Foundation Design
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Lecture - 16B
Earth Pressure Theories- Part 2

So, last class I have started with this earth pressure theories.

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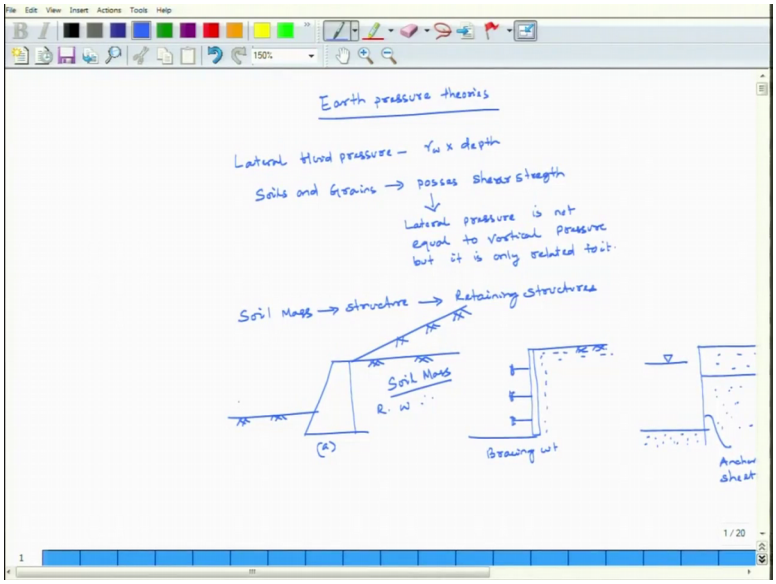

Where it is required particularly to return this soil mass retaining structures.

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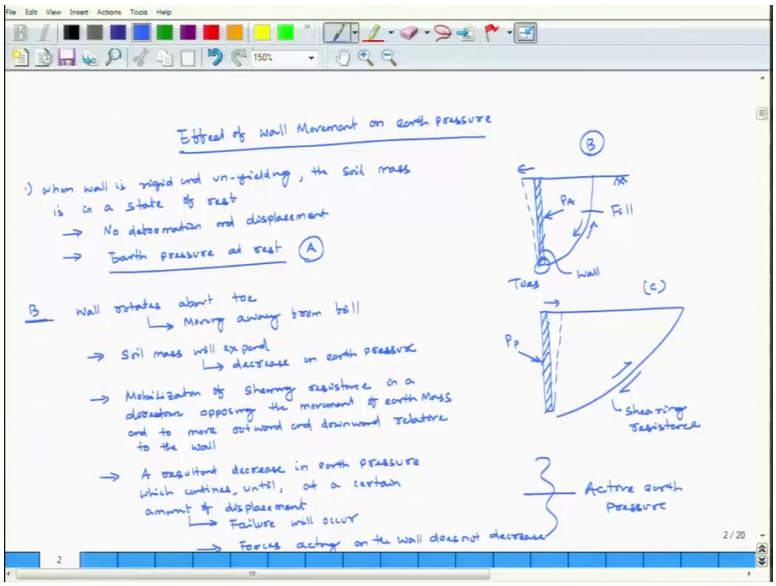

And effect of wall moment on earth pressure, I consider one is your earth pressure at rest, where it there will not be any deformation or displacement. One is wall rotate about the tough, and then wall movie is moving away from the soil mass, that is called your active stage. Other is your wall is moving towards the soil mass, that is called your passive state.

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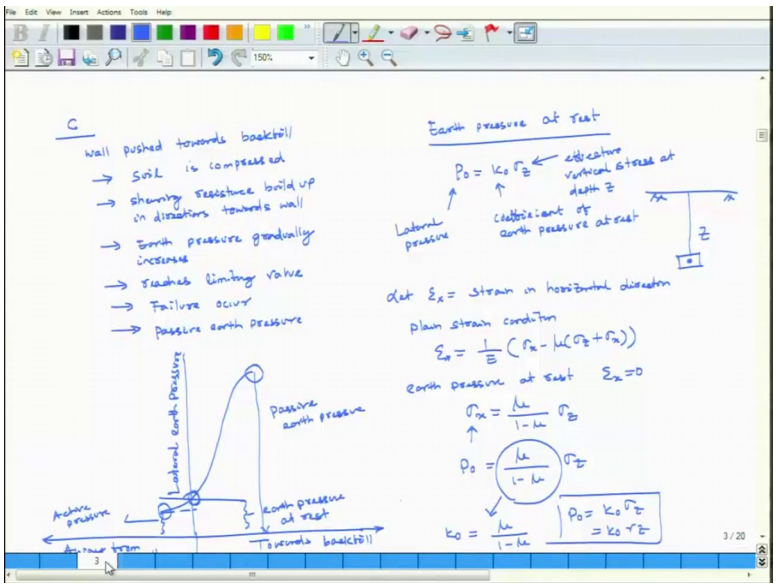

Then earth pressure at rest we have derived p 0 is equal to mu by 1 minus mu into sigma z.

So, mu by 1 minus mu is your k 0 earth pressure at rest mu 0 Poisson's ratio.

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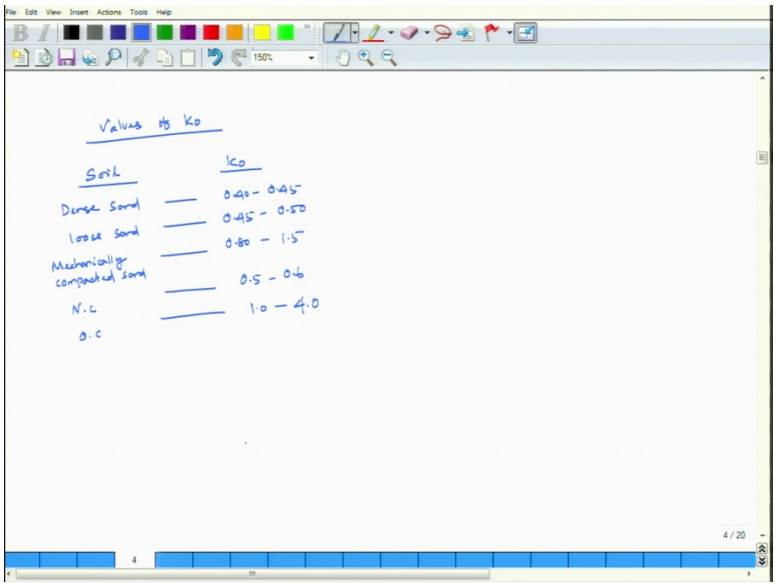

Then different values of k 0, I have discussed for different types of soils. Now let us start with this Rankine's theory of earth pressure.

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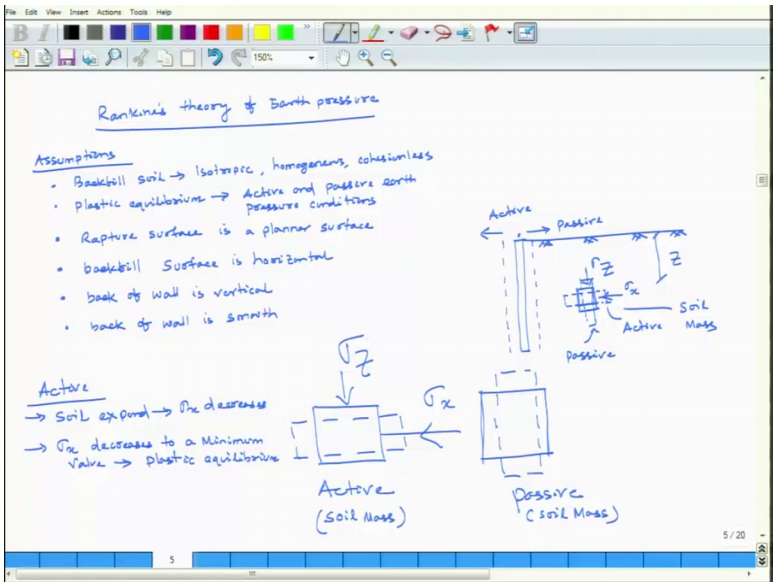

Rankine's theory of earth pressure; so in Rankine's theory of earth pressure what are your assumptions? First let us Rankine's as given earth pressure theory is first. Then what are your assumptions, assumptions are backfield soil is isotropic homogeneous and cohesion less soil. Backfield soil is isotropic homogeneous, then cohesion less. Then soil

is in a state of plastic equilibrium, soil is in a state of plastic equilibrium. Both in case of active and passive earth pressure conditions. Then rapture surface is a planner surface then is your rapture surface is a planner surface. Backfield surface is horizontal, backfield surface is horizontal then back of wall is vertical, then back of wall is smooth.

Now, let us consider a retaining wall. This is my wall; this is your ground surface. Then I have marked it here both the sides this is your passive this is your passive, and this case is your active. And let us consider at this distance Z a soil mass is there, in the soil mass let us say this is my sigma x and this will be the sorry, this is my sigma Z and this will be the sigma x. Now let me draw it in such a way that it will be more convenient for you to understand, original soil mass this is a dotted line.

Then another one is I can write it this is my active, and this will be my passive. If I can write it a soil mass I can show it in a bigger way this is my soil mass. So, this is the case of your active, then there is a soil mass here is the soil mass, and this is the case of passive, active and passive. Now if I say there is a soil mass here this is a soil mass and this is a soil mass in active case and here in soil mass in passive case. Now what will happen once wall moves away from the backfield that is the case your fear active state, then what will happen in case of active first part is your the soil element expand, soil expand and what will happen, sigma x decreases. Sigma x is your horizontal stress sigma Z is your vertical stress, sigma x decreases to a minimum value. So, that it reaches plastic equilibrium.

Now, this is the case of active, now what will happen case of the passive? In case in this case if this is my original soil mass try to understand. And hear it will be sigma Z and here it will be sigma x. Once wall moves away from the field to sigma x decreases and it reaches a minimum value decreases to a minimum value where is your plastic equilibrium observe. Now let us plot in terms of Mohr circle if I plot in terms of Mohr circle.

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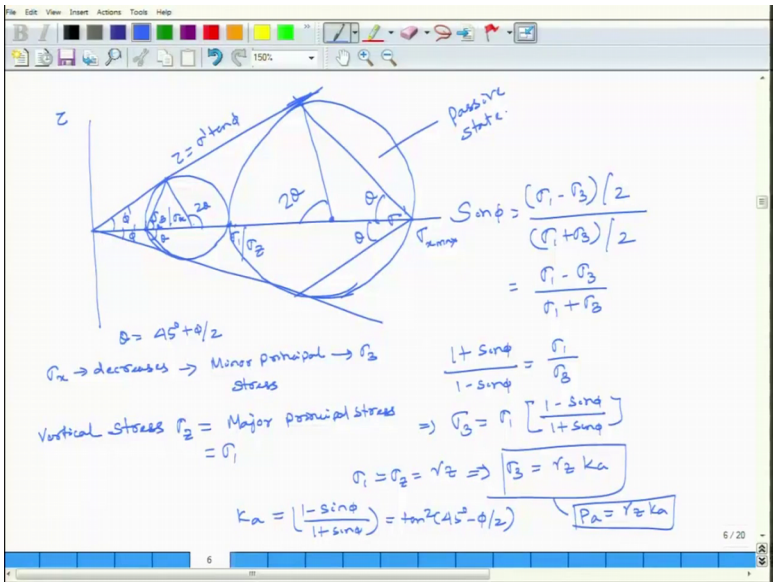

Let us say this is my sigma prime, and this is my tau. So, your stress, now what will happen what will happen if you look at here, one sigma x decreases sigma x decreases So that Mohr circle reprinting to stress test touches your strength line. One sigma x decreases so that means, it will become minor principal stress which is equal to your sigma 3. Then vertical stress, vertical stress sigma Z which is equal to major principal stress which is equal to sigma 1. Now these part will be mine sigma 3 or sigma x, this will be sigma 1 or sigma z. So, this angle will become phi prime, and this will be also phi prime and this will be your theta. And this angle will be your 2 theta, here it is also theta. Here it is equal to theta is equal to 45 degree plus phi b y 2, and this is your tau is equal to sigma prime tan 5.

So, if I if I am taking it from this if I am taking it from this diagram what is it mean, sin phi is equal to sigma 1 minus sigma 3 by 2 divided by sigma 1 plus sigma 3 by 2. Sign phi if this is the phi it will be this by this So, this will be your sigma 1 minus sigma 3 by 2 radius and this will be sigma 1 plus sigma 3 by 2, which is equal to sigma 1 minus sigma 3 divided by sigma 1 plus sigma 3. Now if I put it 1 plus sin phi by 1 minus sin phi which is equal to sigma 1 by sigma 3 that implies sigma 3 is equal to sigma 1 into 1 minus sin phi by 1 plus sin phi, then sigma 1 is nothing but what? Sigma 1 is nothing but is your sigma Z sigma Z which is equal to sigma Z which is equal to gamma z.

So, what does it mean? Sigma 3 is equal to gamma Z into k a or I can write it Pa is equal to gamma Z into k a. Now k a can be written as 1 minus sin phi by 1 plus sin phi into, which is equal to tan square 45 degree minus phi by 2. Look at the physics for active state. In active state what will happen? There is a soil mass retaining and the wall is moving now away from the soil mass.

Once wall is moving away from the soil mass the sigma x decreases to a minimum value, where is your plastic equilibrium reached. Then what will happen if I take a Mohr circle it will touch your failure and envelope, then in that case what will happen, sigma x decreases and it becomes minor principal stress, that is your sigma 3 as compared to your sigma Z. Then vertical stress sigma Z becomes your major principal stress this is your sigma 1.

If I take it this is my phi value phi plan value if I take it, sin phi sin phi is equal to this divided by this then this will be your sigma 1 minus sigma 3 by 2 divided by sigma 1 plus sigma 3 by 2 which is equal to sigma 1 minus sigma 3 by sigma 1 plus sigma 3. Then sigma 3 comes out to be sigma 1 into 1 minus sin phi by 1 plus sin phi then sigma 1 is equal to sigma Z, which is equal to gamma Z then sigma 3 is equal to gamma Z into k a. So, k a is equal to 1 minus sin phi sin phi by 1 plus sin phi which is equal to 10 square 45 degree minus phi by 2. Then Pa is equal to gamma Z into k a. Pa is your active earth pressure which is equal to gamma Z into k a.

K a value is your 1 minus sin phi by 1 plus sin phi. Now similarly if I draw it for passive state; if I draw it for passive state what will happen? What will happen in passive state? So, then this will be your theta of course, this will be your 2 theta, then this will be your theta. So, in these case it will be your sigma x maximum. If I say this is my passive state, what will happen?

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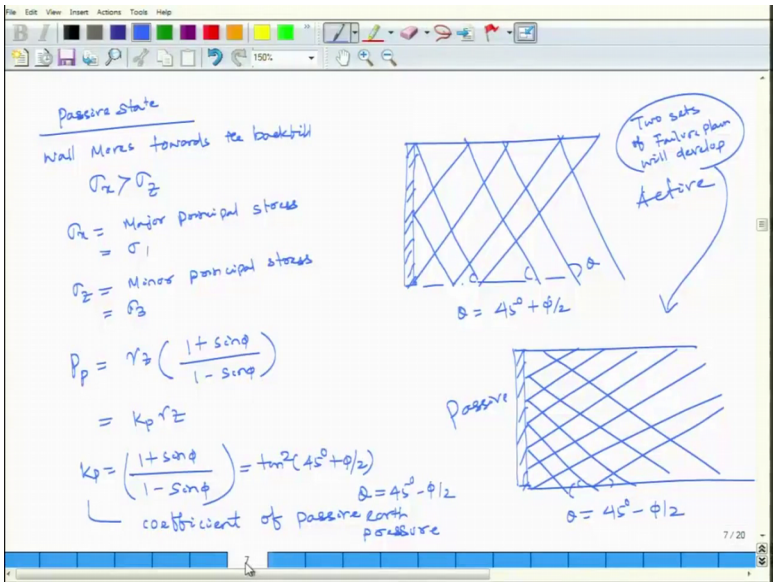

In passive state wall moves towards the backfield, then you what will happen once walls moves towards the backfield look at the diagram. Once wall moves towards the backfield this is your passive state, then this will be your sigma Z, and this will be your sigma x.

So, sigma will be more, sigma Z will be it will be less, sigma x will be more. So, in that case sigma x is greater than your sigma z. So, then sigma x is equal to your major principal stress, which is equal to your sigma 1. Sigma Z in passive state it is your minor principal stress, minor principal stress which is equal to sigma 3. Then if I reverse it, what will happen? Pp I can get it Pp is equal to passive force gamma Z into 1 plus sin phi by 1 minus sin phi. You can get this derivation from this diagram also directly. Then which is equal to k p gamma z. So, k p is equal to 1 plus sin phi by 1 minus sin phi which is equal to 10 square 45 degree plus phi by 2.

This is your coefficient of k p is coefficient of passive earth pressure. So, then in these case theta is equal to 45 degree minus phi by 2. So, I am expecting we are expecting 2 sets of curves we are supposed to get it, solve particularly active and passive case if I write it if I draw this diagram, this is my active. So, angle will be for active case this will be this will be your theta, and theta is equal to 45 degree plus phi by 2. Similarly if you are passive, passive I am supposed to get it. So, this angle as well as this angle will be theta is equal to 45 degree minus phi by 2. This is case of active, this is the case of passive. So, in this case 2 sets of failure plain will develop, 2 sets of failure plain will

develop for active case as well as for passive case also, 2 states of failure plan also will develop.

So, this is what our summary. In active state Pa active earth pressure is equal to gamma Z into k a. K a is equal to 1 minus sin phi by 1 plus sin phi. In passive state Pp is equal to gamma Z into 1 plus sin phi by 1 minus sin phi. And Pp is equal to k p into gamma Z, k p is equal to coefficient of passive earth pressure. So, k p is equal to 1 plus sin phi by 1 minus sin phi. Let us start with this few examples, active earth pressure on retaining walls Cohesion less backfield.

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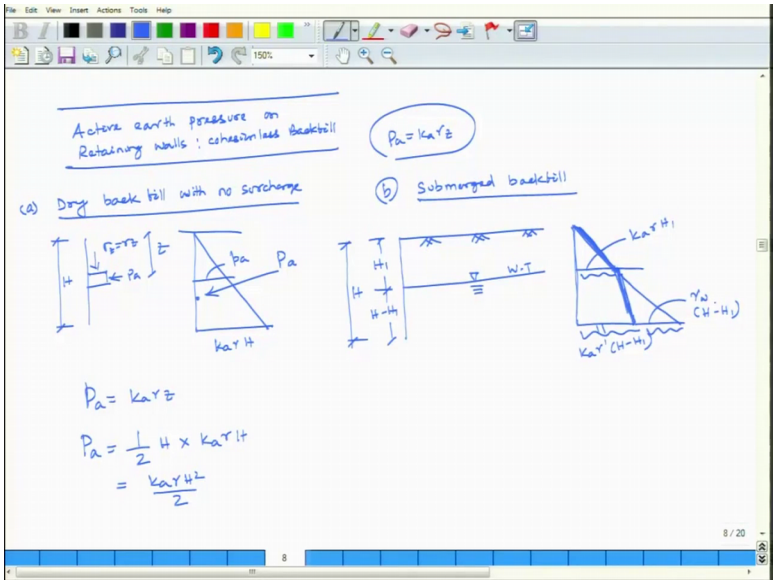

So, case by case let us we will go. Dry backfield with no surcharges case a, so here Pa is equal to you can write it Pa is equal to k a into gamma Z, this is our equation.

So, dry back field with no surcharges. So, this is my wall. In this wall there is a soil mass and this is your sigma Z is equal to gamma Z. And this is your active earth pressure Pa. And his distance is your Z, and this is your height H. Now what should be it? It is will be like, this k is constant gamma is constant Z it is wearing with this. So, then it will be k a gamma prime H. And this will be your small Pa. And this will be acted as a capital Pa active earth pressures. So, here it will be Pa is equal to k a gamma z. So, then if you want to find out what is your active earth pressure take this is the distance H, take the triangle. So, then it will be what actual Pa this is a small Pa p a is equal to half H into k a gamma

H k a into gamma H. And from there it will be k a gamma H square by 2, and this will be act as a c g here 2 third from here it will be one third.

So, this is summation of total force, then submerged backfield. Let us consider your submerged backfield, consider this wall. This is water table, this is your H 1, and this is my total height H. What will happen if there is there is a dry; dry backfield, with no surcharges. Here in this case it is a submerged backfield what will happen? How your earth pressure distribution will be there? Look at carefully. So, up to this part is your dry up to H 1, simple triangle in this case it will be k a gamma H 1. Then there will be a water table, because of water table it will be a submerged conditions. So, because of submerged condition what will happen? Here in this case it will be k a gamma prime H minus H 1. This part, because gamma is your unit weight is your submerged unit weight.

So, that is why it is a gamma prime. Then what will happen there is a water pressure will come into picture. That water pressure will be taken into considerations. This water pressure will be your gamma w H minus H 1. So, look at there are 2 cases I put it drive backfield with no surcharges. Another one is your submerged backfield. In drive backfield there is a very simple way it is a very triangle, k a gamma H are the below and Pa we will act in the triangle at the c g. Total force you can find it out the area half H into k a gamma H k a gamma H square by 2. Then it will look at the submerged backfield suppose part of this there is no water table up to H 1. Water table lies below the ground surface at a distance of H 1 total height is H.

So, for H 1 it is k a gamma H 1, here to here. Then from H minus H 1 this will be H minus H 1. In this case the gamma will be a submerged because the water table is there. So, this will be k a gamma submerged into height. This is your H minus H 1 then what additionally we will be come into picture because water is there. Water pressure we will come into picture. Here it will come gamma w H minus H 1. So, this entire diagram looks like here, here and this will be your this, this part will be this, this part will be this and this will be because of your water pressure. I will stop it here.

Next class I will proceed with more like surcharge, effective of surcharge, then effect of 5 layer soils. Next class I will discuss.

Thank you.