Applications of Soil Mechanics
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Lecture – 36

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Will discussing this class a class design methods by means of federal highway administration whatever they given step by step.

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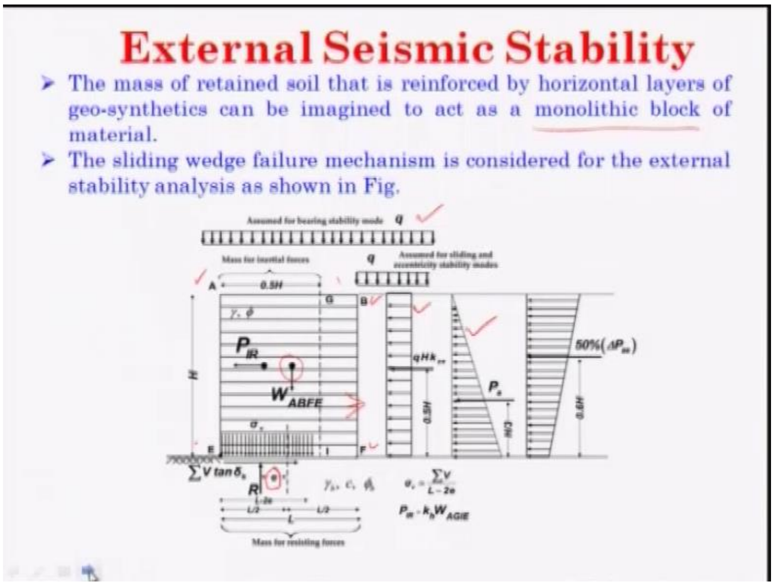

Now, first one is your external seismic stability the mass of retained soil that is reinforced by horizontal layer it should be considered as a monolithic block; that means, it is as if a one unit soil plus reinforced materials has one unit the sliding which failure mechanism is considered for the external stability analysis it look at the figure.

This is your mass of soil mass which has been reinforced by means of geo synthetic layers it has been considered a one layer, and this c g, and in this c g center of gravity unit weight means weight of your soil as well as weight of your of course, geo synthetic materials are counted to uniquelase. So, weight will acted in vertically that is your a b f e; that means, a b f e. If I considered this mass of soil while reinforced by means of geo synthetics, then there are there are result, and force which will act at a distance this result, and force will act at distance of a eccentricity e from the c g, and sliding mass will be considered by means of external stability, we look at here. This is your origin to layer of the course acted which is your summation of beta, and delta b delta b is your opposite of fiction of soil mass are the best with your soil at the top, and earth pressure distribution diagram considered for taking into consideration of surcharge if this is my surcharge say q is your surcharge. So, these diagram is your earth pressure, because of your surcharge, and these diagram is your earth pressure because of soil mass.

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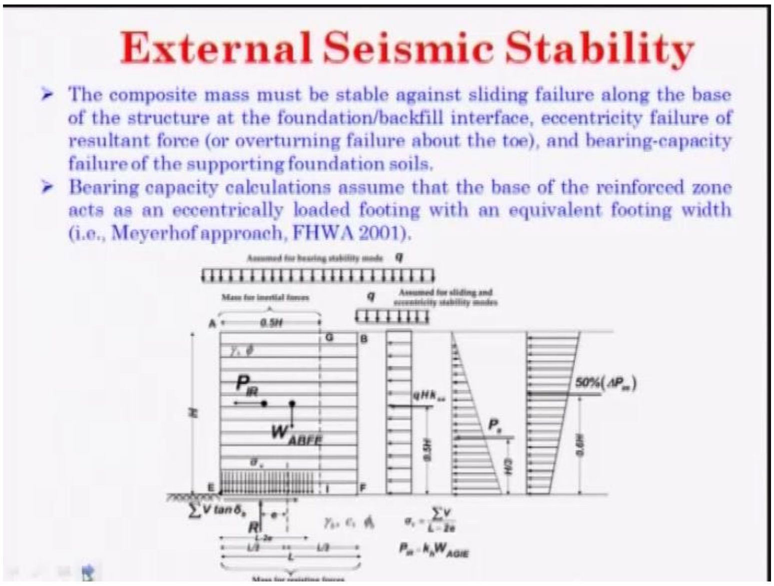

The composite mass must be stable against sliding failure along the base of the structure as I said along the base, this your base of structure, it will be stable against your sliding failure base of the structure are the foundation, and backfill interface at the foundation, and backfill interface, this is your backfill this your foundation.

So, this is your foundation, and backfill interface eccentricity failure of result, and force this is my result, and force r, and this is eccentricity result, and force; that means, because of eccentricity it will be acted as your discuss earlier over study failure over the, and the bearing failure of the supporting foundations soils as well; that means, bearing capacity of the entire soil mass, because of your supporting foundations this is the supporting foundation bearing capacity calculations assume that the base of the reinforced zone act as an eccentrically loaded footing with an equivalent footing width with an equivalent footing width; that means, we assumptions is on is a as if it is a eccentrically loaded footing this is eccentrically loaded footing with an equivalent footing width; that means, this your equivalent footing width.

So, based on that if you are getting a b, then you can find out your bearing capacity calculations, and this calculation has been made as per the meyerh of approach whatever given meyerhof approach. So, it is taken is f h w a two thousand and one.

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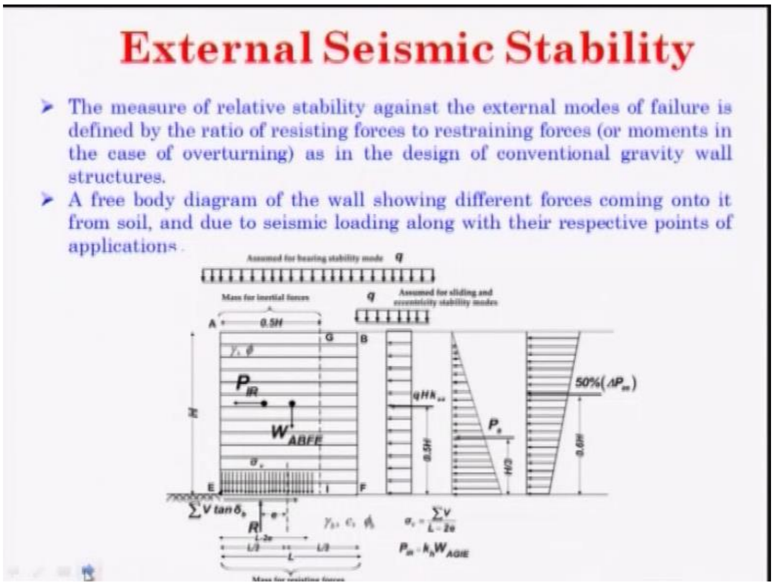

The measure of relative stability against the external modes of failure is defined by the ratio of resisting force to the resisting forces that that measure of relative stability against the external mode of failure, this is we are talking about external seismic stability external modes of failure is defined by the ratio of resisting force to the restraining forces. If you look at here ratio of resisting forces what are your resisting forces this is your resisting forces and restraining forces; that means, lateral forces we are resisting forces as in design of conventional gravity wall structure, then a free body diagram of the wall showing different forces coming onto onto it from soil, and due to seismic loading along with their respective points of applications you have to draw a free body diagram. If you see here this diagram has been drawn, and will have to show difference forces coming or acted on this all mass or the reinforced earth wall. So, this is your weight; that means, acted at the c g this is your forces p i r is lateral course it will be acted in the lateral directions also seismic force all the forces at the respective point of applications, if I draw it here make it into suppose this is your earth pressure because of a surcharge where is your result, and earth pressure will act.

In this case the result, and earth pressure will be act at distance of zero point five h from base of the wall, and this is your pressure distribution diagram similarly earth pressure because of your soil mass. If look at here this earth pressure result pressure pa it will act as distance of h by three similarly your seismic forces, it will act as a distance of zero point six a h from the base.

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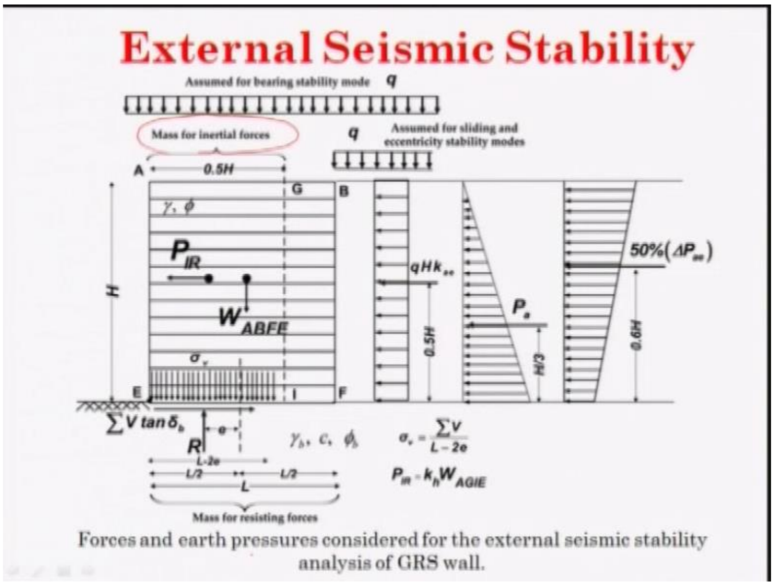

This is all about a bigger picture, if you look at earlier what I have discussed it is here in a bigger picture a soil mass as been reinforced which your geo synthetics, and what are the forces what are the forces external load going to be acted assume in bearing come means your such as going to act, then soil earth pressure, then is your because of your seismic load it will act.

Then will find it out result, and were it will act where it will act at the c g or at distance of eccentricity e, then find it out l minus two e; that means, you have check it is would be less than equal to b y six, then mass of resisting forces these are mass of resisting forces, then mass of inertia forces. If you look at here this your mass of inertia forces, then you can find it out sigma b p i r forces, and earth pressure considered for the external seismic stability analysis of geo synthetic reinforce earth wall g r s walls has been shown here.

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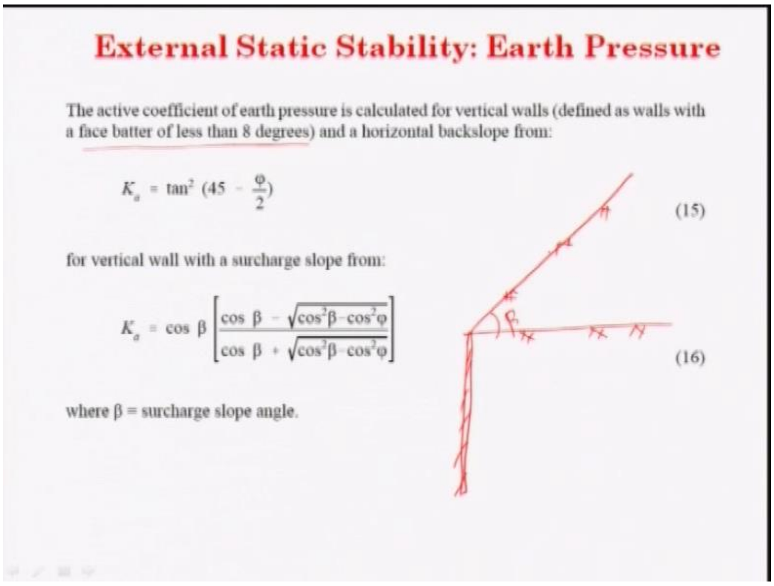

The active coefficient of earth pressure is calculated for vertical walls defined as walls with a face better of less than eight degrees the movement it say it is vertical walls it will defined as face batter of less than eight degree it this is the face of the wall it should be batter less than less than eight degree that it should be incline both less than eight degree. So, that has been defined as a vertical wall. So, and horizontal back slope horizontal back slope means if this my wall this is my wall. If I say horizontal back slope means this is the horizontal back slope; that means, if soil retain on these behind the retaining wall this will be horizontal back slope, if I say in claim back slope, then it will be in these forms; that means, soil retain back face of your wall it will be incline. So, this is called incline back slope now k a active earth pressure. So, coefficient that is your transpire forty five degree earth pressure go sent ka means active that is tens five forty five degree minus five by two for vertical wall with a surcharge slope.

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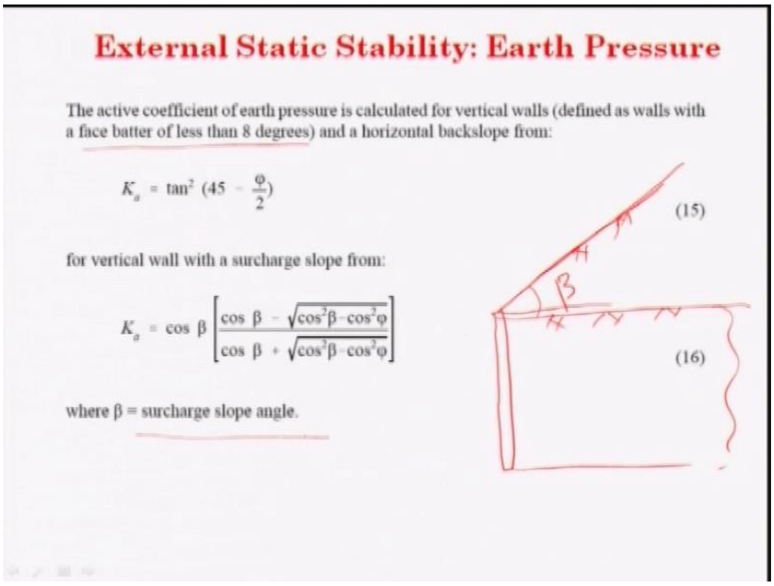

That means if a vertical wall with surcharge slope this is my metrical wall with a surcharge slope these surcharge slope is beta; that means, these surcharge slope what is value of k a this is your k a value earth pressure active earth pressure coefficient k a if it is a if it is horizontal back slope; that means, if this kind of horizontal back slope ka will be tan square forty five degree minus five by two, if it is a in clines surcharge or surcharge slope or in cline back slope beta; that means, in these case k a is equal to cos beta into cos beta minus cos square beta cos square phi root over divided by cos beta plus cos square beta minus cos square phi root over beta is your surcharge slope slope angle is your beta is your surcharge slope angle.

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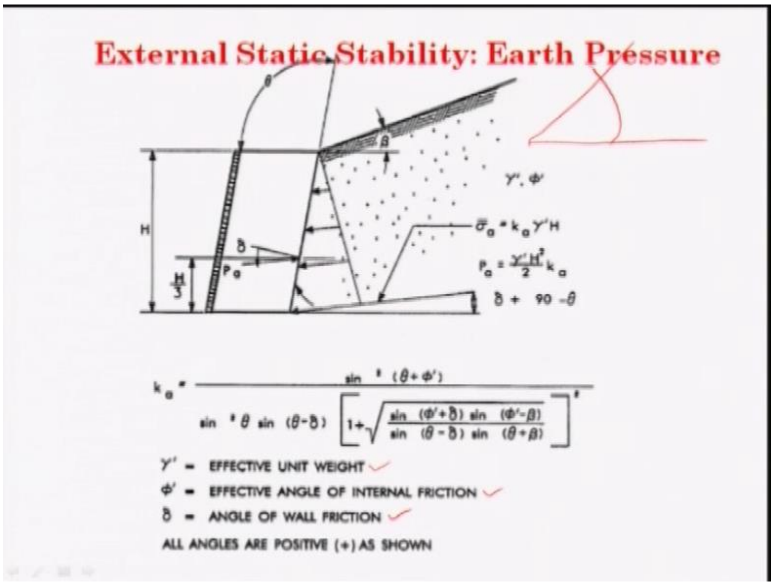

That means, this will be a beta surcharge slope angle Know it has been shown in these case what is your beta what is your theta, and what is your delta delta is your angle between a soil, and the wall; that means, your a; that means, your friction angle between the soil, and wall, and beta is your surcharge angle, and theta is your respect to how much it will be in clime; that means, ka is equal to, if I take in terms of if wall is inclined; that means, in this case wall has been incline at an angle theta.

If this wall has been incline at an angle theta also soil has been inclined at an angle beta also there is a coefficient of friction or between the soil as well as wall that is your delta, then it can find it out k a in this form sins square theta plus phi prime means phi effective divided by sins square theta, and sin theta minus delta into one plus sin phi prime plus delta into sin phi prime minus beta divided by sin theta minus delta into s i h theta plus beta root over whole into square gamma prime is your effective unit weight that is your, and phi prime is your effective angle of internal friction delta is your angle of wall friction; that means, angle between wall, and the soil this is called angle of wall friction all angles are positive as it is shown; that means, if is inclined like these. That means it will be a positive if is inclined like this, this is also a positive, and if it inclined the direction has been shown in these directions this is from to as a positive angle.

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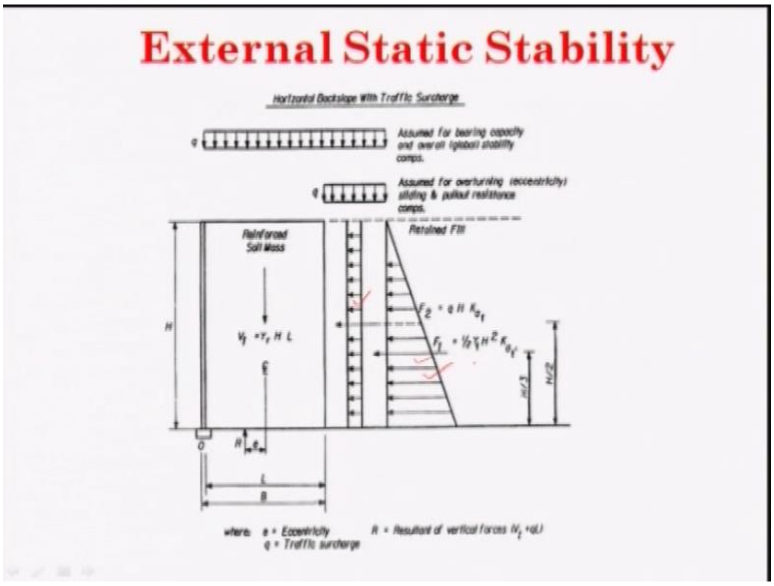

Now, a simple reinforce of soil mass if it take it if considered it this is your reinforced wall, and this reinforce soil mass, and b is equal to how much your force it will be act gamma r into h into l h is equal to height l is equal to up to this, and this is your earth pressure distribution diagram this is become surcharge this is earth pressure because a soil, and how much is result, and force it will at what distance this will a h by three, this will be a h by two. So, f one for the these case it will be f one is equal to in this case f one is equal to half gamma h h square into k a f two is equal to q h sigma prime f two is these case.

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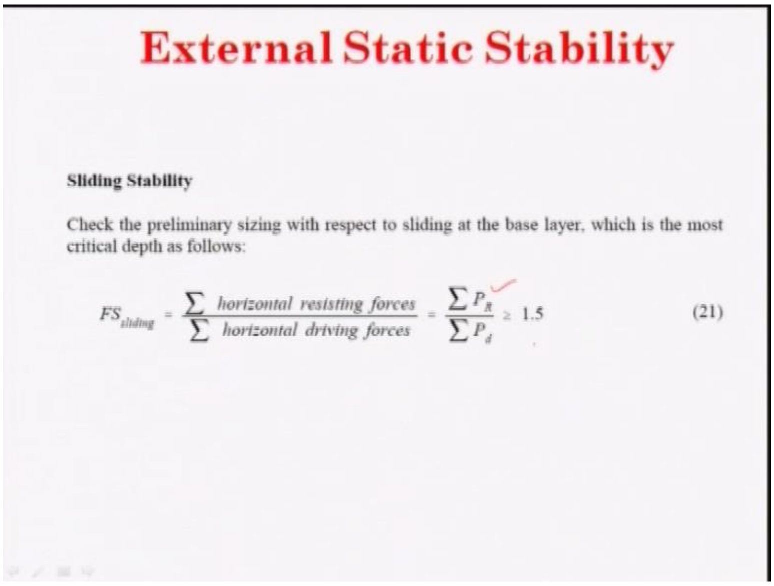

So, sliding stability; that means, check the preliminary sizing of sizing with respect to sliding at the base of the layer which is most critical depth as follows factor of safety again sliding with anally right f s, and below subscript is your sliding it is receive of summation of horizontal resisting forces; that means, p r horizontal resisting forces by horizontal driving forces horizontal resisting forces by horizontal driving forces, and it should be greater that equal to one point five, if your sliding if factor of safety less than one point five, then it is said to be on stable; that means, these factor of safety minimum factor of safety per stability of sliding it should be greater than one point five.

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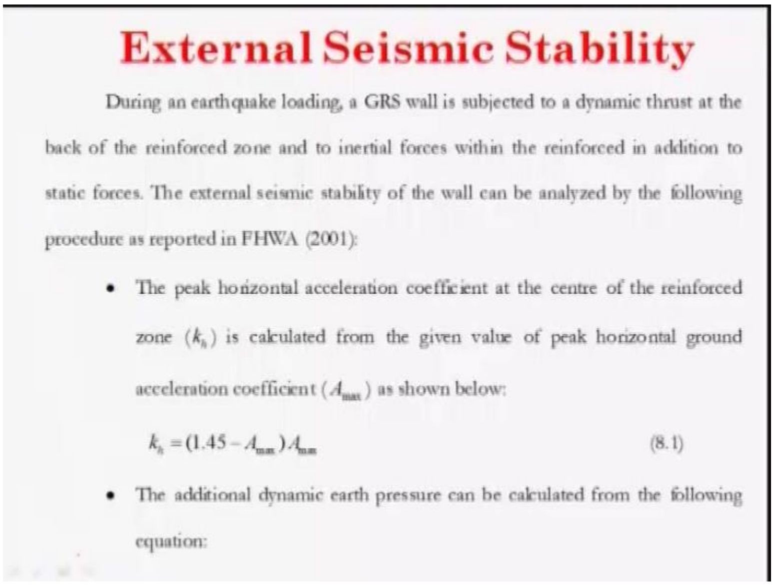

Then come back to during an earth quake loading this geo synthetic reinforce wall is subjected to a dynamic thrust at the back of the reinforced zone, and to inertial forces within the reinforced in addition to static forces; that means, there will be a in addition to static forces there will be another forces that is a inertial forces that has been considered for seismic the external seismic stability of wall can be analyzed by the following procedure as given by federal highway in two thousand one the peak horizontal acceleration coefficient at the centre of the reinforced zone; that means, peak horizontal acceleration coefficient it has been termed as small k subscript of h is calculated from the given value of peak horizontal ground acceleration coefficient a maximum k h has been calculated from your a maximum as soon below.

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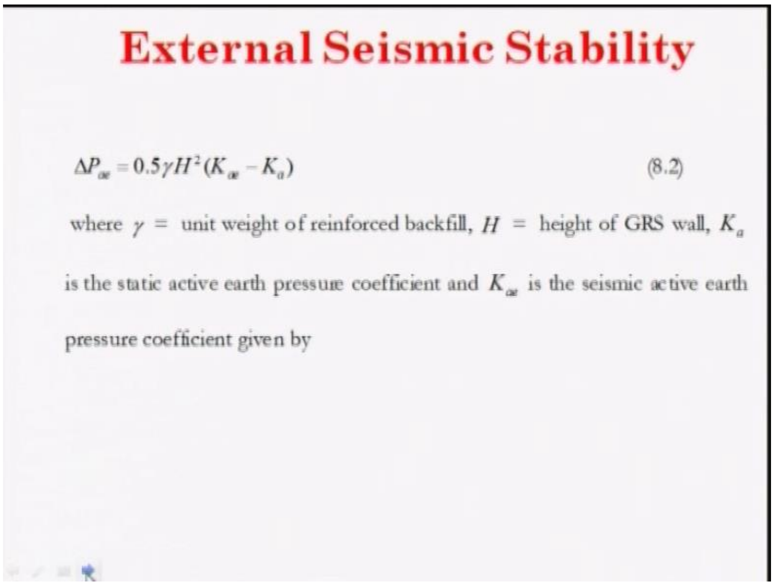

So, k h is equal to 1.45 minus a maximum into a maximum the additional dynamic earth pressure can be calculated from the following equation, this is your calculation of k h the additional dynamic earth pressure can be calculate; that means, your delta p delta p into a e earthquake forces a e is a earthquake forces delta p additional earth pressure, because of a earthquake force, this is your zero point five gamma h square into k a e minus k a where gamma is equal to… If unit weight of reinforced backfill h is equal to height of g r s wall k a is the static active pressure coefficient as we are discussed earlier k a e is the seismic active earth pressure coefficient, this is addition tub k a e is seismic active earth pressure coefficient.

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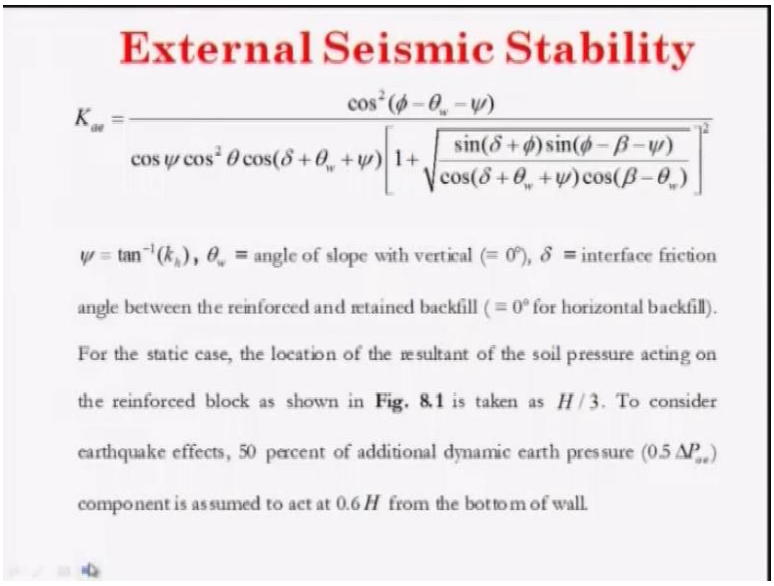

So, you can calculate k a e as given by federal highway of united states of america in two thousand one that is your square square five minus theta w minus psi divided by the whole term were psi is equal to time inverse of k h theta w is equal to angle of slope with vertical angle of slope with vertical it generally if it is purely vertical; that means, it is theta is equal to zero degree, and delta is equal to interface friction angle between the reinforced, and retained the backfill; that means, zero for horizontal backfill for the static case the location of the resultant of the soil pressure acting on the reinforced block as shown is it is generally taken as h by three if you come back to static case it is generally taken as static case this is an earth pressure distribution diagram, it is generally taken as h by three total hide by three is your at that height is your horizontal, it considered your earth to considered your earthquake effects fifty percent of additional dynamic earth pressure fifty percent of additional dynamic earth pressure; that means, zero point five delta p e component is assumed to act as zero point six h from the bottom of the wall; that means, it is define that to considered the earthquake effect fifty percent of additional dynamic earth pressure; that means, zero point five delta pea p a e component is assumed to act a r a zero point six h at height of zero point six h from the bottom of wall if i take it back to slight.

Before this what we have discussed you see this is the earth pressure distribution diagram for your considering a dynamic effect it is your fifty percent of delta p a e, and it will act at a distance from the base, this is your zero point six h h is a total height of the wall.

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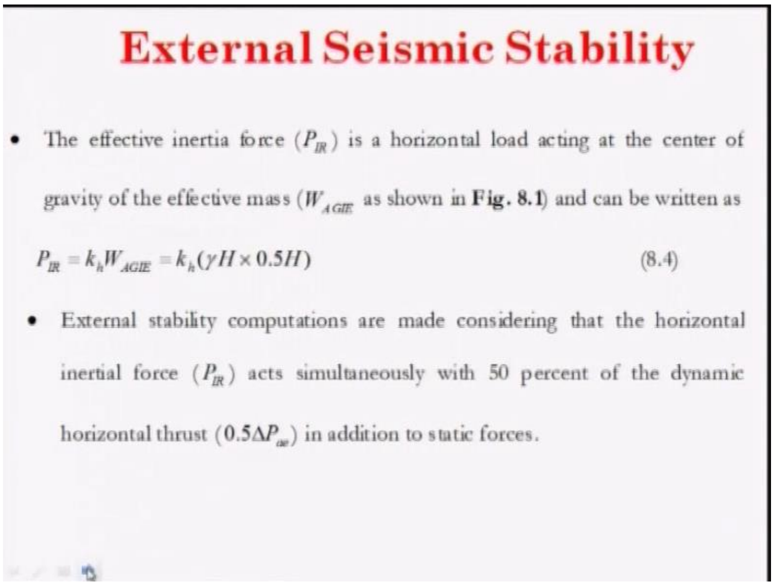

The effective inertia force; that means, p i r i r is effective inertia force p is a force is a horizontal load acting at the centre of gravity p i r is horizontal load it will act at the cg of centre of the gravity of the effective mass of w a g i e, and can be return as you can find it out p i r is equal to k h w capital w a g i e; that means, a k h into gamma h into zero point five h external stability computations are made considering that the horizontal inertial force p i r act simultaneously remember here, it is returns act simultaneously with fifty percent of the dynamic horizontal thrust; that means, is your zero point five delta p a e in addition to static forces it will act simultaneously first one, and second one is on fifty percent of the dynamic horizontal thrust; that means, zero point five delta p a e in addition in addition to your static force whatever the static force is there in addition to that it will act.

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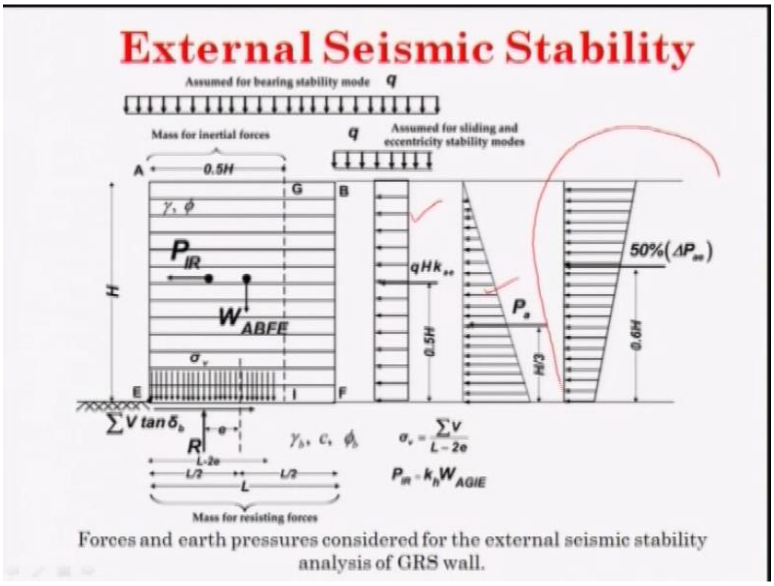

Now, if you considered these forces, and earth pressure of the same, this part is your for static this is your earth pressure distribution diagram as I said for your surcharge; that means, load acted soil mass. This is your earth pressure distribution diagram because of soil as well as reinforce mint materials, and these part is your addition dynamic force because of addition dynamic forces earth pressure distribution diagram, and it will act at a distance zero point six h from the base of the wall.

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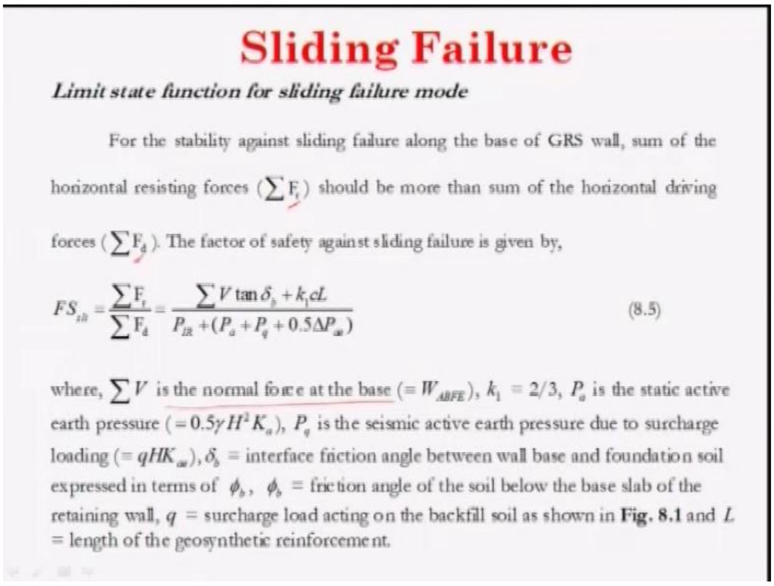

Then limit state function of function for sliding failure mode for the stability against sliding failure along the base of g r s wall sum of the horizontal resisting forces, generally it is retain f r r is capital f subscript of r r is your resistance forces should be more that some of the horizontal driving course d is driving course. That means, resistant force should be more than your driving course the factor of safety against sliding failure. Considering a dynamic forces into picture f s sliding is equal to f r summation of f r by f d.

If I take f r is equal to summation of b t, and delta b plus k one c l divided by p i r plus pa plus p q plus delta p zero point five delta p a e summation of b is the normal force at the base; that means, that is your w a b f e w a b f e, this is your summation of forces that will acted as the base this is clearly written here, then k one is k one is equal to two third, it will at two third pa is static earth pressure pa is a static earth pressure pa is a static earth pressure this is a static earth pressure it will act at the distance of a h by three, and this is zero point five gamma h s square into ka pq is the seismic act active earth pressure due to surcharge that is your q h k a e delta b is your interface friction angle between wall base, and foundation soil expressed inters of five v five v is equal to friction angle of the soil below the base slab of the retaining wall q is equal to surcharge load acting on the backfill soil as q is equal to surcharge load acting on the backfill soil this is q surcharge load acting on the backfill soil.

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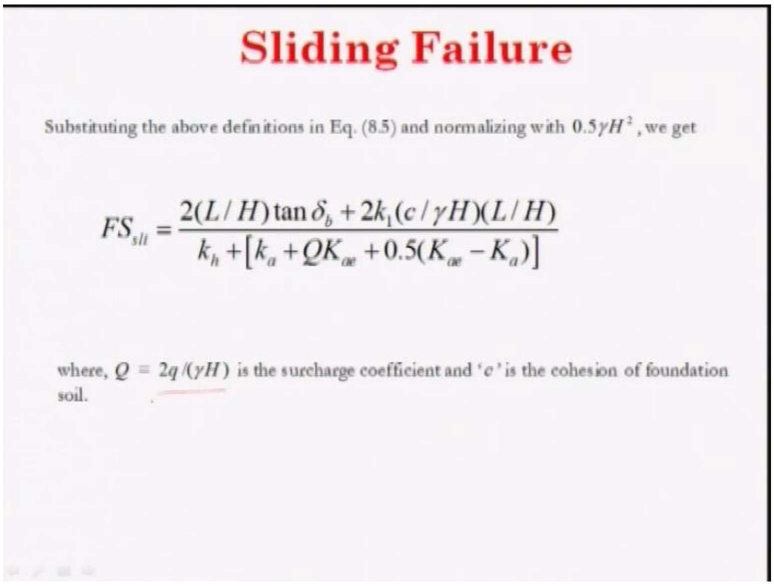

Substituting all the things you can find it out your factor of safety sliding in terms of two into l by h then delta b, and two k one c by gamma h l by h divided by k h plus ka plus capital q k a e zero point five k e minus s ka all. So, are q is equal to two q y gamma h is the surcharge coefficient, and c is the cohesion of foundation soil.

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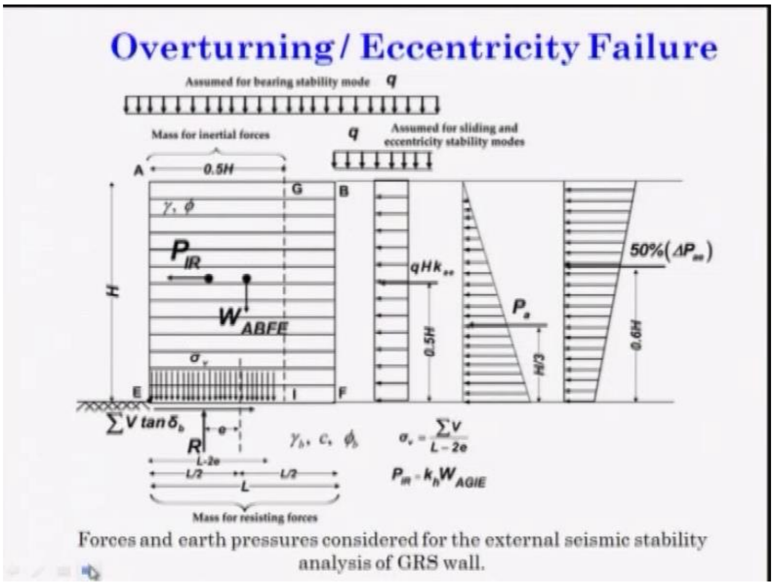

Once sliding over next step is over terming or its eccentricity failure this is all about same figure we are repeating again again, but taking into consideration showing or all the courses static as well as dynamic forces earth pressure distribution diagram, and result enforced, and the eccentricity.

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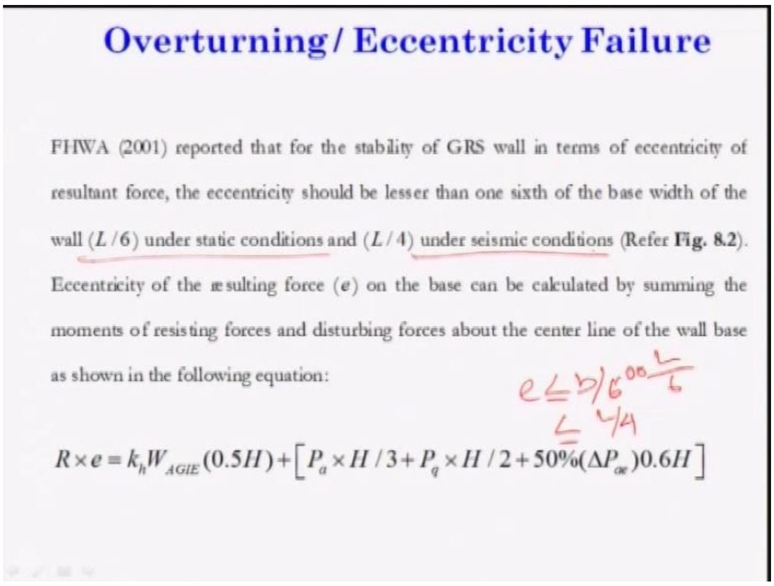

Over terming, and eccentricity failure if you look at the f h w h two thousand one reported that for the stability of g r s wall in terms of eccentricity of resultant force the eccentricity should be lesser than one sixth of the base width of the wall; that means, is would be per stable is would be less than your b by six or sometimes it is l by six l is width or b is equal to width at the base of the wall under static conditions these conditions is under starting conditions, and it should be less that equal to is your l by four under seismic conditions if seismic condition has taken into consideration it should be less than l by four eccentricity of resulting force; that means, e on the base can be calculate it can be calculated by summing the moments of resisting forces, and disturbing forces about the center line of the wall base; that means, summing of the forces by taking its summing forces or summing of the movement of the resisting forces as well as disturbing forces about the center line of the wall base.

So, you can find it out r into e; that means, r into e the moment will be a clock wise r into e this is your clock wise, then k h w a g i e into zero point five base; that means, k h w h is zero point five page in this reason is to lack all this has been some us; that means, clock wise movement, and anti clock wise movement movement in means movement you can summation summit of clock wise as well as anti clock wise they equity.

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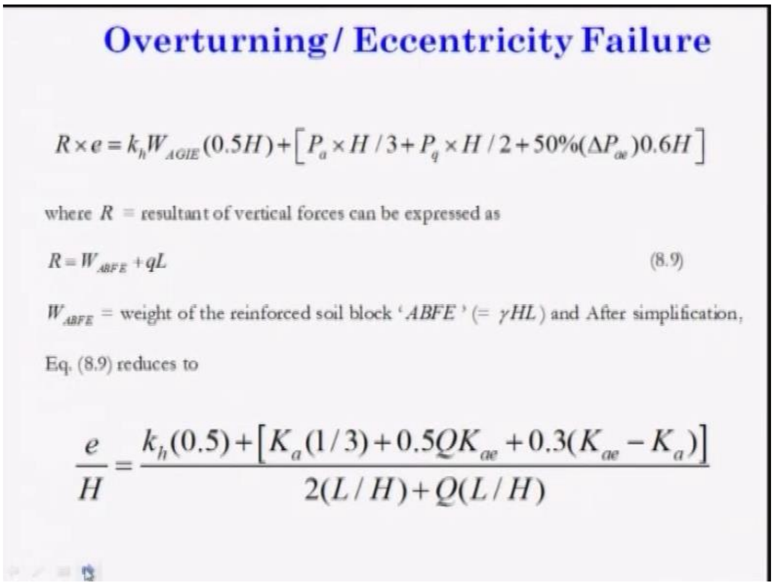

You can find it out in terms of r is equal to result, and vertical forces, and in terms of e by h he will get it in terms of e by h e is equal to eccentricity divided by a total height of wall in term of k h k a k a e into divided by all this term q l h l and h.

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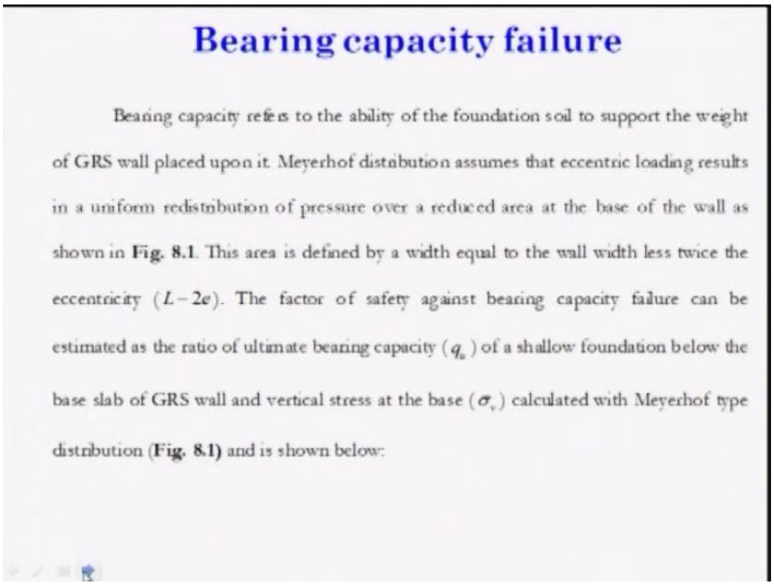

Then one this movement, and eccentricity part is over next step of next check is your bearing capacity failure bearing capacity refers to the other ability of foundation soil to support the weight of your g r s wall placed of of a need; that means, foundation soil to support is whatever the wall constructed about the foundation soil meyerhof generally meyerhof distribution assume that eccentric loading results in a uniform redistribution of pressure over a reduced area at the base of the wall these area is defined by width equal to your wall width less this eccentricity; that means, l minus two e.

Here once there is an eccentricity this area will be reduced; that means, once there is a eccentricity what will happen there will be tension of the base of the wall; that means, one the reject tension in the base of the wall there is gap between in your reinforcing material, and foundation soil as per the meyerhof distribution you have to remove that eccentricity, and the enter width will be l will be redistributed it will be has l minus two e. So, that is why it will be l minus two e the factor of safety against bearing capacity failure can be estimated as the ratio of ultimate bearing capacity that is your q u of a shallow foundation below the b s e slab of g r s wall, and vertical stress at the base; that means, sigma b calculated with.

The factor safety against bearing capacity failure can be estimated as the ratio of ultimate bearing capacity shallow foundation below the b s e slab of g r s wall, and vertical stress at the base; that means, sigma b calculated with meyerhof type of a a distribution.

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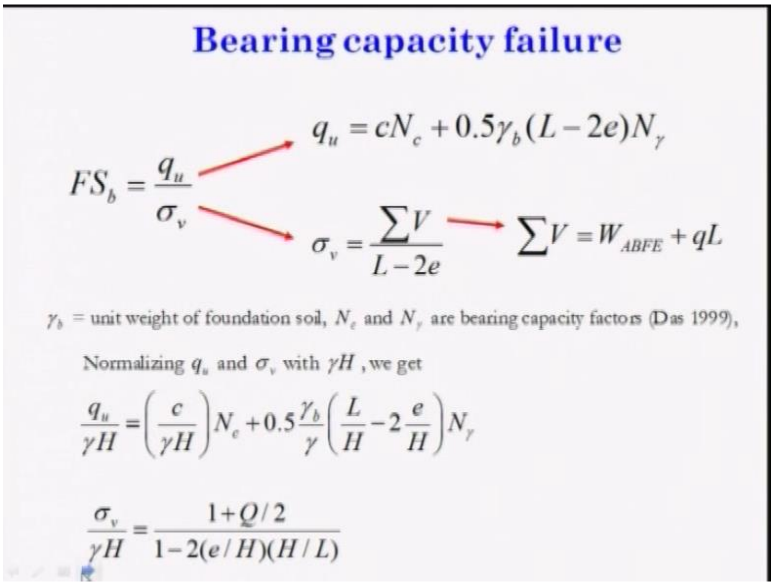

If I calculated the factor safety bearing capacity failure; that means, q u ultimate bearing capacity by sigma b q u is your as per meyerhof calculation a a; that means, c, and c plus zero point five gamma b l minus two e to n gamma n c, and n gamma is bearing capacity factors, and sigma b is your total vertical forces divided by l minus two e. So, gamma b is your unit wait of foundation soil as b is base b is unit weight of foundation soil n c, and n gamma are bearing capacity factors a g given by das, and nineteen ninety nine normalizing sigma q u sigma b gamma h, we can get q u by gamma y h is equal to c by gamma h n c plus zero point five gamma b by gamma l by h minus two e by h n gamma, and from their you can find it out sigma b in terms of gamma h will get it.

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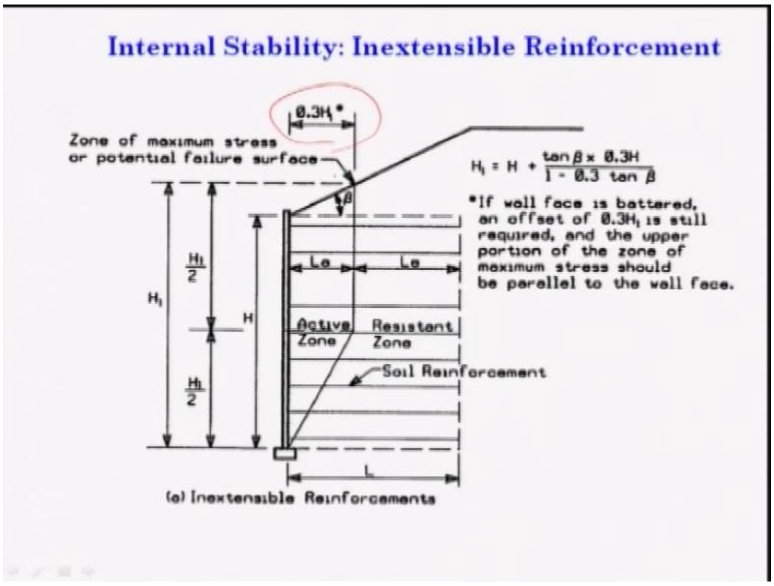

The next step is your internal stability; that means, is your in extensible reinforcement if wall face battered if wall face is battered none; that means, on offset of zero point three h one is still required if it is battered; that means, and offset of zero point three h one still required, and the upper portion of the zone of maximum stress should be parallel to the wall face person of the zone of maximum stress should be parallel to your wall face; that means, it should be the zone of maximum stress or potential failure it should be parallel to your wall face, and h one based on that h one should be calculated was h plus tan beta into zero point three h by one minus zero point three into den beta.

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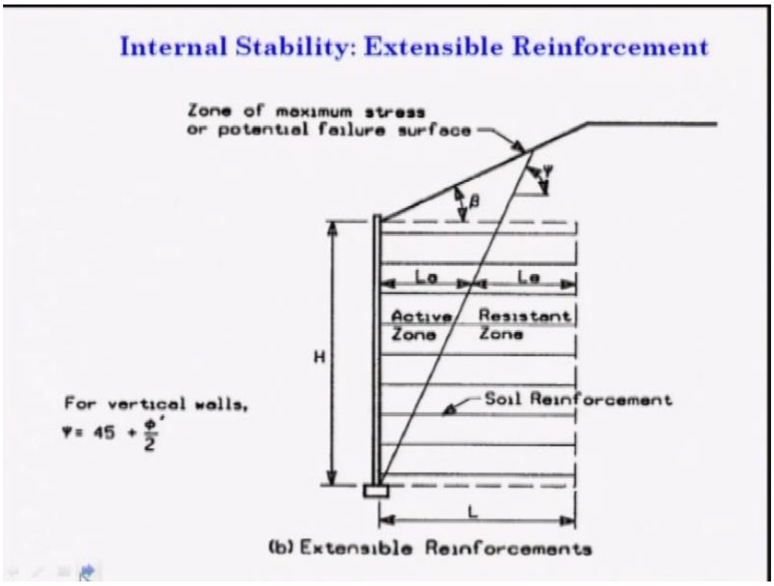

So, this is your zone of maximum stress of potential failure surface, if I take it here this is my zone of maximum stress of potential failure surface with an angle s i e s i e is equal to forty five degree plus five by two, and as I have already discussed earlier this is your active zone, and this is your.

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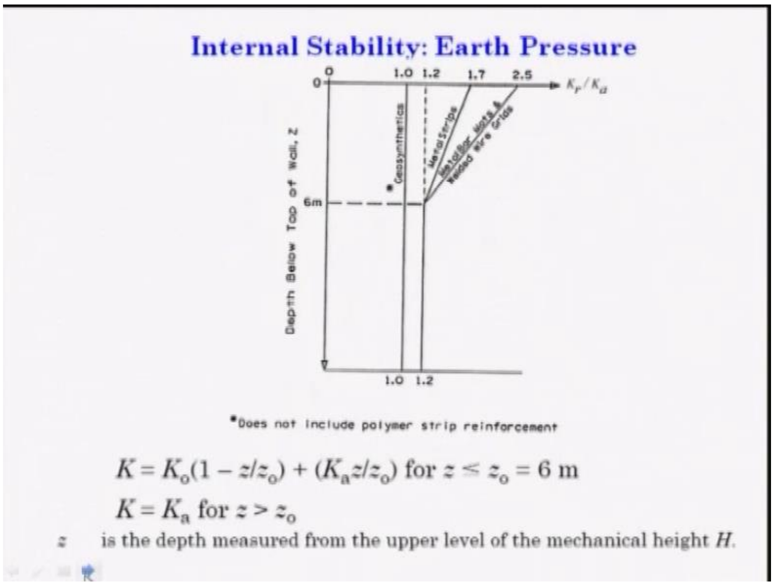

And this is your resistant zone will discuss about the internal stability of different earth pressure, tomorrow I will discuss all this teaching thanks.