Geosynthetics Engineering: In Theory and Practices
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Lecture - 3
Geosynthetics for Reinforced Soil Retaining Walls

Dear student, a warm welcome to NPTEL phase 2 video courses on geosynthetics engineering in theory and practice. My name is Professor J. N Mandal department of civil engineering, Indian institute of technology Bombay, Mumbai India. This is lecture number 33. The name of the course is geosynthetics engineering in theory and practice. This is module 6, lecture 33, and geosynthetics for reinforced soil retaining wall. I will just show you the recap of the previous lecture.

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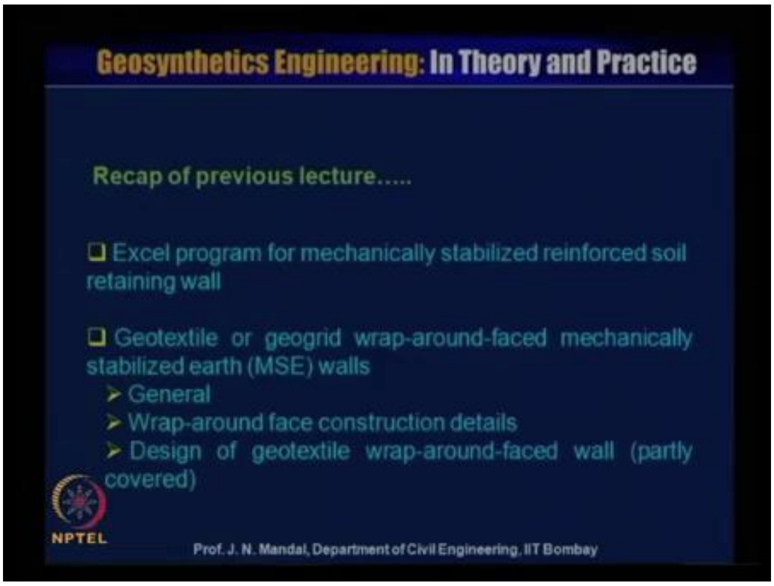

We covered the excel program for mechanically stabilized reinforced soil retaining wall, geotextile or geogrid wrap around faced mechanically stabilized earth wall. General, wrap around face construction, design of geotextile wrap around faced wall that partly covered.

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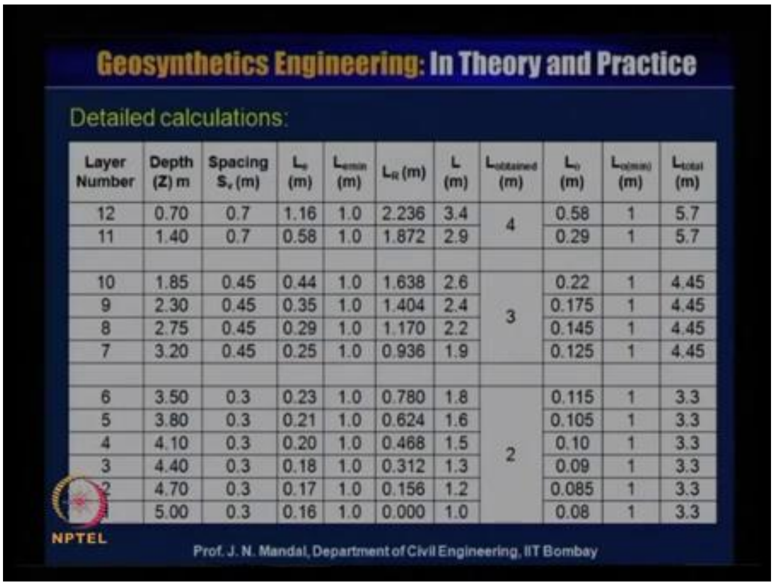

Layer Number	Depth (Z) m	Spacing S_v (m)	L_e (m)	L_{emin} (m)	L_R (m)	L (m)	$L_{obtained}$ (m)	L_o (m)	$L_{o(min)}$ (m)	L_{total} (m)
12	0.70	0.7	1.16	1.0	2.236	3.4	4	0.58	1	5.7
11	1.40	0.7	0.58	1.0	1.872	2.9		0.29	1	5.7
10	1.85	0.45	0.44	1.0	1.638	2.6	3	0.22	1	4.45
9	2.30	0.45	0.35	1.0	1.404	2.4		0.175	1	4.45
8	2.75	0.45	0.29	1.0	1.170	2.2		0.145	1	4.45
7	3.20	0.45	0.25	1.0	0.936	1.9		0.125	1	4.45
6	3.50	0.3	0.23	1.0	0.780	1.8	2	0.115	1	3.3
5	3.80	0.3	0.21	1.0	0.624	1.6		0.105	1	3.3
4	4.10	0.3	0.20	1.0	0.468	1.5		0.10	1	3.3
3	4.40	0.3	0.18	1.0	0.312	1.3		0.09	1	3.3
2	4.70	0.3	0.17	1.0	0.156	1.2		0.085	1	3.3
[illegible]	5.00	0.3	0.16	1.0	0.000	1.0		0.08	1	3.3

Now, I will show you this table. I will focus that how we have calculated the L of E and total L and the L T. What we have considered is the 12 layer, 1 to 12 and depth, we have taken 0.7 0 to 1.40. That means spacing for the layer 11 and 12 is 0.7 meter, and then 7 to 10, we have kept 0.45. Then, from 1 to 6 is 0.3 meter spacing. Now, this is the L of E, which you call embedment length. Embedment length we have earlier calculated that is L of E is equal to 0.81 divided by Z at any particular depth. You can calculate that what is L of E that means L E will be equal to 0.8 divided by Z.

So, we know the Z. So, we can calculate the L of E. So, this way, you can calculate all the embedment length value L E. However, that embedment length minimum is required for 1 meter. That is why it has shown 1 meter. Then, we calculated L of R that L R is equal to H minus Z into tan 45 degree minus phi by 2. I have shown earlier. So, you know at any depth, you can calculate the L R using the expression L R is equal to H minus Z into tan of 45 degree minus phi by 2.

So, you know what is Z? You know what the height of the wall is. So, you know the phi value. So, you can calculate what L of R here is. L of R is calculated knowing the various Z value and height is constant. So, this length this is total length, the total length is equal to embedment length plus L R that mean L E plus L R. So, if you sum up L E plus L R, this will give 13.4. Similarly, 0.58 plus 1.67872, this will give L value 2.9.

Like this, you can calculate the total length of the reinforcement, the length of the reinforcement at various layers.

So, in this design, we have considered that what will be the L obtained; so instead of 3.4 to 2.9, we obtain, and we take it as a 4 meter. This 1.9 to 2.6, we consider as a L obtained 3 meter and 1.0 to 1.8, we obtained as a 2 meter and l 0 what you call the overlap length. So, L 0 is basically L E by 2. If you know the L E 1.16, so half of that will give the L 0 value as 0.58. Like that, you can calculate what the L 0 for other layers is, but overlap length minimum is required 1 meter.

So, this is 1 meter. So, this is the total length, L total is 5.7. This shows that overlap length is 1 meter. This length is 4 meter, 4 plus overlap length 1, 5 plus spacing 0.7. That is why, this is 5.7. So, 7 similarly, for this 7 to 10, this is 3 plus 1, 4 and spacing is 0.45. So, total length will be 4.45. Like that, this is 2 plus 1. This is overlap length 3 plus spacing 0.3, that is why 3.3. So, total length you can calculate. So, you will know that what quantity of geotextile material is required for the design of the geotextile reinforced soil wall. So, this is the final arrangement of the geotextile reinforcement.

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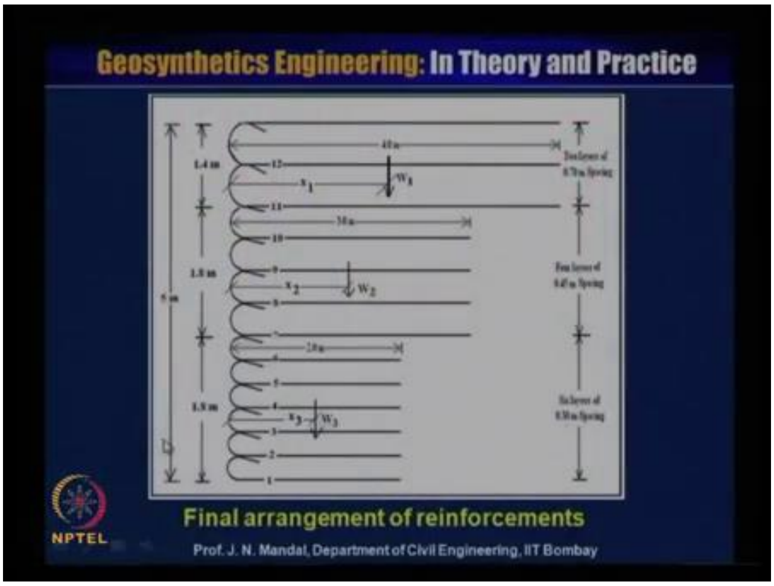

Here, you know the height of the wall is the 5 meter and here is the first 2 layer is the 4 meter. So, that is why, it is a 4 meter length that means 2 layer at a rate of 0.70 meter spacing. That means this will give you 2 into 0.7. That means this height will be 1.4 meter. So, this is from you can see this table because there are 2 layers. This length is 4 meter. This is 2 layers. This spacing is 0.7, the 2 into 0.7, 1.4. This length is 4 meter, length of the reinforcement 4 meter and this height is 2 into 0.7 means 1.4 meter.

Now, next you can see that this length is 3 meter because this is length is 3 meter and 3 meter and spacing is 0.45. So, this is 0.45. When you check the how many layer 1, 2, 3, 4, so here you can calculate 4 layer at the rate of 0.45 of spacing. That means 4 into 0.45, which will give you that 1.8 meter. So, this height is 1.8 meter, but this length of the reinforcement is 3 meter. Now, next the 2 meter length and spacing is 0.3 and layer is 1 to 6.

So, here this is 2 meter. This is 2 meter. This is 6 layers into 0.3 meter spacing. So, 6 into 0.3 that means this height will be the 1.8 meter. So, if you add 1.4 plus 1.8 plus 1.8, which will give you the 5 meter height of the wall. So, this way you can finally, arrange the reinforcement in different layer. So, longer length on the top, and then gradually, it is decreasing at the bottom. Each zone has its own weight.

Suppose this 2 layer is if it is a weight is w 1, for this 4 layer, for 2 meter length, this weight is w 2 and also for this 6 layer and weight is w 3. This weight is located from the facing of the element. For w 1, it is distance is x 1 from the facing element of the wall. Similarly, for w 2 is the x 2 and w 3 is equal to it is x 3. So, this may be required when we will calculate the overturning moment. So, ultimately we show that what the final arrangement of the geotextile reinforcement is. Now, we will design the external stability step 1. So, you have to find out what will be the stability against the sliding.

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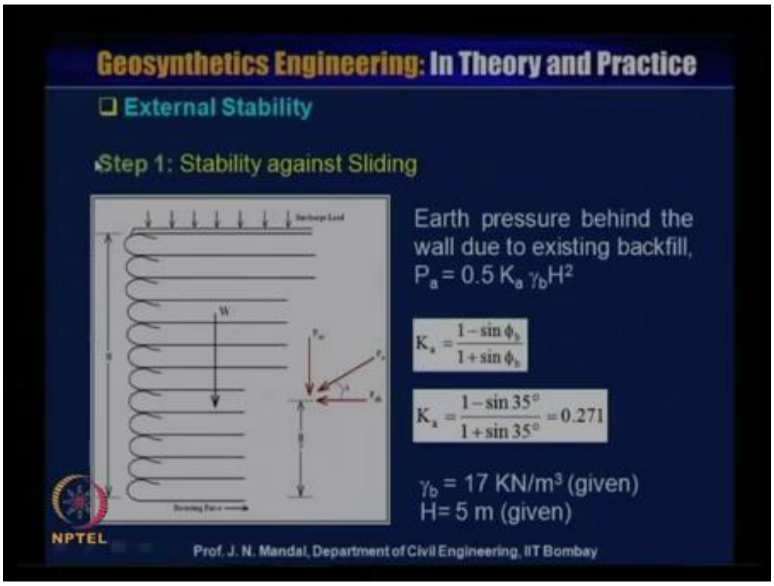

So, you have seen that arrangement of the reinforcement and this is the earth pressure. You have to calculate what will be the earth pressure behind the wall due to the existing backfill. That is P a will be equal to half K a into gamma b into H square. What is K a? K a is equal to 1 minus sin phi b by 1 plus sin phi b. Phi b value is 35 degree. So, K a is equal to 1 minus sin 35 degree divided by 1 plus sin 35 degree is equal to 0.271. Gamma b value is given is 17 kilo Newton per meter cube. It is given. Height of the wall is 5 meter.

So, you can substitute this value here. K a is equal to 0.271, gamma b is equal to 17, height is equal to 5. So, you can calculate what will be the earth pressure behind the retaining wall that is P of a. This one also has a surcharge load. So, this wall may move this direction. So, that is why, it is resisting force here. It will act the resisting force here. So, you have to calculate what will be the factor of safety against the sliding. The wall wants to move this direction. This is the resisting force. So, we first of all calculate what will be the earth pressure acting on this wall.

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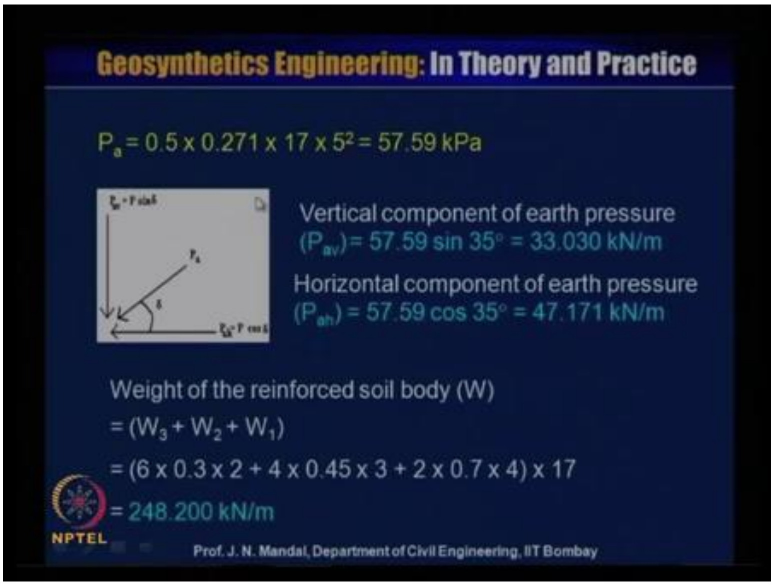

So, P a, we calculated. It gives 57.59 k P a. Now, this P a is making at an angle of delta. So, it has 2 components that is P a v and P a h. This is horizontal component. This is vertical component. So, vertical component of the earth pressure, P a v will be equal to P a into sin of delta. This P a h, horizontal component of earth pressure is equal to P a into this is cos of beta. So, that way, you calculate what will be the P a v. 57.59 is the P a into sin of 35 degree. This gives P a v, vertical component of earth pressure, 33.030 kilo Newton per meter.

Similarly, horizontal component P a h is 57.59 into cos 35 is 47.171 kilo Newton per meter. So, we calculate what will be the vertical component, what will be the horizontal component. Now, we want to calculate what will be the weight the W. So, W is equal to W 1, W 2, W 3. So, we can calculate that W is equal to this is W 1, W 2 and W 3. So, here that W 1 means that that weight of the reinforced soil body.

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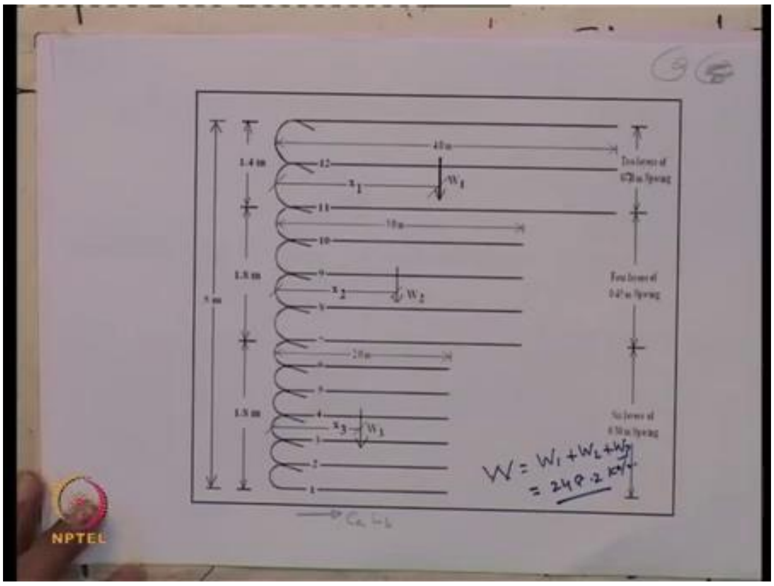

Let us say this is the total weight, W is equal to W 1, W 2 plus W of 3. So, weight of the reinforced soil body is expressed as W. W will be equal to what is W 3? So, W 3 will be equal to this is 6 layers and 0.3 is the spacing. So, 6 into 0.3, 1.8 into this length is 2 into gamma r that is 17. So, that means 6 into 0.3 into 2 into 17 for W 3. Similarly, for W 2 will be equal to this are you see that there are 4 layers. So, 4 into 0.45 with the spacing 4 into 0.45 and this length is 3 meter into 17 gamma. That means gamma into H into L. So, for W T, you can calculate.

Similarly, W 1, this length is 4. This height is 2 at the rate of 0.7. That means 1.4. That means 2 into 0.7 into 4 meter into 17. So, if you calculate individually for W 3, W 2 plus W 1, so this will give you what will be the total weight. So, this total weight that W, which we can say W 1 plus W 2 plus W of 3, this it will come 248.2 kilo Newton per meter. So, you obtain this is the weight, which is acting on the wall.

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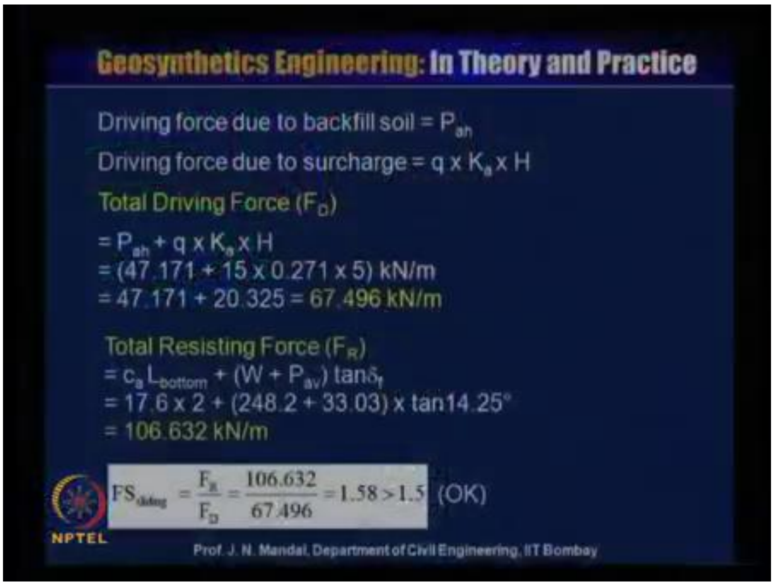

Now, you have to what will be the driving force due to the backfill soil that means P of h? So, driving force again due to the surcharge because there is a surcharge load q. So, q into K a into H, H is equal to height of the wall. So, total driving force F D will be equal to P a h plus q into K a into H. That means P a h, you have calculated 47.171 plus q.

The q is the surcharge load is 15 K a is equal to you calculated 2.271 and height of the wall H is 5. So, if you calculate, then total driving force F D will be equal to 67.496 kilo Newton per meter. Similarly, total resisting force, so resisting force, so if you look here, this is the resisting force. The resisting force is acting along this.

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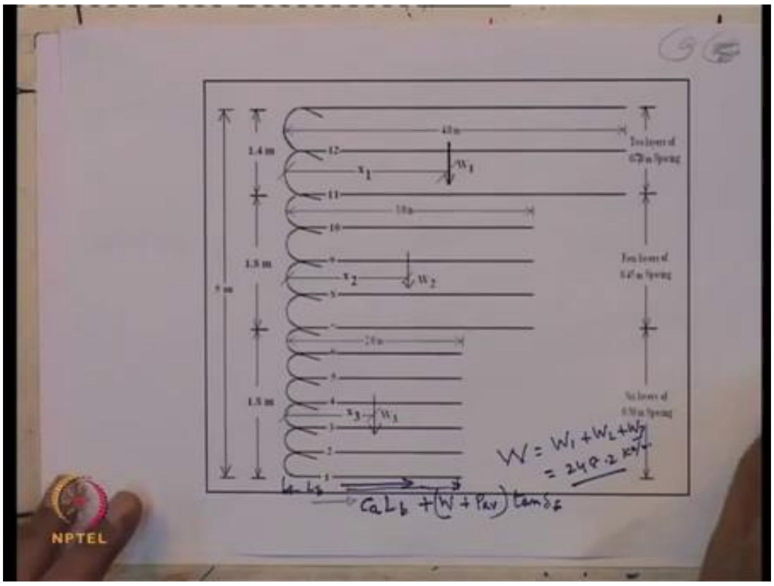

So, this resisting force, there is C of a adhesion. This is the bottom length is 2, that means this length is 2. This is 2 meter. So, this if you can say that this is L of b, L of b, so C a into L of b, this is due to adhesion plus there is a weight. That means w plus there is P a v, P a v component, vertical component P a v, this into tan of delta L tan of delta L. So, this is the friction between the soil and the foundation soil.

So, now you are substituting this value. So, you are substituting this value here. That means C a is given 17.6 and L bottom is 2 meter plus weight we calculated. That is 248.2 plus P a v we know that is 33.03 into tan of 14.25 because delta f value is 14.25 degree. So, you calculate total resisting force F R is equal to 106.632 kilo Newton per meter. So, you have to calculate that what will be the factor of safety against sliding. So, factor of safety against sliding is the ratio of F R by F D. That means it will be the resisting force divided by driving force. So, resisting force is 106.632 divided by driving force is 67.496, which will give 1.58, which is greater than 1.5. So, it is okay.

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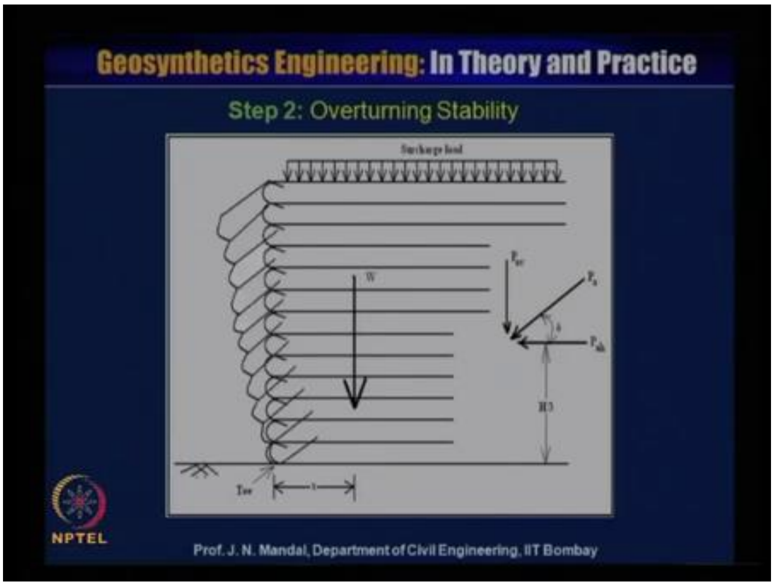

Next is step 2 that overturning stability. So, there is a possibility that structure can overturn like this. It may be overturned. So, it has a weight. This weight is acting at a distance x from the toe. So, we have to take the moment at this toe for the various forces. This force is horizontal force is acting one third of the height of the wall. If H is the height of the wall, so this P a h is acting at a depth of one third from the base of the wall.

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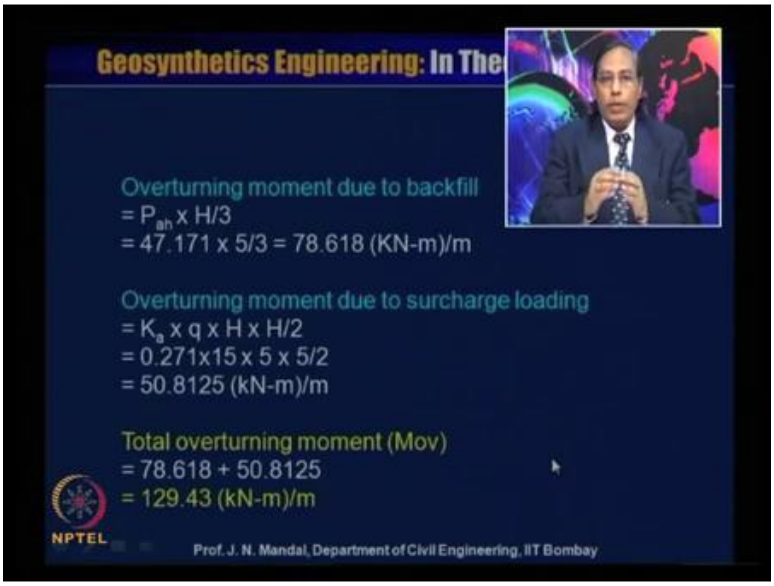

So, you have to calculate what is overturning moment due to the backfill that is P a h into H by 3. P a h we know 47.171 into height of the wall 5 divided by 3 is 78.618 kilo

Newton meter per meter. What is overturning moment due to the surcharge loading? So, surcharge loading is equal to K a into q into H by H by 2 because this is a surcharge load, which will be at the middle of the reinforcement. So, this K is 0.271 into surcharge q is 15. Height is equal to 5 and H is equal to 5 meter that is 5 divided by 2. So, this will give overturning moment due to the surcharge loading is 50.8125 kilo Newton meter per meter.

So, what will be the total overturning moment? M o v will be thus summation of overturning moment. M o v will be the summation of overturning moment due to backfill plus overturning moment due to surcharge loading. So, overturning moment due to backfill is 78.618 plus overturning moment due to surcharge loading is 50.8125. So, total overturning moment M o v will be equal to 129.43 kilo Newton meter per meter.

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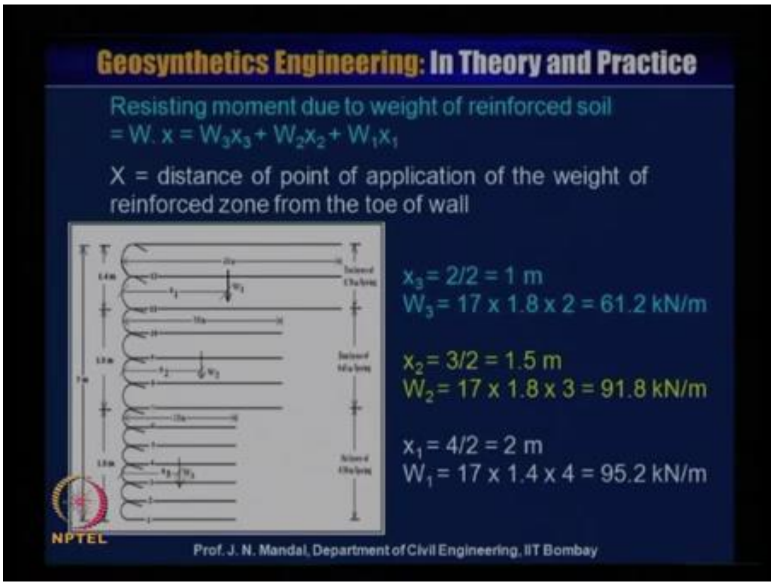

So, now what will be the resisting moment due to the weight of the reinforced soil? So, resisting moment will be equal to W into x. That means if this is the W 3, so you are taking a moment at the toe for this W 3. This will be W 3 into suppose this distance from the toe is x 3. So, this is W 3 into x 3. Then, for this case, it is W 2, which is acting at a distance of x 2 from the toe. So, this is W 2 into x 2. Similarly, this weight is W 1. So, from this toe, it is acting at a distance of x 1.

So, this will be the W 1 into x 1. So, what will be the resisting moment? If we take a moment at this toe that means W 1 into x 1 plus W 2 into x 2 plus W 3 into x 3, where you can say x is the distance of a point of application of the weight reinforced zone from the toe of the wall. This is the toe of the wall.

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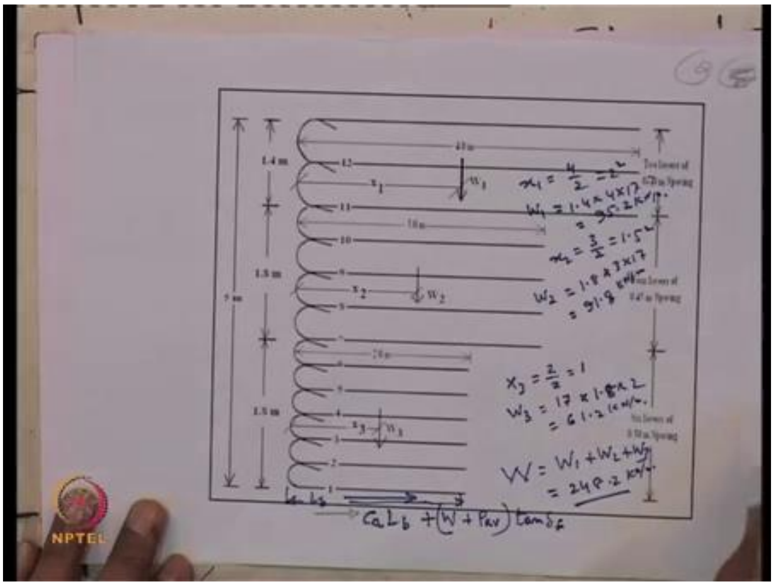

So, now here what is x 3? x 3 is if this is a 2 x 3 will be 2 by 2, so x 3 will be is 2 by 2 is equal to 1. What is W 3? That means this weight will be this is 1.8 meter. This length is 21.8 into 2 into gamma r that is 17 that means W 3 will be equal to 17. Let us say W 3 is equal to 17 into 1.8 into 2. This is 1.8 and this is 2. So, 1.8 into 2 is you know W 3.

So, this will give about 61.2 kilo Newton per meter. Similarly, for W 2, what is x 2? This length is 3 meter. So, x 2 will be 3 by 2. So, in this case, x 2 will be 3 by 2. That means this is 1.5 meter. Then, W 2 will be equal to this is also 1.8 meter. This length is 3 meter. So, 1.8 into 3 into unit weight 17, so you can write 1.8 into 3 into 17. So, this W 2 value will be 91.8 kilo Newton per meter.

Now, for W 1, this length about 4 meter, so x 1 will be this x 1 will be half of that 4. So, that means this is 4 by 2 is equal to 2 meter. W of 1 will be equal to this is 1.4 into 4 into gamma r is 17. So, 1.4 into 4 into gamma r 17, this W 1 will be 95.2 kilo Newton per meter. So, you know that weight. You know that the distance x 1 from at what distance this is located from the toe of the wall; you know for W 3, you know for W 2. Also, you know for W of 3. Hence, resisting moment will be W 3 into x 3, W 2 into x 2 plus W 1 into x 1.

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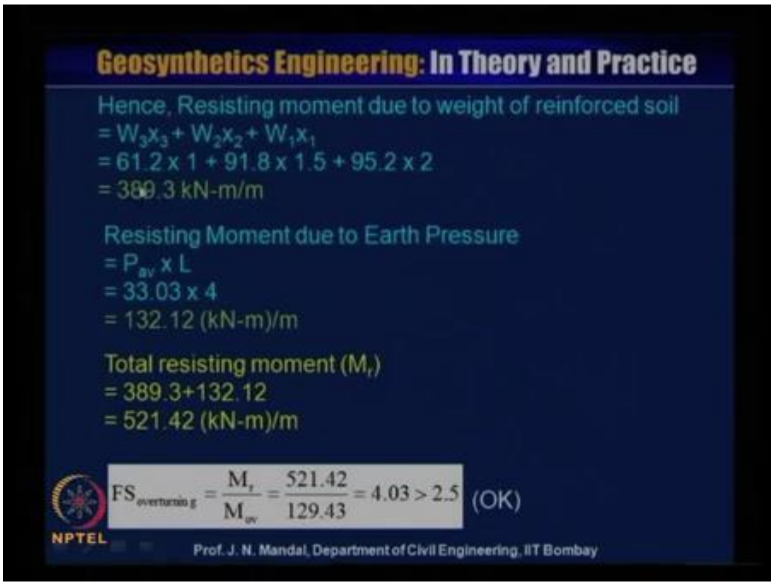

So, here you can see W 3 61.2 into X 3 is 1 plus W 2 is 91.8 into X 3 is equal to 1.5 plus W 1 is equal to 95.2 into x 1 is equal to 2. So, total resisting moment due to the weight of the reinforced soil is 389.3 kilo Newton meter per meter. Similarly, resisting moment due to earth pressure that is P a v into L, this is the vertical and this is the length of the reinforcement at the top. So, this is 33.03 into this length top is 4. So, this will give 132.12 kilo Newton meter per meter.

So, total resisting moment that is M r will be equal to 389.3 plus 132.12. So, this is 521.42 kilo Newton meter per meter. Now, you calculate what will be the factor of safety against overturning that is M r by M o v. We know what M r resisting moment is. So, resisting moment is 521.42, this divided by overturning moment M o v, 129.43, this will give this factor of safety against overturning. It is 4.03. So, that is greater than 2.5. That means it is okay. So, you have checked the factor of safety against the sliding. You have checked that factor of safety against this overturning. So, it satisfies these criteria. Now, step 3, you have to check for bearing capacity that means this foundation soil here.

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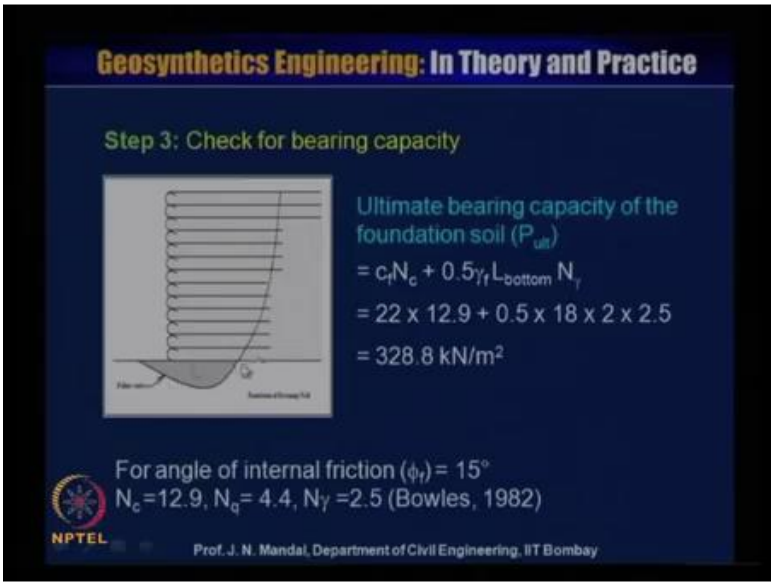

So, there is a possibility for the failure surface due to the bearing capacity of the soil. Even the foundation soil is poor. Then, you have to check what will be the factor of safety against bearing capacity. Now, we know the ultimate bearing capacity of foundation soil. Let us say P ultimate. You know this equation is very standard equation P ultimate is equal to c of f into N c plus 0.5 gamma of f into L length at the bottom into N gamma.

So, this c of f N c and the N gamma value is given. That is N c value 12.9, N q value 4.4, and N gamma value 2.5. This from the Bowles 1982 for the friction angle of pi r is 15 degree. So, for this value, so you know that what is N c. What is N gamma here? It is required only N c and N gamma. So, this is c f is given 22 into N c value 12.9 plus 0.5 into gamma f is 18. It is given L bottom that is 2 meter that is why L bottom 2 meter. N gamma is 2.5. This is 2.5. So, you know what will be the ultimate bearing capacity of the foundation soil or P ultimate is 328.8 kilo Newton per meter square. So, you know what ultimate bearing capacity is…

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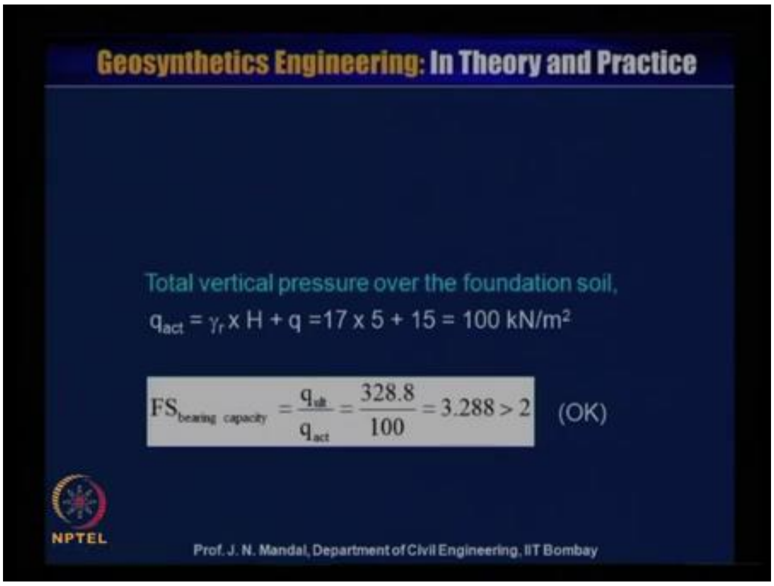

Now, what is total vertical pressure over the foundation soil? So, that is q of actual that you know what will be the height of the wall. You know what is the gamma r plus due to the surcharge load is q. So, gamma r is equal to 17 into height is 5 meter plus q surcharge is 15. So, 17 into 5 plus 15 is equal to 100 kilo Newton per meter square. So, you check what will be the factor of safety against bearing capacity that is ratio of q ultimate divided by q actual. That means 328.8 divided by 100 is equal to 3.288 that is greater than 2. That means it is factor of safety against bearing capacity.

Also, we have checked that what will be the factor of safety against the sliding factor of safety against the overturning, also the factor of safety against the bearing capacity. Also, you have to check what will be the factor of safety against the global stability. They are commercially available this computer program. So, you can make use of the program and can check also that what will be the factor of safety against this overturning. It should be about 1.3. So, if that satisfies, then the structure is safe because sometimes, there is a possibility for the failure due to the global stability or the deep seated stability. So, we complete this example. Now, you know how to design the wrap around face geosynthetics reinforced soil wall.

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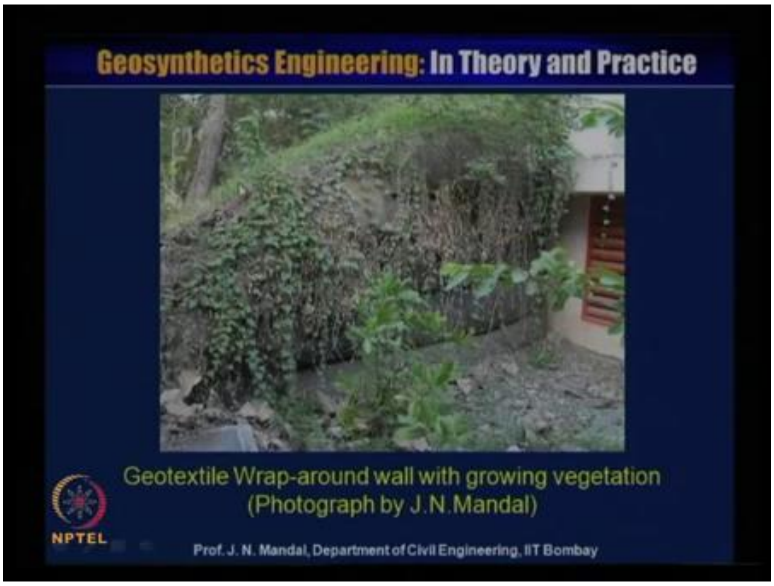

This is the geotextile wrap around wall this in IIT near centrifuge modeling. Here, you have used the non woven geotextile material. This is about 5 to 6 meter height. You can see this is the geotextile material have been wrapped; even then if it is teary tough and there is a possibility for growing the grass. So, it looks also greenery.

So, this is the geotextile around wall with the growing vegetation. Initially, here also this is contractor does not like to go ahead with the geotextile wrap around system wall. They wanted to go for the reinforced concrete system. Ultimately, we saved about 55 percentage with respect to the conventional reinforced concrete retaining wall. So, here that welded wire mesh facing with geogrid geotextile wrap and vegetation erosion control have shown.

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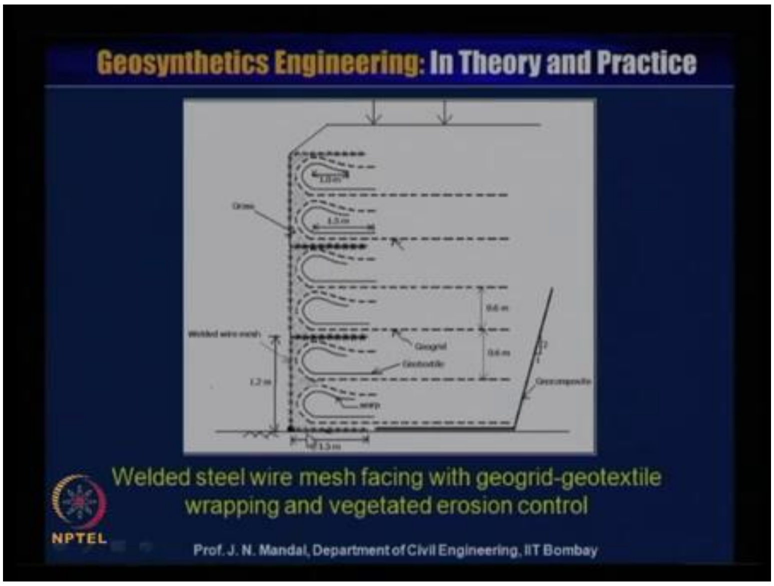

Here, you can see. This is the geogrid material. Also, it can be wrapped like this dot, dot from dotted because there is an opening of the geogrid material. So, there is a possibility that soil may comes out from the geogrid. So, you can provide with some small piece of the geotextile material or the natural jute material. Also, here this is the number of the layer of the geogrid and spacing about 0.6 meters. That is also the drainage at the back with the 2 vertical 2 1 horizontal. You can provide with the geo composite material at the back of the wall. Also, at the base, this length is about 1.5 meter.

So, you can provide this welded wire mesh like this. It is a kind of L shape like this. You can provide the welded wire mesh. Why you are providing the welded wire mesh? This is about 1.2 meter and this is 1.5 meter because this geogrid material may be damaged or sometimes any animal can attack. Then, there is a possibility for damage of the geogrid material. So, we provide with the welded wire mesh.

Nowadays, also this system is also going on welded wire mesh. At the same time, that here you can provide with the fertilizer kind of the soil at the facing element. Then, the grass can grow so easily grass can grow. So, even then at the welded wire mesh, grass comes out and this structure looks like a greenery. So, this system also can be adopted. So, these are all about this geosynthetics reinforced soil retaining wall.

So, we covered that how you can design the mechanically stabilized reinforced soil. Retaining wall it is in the form of wrap around face reinforced soil retaining wall and also that you have used also the panel or the block. So, you know how to design this mechanically stabilized reinforced soil system.

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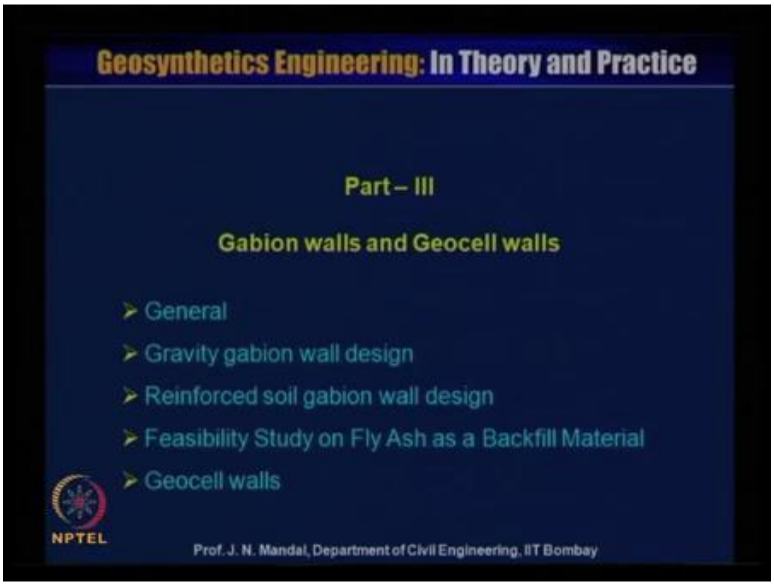

Now, part 3, we will discuss the gabion wall and the geo cell wall. Now, this will cover general, then gravity gabion wall design, reinforced soil gabion wall design. Apart from that, we also cover the feasibility study on the fly ash on as a backfill material whether what kind of the fly ash is suitable for the backfill material. This is very important to us. You cannot use any kind of the fly ash material as a backfill material. How you have to compact what kind of the moisture content and density will be required and also apart from that, we also we will cover the geo cell wall design. This is 1 new innovative system is coming up. So, this we can also cover in our course.

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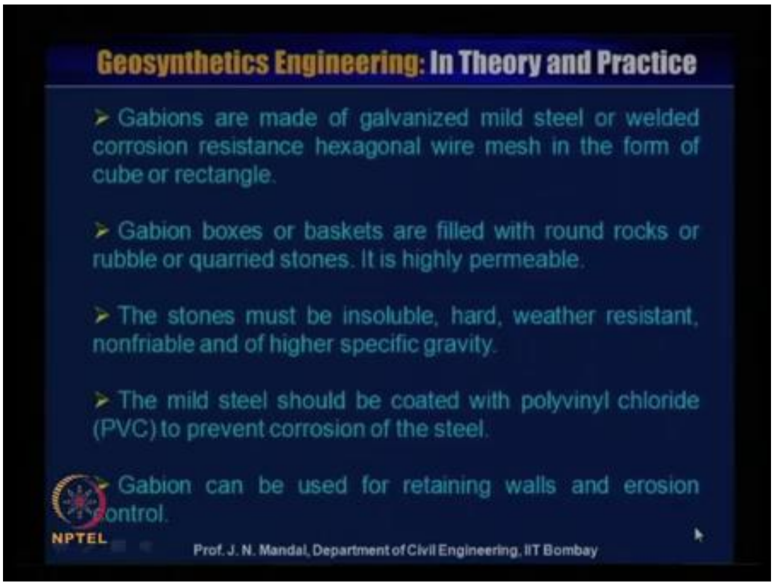

Now, this gabion is basically like this kind of the material.

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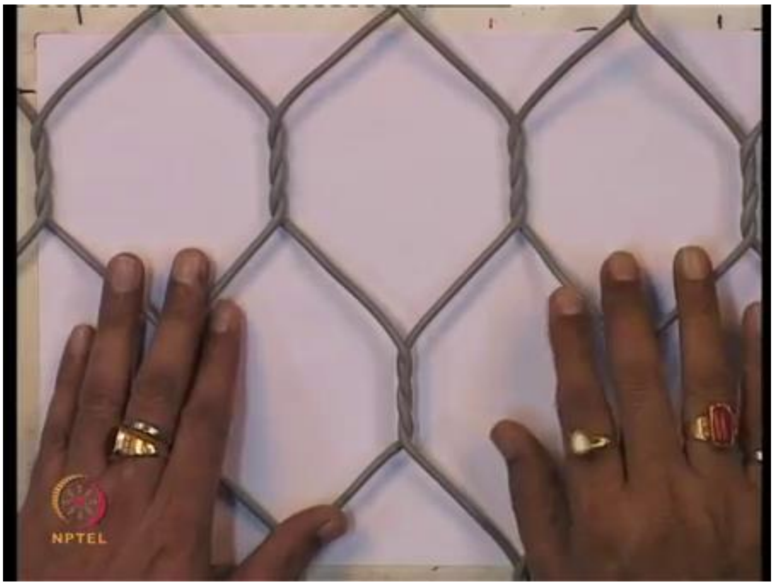

It is galvanized mild steel. While you can use welded resistant hexagonal, you can see this is hexagonal wire mesh in the form of you can also have in the form of cube, also in the form of the rectangular. This is like a 1 meter by 1 meter 1 meter a cube. So, gabion box where you can make the basket, this are filled with the round rock or the rubble or quarried stones.

It is highly permeable material. This stone must be insoluble, hard, weather resistance, and non friable and of hard specific gravity. The mild steel should be coated with this is the polyvinyl chloride, which you call PVC to prevent the corrosion of the steel. Also, we know that when we will use this kind of the gabion or the hexagonal shape of the gabion.

Then, we should know what will be the tensile strength in the longitudinal direction. What will be the tensile strength in the transverse direction? Also, what will be the strain in the longitudinal direction and also in the transverse direction? Apart from that, you have to calculate what will be the depth, what will be the diameter of the galvanized mild steel and what will be the tensile strength of the mild steel. Apart from that, you should know because it will be the corroded. So, you have to check the effect of the corrosion, which we have covered in our testing that how you can say that what will be the suitability of the material for the use for the construction of the retaining wall this gabion as a retaining wall.

So, this is the property that is important. Also, at the same time, when you are covering with the PVC kind of the material, this also has to be checked. So, it takes lot of time that soil spray technique you take may be more than 15, 100, 3000 hour and with a high temperature. So, this is very important that because that otherwise this PVC will be the spoil. So, where there is a salt, you have to be very careful. So, this kind of the gabion can be used for the retaining wall and also the erosion control or river band protection etcetera.

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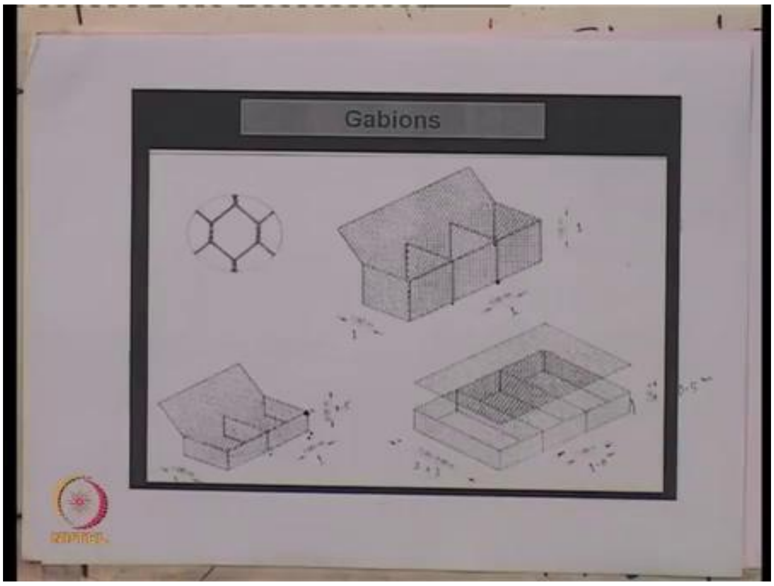

So, this here, we are showing that some of the gabion. So, this is 1 meter and this also 1 meter. So, this is a 1 meter like a cube. So, you can have like this or you can have this also 1 meter. This is like 0.5 meter. So, you can have a bucket like this. Also, you can have this is 2 to 3 meter. This is 1 meter. This height is 0.5 meter. So, you can have the different shape and configuration of the gabion material.

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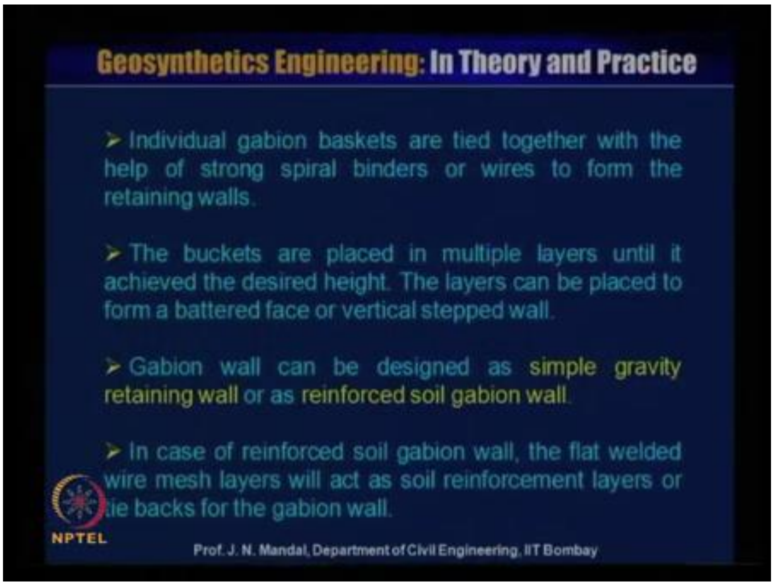

So, individual gabion baskets are tied together with the help of a strong spiral binder or wire to form the retaining walls. So, the buckets are placed in multiple layers until it achieve the desired height. The layers can be placed to form a battered space of vertical stepped wall.

Gabion wall can be designed as simple gravity retaining wall or as reinforced soil gabion wall. In case of reinforced soil gabion wall, the flat welded wire mesh layer will act as a soil reinforcement layer or the backs of gabion wall. So, you can construct a wall only you can provide with the gabion 1 meter by 1 meter cube. We can place horizontally like this.

Then, you can reduce the length of the gabion. You can construct let us say 4 meter, then, to 3 meter, then to 2 meter and then to 1 meter. So, you can construct a gabion wall like this. So, this is what we call simple gravity retaining wall. Sometimes, this gabion itself will act as a facing element. So, 1 meter by 1 meter and then another, if you place 1 meter by 1 meter on the top of that and in place, there is a layer of the reinforcement material.

So, we will cover that. Also, we will give example. We will show how we can design that simple that gravity retaining wall. Also, the reinforced soil gabion wall, gabion wall is a facing. This reinforcement, which will be attached with the gabion wall that design we will show you. So, design of gabion wall is conservative.

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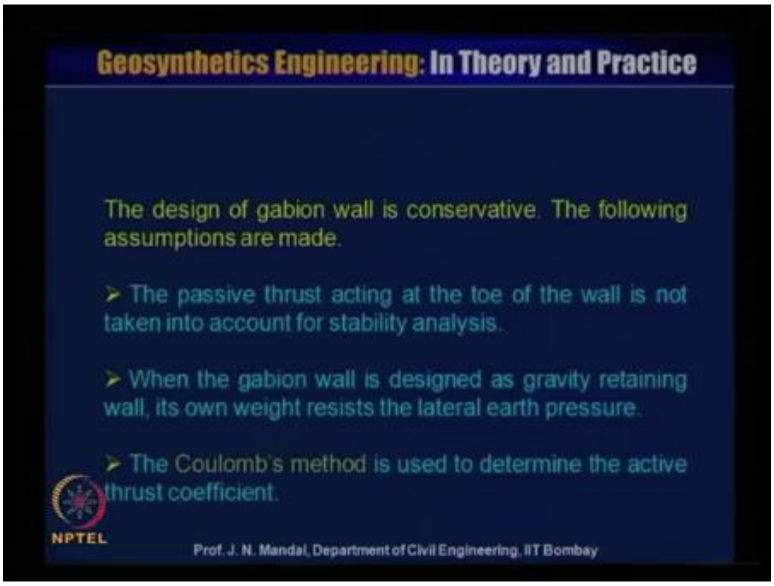

The following assumptions are made. The passive thrust acting at the toe of the wall is not taken into account for stability analysis. When the gabion wall is designed as gravity retaining wall, its own weight resists the lateral earth pressure. The coulomb's method is used to determine the active thrust coefficient.

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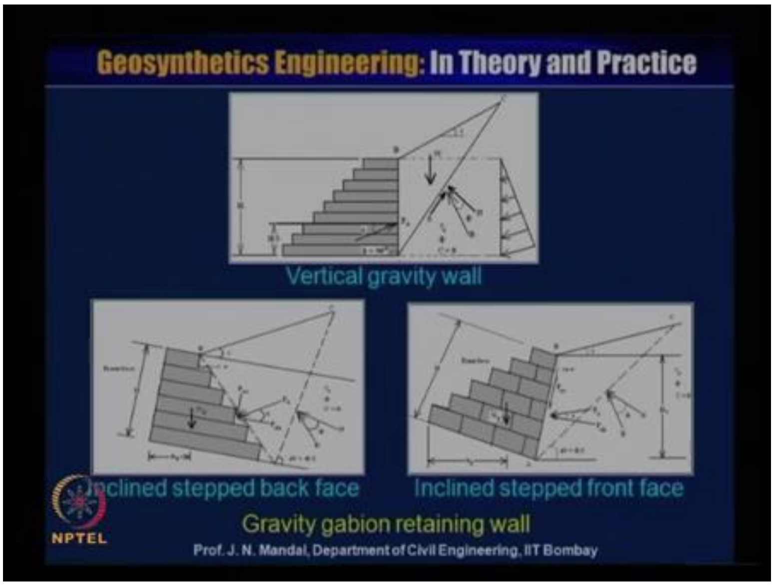

So, here 3 types of this wall are shown. One is the vertical, this is vertical gravity wall. Also, one is show that inclined stepped back face; this is inclined step back face. Here, you can see that when the vertical, this is absolutely the vertical retaining wall. So, this is a kind of the box. You can place box number of the box. Then, you reduce 1 box. Then, you place next layer. Then, you reduce another box. Then, you can place like this. You can construct a gravity wall or gabion retaining wall. This is the failure surface. If there is a surcharge that is b c, which is making at an angle i and this is the failure line. Then, you have to calculate what are the pressure is acting on this wall.

So, this is 90 degree. Also, you can have this inclined step, inclined step back face. Also, I can show you that inclined stepped front face; this is inclined stepped back face. So, here I just mention that if this is the failure and b c this is the weight of the wedge and this is the w g is the weight of the gabion. Here, r is the resultant of the normal force and the shearing resistant force at the failure surface. This is a c and act at an angle of phi to the normal force and phi is the angle of internal friction of the soil.

This is i, this is the backfill surface b c, which is inclined with the horizontal. This alpha angle, this is acute angle of the back face of the wall with vertical. That is why, this plus alpha, if it is a front face, then this will be the negative alpha. I will show you delta is the angle of wall friction. This P of a is the active earth pressure force per unit length of the wall. So, it has a 2 component that is P a h, which is making at an angle of delta here. This is the P of v.

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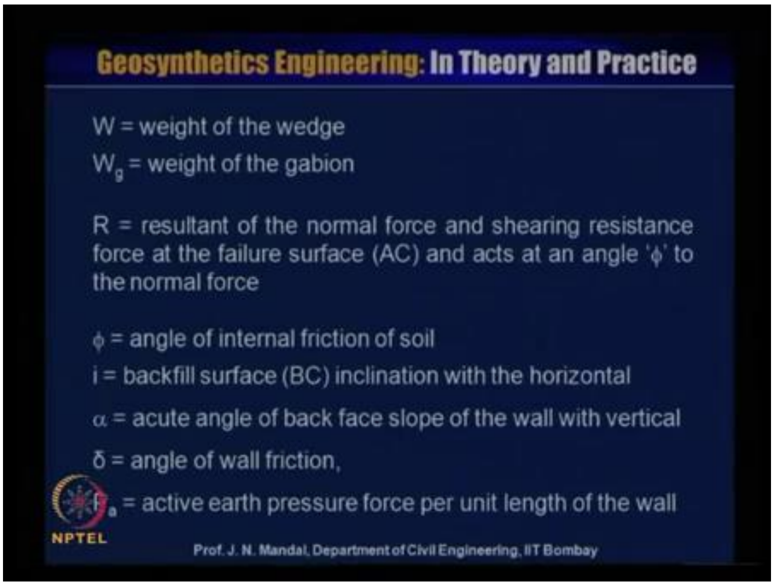

So, this term is the same for all other cases also. So, here this is negative this alpha. This is inclined step front face. So, it is a negative this here alpha. So, it may be the positive while at the back face it is negative pointed to the front face and other parameters are the same. So, all 3 cases, it is the same whether it is a vertical, whether it is inclined step front face, whether it is inclined step back face.

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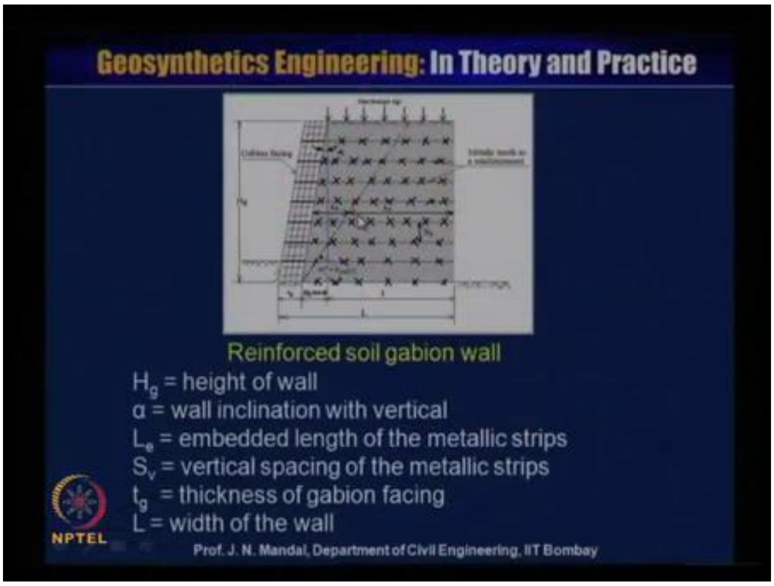

Now, this is the reinforced soil gabion wall. So, here is the reinforced soil gabion wall.

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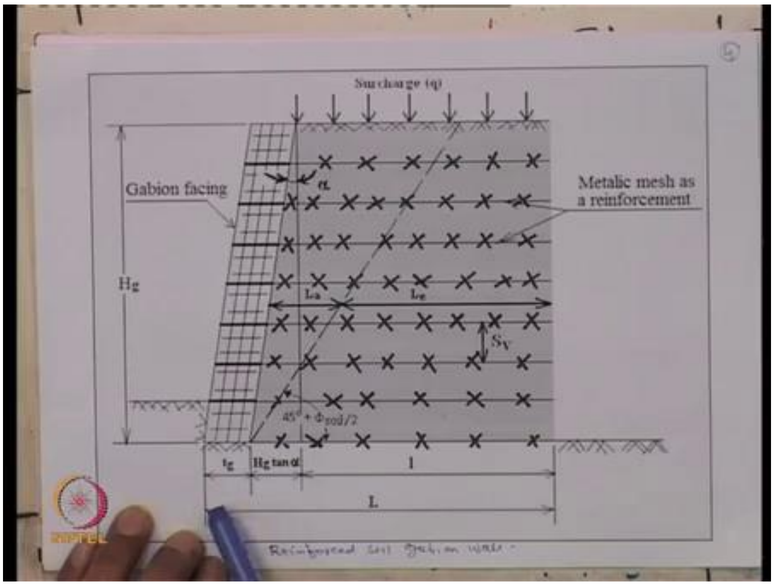

So, here this is a gabion wall. This is the reinforcement number of the layer of the reinforcement, this number of the layer of reinforcement attached with the gabion. So, earlier we saw only the gabion itself is forming a retaining wall. Now, gabion here only acts as a facing element. Then, the numbers of the layer of reinforcement are placed here. There is also the surcharge load is q. So, height of the wall that is designated H g. This is alpha, which was inclined with the vertical this wall inclined with the vertical.

This is the failure line, which is making at an angle of 45 degree plus phi by 2, this also reinforcement at a metallic mesh as reinforcement. You can add L of e, it is the embedment length of the metallic strip. Here that spacing between the 2 metallic strip reinforcement is designated as S V. This is the thickness that is t g is the thickness of the gabion facing. This is L is the width of the wall. So, if this angle is alpha, then this height is H. So, this distance will be H g tan of alpha.

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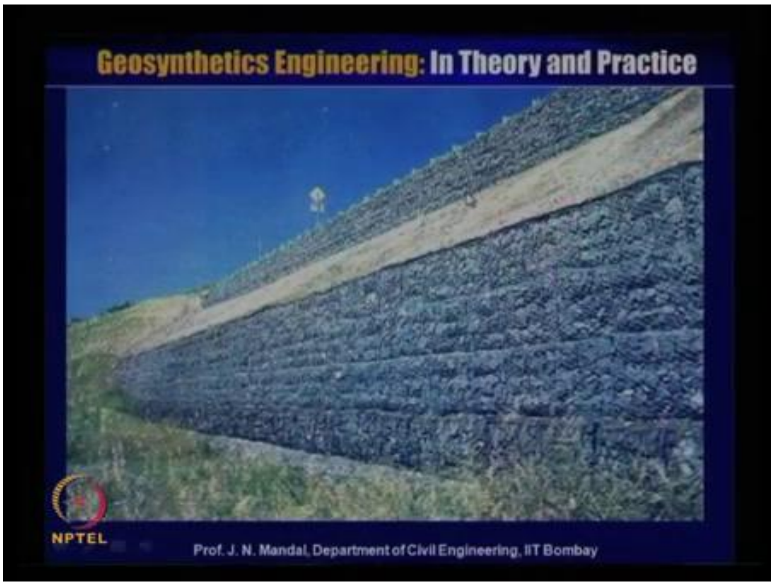

So, you can construct a wall like this.

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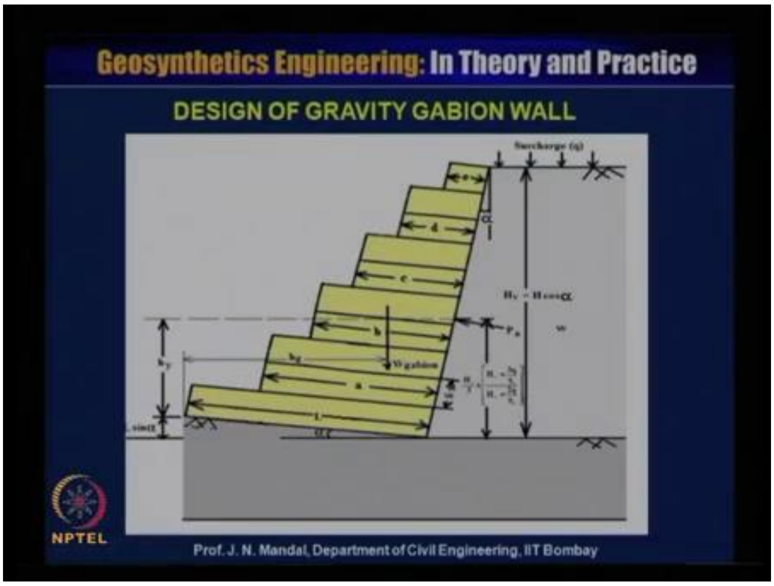

So, now, I will show design of the gravity gabion wall. Now, you can design the gravity retaining wall. So, this is the wall gravity retaining wall. Here this wall height is H and you have a surcharge load is q and backfill slope angle is let us say i. The angle of friction between the wall and soil is delta and wall inclined with the vertical is alpha. Let us say soil friction angle is equal to phi soil density is equal to gamma s gabion fill has a density is equal to gamma of g and soil also bearing pressure, which we can say q of allowable. Scale correction factor is C i. Maximum total base width is L generally 0.7 times the height of the wall. Here, it should be noted that this is a b c d e.

So, this is the width of the gabion. You can see there are 2 layer of the gabion whose width is a. After this, you can see the 2 layer of gabion whose width is b. After that, again 2 layer of gabion whose width is c, after that 2 layer of gabion whose width is d, after that 1 layer of gabion whose width is e. So, this you have to remember because like that you can construct a gravity gabion wall. Suppose that width is 7 meter. Then, this is if the gabion wall is 1 meter and 2 layers, 1, 1, 2 meter, so 1 meter, 1 meter, then again 1 meter, 1 meter, 4 meter, then 5, 6 meters, 7, 8, 9, 10. Like that, you can make a gabion wall at any height.

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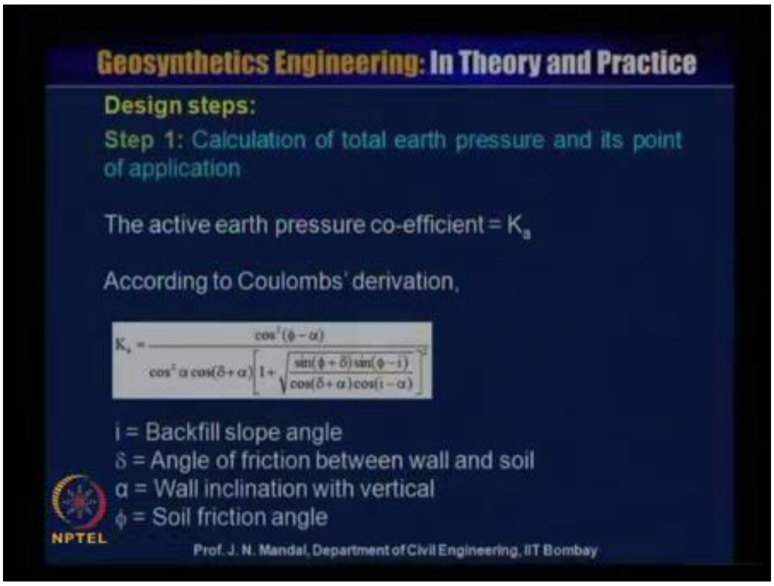

Now, design step, now step 1 is the calculation of total earth pressure. It is point of application. You have to find out that what will be the active earth pressure coefficient that is K a. According to the coulombs equation you can calculate this K a with this equation. K is equal to cos square phi minus alpha divided by cos square alpha into cos square delta plus alpha into 1 plus root of sin phi plus delta into sin phi minus i divided by cos delta plus alpha into cos i minus alpha where i is the backfill soil slope. Delta is the angle of friction between wall and the soil and alpha. Alpha is the wall inclination with the vertical and phi is the soil friction angle.

So, whatever the value will be given, i delta and alpha and phi, you can substitute this value here. Then, you can calculate the K. Sometimes that is backfill of the slope angle is not there. Then, i will be the 0 where wall inclined vertically there alpha will be 0. So, this equation you have to adopt for the determination of the earth pressure coefficient K of a.

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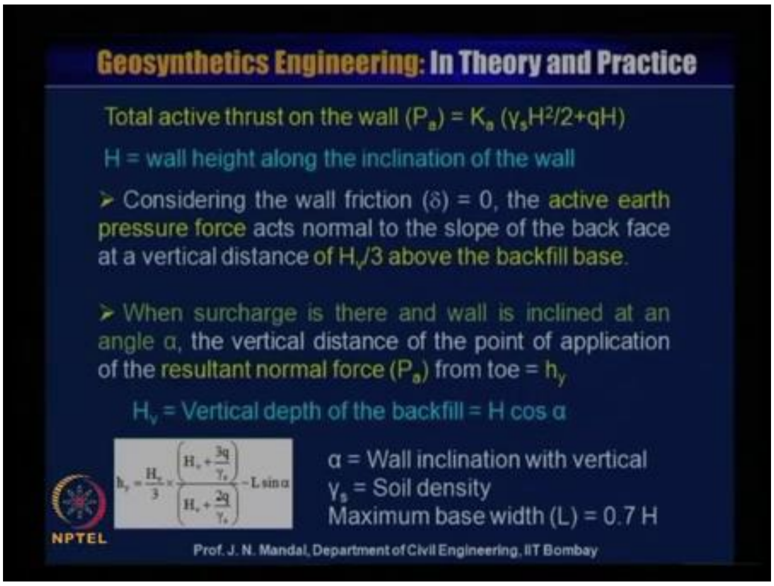

Now, total active thrust on the wall P a will be equal to K a into gamma s H square divided by 2 plus q into H that is due to the surcharge load. Also, H is equal to wall height along the inclined of the wall. So, here considering the wall friction angle delta is equal to 0, active earth pressure forces act normal to the slope of the back face at a vertical distance of H by H by 3 above the backfill base. When the surcharge is there and wall is inclined at an angle alpha, then vertical distance of the point of application, the resultant force P a from the toe is equal to h of y. So, H v is equal to vertical depth of the backfill I am showing you here.

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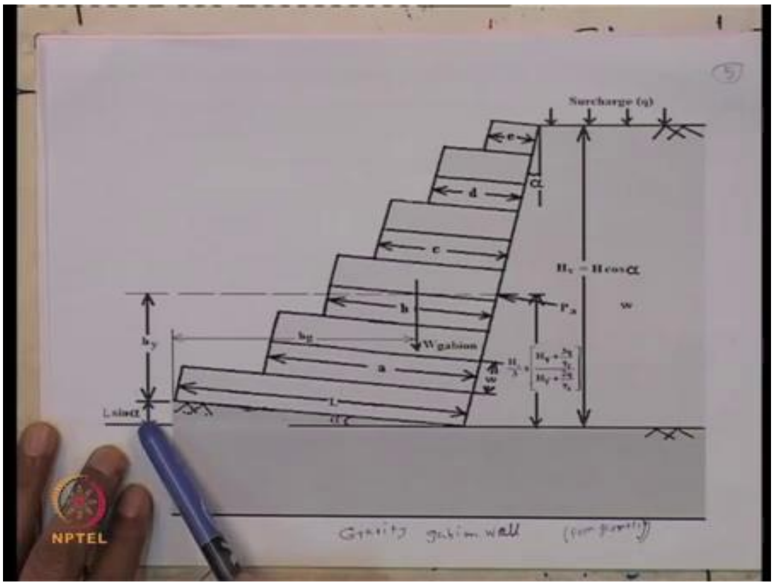

That is H of v is equal to vertical depth of the backfill that is H into cos alpha. This angle is alpha i say H of the wall height. So, this will be the H cos alpha. Alpha is the wall inclination with the vertical and gamma s you know that is the vertical soil density. You have to determine what is the h of y because this P a, which is acting at a distance from this base, so you have to calculate what is h y. So, this h y will be equal to H v divided by 3 into H gamma plus 3 q by gamma s divided by H v plus 2 q by gamma s. This is from the geometry of this. You can calculate that what should be the h value. So, this h y because you know this and you know this is alpha, so this will be the L of sin of alpha.

So, this h y will be from here to here this minus of L f sin alpha. So, h y will be this minus L of some sin alpha. So, this will give you what will be the value of h y. So, this you can obtain from the geometry of the gabion structure. So, for this gravity retaining wall, so you have understood that what will be the different types of the gabion retaining wall. The retaining wall with gabion, it will act as a facing element and then also the gabion itself will act as a gravity wall. So, you know some theory behind this, how to calculate that total active thrust on the wall and at what distance. With this, I finish this lecture today, and let me hear from you any question?

Thank you for listening.