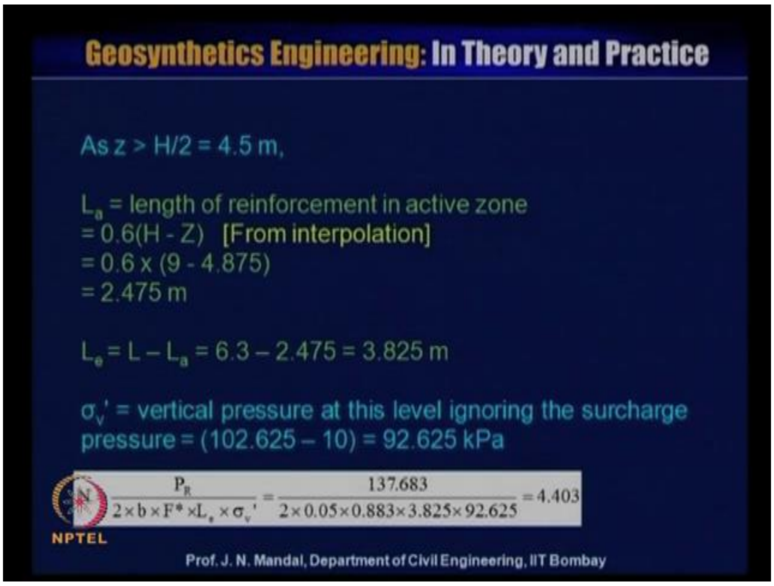

How we have calculated that L a is equal to 0.6 H minus Z from the interpolation.

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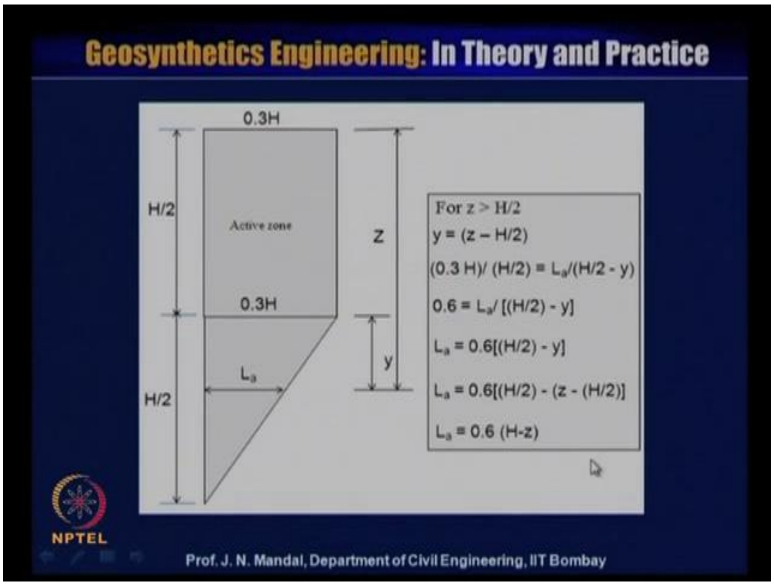

And showing in this figure, this is in the active zone if the, if you know that the length of the wall is H. So, this will be 0.3 times of H; that means, this is 0.38 this is in the active zone and you know that in case of the metallic reinforcement it is bilinear kind of the failure it goes, in the half of the height of the wall and then ((Refer Time: 46:51)). So, we have to calculate at this level, at a level of z what should be the active length; that means, L a because that our z value is greater than H by 2 that is why we have considered some typical value, that is 4.875 what we have considered which is beyond the H by 2, so for z H by 2.

So, at the depth date we have to calculate L a. So, what will be the y value, y will be equal to z minus H by 2 and this is 0.3 H, this is 0.3 H divided by H by 2 is equal to this L a divided by H by 2 minus of y. So, from this, we can have 0.6 is equal to L a divided by H by 2 minus y. So, L a will be equal to 0.6 H by 2 minus y. So, L a will be 0.6 H by 2 again y is equal to this is z and this is H by 2. So, y will be z minus H by 2, so z minus H by 2. So, we can have L a is equal to 0.6 h minus z which we have shown.

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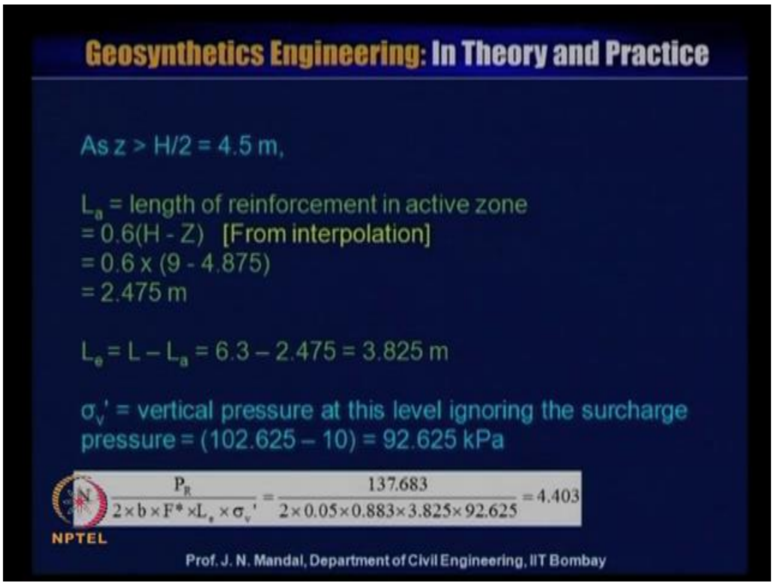

Here L a is equal to 0.36 H minus Z. So, that way we calculated what will be the L a value.

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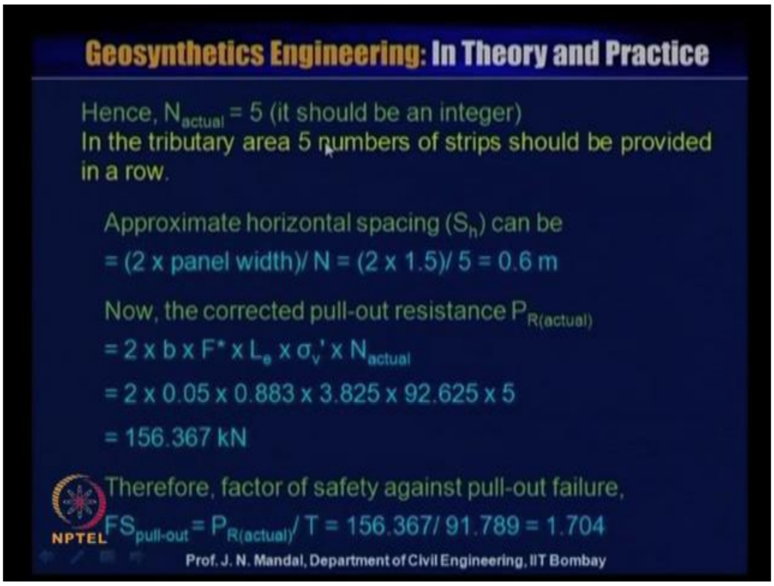

Hence the N actual is 5 which should be an integer value. So, we have taken roundup figure in actual 5, in the tributary area 5 number of strips should be provided in a row. Approximate horizontal spacing S h can be 2 into panel width divided by N 2 panel width 1.5 meter; that means, 2 into 1.5 divided by n round figure 5. So, you can have the s h value horizontal spacing is 0.6 meter.

Now, we have to calculate that what would be the corrected pullout resistance P R actual. So, P R actual will be equal to 2 into b into F star into L e into sigma v dash into N actual; that means, 2 into 0.05 width of the strip L e value F star value you have calculated 0.883 sigma v is equal to 3.825 L e into this value 92.625 into 5 into sigma v N. So, ultimately you calculate that P R actual is 156.367 kilo Newton.

So, you have to calculate what will be the factor of safety against pullout failure. So, pullout failure, factor of safety against pullout failure will be equal to P R actual divided by T. So, P R actual 156.367 divided by 91.789; that means, 1.705. So, it is greater than 1.5.

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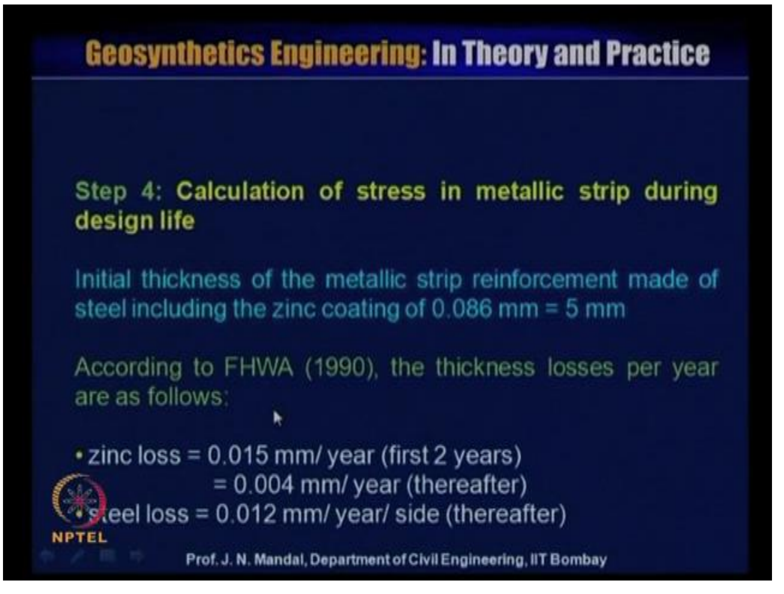

That means factor of safety against this pullout failure is. Now, in step 4, we will calculate the stress in the metallic strip during design life. So, initial thickness of the metallic strip reinforced made of steel including the zinc coating of 0.086 millimeter is equal to 5 millimeter, according to Federal High Way Administration F H W A 1990 the thickness losses per year, are as follows, zinc loss 0.015 millimeter per year first 2 years and then 0.004 millimeter per year thereafter, steel loss 0.012 millimeter per year per side thereafter.

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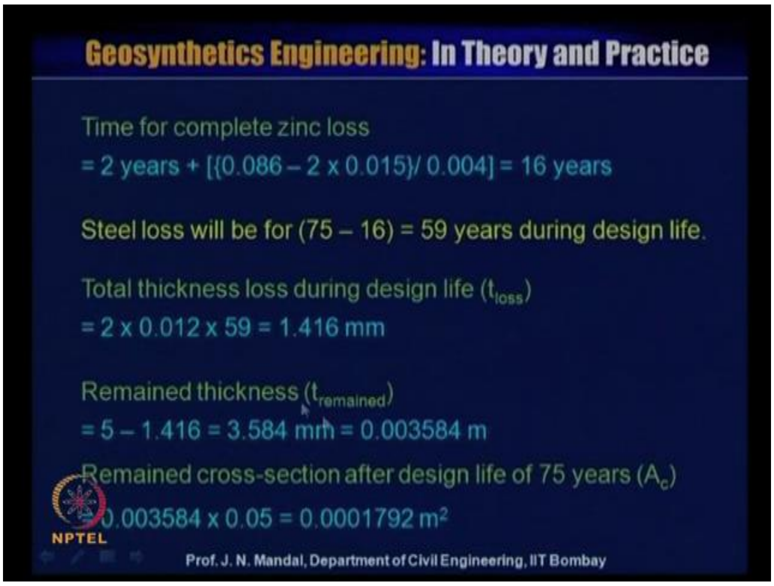

So, now we have to calculate that, what will be the time required for complete zinc loss, time for complete zinc loss is equal to 2 years plus 0.086 that is initial loss which is being given, minus 2 into 0.015 that is zinc loss, that zinc loss 0.015 millimeter per year plus 2 year. So, 0.015 into 2 divided by that is 0.004 millimeter per year thereafter. So, this will be the 0.004. So, if you can calculate then complete zinc loss, it takes time about 16 years.

So, steel loss will be this is a 75 year minus 16. So, 59 years during the design life. So, what will be the total thickness loss during design life, that is designated as steel loss. So, steel loss will be the 2 into 0.012 into 59 year, 0.012 is the steel loss, 0.012 millimeter per year, per side thereafter. So, it will be both side therefore, 2 into 0.012 per year 59 year; that means, 1.416 millimeter.

So, remained thickness t remain will be the 5 minus 1.416; that means, 5 millimeter thickness, we consider for steel strip, this minus, this will be 3.584 millimeter or 0.003584 meter. So, even cross section after the design life for 75 years that is A c will be equal to 0.003584 this thickness, into this 0.05; that means, 0.0001792 meter square.

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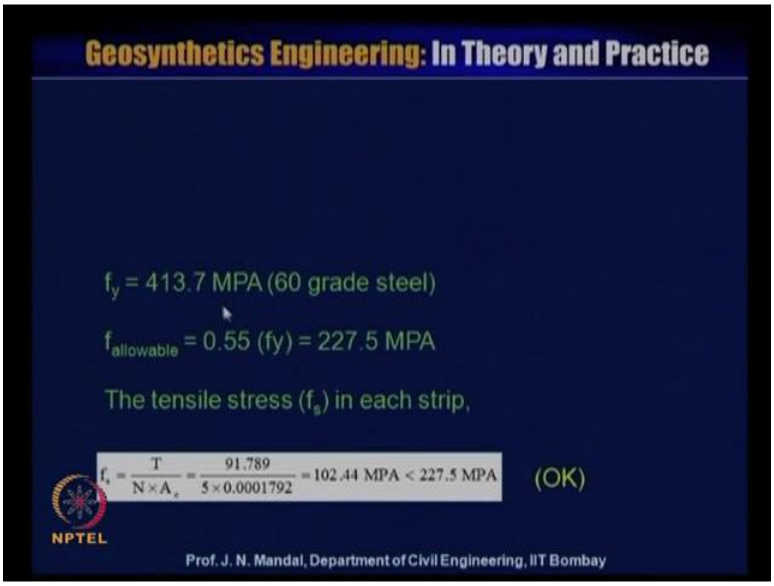

Now, we have considered the steel strength is f y is 413.7 mega Pascal per 60 grade steel. So, you have to calculate what will be the allowable. So, allowable f allowable will be 0.55 into f y is equal to 227.5 mega Pascal. So, tensile stress f a in each strip can be defined as T divided by N into A s; that means, T is 91.789 divided by N is 5 and A is as calculated 0.0001792. So, this will give 102.4 mega Pascal which is less than 227.5 mega Pascal; that means, it is ok.

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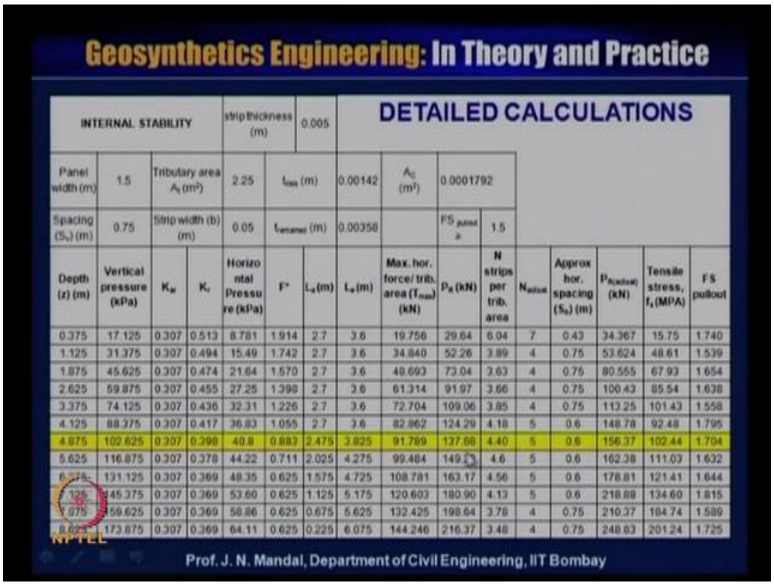

INTERNAL STABILITY		strip thickness (m)	0.005				
Panel width (m)	1.5	Tributary area A_t (m²)	2.25	t_{loss} (m)	0.00142	A_c (m²)	0.0001792
Spacing (S_v) (m)	0.75	Strip width (b) (m)	0.05	$t_{remained}$ (m)	0.00358	FS pullout	1.5

Depth (z) (m)	Vertical pressure (kPa)	K_a	K_r	Horizontal Pressure (kPa)	F*	L_e(m)	L_a(m)	Max. hor. force/ trib. area (T_{max}) (kN)	P_R (kN)	N strips per trib. area	N_{actual}	Approx hor. spacing (S_h) (m)	$P_{R(actual)}$ (kN)	Tensile stress, f_s (MPA)	FS pullout
0.375	17.125	0.307	0.513	8.781	1.914	2.7	3.6	19.756	29.64	6.04	7	0.43	34.367	15.75	1.740
1.125	31.375	0.307	0.494	15.49	1.742	2.7	3.6	34.840	52.26	3.89	4	0.75	53.624	48.61	1.539
1.875	45.625	0.307	0.474	21.64	1.570	2.7	3.6	48.693	73.04	3.63	4	0.75	80.555	67.93	1.654
2.625	59.875	0.307	0.455	27.25	1.398	2.7	3.6	61.314	91.97	3.66	4	0.75	100.43	85.54	1.638
3.375	74.125	0.307	0.436	32.31	1.226	2.7	3.6	72.704	109.06	3.85	4	0.75	113.25	101.43	1.558
4.125	88.375	0.307	0.417	36.83	1.055	2.7	3.6	82.862	124.29	4.18	5	0.6	148.78	92.48	1.795
4.875	102.625	0.307	0.398	40.8	0.883	2.475	3.825	91.789	137.68	4.40	5	0.6	156.37	102.44	1.704
5.625	116.875	0.307	0.378	44.22	0.711	2.025	4.275	99.484	149.[illegible]	4.6	5	0.6	162.38	111.03	1.632
6.375	131.125	0.307	0.369	48.35	0.625	1.575	4.725	108.781	163.17	4.56	5	0.6	178.81	121.41	1.644
[illegible]	[illegible]45.375	0.307	0.369	53.60	0.625	1.125	5.175	120.603	180.90	4.13	5	0.6	218.88	134.60	1.815
[illegible]	[illegible]59.625	0.307	0.369	58.86	0.625	0.675	5.625	132.425	198.64	3.78	4	0.75	210.37	184.74	1.589
[illegible]	173.875	0.307	0.369	64.11	0.625	0.225	6.075	144.246	216.37	3.48	4	0.75	248.83	201.24	1.725

So, here for this entire detailed calculation, we know that what if the panel width 1.5 and tributary area, what will be the strip thickness 0.005 millimeter, here I am showing only one calculation which is at a depth of 4.875 we calculated what will be the vertical pressure in kilopascal, what is K w what is K r what will be the horizontal pressure in kilopascal, we have calculated L a we have calculated L r. So, if we combine these then we can have this what will be the total length and maximum force is this and what is P a in kilo Newton in number is 4.5 you make a round figure is 5.

So, you have calculated what will be the horizontal spacing, then what will be the pressure, what will be the tensile stress, then what will be the factor of safety. So, I have shown only one calculation and accordingly you can calculate, at the different depth l can design the metallic reinforced soil retaining wall.

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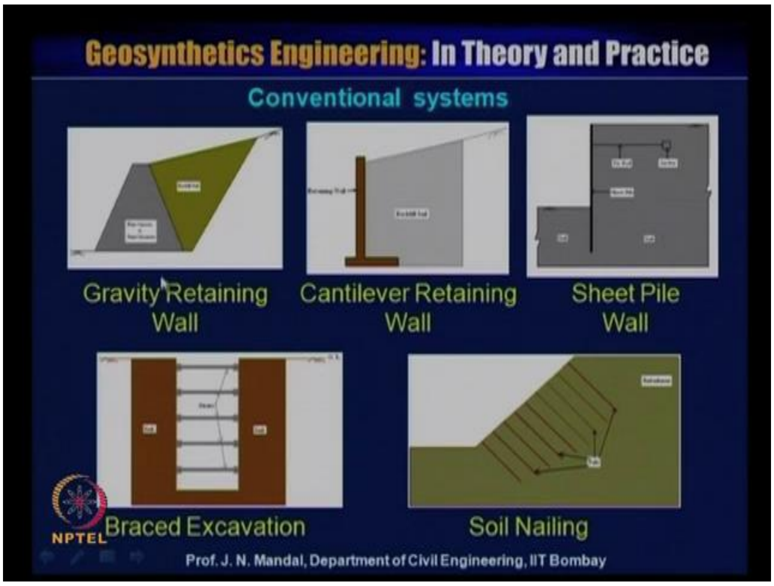

Now, we can see that there are different types of the system in the conventional method gravity retaining wall, cantilever retaining wall, steel pile wall or the braced excavation and soil nailing.

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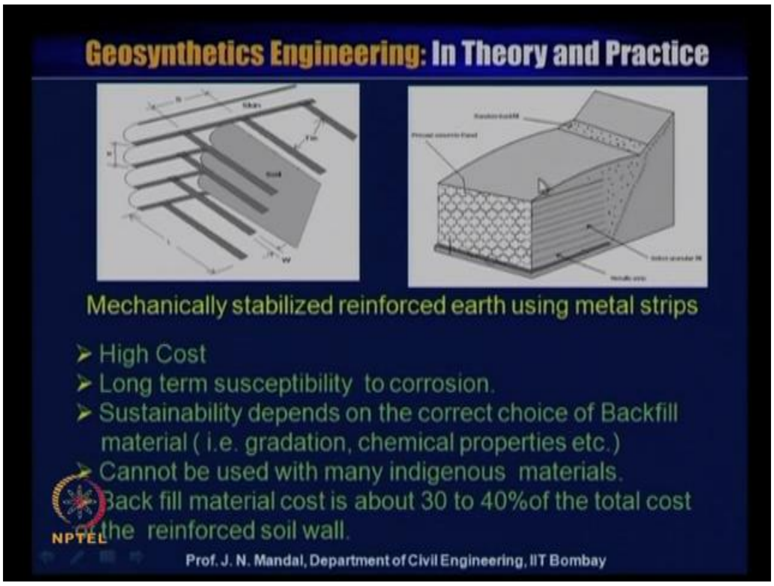

So, alternative to this system that this is the Vidal vision, how he has developed the mechanically stabilized reinforced earth wall using the metallic strip. So, he this is the metallic strip, this is the facing element, this is the length, this is the width of the strip and there is also vertical spacing, also the horizontal spacing and you can make a different types of the facing elements.

So, when we go for this kind of the metallic reinforced earth retaining wall. So, most of the cases as metal is very costly, this will be the high cost and it is a long term susceptibility to cohesion, because it is metallic reinforcement, that is one of the disadvantage of this kind of the material and also at the same time the sustainability, depend upon the correct choice of the backfill material and it depend upon the gradation and chemical properties etcetera.

Because, it is a metal so you have to select proper kind of the gradation material and you cannot be used all the time as a indigenous material and in general the backfill material cost is about 30 to 40 percent of the total cost of the reinforced soil wall.

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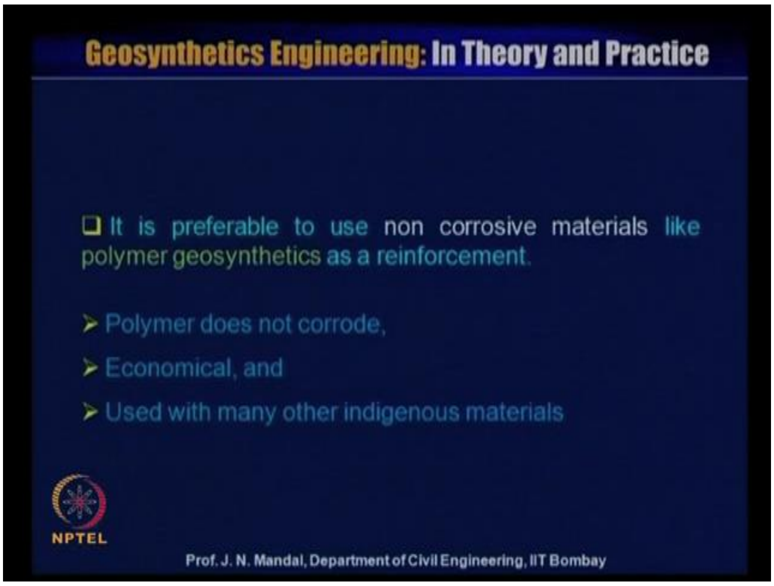

So, sometimes it is preferable to use the non corrosive material, like polymer geo synthetics material as a reinforcement I am not trying to say that you cannot use this metallic reinforcement, metallic reinforcement can be used, but one has to be careful for using this metallic reinforcement because it has some corrosion effect and because polymer one advantage is that, this polymer does not corrode and also it is economical also used with the many other indigenous material, also some disadvantage that it is a key factor and also it will be kept to about the sunlight or mannerism.

So, with this high ended this today’s lecture, please let us hear from you any question and thank you for listening.