Application of Soil Mechanics
Prof. N. R. Patra
Department of Civil Engineering
Lecture – 39

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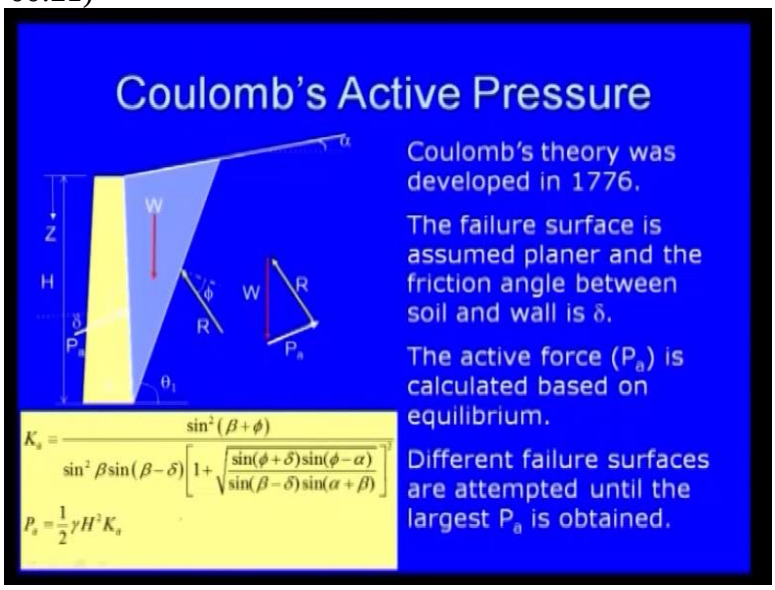

We've finished this Rankine's artificial theories. Now Coulomb's active earth pressure, so Coulomb theory was developed in seventeen seventy six. So in this case, what will happen the failure surface is assumed to be a planer and they have consider the friction between friction angle between soil and the wall in the if you look at here this Rankine case, this wall is assumed to be a smooth wall. So the friction angle between this wall and this soil is not taken into consideration. In Coulomb's theory, we've consider this friction angle between soil and wall, and it is taken as delta. The active earth pressure is calculated based on the equilibrium. They have taken a planer failure surface and based on the equilibrium. When they consider the weight of the in that planer failure surface, weight of the soil, as well as P a – active earth pressure, resultant and they make the force polygon, so that it has to satisfy this ah equilibrium conditions.

So what will happen, different failure surfaces are attempted. So this is your number one failure surface like this you can attempt number two, number three, number four until the largest P a is obtained, until this largest active power pressure is obtained. From they are coefficient of earth pressure, active earth pressure K a is found out to be sin square beta plus phi, if you look at here beta, beta is your angle - wall angle. Wall angle, it makes with this vertical that is your beta plus

psi phi is your angle of internal friction of this soil and sin square beta plus psi into sin beta minus delta into one plus sin phi plus delta into sin phi minus alpha. Alpha is your, if you look at here alpha is coming out to be, alpha is your surcharge angle, this is your alpha, this is your alpha. This failure, failure surface planer failure surface makes an angle with this. This is your theta one and theta two. And from there, you can find it out P a, P a is equal to half gamma H square into K a.

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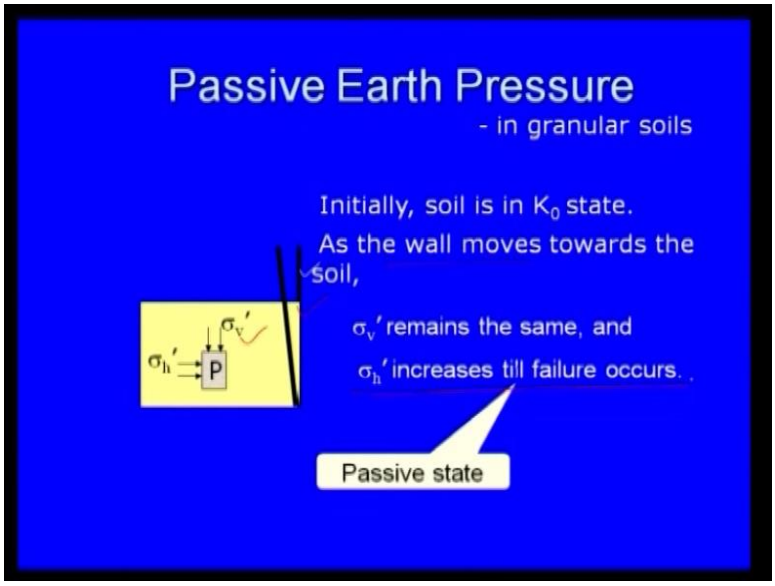

Now passive earth pressure in case of granular soil; initially, soils is in K zero condition. If this is your retaining wall, if this is your retaining wall, if you consider this is your retaining wall and this is your soil mass. Initially, this soil mass is in rest conditions that means, this is your sigma v prime and sigma h prime. Then as the soil moves towards this soil, as the wall sorry as the wall moves towards the soil that means this is your wall, it's moves towards the soil, what will happen? The sigma v prime that means your surcharge it remains same – sigma v prime remains same, sigma h increases till the failure occurs. This is the difference. Where in case of active state, active state sigma h decrease till the failure occurs; in case of passive state, sigma h increases till the failure occurs. Now this is called your passive state that means sigma h increases increases till the failure occurs.

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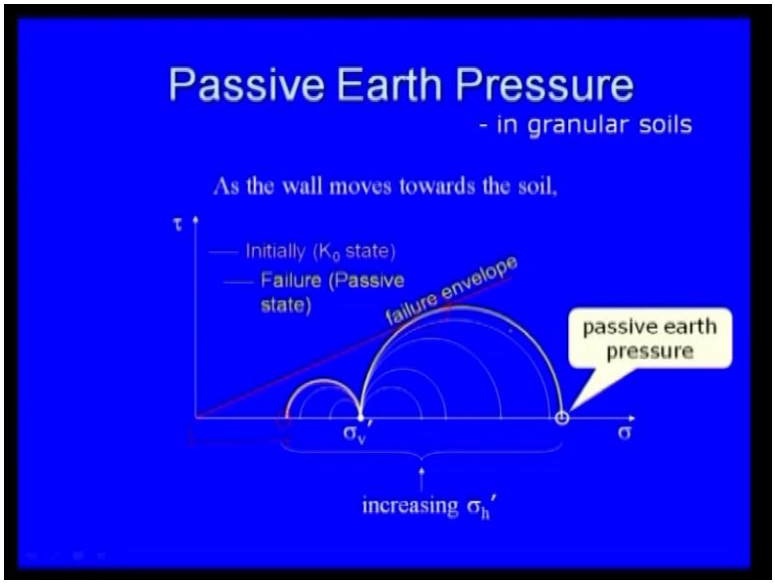

Now if I come back to in terms of Mohr circle diagram, if you look at here initially, this is your K zero that means earth pressure at rest condition where is your sigma v prime and sigma h prime. What will happen, as the wall moves towards the soil, so passive earth pressure in granular soil, ah if you look at these in terms of [FL] circle, initially it is in a K 0 state that means it is at rest. Then wall moves towards the soil, so what will happen, it will go, it will increase in this sigma h initially. Initially this sigma h value, initially sigma h value is they here, that means if you look at this value here increasing from here to here, so till it touches your failure envelope, touches the failure envelope that means at this point your failure occurs. It touches this Mohr circle failure envelope. So this is called a passive state or passive earth pressure, this is your passive earth pressure.

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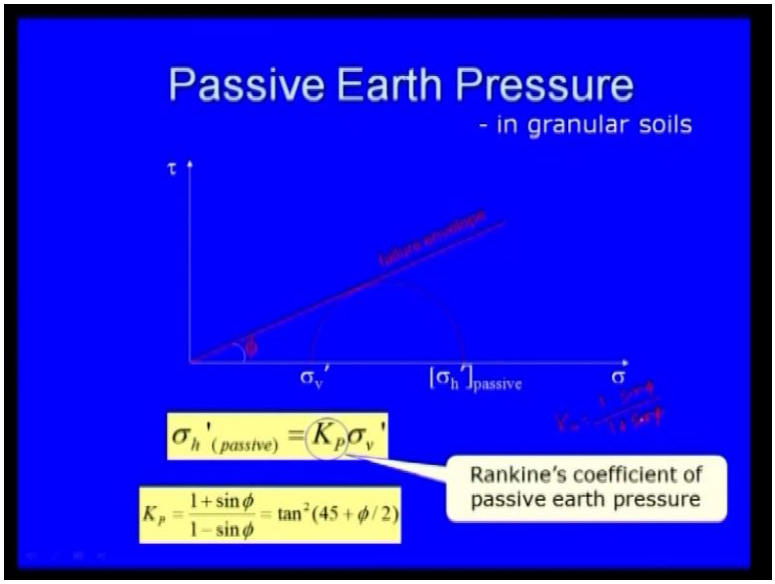

Now sigma h prime of this passive is equal to K p into sigma v prime. So Rankine's coefficient of passive earth pressure, so K p is equal to 1 plus sin phi by 1 minus sin phi, this is Rankine's ah earth pressure, so where the K p is your in terms of phi, there is no delta. As I said Rankine's theory ah assumed that ah this wall is smooth. So in case of Coulomb's theory, the friction angle between the soil and wall, delta has been taken into consideration, so K p is equal to one plus sin phi by one minus sin phi; where are in case of active case, K a is equal to one minus sin phi by one plus sin phi. So, this will be tan square 45 degree plus phi by 2.

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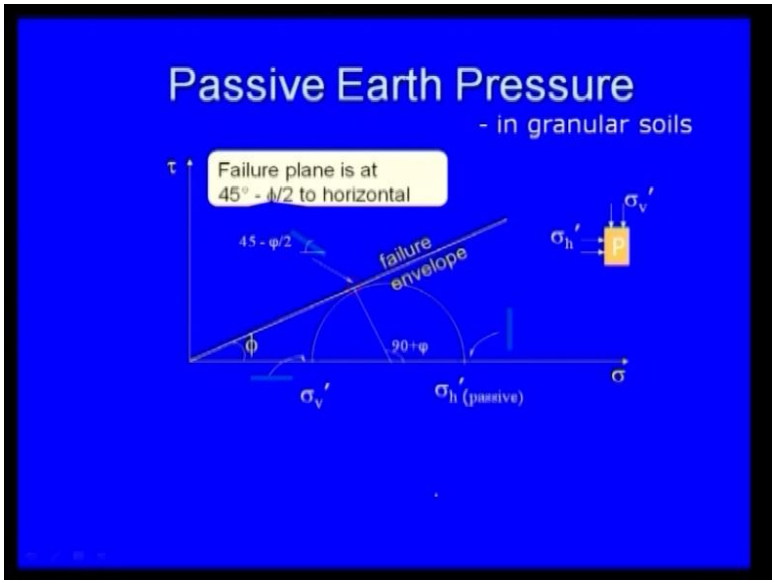

Now passive earth pressure in granular soil, so failure plane is at 45 degree minus phi by 2 to the horizontal. So this is your sigma v prime, this is your sigma v prime, sigma v prime and sigma h prime passive state.

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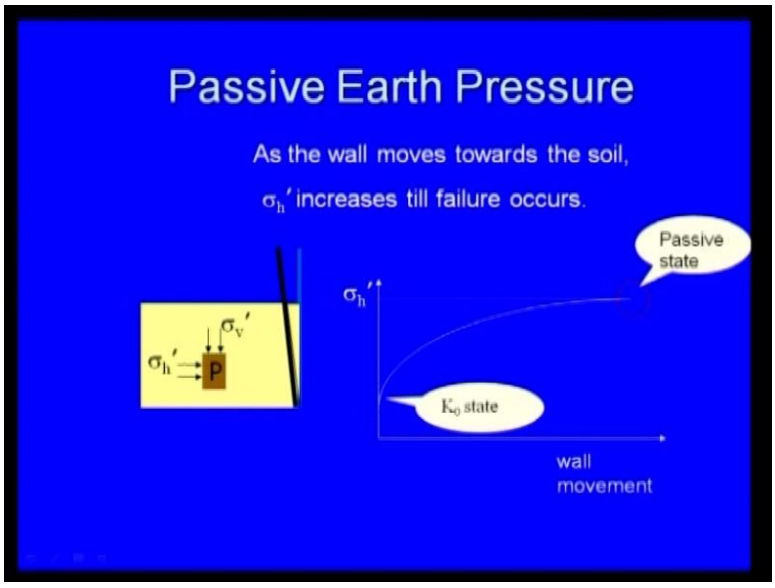

Passive earth pressure now if you would take at this as the wall moves towards the soil, that means sigma h, sigma h is increases. This wall is moving towards that means wall is generating pressure towards this field till the failure that means this is your K zero condition that means

earth pressure at rest. It will increase, increase, increase and it will reach here, this is called your passive state in terms of graphical representations and as well as your wall movement.

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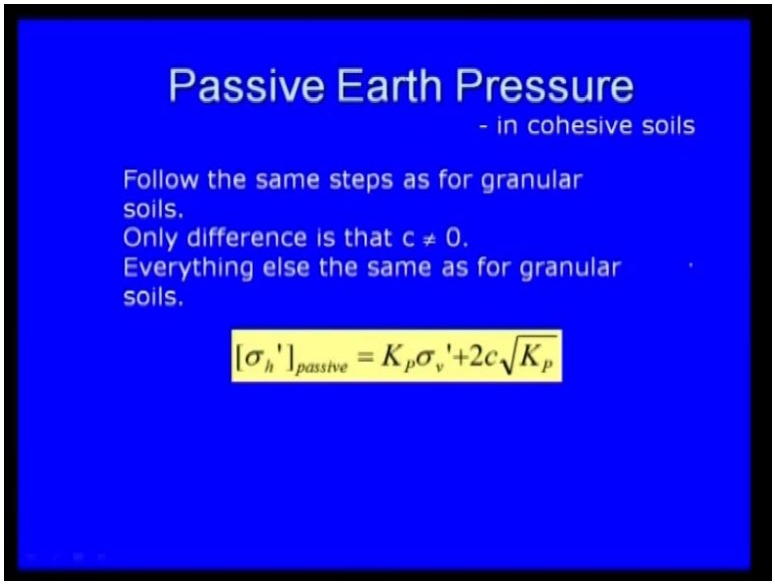

For cohesive soil, these steps are same. For cohesive soil, for calculation of your passive earth pressure, these steps are same like your granular soil. Only difference is that c is not equal to 0, c is not equal to 0, that means cohesion force is not equal to 0 – c is not equal to 0. So sigma h prime passive is equal to K p into sigma v prime plus 2 c root over of K p.

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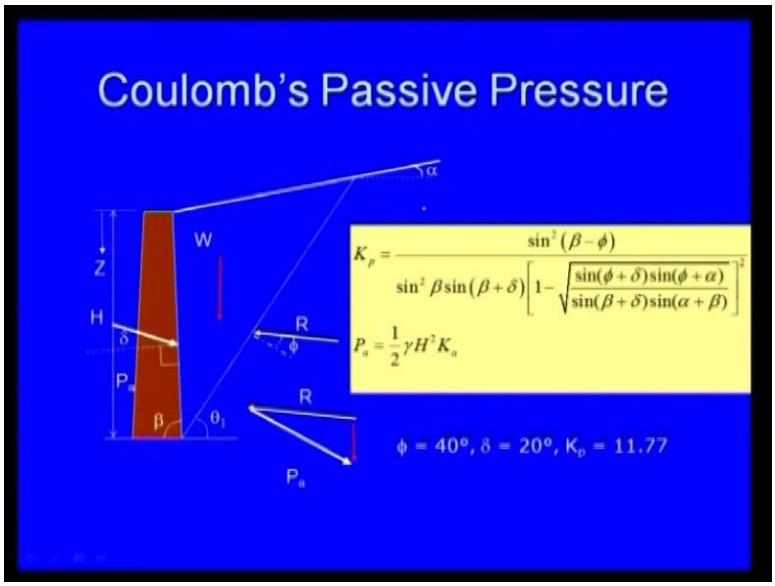

Now Coulomb's passive ah pressure, the K p this things I said earlier also ah P a is equal to half gamma H square into K a. Suppose, for example, if you take the value of phi is equal to 40 degree, suppose this is a back field soil of inter frictional angle of this soil, phi is equal to 40 degree, delta that means coefficient of friction between soil and wall is equal to 20 degree, so K p value comes out to be 11.77.

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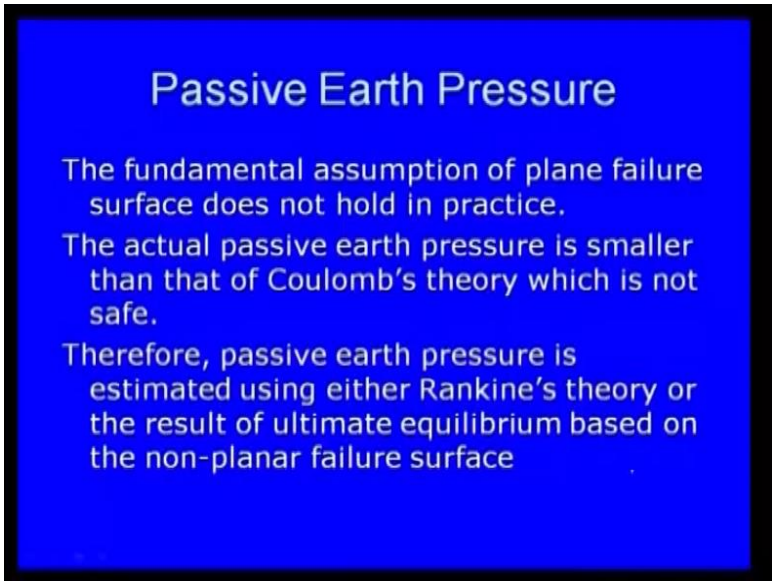

So passive earth pressure that means ah what are the limitations, the fundamental assumption of plane failure surface does not hold in practice. If you look at this assumption by Coulomb's theory, the fundamental assumption of plane failure surface does not hold in practice; in practice, it is not possible to be a plane failure surface. The actual passive earth pressure is smaller than that Coulomb's theory which is not safe. Whatever the actual ah passive earth pressure observed, it is much smaller than your Coulomb's theory. Therefore, passive earth pressure is estimated using either Rankine's theory or the result of ultimate equilibrium based on non-planar failure surface. Generally it is recommended, either you go for passive earth pressure calculations by using ah Rankine's theory or ultimate equilibrium based on the non-planar failure surface.

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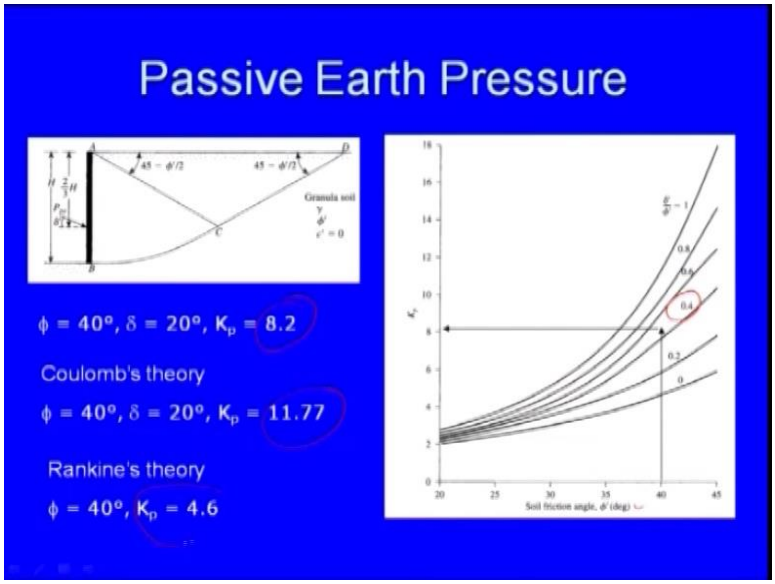

Now if you look at case of non-planar failure surface that means logarithmic spiral if I take into considerations of a granular soil gamma and phi prime and c prime. This chart has been given for different ah friction angle of phi; phi varying from 20 degree to 45 degree and K p value is given. And delta by phi also varying from 0 to when delta by phi is equal to 0, it will be same as like Rankine's theory. So it is varying from 0 to delta by phi is equal to 1; delta by phi is equal to 1 that means the frictional angle between soil and wall, and inter frictional angle of soil is equal to same, means equal to one, that means it is same, that means soil and soil with wall act as rigid body.

So with this chart, once you know the value of phi then you can find it out what is the value of K p, depending upon suppose this is the value of phi is equal to 40 degree and delta is suppose phi is equal to forty degree for delta by phi, suppose delta by phi is equal to 0.4from this chart, we can get it directly K p that means it is a non-planar failure surface. So K p is coming about to be 8.2, if I go by Coulomb's theory for phi is equal to 40 degree, delta is equal to 20 degree, K p is coming about to be 11.77, if you look at here by Coulomb's theory, it is coming 11.77. And for by means of non-planar theory, it is coming about 8.2, and for Rankine's theory, K p is coming about 4.6 that means actual value of K p is lying between Rankine as well as in between this Coulomb theory.

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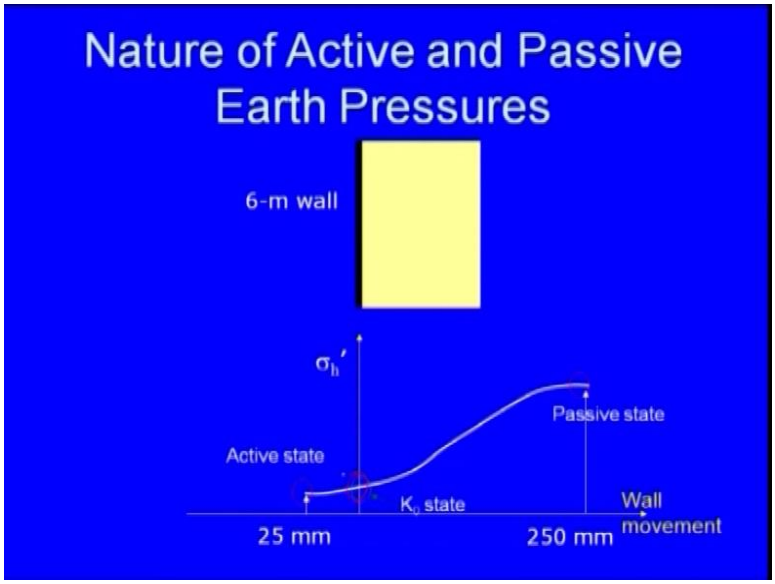

So nature of active and passive earth pressures, suppose you consider a 6 meter of wall, so this is your value of K 0 state at rest, so you can say that active state it comes about to be 25 mm then passive state, it comes about to be 250 mm. How this nature of active and passive earth pressure is varying from active to passive state. This is the variation.

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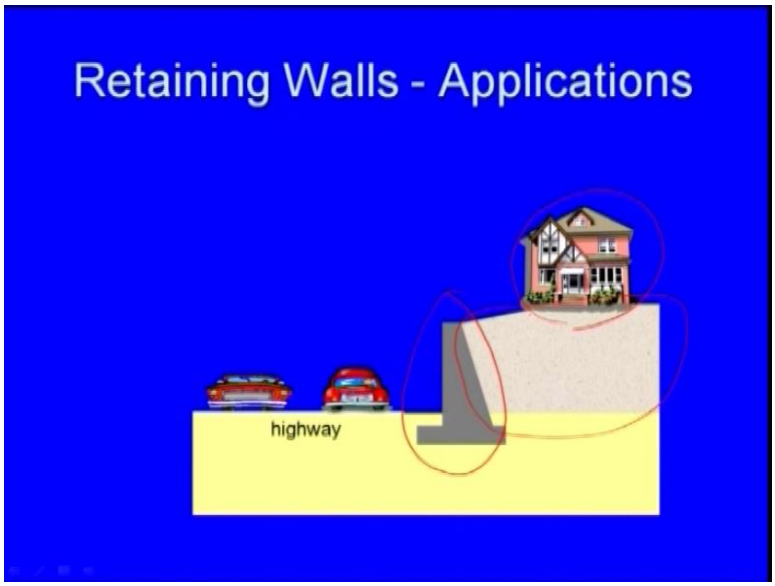

Then where it has been applied, this active state and passive state we have discussed lot about design of retaining walls and design of reinforced earth walls, these are the applications. Look at

the few applications, retaining wall applications. Now this is a highway, there is a retaining wall already existing a building. So first case is your if you look at this case one, this one part is your retaining wall that means retaining wall suppose to retain the soil mass, these soil mass has been retained, soil mass has been retained. So these soil mass will retain pressure on these wall, it will be in the active. So above this soil mass, you can go for a construction also, and nearby also here there is a highway, these also exerts pressure. So this is one example where the active and passive state come into picture.

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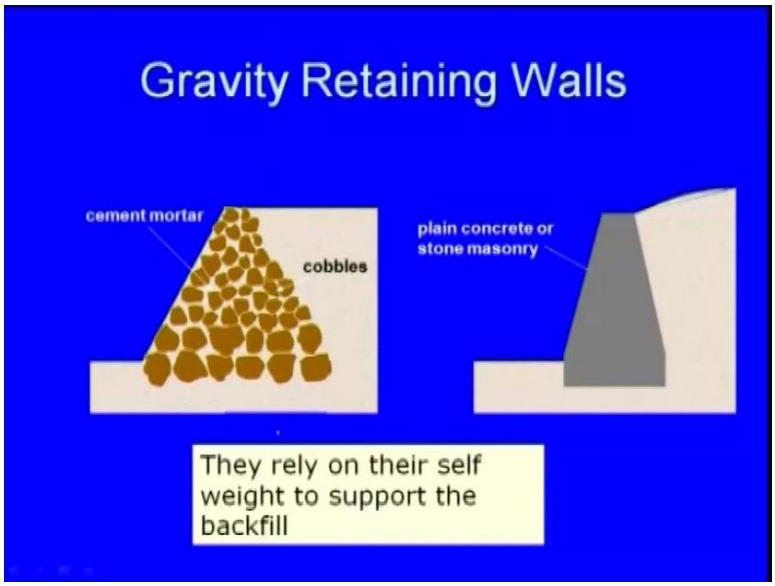

Now second one is your gravity retaining wall; cement mortar and cobbles, it is there one way. So, it will act ah they rely on their self weight to support the backfill. Particularly gravity retaining wall, they rely on the self weight to support the backfill, because the backfill will exert some pressure, by means of gravity retaining wall as I said also earlier in the beginning. The stability analysis will be done based on its self weight, so generally this self weight by means of self weight, it will counter this pressure coming from the backfill to the wall.

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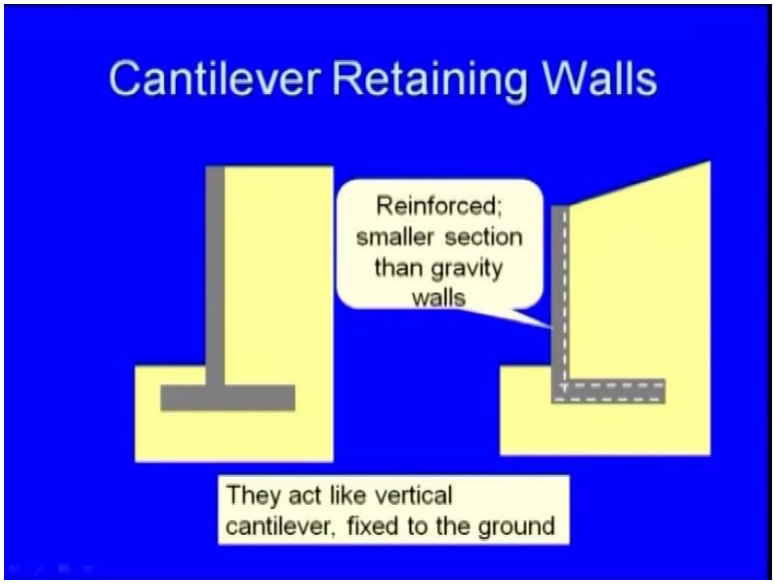

Now reinforced earth wall reinforced earth walls generally it is generally smaller than your gravity walls. If you look at they act like a vertical cantilever, this is just repetition, this I have already ah explained in the beginning of this lecture, ah what are the different types of retaining walls. So in case of ah reinforced cantilever retaining walls, what will happen, cantilever retaining walls, they will support this earth pressure by means of cantilever accents. This will be your by means of cantilever accents, they will support this earth pressure, and it will be peaks to your ground surface.

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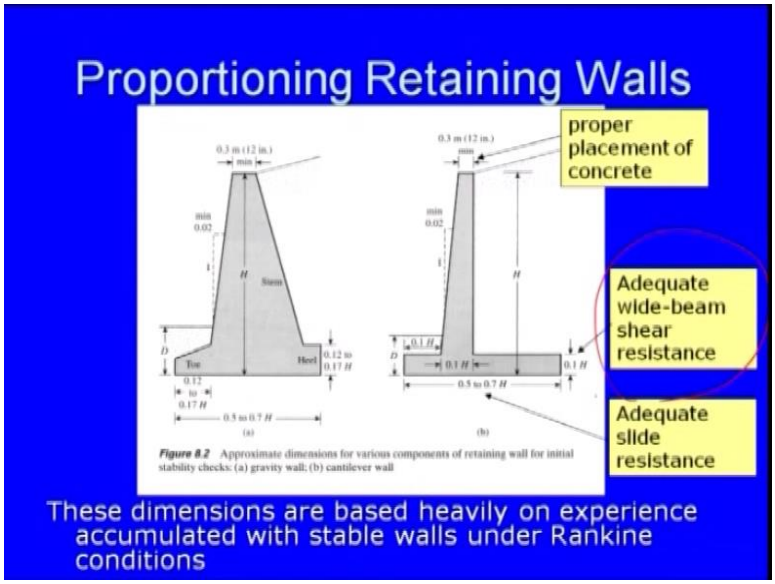

Now proportioning these retaining walls also I have discussed earlier. So proper placement of concrete at the top and adequate width-beam shear resistance, adequate width beam shear resistances then adequate slide resistances.

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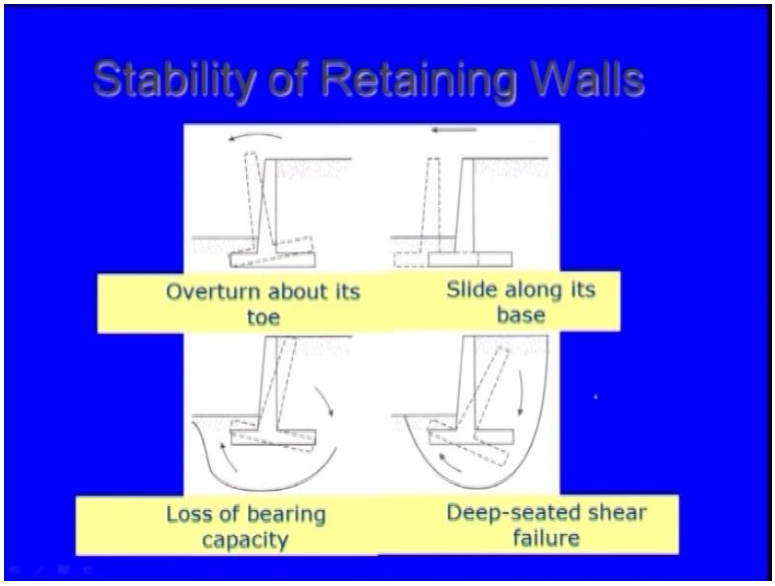

Then different failure of your retaining wall or stability analysis of retaining wall, we have already also discussed. Overturning about toe, sliding along its base; this is the overturning above the toe, sliding along the base, loss of bearing capacity, deep-seated shear failure.

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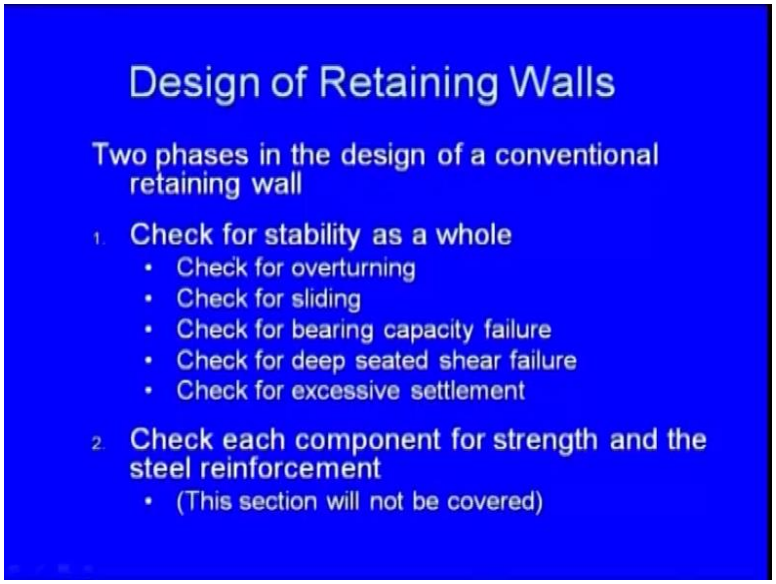

So the design of retaining wall generally done in two phases that means check for stability as a whole and check each component for strength and steel reinforcement. So, this things has been covered also earlier.

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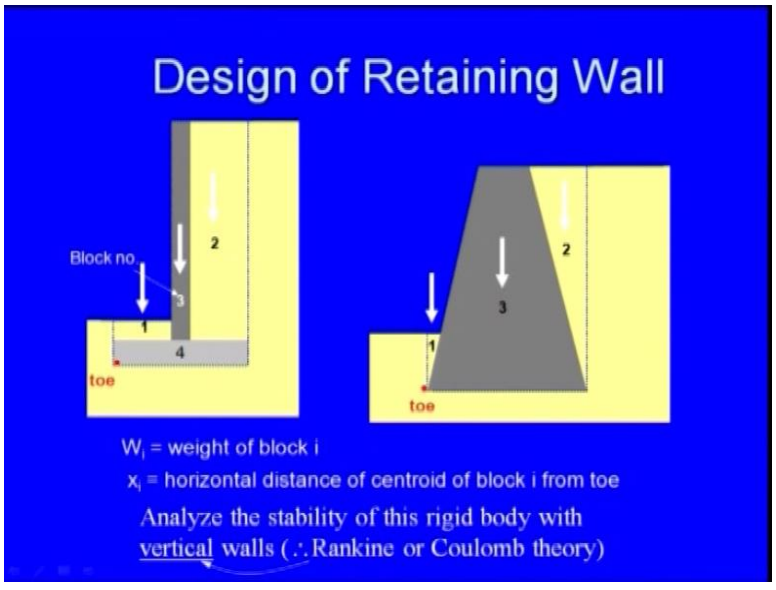

This has been I have covered earlier, so no need to discuss.

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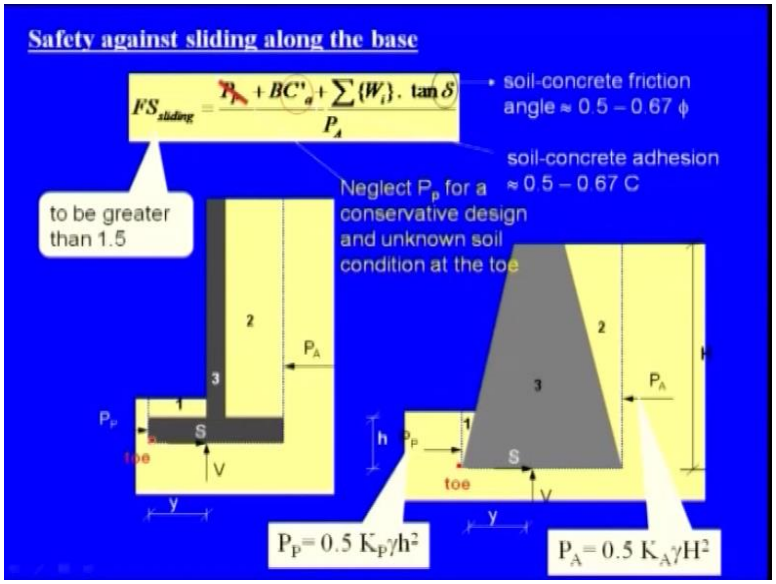

So, bearing capacity failure, it should be greater than 1, at this bearing capacity also we can calculate this stability analysis of bearing capacities.

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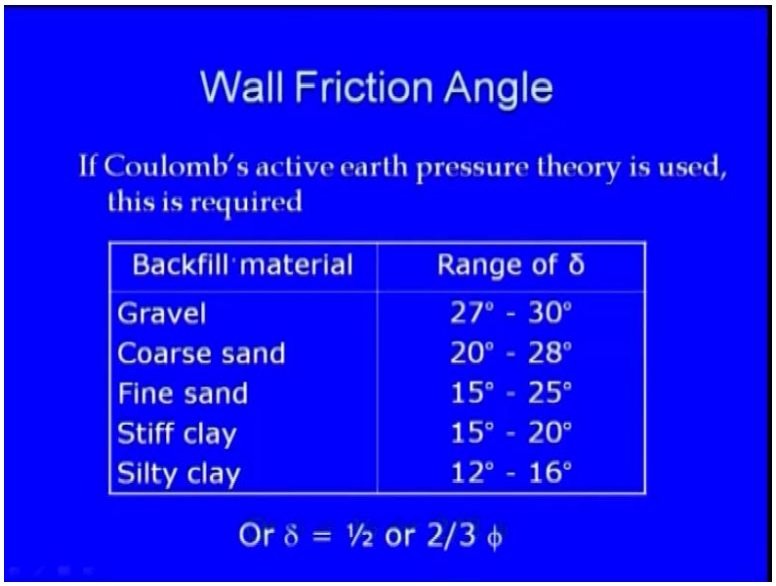

So wall friction angle – if Coulomb's active earth pressure theory is used, this is required. Generally, this is required, suppose if you are using by means of Coulomb's theory, active earth pressure theory, then backfill material if you are taking gravel this range of delta is should be varying between 27 to 30 degree; for coarse sand, it should be varying 20 degree to 28 degree.

Fine sand, it is varying 15 degree to 25 degree; stiff clay, it is varying 15 degree to 20 degree; and silty clay, it is varying 12 degree to 16 degree. Generally the delta value has been provided one-half or two-third of phi, half or two-third of this phi, generally delta value has been taken. This is all about this course of retaining wall means earth pressure theories and discussion.