Application of Soil Mechanics
Prof. N.R. Patra
Department of Civil Engineering
Indian Institute of Technology, Kanpur

Lecture – 35

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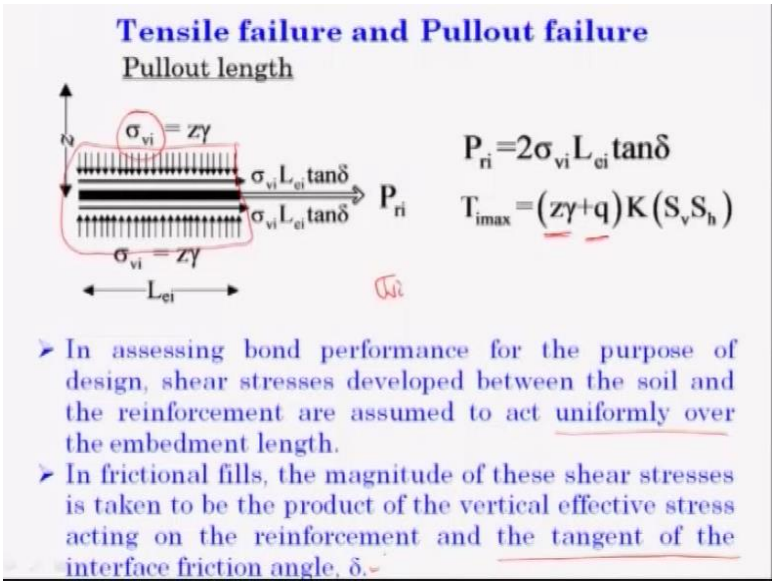

Next part of this lecture is tensile failure, and pullout failure first part is your pullout length. If you come back to last class; there are two zones one is active zone other is resistant zone. So, particularly in this case l e i is your acted upon by this resistant zone now this pullout length, it is if we look at there is a reinforcement of this; these part is acted upon by this soil, and sigma v i soil over this it is gamma z at the bottom of it is gamma z. So, p r i is equal to two sigma v i l e i delta, and t i maximum is equal to z gamma z. So, p r i is equal to two sigma t i l e i delta, and t i maximum is equal to z gamma z gamma z is or soil q plus q, if is there any searcher in to k times s v into s h s v is spacing in vertical direction s h is spacing in lateral directions; that means, suppose this is wall if you are placing like this; that means, spacing in vertical direction s v if this wall is going distance like this.

So, spacing in lateral also horizontal direction also s h now in accessing bond performance for the purpose of design shear stresses develop return the soil, and the reinforcement are assume to are uniformly over the abandonment length in frictional fields the magnitude of this stresses is taken to the product of vertically effective stress vertical effective stress is this particularly with magnitude of shear stresses; that means,

magnitude of this shear stresses is vertical effective stress sigma v i, and the tangent of the interface friction angle delta, and tangent of the interface friction angle delta.

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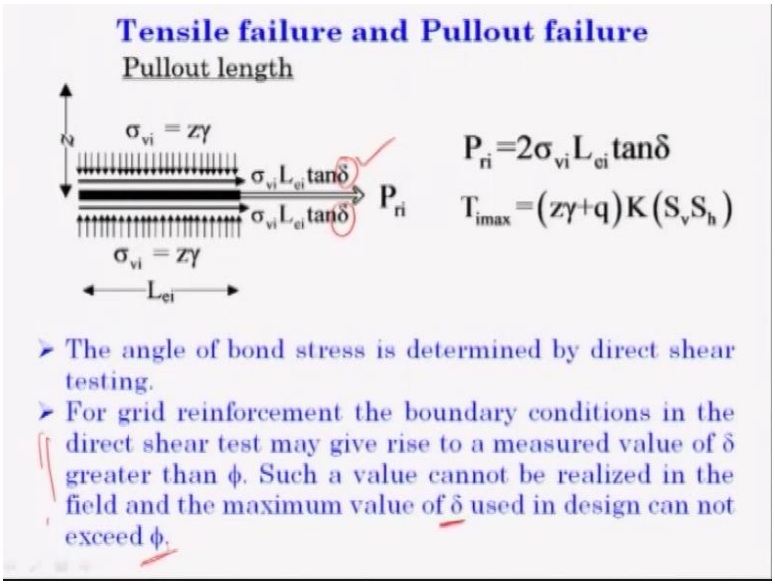

The angle of bond stress is determined by direct shear test how do find it out this delta; that means, coefficient of friction between soil, and this material. Now, if there is a shear box test in that shear box test one side you can put it at the bottom soil about of this we can put the reinforcing material, and from there we can get it the value of delta get the value of delta sigma b into than delta is usual sigma h into l e i over a length for grid reinforcement the boundary conditions in the direct shear test may give rise to a measured value of delta greater than five such a value cannot be realized in the field, and the maximum value of delta used in design cannot exceed five look at this the maximum value of delta the condition is the frictional angle with soil, and this reinforcing material; that means, your delta it. So, not be exceed to five; that means, internal frictional angle of the soil.

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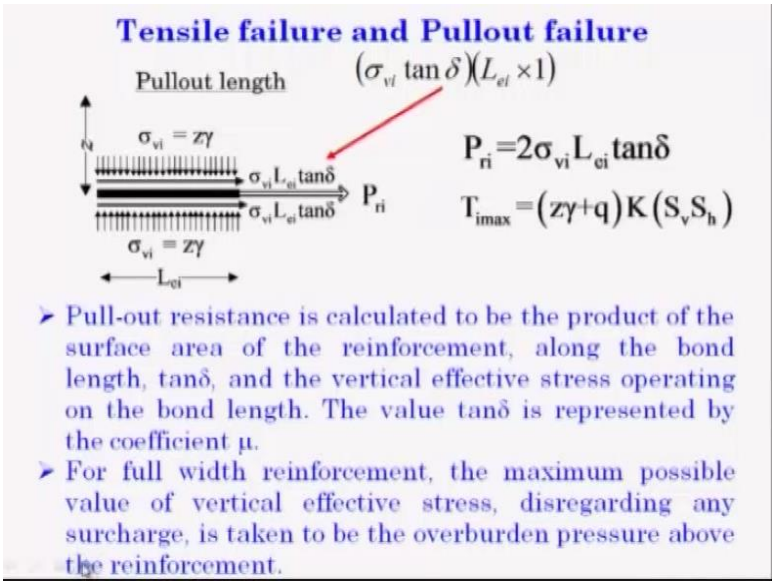

Now, pullout length pullout registration is calculated to the product of surface area of reinforcement along the bond length tano delta, and the vertically effective stress operating on the bond length the value of tano delta is represented by coefficient view the value of can delta we can take it has four percent of mew. If we look at this if a product of sigma v i is tang delta l e i is length, and over this surface area it darks or cool width of this enforcement of maximum possible value of vertical effective stress, and disregarding any surcharges is taken to be the over burden pressure about the reinforcement without any surcharge without any surcharge it comes output zero q zero surcharge. So, this will be a gamma j into s v into s h now if we look at this picture view.

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If I take it in a pectoral view this is the spacing, if this is the spacing in lateral direction or horizontal spacing. Once you place one layer nice you place one layer of your enforcement layer; these are all your enforcement buts these are all reinforcing buts once you place a, but once you fill it, then again once you place a another buts this direction is spacing vertical this is your spacing in lateral or horizontal direction pullout resistance is calculated to be the product of the surface area of the reinforcement along the bond length as I said tan delta, and the vertical effective stress operated on the bond length the value of tan delta is represented by coefficient mew. Now the another tow is coming into picture, that is your n n mean how many number how many numbers in that directions you can write it in terms of n this is your n.

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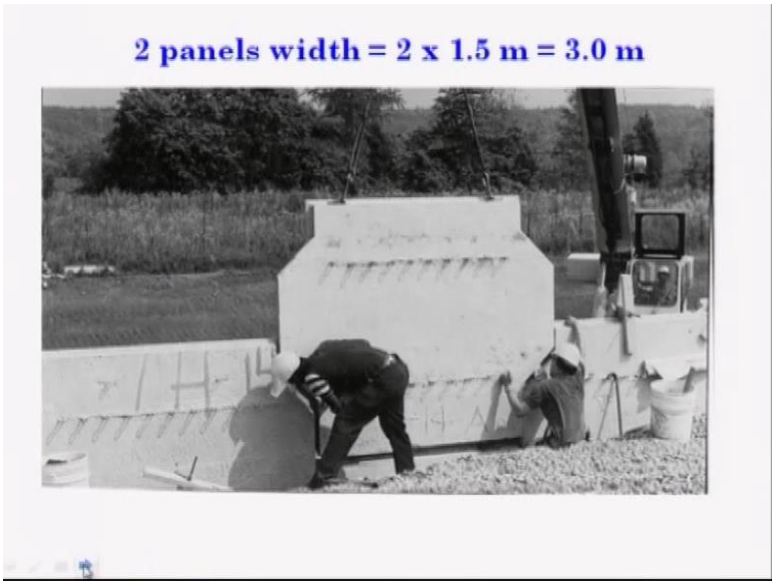

Now, two panel look it there are two panel if we can look at here the panel shape is the panel shape is it is like this, and t is like this. So, one will be connected here, and one will be connected here if it is two panel it, then two into one point five generally three meter of spacing we can keep it this is all about here pullout length whatever we have discussed tensile failure, and pullout failure pullout length.

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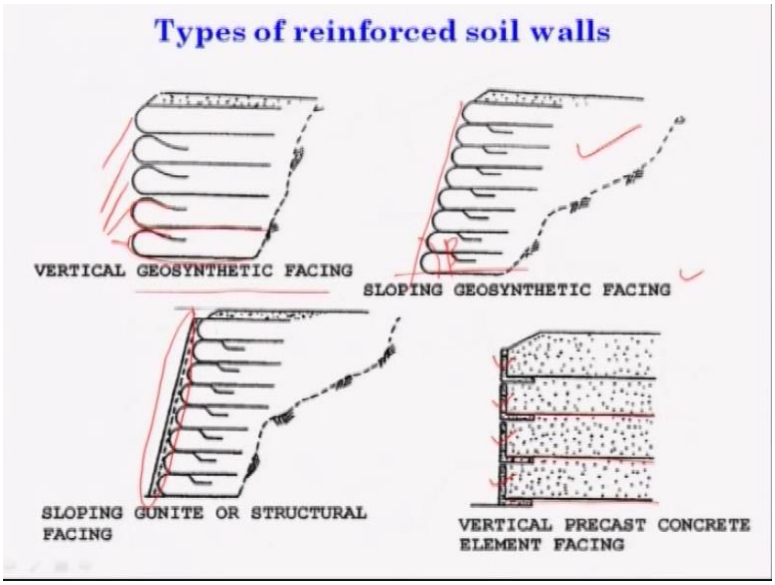

Now, come to the next types of reinforced soil walls what are the different types of reinforce soil walls one is your vertical geo synthetic face; that means, the reinforce wall

can be arrange in such a way that it will stand vertically with geo synthetic face; that means, this is your geo synthetic face in vertical direction, other is your sloping geosynthetic facing; that means, you can arrange you can make a ground reinforce or wall. So, that you can make it as a slope with respect your horizontal make it as a slope this is called sloping geosynthetic facing, then third one is sloping gummite or structural facing after in this case what will happen?

First prepare the reinforce soil wall this is your reinforce soil wall sloping soil wall as it is like this, then a structural facing along with the after this reinforce soil wall has been prepared, then its structural facing it can place over a side, then third one is vertical precast concrete element facing other the means either you can concentrate by means of geosynthetic by means of reinforce wall one by one; that means, one reinforcing material you are taking, and hold it, then hill the soil, then another reinforcing material you are taking hold it. So, what will happen? No structural element is required. Fourth one is in these case precast concrete element facing these are all your precast this is precast concrete facing a element, then in this precast concrete element facing layer by layer we can place your reinforcement here layer by layer with connected to precast concrete element facing these are all your four types of reinforcing soil walls also transortize.

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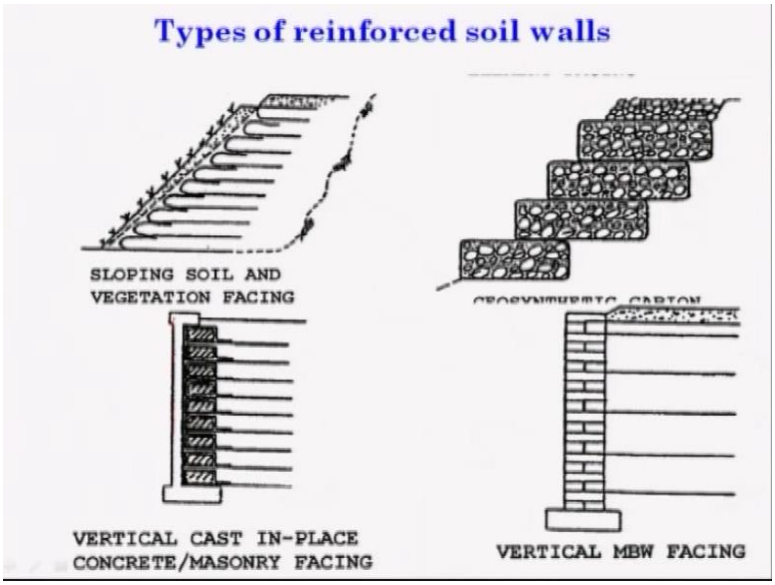

Then second one is your sloping soil, and vegetation facing what happened for the economic point of you these, because once you are making a sloping once you are

making a sloping face of this reinforcing wall reinforcing wall these are all exposed to outside these are exposed to outside to prevent this you can go for you can do it by means of vegetation, then allowed the vegetation; that means, you can allowed grass. So, that it will be protected third one is your by sloping, and geosynthetic gabion; that means, you can geosynthetic gabion by means modes, and wears or geosynthetic wears you can provide the gabion wall by stepping fourth one is vertical cast in place concrete or missionaries; that means, you can straight way instead of earlier is there. It will look at here vertical precast concrete element facing that is you can take one precast another precast place one or other, and connected, then go for your reinforced wall construction, but in these case we can go for a single vertical cast in place concrete this is your single vertical cast in place concrete with missionaries facing this is all your missionaries facing, then allowed this reinforcement to be placed the vertical now facing also you can face it you can you can do it also.

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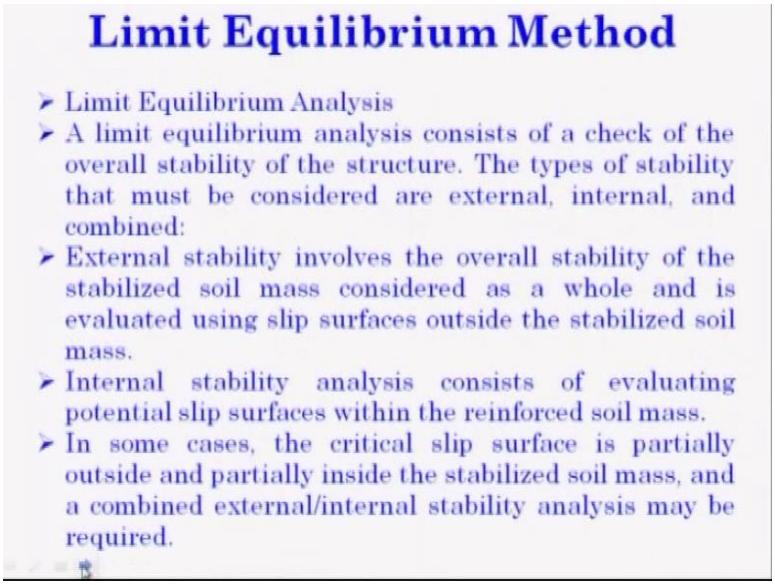

Then these are all about basic properties, and how these full outing, and how is your, and what are the different types of reinforced. Now we are going for analyzing, first analyze is your liquid limit equilibrium method in limit equilibrium analysis, in case of limit equilibrium analysis the limit equilibrium analysis consists of a check of overall stability of the structure once you go for limit equilibrium method; that means, you are taking this overall stability of structures the types of stability that must we considered an external internal or external internal both the stability you are going to take particularly in case of

limit equilibrium method; that is your external or an internal an either external or internal or external or internal mix external stability price says it is not stability external stability involves the overall stability of the stabilized soil mass overall stability of the stabilized soil mass considering as a whole taking into consideration as a whole of soil, and reinforcing are as a whole what is this overall stability.

And is evaluated using slip surfaces outside the stabilized soil mass, it has been evaluated by using a slip surfaces outside the stabilized soil mass in case of internal stability analysis. We can evaluate internal stability analysis evaluating potential slip surface within the reinforced soil mass once you are saying that internal; that means, what happened internally inside your reinforcing materials what type of in some cases the critical slip surface is partially outside, and partially inside this stabilized soil mass, and a combined external, and internal stability analysis may be required in some cases what happened the critical slip surface is inside the soil mass, and outside the stabilized soil mass in that case we will considered both external as well as internal as a combined stability analysis.

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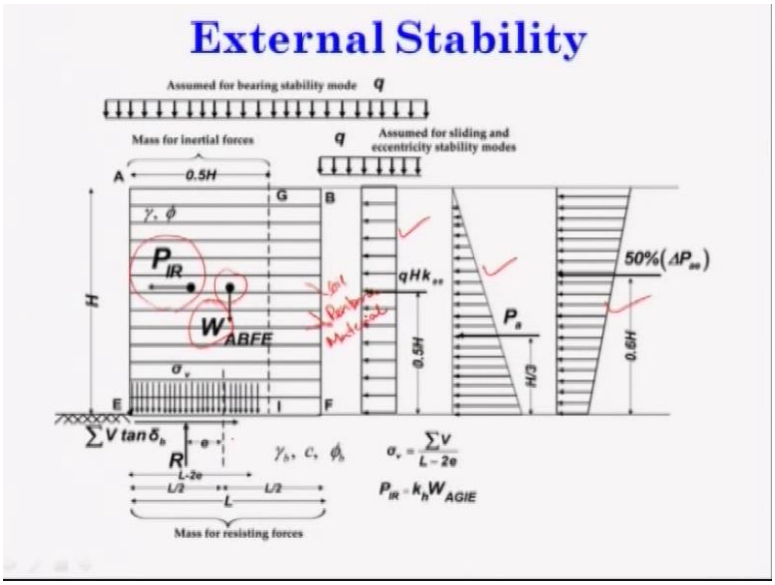

Now, if you look at this external stability. If you look at this external stability, because if there is a soil mass in these soil mass it is acted upon by soil start, then we can find it out, because of sub charge what is your active of pressure, because of soil what is your pressure acting on this, because of other load what is your pressure acting on this you

taking into concentration on it you take into concentration on of all process, then find it out what is your result of lateral process, then if I am going to consider soil mass if this is soil, and these are my enforcing material enforce material, then this enter soil mass, and reinforce material, it has its own way, it is own way that is own weight, it has its own weight, that is your own weight w is equal to own weight. If I am considering a b d a of these own weight, then it can find it out the own weight of how much is your own weight how do you find it out by if you know the unit weight of the density of these soil as well of the enforcing materials, then you can find it out its own weight, then it will you can find where is your c g it will act on the c g, then based on that what is your reaction course are the bionomic, and find it out how far this reaction force is going to are from the certeriod of the center of this soil mass of the enforcing material, and what are your lateral forces acted below the reinforcing material.

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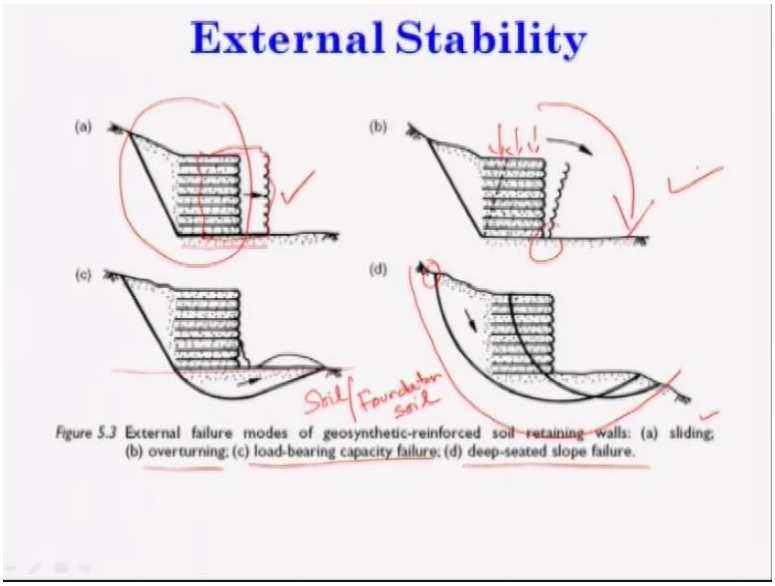

If you look at the external stability this in combined, I have soon this in combined I have soon if you go to the external stability external failure most of geosynthetic reinforced soil retaining walls first one is your slidy, if we look at your a is your slidy; that means, what will happen? It may positive that inter soil mass along with inter soil mass reinforcing material it may slide it may slide. Suppose it is there it will slide, and it is will take a new position from here to here second part is your external stability, if it is it cannot take the enter load coming to the reinforce earth will whatever the load coming to it may possible that it may over turn it may over turn at some point. So, it will overturn at

some point this is called over turning third is your load bearing failure; that means, if this is my reinforcing soil wall reinforcing wall, then what will happen it will be it will be placed over the soil mass or the foundation soil or you can say foundation soil. Now you can check how much is this load bearing capacity; that means, what is your bearing capacity whether it is load bearing capacity failure this is also coming in to taken into consideration in external stability.

Then deep seated slope failure deep seated slope failure means, if there is a possibility that if there are loose fill materials are there the failure surface may occurring deep seated means it will cover it will start from this reinforcing mask it will go beyond, and it will cross over the foundation soil this is called deep seated failure surface. If I summarize external failure modes of the geo synthetic reinforce soil retaining walls first one is your sliding, second one is your overturning, third one is your load bearing capacity fourth one is your deep seated slope failure bearing, and tilt failure is…

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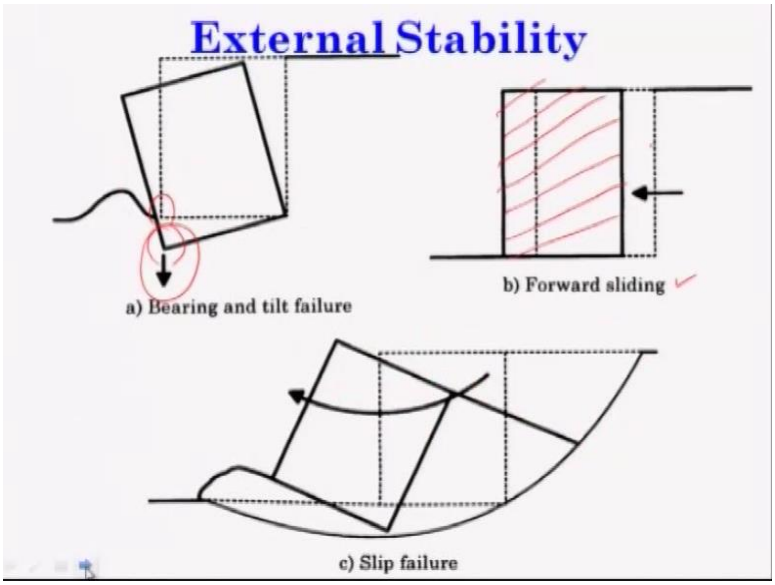

If we look at it; that means, what I said it will it will rotated at one point it will rotate if we look at that over turning; that means, in this case with respect to one site of this it will rotate that it will say that that sliding; that means, if this is the this is the original say oh original mass of the reinforce wall. So, what happen if this lateral forces are maximum. So, what happen from this position to this position it will slide. So, forward sliding this is called forward sliding this is called forward sliding, then third is slip failure; that is

failure surface, we can take into consideration of the slip failure External stability in overall it is your slidy; that means, it will slide from its original position to another position over turning if it is eccentricity it is there over turning when it is possible. If you go if the result, and force this is my result, and force if it is not acted at the center it if it is acted at a distance of e this is called eccentricity at a distance e, then there is chance over training; that means, eccentricity. So, it will top all or it may overturn at one point, then bearing capacity this is your basically foundation failure bearing capacity.

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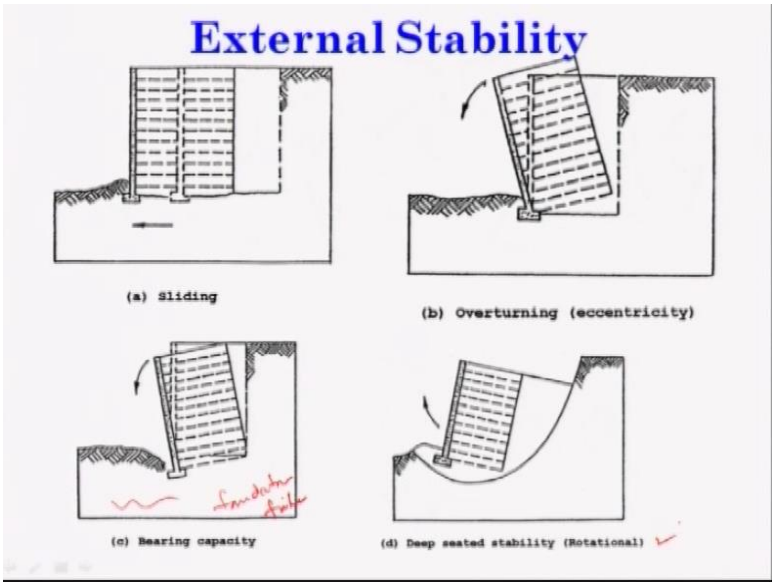

Then fourth one is deep seated stability or rotational stability some time, we say it will go deep root of this soil mass.

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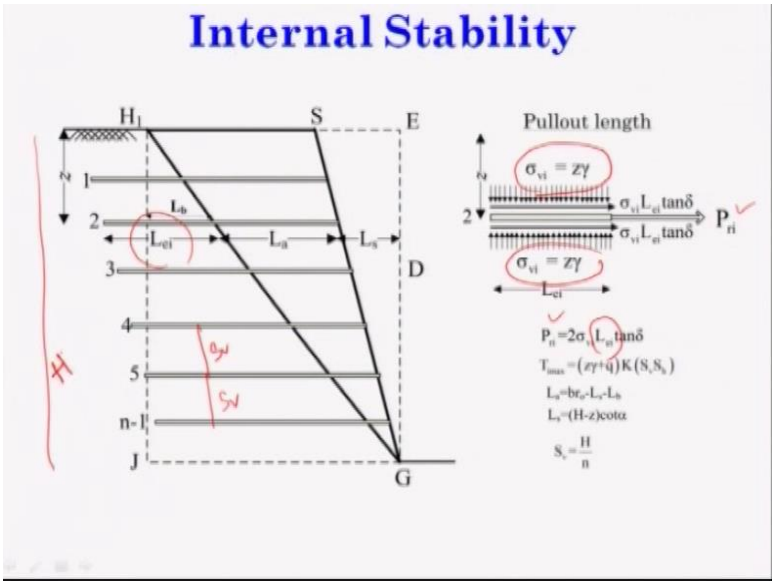

Then next part is your internal stability what are the internal stability, if I make it into two part one is your, if you come back to earlier slides.

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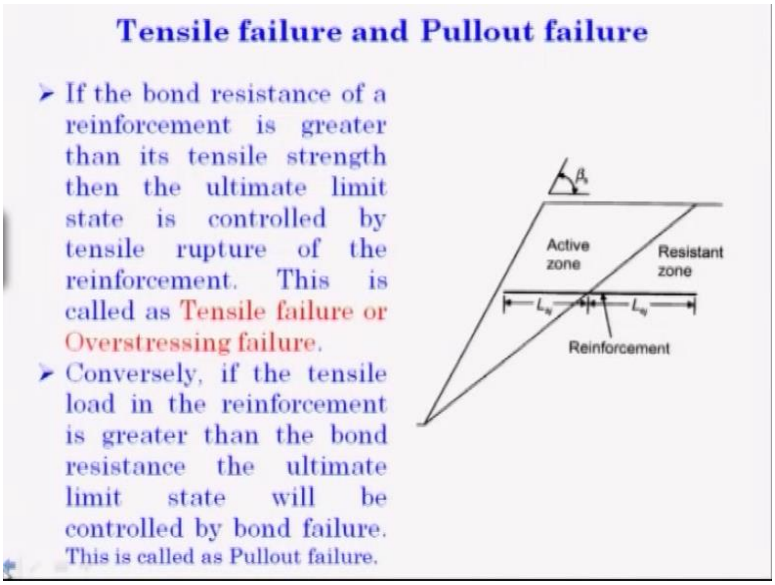

Where I have shown it active zone, and resistance zone, if you provide reinforcement; there are two zone; one is your active zone, and other one is resistance zone. If you take this two into considerations in the internal stability failure. Now this is your active zone, and this is your resistance zone, now it from there with these we can find it out how much is your pullout length, how much is your pullout length waste on your over burden

or may be the the surcharge. So, p r i pullout length is two big why it is two at the top this is sigma b i j at the bottom of the sigma gamma j, and at the surface, because two surface one is your top surface, and other is bottom surface.

So, two sigma p i, and delta into l c i l e i that is your piratical length or you can say that pullout length. So, from there you can find it out t i maximum from there you can find it out a lay now a from here also we can get it. If we look at we can get it l e i lei from your pullout resistance if you know the pullout resistance p r i, then you can find it out l e i; that means, for active zone what is your length or pullout length, then if you know the maximum pullout resistance t, then from there we can find it out a lay in this zone a, then l s also we can find it out h minas j. If this is the this is the total is your total height is you are say h, and this at any distance j, it will be h minas j into, and s g is vertical spacing in vertical direction, which is equal to total height age if this is my total height h, if this is the total height h they need to be h by n n is equal to number of reinforcement n is equal to number of reinforcement.

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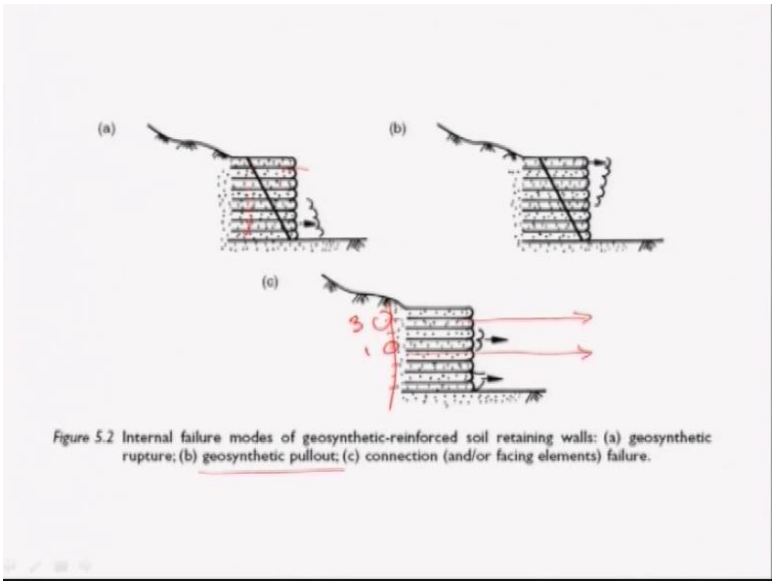

Figure 5.2 Internal failure modes of geosynthetic-reinforced soil retaining walls: (a) geosynthetic rupture; (b) geosynthetic pullout; (c) connection (and/or facing elements) failure.

Now, come back to internal failure modes of geosynthetic reinforce soil retaining walls, if you come back to internal failure there are ones geosynthetic rupture, it may possible that this geosynthetic walls. If these are my geosynthetic walls; that means, wall one two three four five six seven eight these are all reinforcing walls it may possible that over the period of the time these tiles walls made rapture it may rapture. So, what will happen this

is called one of the internal failure, then geosynthetic pullout. If it is a expose to this outside, then what happen by means of animal or by means of cattle it may possible that it may be pullout number one number two case is that if the pullout resistance is less, then what ever this whatever the lateral resistance, then what may possible that there may be pullout failure of this geosynthetic reinforcement, then connections; that means, facing a limit. Suppose it has not been properly connected, if you go back to this connections look at here here particularly here these walls these geosynthetics or reinforce reinforce reinforcing material it has to be properly connected with your wall it has to be properly connected with your wall here there is a proper connection with your wall if there are not proper connection between this wall, and the reinforcing material what will happen it is called connection failure suppose this is your wall this is your wall, and you are connected one by one. So, there suppose in between at this point one say point three there is no connection by or may be a faulty connection is not connection failure is there what will happen over the period of time these wall will come out from the reinforcing marks also these walls will come out from the reinforcing mask.

So, there are are three type of failure, we can say that internal failure modes ones your geosynthetic rupture; that means, over the period of time it may possible that geosynthetic will rupture second is geosynthetic pullout, because one of the geosynthetic may be pullout, then third is there is connection failure; that means, facing a limit, if it has not been properly connected it may fail by means of connection failure.

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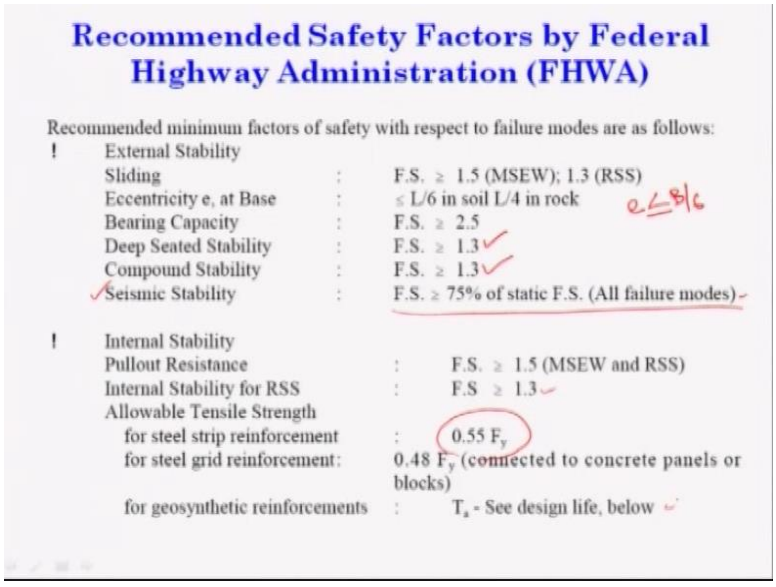

These are all here too per limited, if I summarize there are two stability analysis one is your external stability, and other is internal stability or this stability analysis what are the recommended factor of as given by federal highway administration f h w a, what is the recommended value for external sta stability. It has been summarized by one is your external, and other one is your internal external stability for sliding for sliding the factor safety should be greater than one point five or if is a m s e w wall it is one point, if it is r s s it should be one point three eccentricity at base it should be less than equal to six.

Otherwise there will be a tensile stress below this below this wall. So, it should be less than equal to; that means, e eccentricity should be less than equal to b by six bearing capacity factor safety should be greater than equal to two point five. If it is not greater than means there is a bearing capacity failure deep seated stability factor safety is greater than equal to one point three compounded stability factor should be greater than greater, then equal to one point five stability more importantly, and going to discus later an seismic stability factors safety should be grater, then equal to seventy five percent of static factors safety; that means, seismic stability is seismic factors safety should be greater than equal to seventy five percent of static factor safety all failure mores, then internal stability if you come back to internal stability pullout resistance for pullout resistance the factor safety should greater than one point five for all internal stability for r s s factors safety should greater than one point three allowable tensile strength for steel strip reinforcement there are different types of reinforcement for steel strip reinforcement.

It should be zero point five five f y for geosynthetic reinforcement t a design life of this below this are all the recommended value, this are all the recommended value of federal highway administration awaits w a in united states of America different recommended factors of the value. Now will start the design method for inextensible reinforcement means it will be there are two types of reinforcement one is extensible reinforcement other is in external reinforcement in inextensible reinforcement number.

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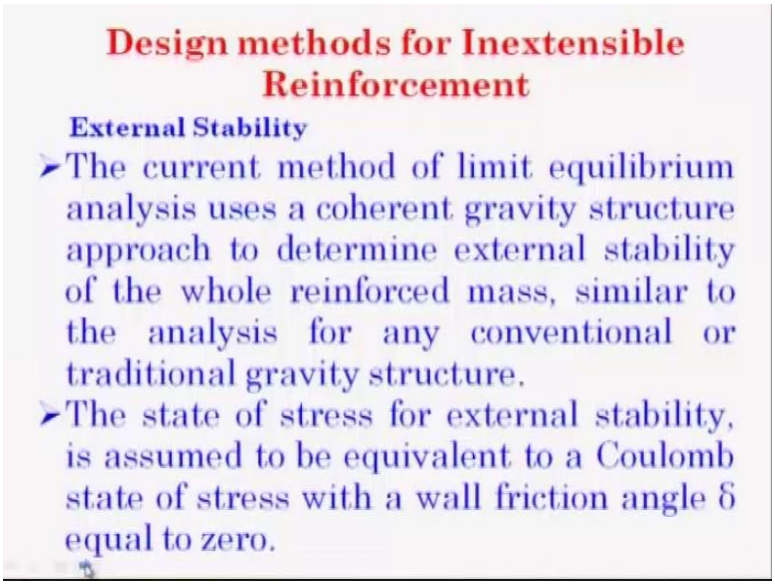

One is external stability the current method of limit equilibrium analysis uses a coherent gravity structure approach, look at here uses a coherent gravity structure approach to determine external stability of the whole reinforced mass, similar to the analysis for any conventional or traditional gravity structure; that means, the current methods it says as like conventional or traditional gravity structure it as been assume for external stability it will be taken as a whole mass whole reinforced mass the state of stress for external stability is assumed to the equivalent to a coulomb state of stress with a wall friction angle delta equal to zero with a wall friction angle delta equal to zero; that means, it is a smooth wall delta equal to zero means consent of frictional between soil, and wall if it is suppose to be zero; that means, it is called as a smooth wall.

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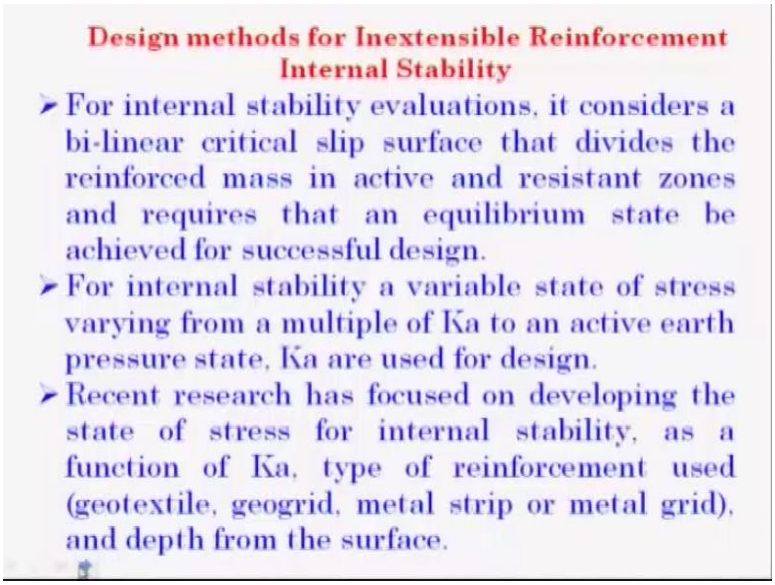

Similarly, design methods for inextensible reinforcement in external stability; first one is your external stability, second one is internal stability for internal stability evaluations, it considers a bi linear critical slip surface. Look at here it considers a bi linear critical slip surface that divides the reinforced mass in active, and resistant zones as we discussed also earlier that dived the reinforce mass in two parts one is your active, and other is resistant zone, and requires that an equilibrium state be achieved for successful design for internal stability a variable state of stress varying from a multiple of k a k a is your active earth pressure to an active earth pressure state ka are used for the design; that means, for internal stability a variable state of stress varying from a multiple of k a multiple of k a means multiplication of k a k a is your active earth pressure, recent research has focused on developing the state of stress for internal stability as a function of ka type of reinforcement used geotextile geogrid metal strip or metal grid, and depth from the surface.

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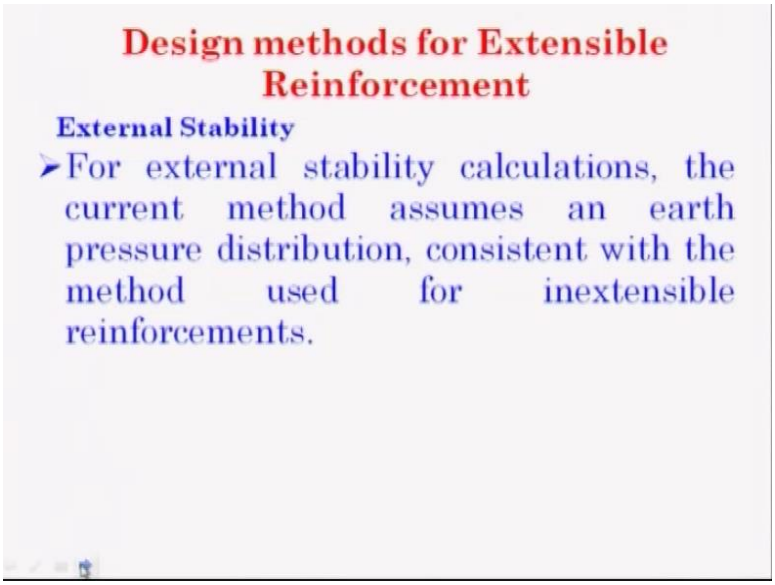

Inextensible early what early what we have discussed that is your inextensible reinforcement external as well as internal stability now second one is extensible reinforcement external stability. For external stability calculations the current method assumes an earth pressure distribution look at here in this case whole entire entire reinforced mass as been consider as one mass for in extensible reinforcement for extensible reinforcement extensible reinforcement it assumed an earth pressure distribution earth pressure distribution, and consistent with the method used for inextensible reinforcements.

First it has been assumed for earth pressure distribution, then ones earth pressure distribution as been made, then it will follow the similarly procedure for external stability in case of inextensible reinforcement similarly internal stability.

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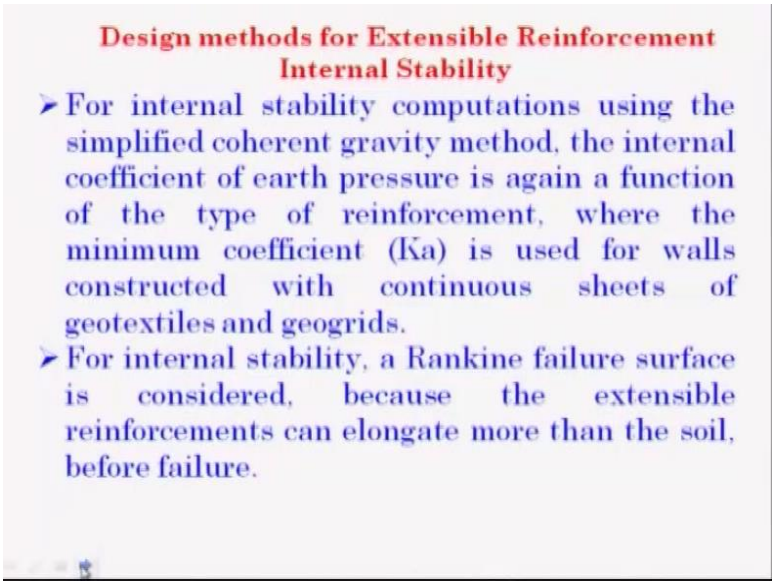

For internal stability computations using the simplified coherent gravity method the internal coefficient of earth pressure is again a function of the type of reinforcement the Internal stability internal coefficient of earth pressure internal coefficient of earth pressure is a function of the type of reinforcement where the minimum coefficient ka is used for walls constructed with continuous sheets of geotextiles, and geog rids for internal stability a rankine failure surface the difference if you look at here in this case the rankine failure surface is considered, because the extensible reinforcements can elongate more than the soil before failure. I will stop it here, then will start detail discussion about British standard other method along with seismic design also next class.

Thanks a lot.