Foundation of Offshore Structures
Professor S Nallayarasu
Department of Ocean Engineering
Indian Institute of Technology, Madras
Module 1
Lecture 7
Basics of Soil Mechanics 7

So we will just look at the failure criteria for the soil is here. The original criteria by Mohr in in a failure envelope you can see it a curved surface, depicting failure non-failure cases as well you look at the point B is on the line where the failure occurs.

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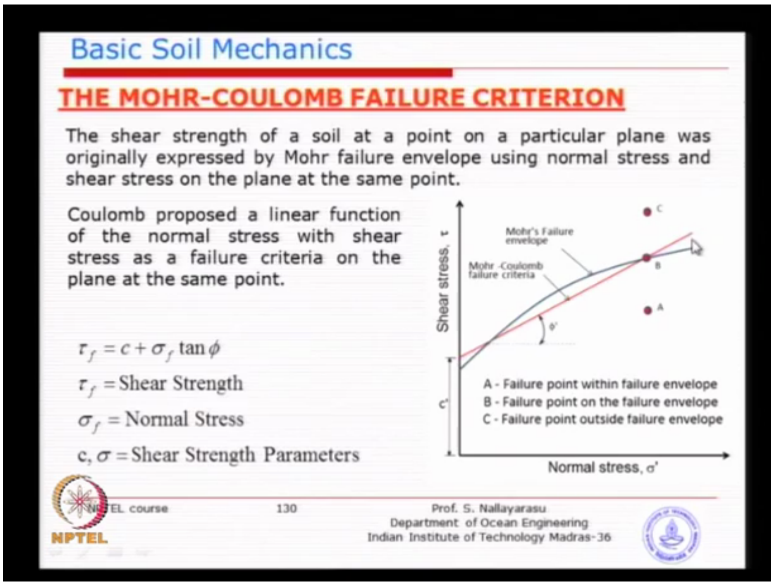

Now the simplified the Mohr coulomb failure criterion is a simple straight line between the shear and direct stresses. So you can see here is quite easy to simulate as well to predict this stresses because it makes straight line with a intercept of shear strength, which is something that we derived earlier you know if you look at this equation is a component of address and plus the path of the shear stress As a failure criteria coming from the normal stress. So basically this gives a linear principle in comparison to the original failure criteria which is curve and linear.

In in cases of three dimensional stresses it will be complex surface which will be difficult to derive. So that’s why this simplified Mohr coulomb criterion is commonly used in most of our foundation designs because of its simplicity and we will be using that in our course throughout the course which will be very useful. So one of the parameter what we see here is undrain shear strength or shear strength you call and the angle of internal friction. This is a typical sea phi soil which is comprising of sandy layer clay sand with several fractions.

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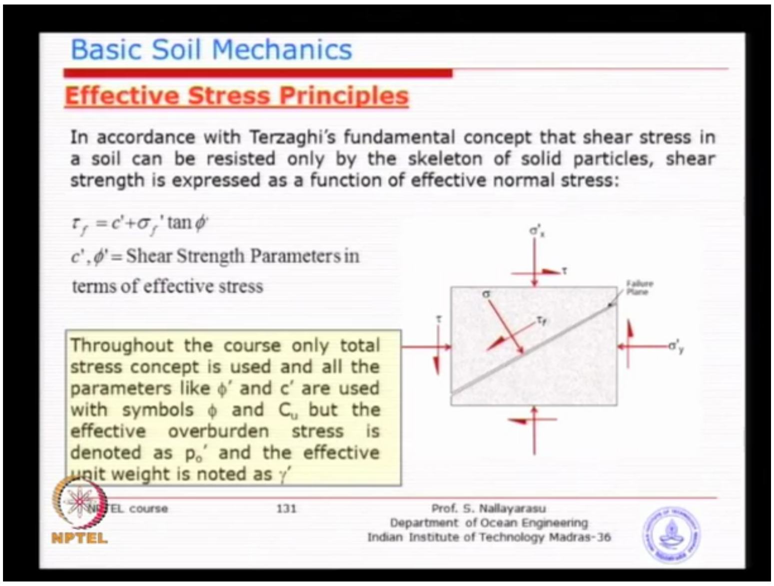

So basically and the second thing is effective stress principle as you know I think I have shown you some slides with solid particles wides and solids particles in contact. I think earlier first two classes we have talked about the arrangements of particles in a soil space, so when you apply the loading the contact surfaces between solid particles and solid particles is transferring the stresses and basically the fluid around suppose it is a fully saturated size like marine type of sediments then it is uniform everywhere.

So they don't take any load and only the loads are transferred by, so this principle of effective stress was actually originally introduced by Terzaghi and you know basically it was meant for partly saturated soil as well on ground conditions whereas in marine type of soils with doset matter is fully saturated and also the hydrostatic pressure is same at every point in the soil medium. So that's why we don't bother whether it is effective stress principle or total stress principle. Total stress is part of the load transfer is via the fluid surrounding which is anyway later on we are going to remove it because ultimately we are looking at the behaviour of soil itself.

So that's why throughout this course though we call it effective stress we normally use the total stress principle because we are going to take the point rate of the soil particle itself. So because it is fully submerged underwater at certain hydrostatic conditions so I doesn't matter whether you are working on effective stress or total stress principle because the weight of the soil is taken minus the point C, so if you actually have the particles down there and you take only the effective so the symbol instead of using c dash and sigma dash phi dash we will be using for simplicity c phi and corresponding notations so you don't have to worry you will be working on the total stress principle.

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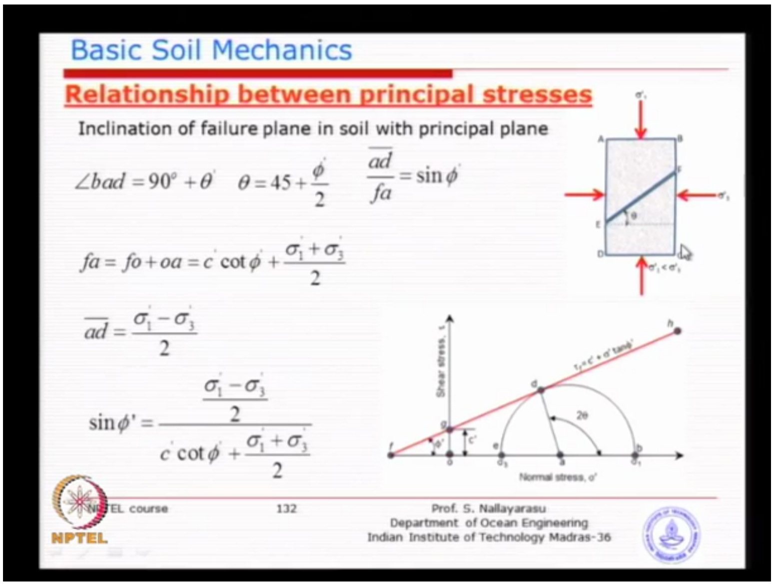

What we need to actually look at is the relationship between principle stresses as you know if you look at the hydrostatic state up stress the principle phases in all directions is same no? So what exactly we gather from there you know if you apply state up stress to a particle whether its solid or a fluid particle it is going to experience the internal stresses. So what we are trying to derive if you apply sigma one sigma three in just two dimensions what could be the relationship depending on what type of material, because this will be very often used in the later part of the derivations.

So there is barring capacity or file capacity or lateral behaviour so we just need to know the relationship between sigma one and sigma three in this particular case sigma one I have just taken as the vertical stress and sigma three as horizontal stress, so we can have vice versa depending upon which is more and which is less for example if we have lesser sigma three and more sigma one something is going to happen. Similarly if you reverse the stress sigma three is larger soil is going to squeezed up down isn't it?

So just now let us look at this, if you look at this you know the theta is natural failure plane, just any angle, it can be any angle depending upon type of soil and basically the strength so when you look at this picture when you put in you know on Mohr's envelope or Mohr's diagram so you can see sigma one is larger and sigma three is smaller basically sigma three is here and look if at the triangle in this using similar triangle principle you can here a, d and b, a, d basically this triangle and this triangle you can get the properties.

One of the important parameter that we are trying to derive is the relationship between the radius of this Mohr circle through the distance from this point to this so basically is sin theta and substitution of so what you get is a,d is the intercept extended toward the zero point plus difference between sigma one and sigma three divided by two basically it's this distance and when you try to do this sin theta or sin phi you are trying to get relationship between sigma one and sigma three, so very simple triangle principle.

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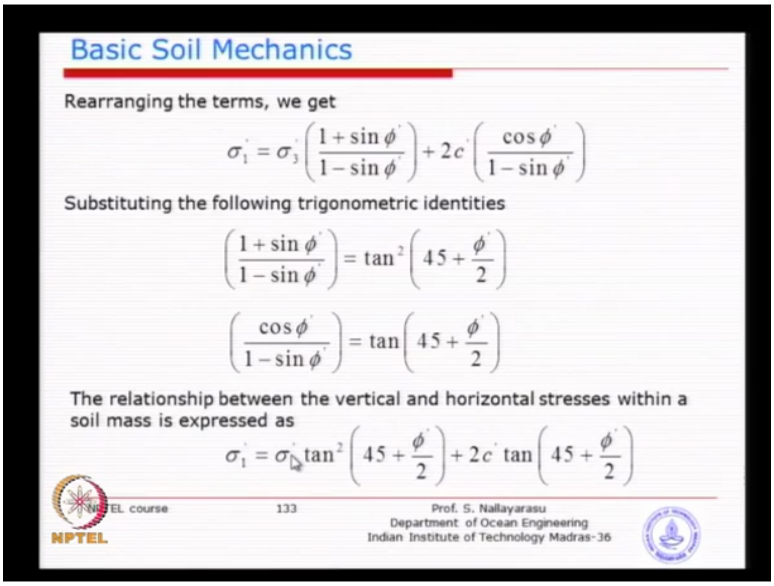

So what we started was using this ninety plus theta and phi is taken as 45 by 2 because sigma 1 is larger sigma 3 is smaller and you do this exercise ultimately we are going to just simplify this if you just go to this you can rearrange the terms you will get something like this sigma 1 is a fraction of sigma 3 plus addition factor you know basically two components and you can actually substitute using mathematical trigonometric functions of 1 minus sin phi by 1. So you can do that find will it in many of the trigonometric identities or you can derive it and substitute just you are having just a relationship between sigma 1 which is a phenomenon stress applied vertically and sigma three is a stress applied horizontally.

Now if you go to hydrostatic state up stress both are equal, so the coefficient of or relationship between sigma 1 and sigma 3 is 1. Whereas see here depending upon soil material whatever type of soil is very soft clay you will go almost very close through it. It is a good material you will be different. So that's basically later we will see is called coefficient of that pressure, how much part of the lateral effect is going to be same as the vertical part of the stress.

So in here if you see here sea is coming here typically as we have generalise it sea phi soil. If it is a sandy material this will disappear. If it is a clayey material then typically we will have clay type material or it will become like it .So this relationship why we derived basically we will be used in this active or passive earth pressure cases.

Because remember when are deriving a foundation capacity when you apply a loading and to a foundation transfer the loading vertically down and it puts pressure on the soil under sides and that process horizontal pressure actively and what happens to soil the state up stress from a you know the rest case is going to get compressed. So what happens to the soil and if the soil stress is achieved the soil will come outside.

So that is basically the idea whether you apply vertical stress or horizontal stress we need to know the relationship.

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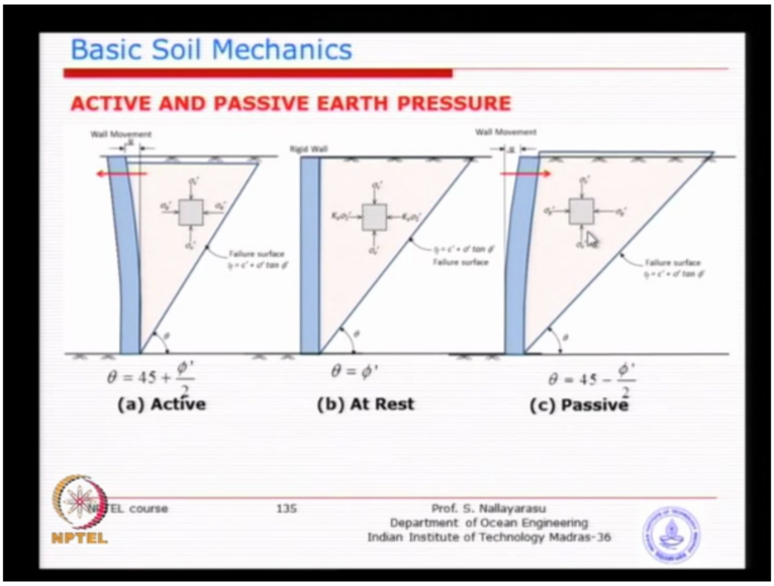

So we will just go to 3 cases in this particular earth pressure theory we will see this picture if you see at the centre, the soil is subjected to vertical horizontal and stresses, vertical stresses is primarily due to in this case is due to its own weight and horizontal stress is due to consignment. Basically the horizontal stress is a fraction of the vertical stress with certain multiple factor and the soil is in equilibrium it neither move nor goes back and that condition is a twist and at that time the state up stress is such a way that the soil doesn't move and not the wall nor the soil face.

Basically the relationship that we are looking at, which will be quite difficult to find out basically with this condition there are several numerical and some formulas which we will look at it, but when you look at this case for example when the wall is weaker, you constructed a wall and tries to move towards the left so what happens you know the soil tries to come down or grow up depending upon the wall whether the wall is moving up or wall is moving this left and right. So basically the state up stress here you know basically this soil is trying to come down and putting pressure downwards which is going to create an active case that is the soil weight going down.

Whereas in the passive case we are trying to compress the wall towards the soil and giving up basically is a passive case. So we need to see how we can relate sigma vertical to sigma horizontal or passive I just denoted as P so that you can see. So this as basically sigma A and this is sigma B but both times the stress due to its own weight is sigma V. So in this particular case the soil weight produces the horizontal stress whereas in this cases the wall movement produces primary stress is horizontal tries to apply the you know the, it is against the weight of the soil.

So we just need to derive this 3 cases depending upon the situation we can use this in the foundation design.

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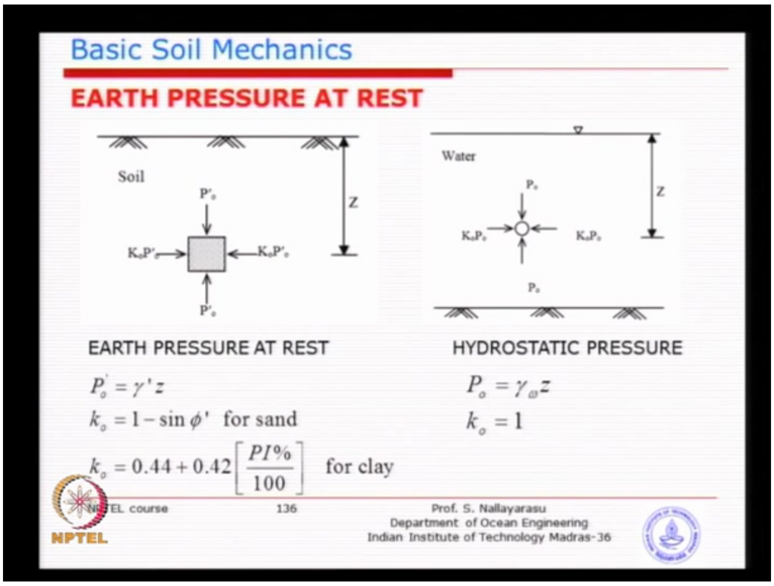

The first one you can see here this is what I was trying to explain earlier the state up stress in the fluid medium like water you will have the pressure coefficient all around is 1 so you don't have you have a hydrostatic state up stress whereas if you go to a soil stress you know the vertical pressure is basically the submerged unit weight all the time we will talk about gamma dash because the soil is fully submerged in marine conditions.

So depending on the depth at which its acting gamma dash times H will give you the pressure at the point of consideration and K knot for sand many times people have expressed this again kind of position used many times 1 minus sin phi. So if you look at 30 degrees what will happen to phi, find 0.5, so you will get 50 %, so similarly there was a different proposal like using plasticity index for clay type soil this this was given by one of the literature I have just given you for example which cannot be derived directly using a numerical formula.

So earth pressure at rest that means the soil is in the equilibrium condition neither moves and it is in static condition is basically you see this type of idea, whereas for hydrostatic pressure is very simple and easy to understand that it's all around uniform.

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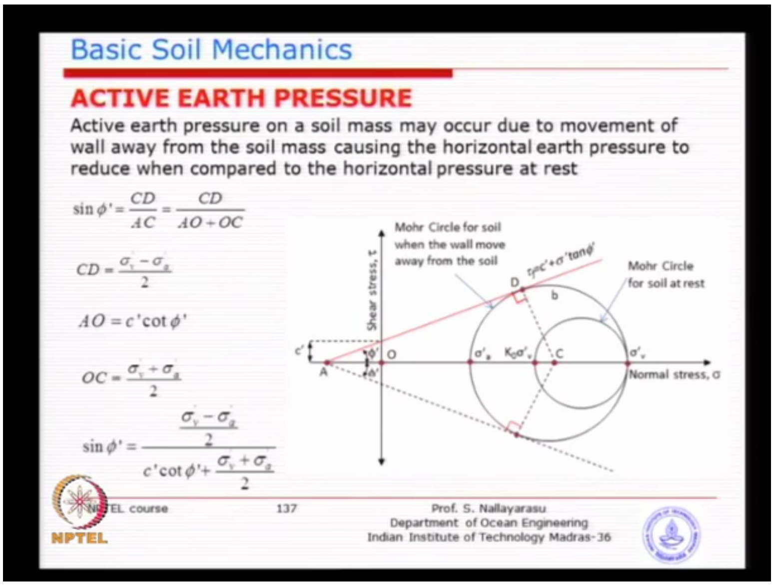

Now when you go to active earth pressure case basically the wall move towards outside and the soil is trying to settle down it could be either due to you know over surcharge sometimes you have like total harbour structure where you have surcharge soil is getting compressed, similar derivation which we just now did it here exactly the same. I just repeat it here, basically take the triangle from this path as well as from this angle you try to derive the relationship between sin 5 which is this C D by A CC. CCD is from the central of the circle to the horizontal. So this 90 degree know because it is taken tangent to the circle itself and then trying to rewrite the values of CD and AC in terms of this triangles and then substitute here and then rearrange.

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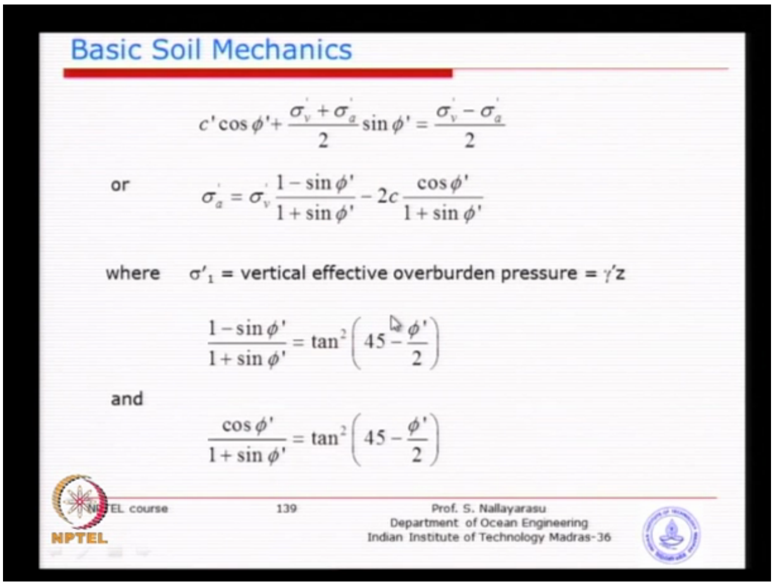

This cot 5 you can rearrange ultimately you will get the similar formula what we were deriving, so the relationship between the sigma 1 was there and other derivation is just replaced by sigma A sigma 1 was here and sigma 3 was here so just rearrange that's why you see a negative here. And then you can substitute I think of the term is in between I just skipped because we have derived here. In this this is just skipped because it was arrived from the other side, so that's why you see a negative sign here and then replaced this trigonometric identity you can just get the formula something like this.

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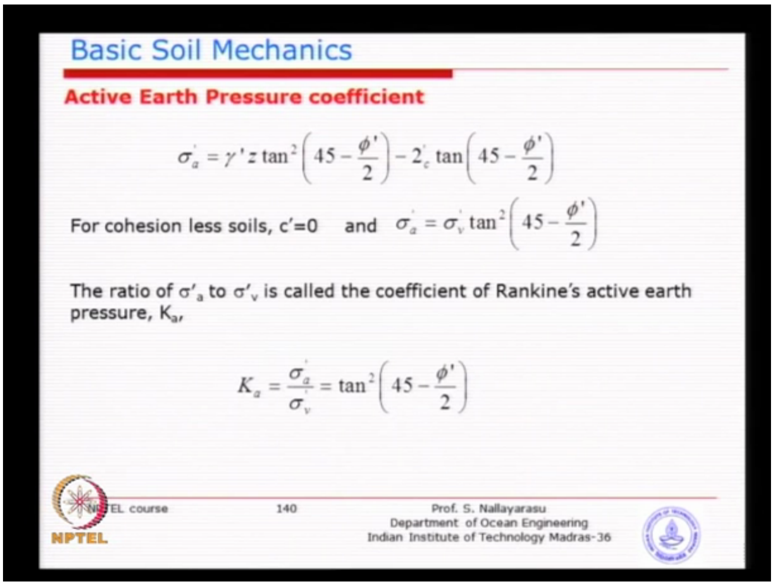

So activate pressure is a function of your sigma 1 which is gamma times Z and basically the second and third terms are similar to what we derived. And when in case of C is equal to 0 that means is purely sandy type of material it will reduce to this relationship between sigma A and sigma B which is easy to find out the phi will be known to you and the ratio of sigma active or the horizontal pressure to vertical pressure is called coefficient of earth pressure for active case.

That is why we called it KA so as long as you know the value of phi you will able to find out the, so what we are trying to derive is when you apply some sort of stress in a vertical direction what will be the induced stress on the soil in that vicinity in horizontal direction, that's why what we are trying to. It is easy to understand for example when you open up a hole in the soil and try to apply the loading, due to foundation coming from super structure, you apply the loading what happens to the vicinity the soil is getting squeezed laterally because of the infinite semi-infinite soil medium so just getting compressed.

As long as the compression is not visible because the soil surrounding is very stiff, what will happen the soil will not move down, because then settlement will not happen that means you can classify as a good barring soil. But if the soil surrounding is actually going to squeezed away because of ferocity or the soil is not very strong enough then the soil will just squeezed away and try to settle down. So two things can happen either the over burden is too small so the soil will also come up you know we will see this failure cases of foundation later on.

When you apply foundation pressure if the soil under side is very weak the soil can get squeezed up also instead of laterally it can also come up. Once that happens the foundation will keep on sinking and that’s straight that’s where the weight of soil above the foundation layer is very important. If it is heavier and heavier you are not going to allow the foundation to settle that means this barring layer is good .That is why we need to know what will be the pressure put forward by a vertical pressure applied from a foundation on the super structure to the soil in the horizontal direction, this relationship is very important.

Because all along whether it’s a file foundation design or its shallow footing design or any type of foundation this will be very-very important because that’s what the relationship will be using it. To derive several formulas for foundation capacity so that’s why I just was thinking to introduce this.

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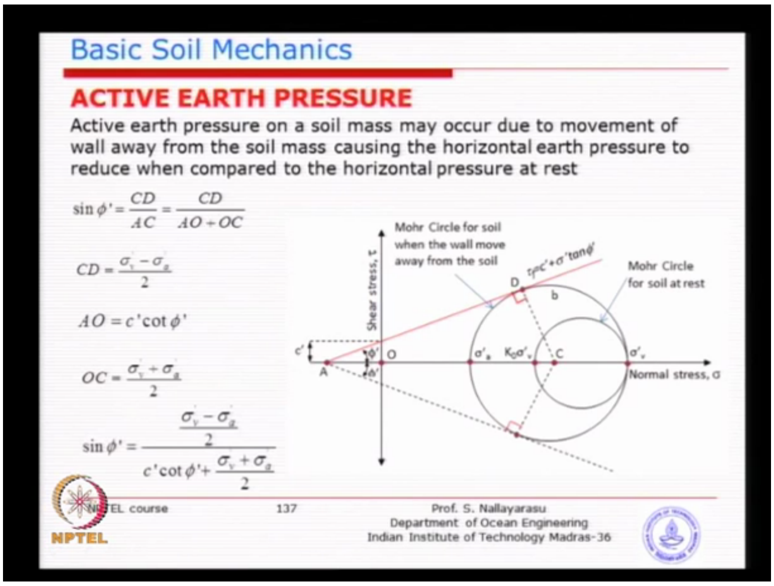

So basically what you see here is the you know the state up stress in a two dimensional space, horizontal stress vertical stress, and using Mohr circle you try to derive the relationship between the property so called you know the angle of internal friction and the intercept which is basically this cohesive component of the c5 type of soil.

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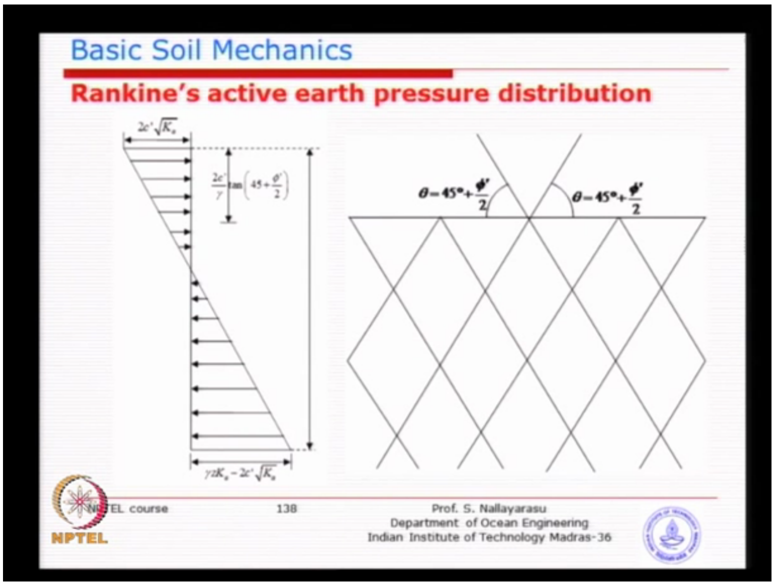

And that is what you see here the distribution of the earth pressure along the depth you know wherever you have the clay type of soil you will have negative. You know that is one of the important parameter if you have a top soil is clay then you are not actually going to get anything from it. And the angle at which the failure occurs is very important, the soil natural failure by wedging you go back to this first feature.

When it is trying to fail by deflecting the wall away from the soil the angle is theta, which is basically 45 plus phi by 2, whereas when the soil is trying to get squeezed away by the wall towards the soil itself is 45. So you can see here you can just imagine it is trying to come down on its own the failure plane is defined slightly steeper from the horizontal that means is, you can easily understand soil is not going to take a very a flat failure plane. Whereas when you see here, when you are trying to push the soil away, its taking a slightly reduce the angel which is , soil is trying to give up towards the the land side. So you can see this is lesser angle for sure this is greater angle because its failure plane is defined by and minus or 45 minus phi by 2 , you can easily see that the both soil is trying to go away from the both towards the land.

So that is something you need to remember. Passive case is 45 minus phi by 2, active cases is 45 plus phi by 2, the angle to the leisure. Now imagine if you take a rock or a material is very good. This can actually go into vertical plane isn't it? If you have a good material is not going to take 45 plus phi by 2 it can even go 80 degrees failure plane, because you have a stronger strength and it is able to stand in that plane and if it is water what will happen? This will become flat, so that it means the failure plane is almost zero. So that is where you find the difference the active case it will take its natural failure plane whereas the passive case we are trying to create artificial failure plane depending on the magnitude of the reflection.

So it takes the lower angle it seems both flies towards the landside. So that that that is something that I have just described by this failure plane. Occurring in throughout the medium and this this is the plot of the profile of the pressure calculated this pressure.

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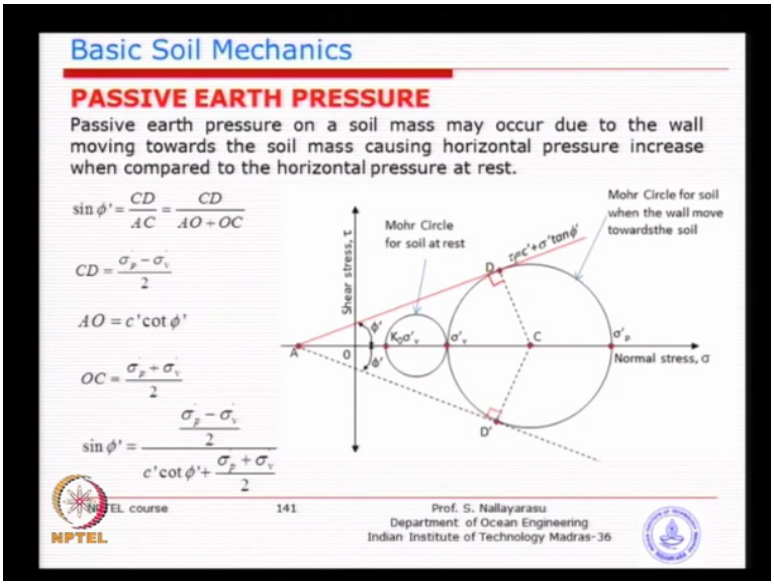

Basically you can plot the coefficient or you can plot the pressure. Similarly we could derive exactly same procedure only thing is in this case horizontal stress is higher so passive earth to earth pressure or the soil is the pressure applied on the soil by the movement of the wall is more so sigma B becomes larger and sigma V becomes smaller , so that’s why the soil is able to move.

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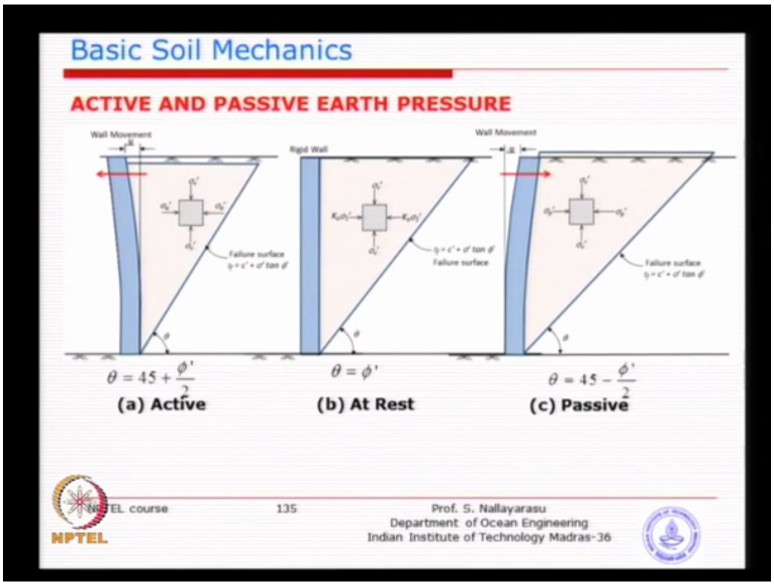

Imagine if we go to this picture I just go back again if you have sufficient amount of vertical stress under curve for example if you put so many accounted blocks what will happen? The size will not be able to keep upwards. So that's why in this case we are making the effort required to move the wall is more than the weight of the soil which is basically from this point to this point applied there, then only the soil will move. Suppose if the sigma V is larger for sure the wall is not going be able to move towards the soil. That's the conditions we are looking at.

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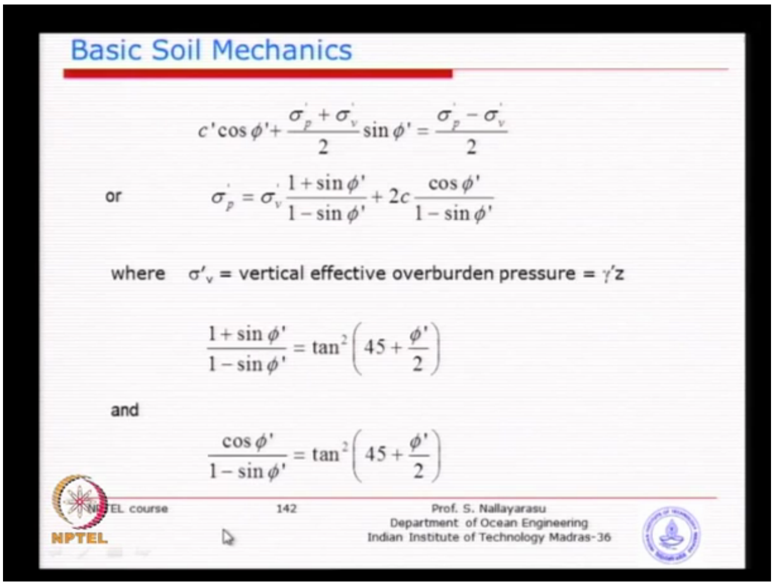

So that is why in the Mohr circle you see the sigma P is larger sigma B is smaller ,so basically that's the idea behind the passive and you just do exactly the similar triangular principles and try to find out the relationship between the phi and the other variables and substitute. What you are going to get is similar expression

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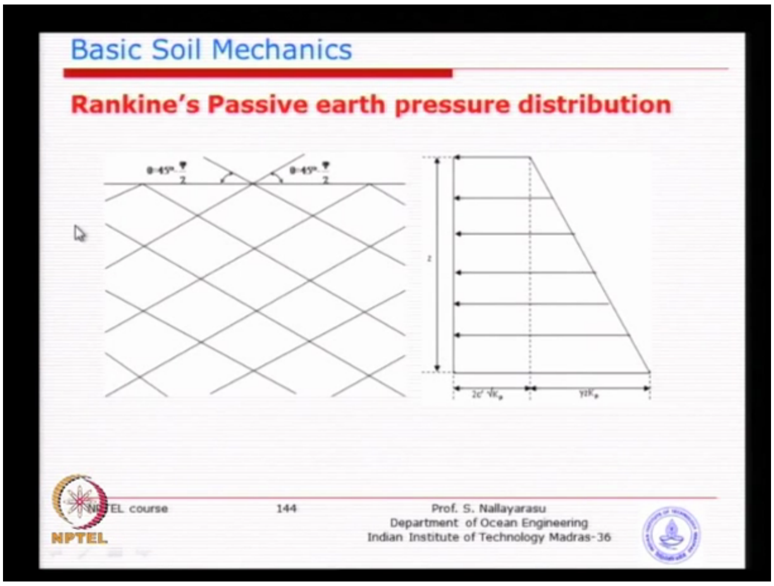

Except that you are going to see plus here because it is changed the other way around. So you can also substitute similar and the relationship you see here the passive earth pressure is vertical component plus the cohesive component which is similar picture you can see in the diagram. This failure plane is 45 minus phi by 2 because it is shallow and you can get the distribution of the passive earth pressure along the depth.

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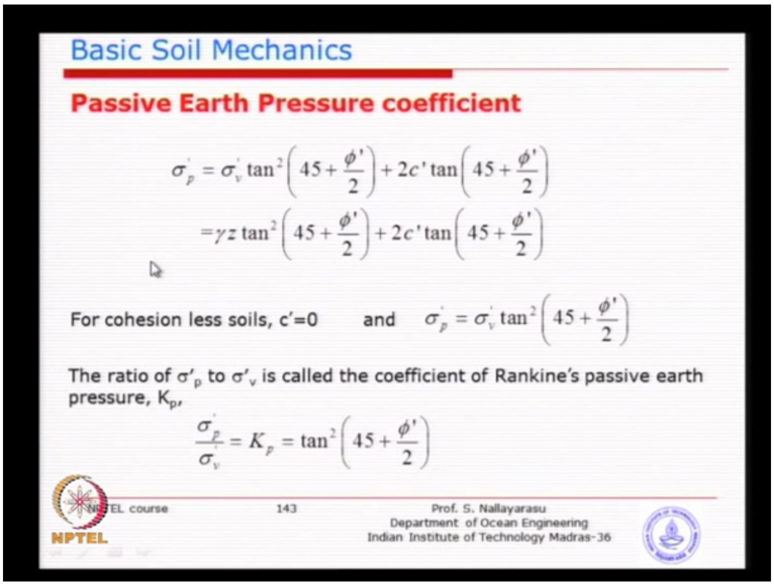

So this relationship will also guide us in several cases so for example when I apply a foundation pressure below the foundation the soil is getting vertical stress and getting horizontal stress due to this. And then on the side of the foundation the primary stress is horizontal trying to squeeze the soil upwards.

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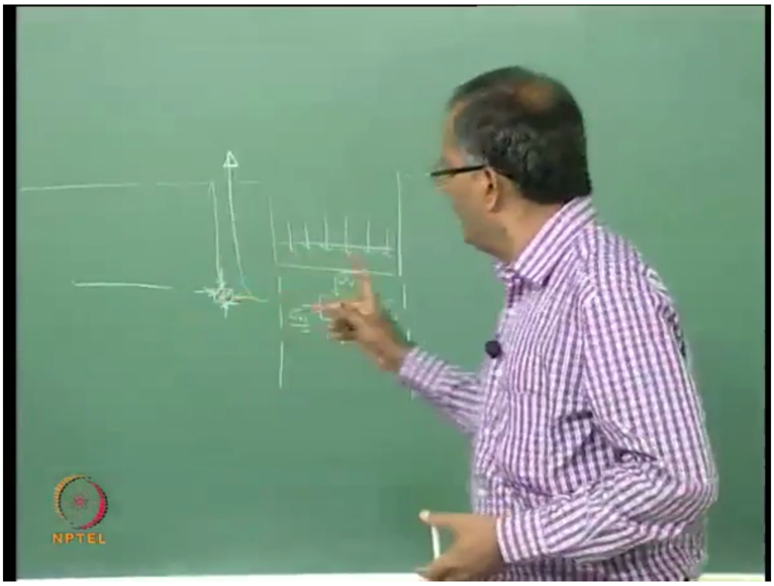

If we draw one picture for example you take a cut foundation, something like this ,if I apply you take one soil element here the phenomenal stress applied here is vertical pressure which is sigma V and sigma H. For this foundation to be in equilibrium whatever the sigma H applied should be able to satisfy the equation for sigma V so that it will not move down, so in order for the sigma H to be there if you take a soil sample soil here.

This soil sample the soil part the soil elements should be in equilibrium otherwise if this gives away for example if this height is sufficient not sufficient enough the soil will get squeezed away because this is a free area whereas it cannot goes away this way because the soil is continuously infinite. So that’s where we will be requiring the passive case here where the applied stress is horizontal which is which we are going to relate. That’s why we need to know this both active and passive cases will be used in derivation of foundation capacity.

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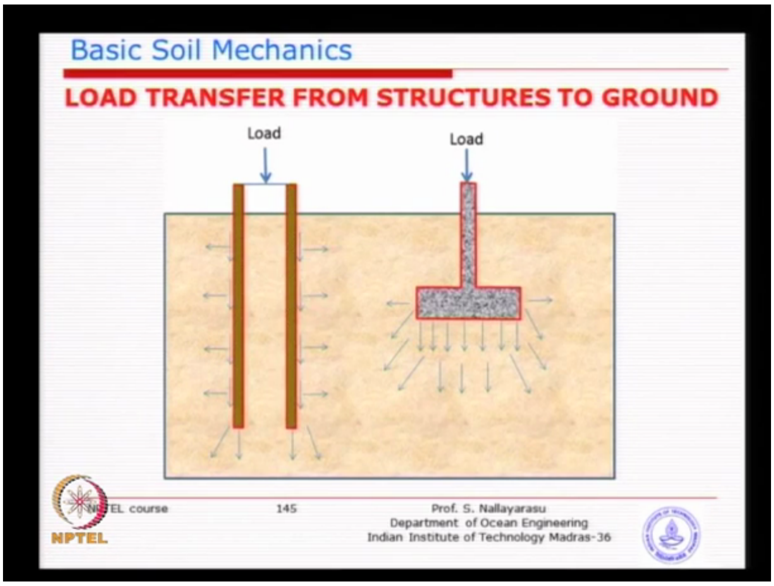

So when you look at load transfer so that we can easily derive some barring capacity of footings or file foundations. So if you look at the reason why we were trying go for pile foundation in many cases of large load or soil is not good. So you see this this particular case predominantly the footing type of soil footing type of foundation the soil is getting vertical pressure just immediately beneath the foundation but then it distributes in a manner depending on the type of soil, if it's a sandy soil it takes certain path if it is a clay type of soil takes different load distribution or if it is a rocky material directly it is taken by gearing.

So you can see here if it is a c5 soil with sand and clay you will see that the mixed pattern of soil (distribu) soil pressure distribution will take place whereas in the case of file foundation predominantly we are trying to fill the soil by shear along the surface between the soil and the foundation material and off course when it is being done what is happening is the soil on the side is getting squeezed away because the pile is getting inserted so whatever this friction that is has to overcome during the same period during the same time the soil is actually getting lateral pressure and which needs to be taken into account when we are doing the foundation capacity.

I think with this we will stop so that we can go into foundation types probably will start with the shallow footing with some derivations to understand how we can relate the bearing capacity to parant parameters.

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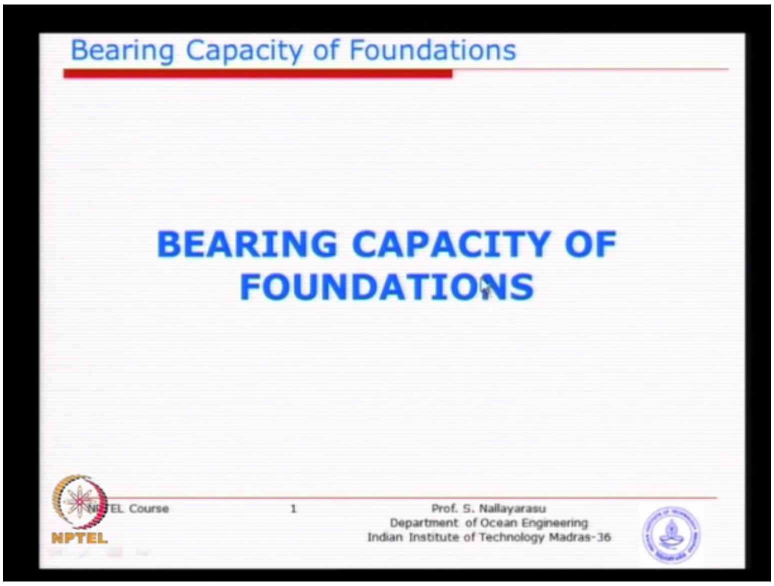

So what we will do is will just quickly derive because if we derive this relationship between the bearing capacity and parant parameters.

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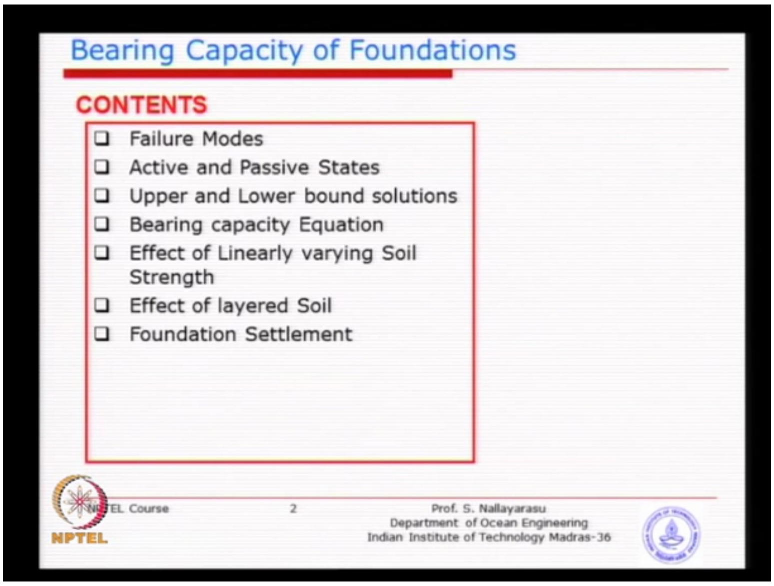

For phi soil sea phi soil or sea soil, then we use the same principle to extend the bearing capacity for file foundations, before that we will just quickly understand what is the failure modes

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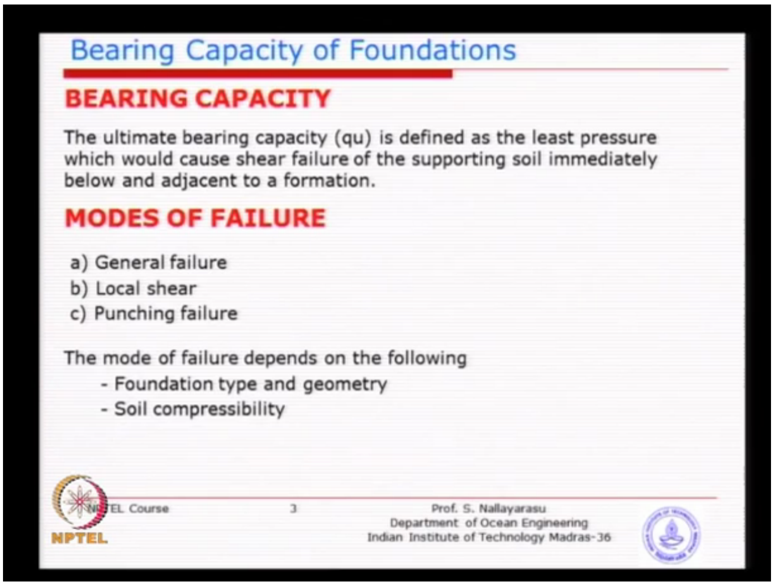

As I was just explaining here you know predominantly the type of failure for various types of soil is very ethical to predict and that's why you will see that certain uncertainties arise because it is not a uniform material. I think the first class itself I was trying to talk about when you have a hypothesis of a failure pattern for example you take a steel material when you explain failure by tensile means by making and then breaking is going to happen.

For most of the steels 99 percent of steel materials will behave similar manner whereas in soil conditions depending on the soil at the particular to the foundation location in the vicinity and type of soil the failure pattern is going to be different. So what the researchers have done they have just proposed several types of failure and then finding out the solution for each one of the case and then they have adapted the least one for some cases they have adapted mean cases for sometimes, and that's why you will see that numerical coefficient play a major role combining some of them.

You know you take combination of some the failure patterns that is why we need to understand what's the mode of failure and then based on that we can find out the foundation capacity. So what we define is ultimate bearing capacity is the least pressure by which the foundation will fail by shear, so basically what we are looking at here

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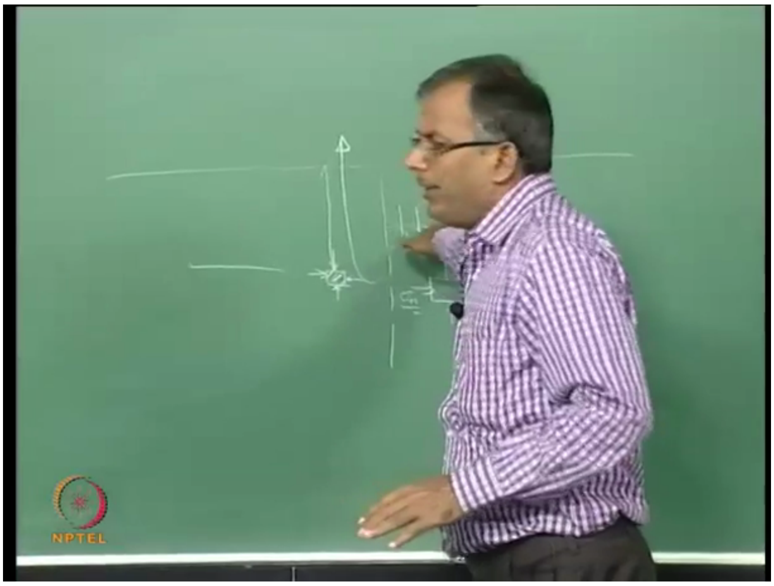

If you put the pressure here at this point when you apply that pressure the foundation will just fail by or it will make the soil to fail by shear and that will be the pressure that we are looking at called ultimate bearing capacity.

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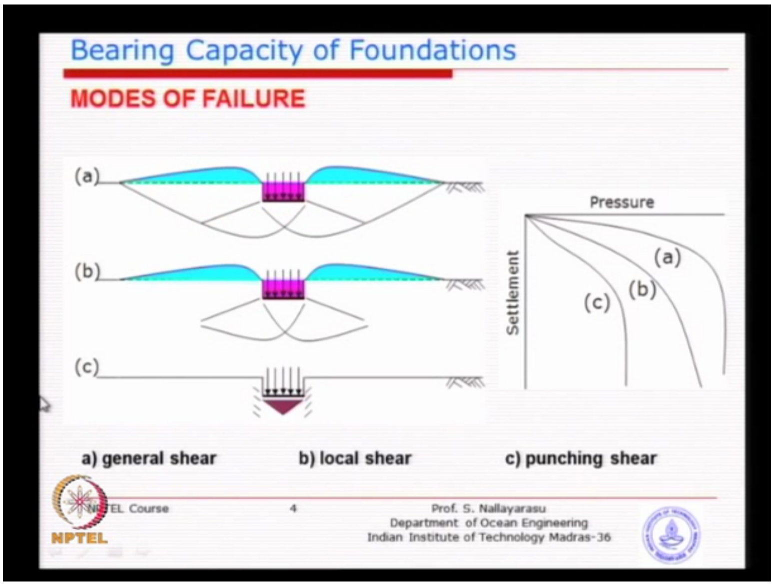

So that means is we are going into ultimate strength principles rather than when you are looking at the previous semester we were talking about design of steel structures, we were looking at allowable stress method you take the fraction of healed as the allowable strength. In this particular case we want to look at the ultimate strength then later on we apply factor safety to arrive at the allowable bearing capacity which we will compare with the working stress principles.

In many cases this will be quite useful because that is the maximum that the soil can take and that's what we are trying to derive at it. so if you look at this pictures the first and the second and the third I think we can spend some time on this. So if you apply a bearing pressure from the super structure and foundation and the soil beneath is getting stressed in a similar way what we were deriving just now basically the active pressure case soil is getting compressed which is exerting lateral pressure on the soil beneath on the sides and because this doesn't have sufficient strength the soil squewing away and that means the foundation is going to settle and at certain point it will find an equilibrium and then will stop.

And that is the point that we are interested to find out when it stops how much is the settlement how much is the bearing capacity, several people have worked from 1940's starting with Terzaghi, Mayor Horf, and several others such as come up with different-different ideas we will see all three of them so that we could understand what exactly is going on. So the general failure is basically a pattern which has got soil displacement laterally, soil moving up vertically, so by doing this what has happened is some amount of overburden is created at the top because the soil is going up. Have you go to the extreme case in this last one. Imagine this is what will happen when you have very soft clay for example the other day I was talking about if you go into a marshy area, you step on it what will happen?

You will simply go down vertically without any resistance and that's what will happen, if the material is too soft or too loose even it is sand for example. Now this is the intermediate case shear combined with some amount of general failure so basically local shear. This is purely a punching shear very similar to what you normally study with the concrete punching shear which is vertical cut. This is what will happen if you step onto water isn't it? Straight away go down. Now you compare on the right hand side there are there are three diagrams given to you to understand what exactly happen for given pressure for example you take a particular pressure you come to A it has got lesser settlement which is this and if take the same pressure to C , you see that settlement is larger

So you can easily understand depending on the type of you know basically the material. For a given pressure A B C you will have a larger settlement or for a given limiting settlement that's what we will be working out when you are designing a foundation, we will be limiting the foundation settlement to say 25 mm for particular structure, so you take a particular settlement case and then just go around this gives you the lower bearing pressure.

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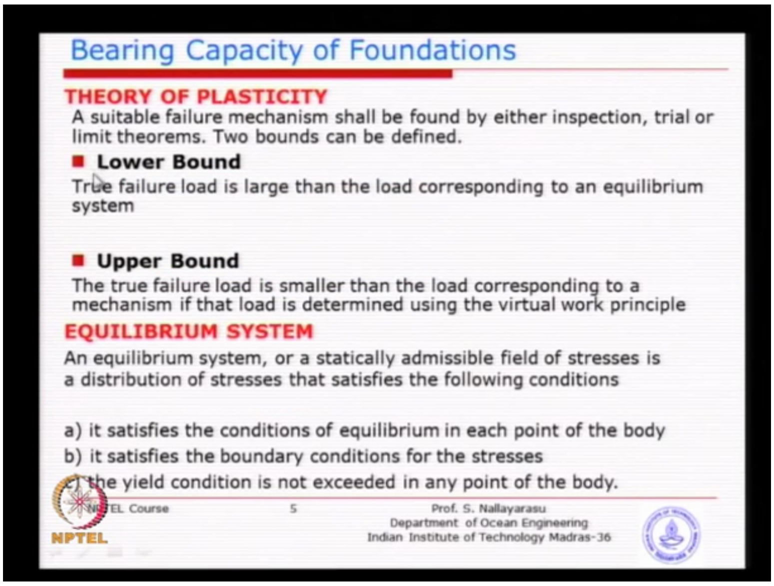

Which is basically easy to understand , the last one because of local failure but if go to the A which is the more general failure you can take a large bearing capacity because its movement is restricted by soil in the beneath and the surrounding areas. So anyone of them can happen depending upon what type of soil but we can easily see. This will lay upon definitely on a very soft material whereas this will be a good soil with good bearing strengthen. So that's something we can derive.

So what we will do is will just quickly look at what we need to do is, when I was talking about soil in equilibrium there are two cases basically an upper bound and a lower bound, upper bound true failure load will be larger than corresponding to equilibrium, lower bound sorry lower bound is you will find the load will be higher than the equilibrium case the upper bound will be a mechanism case, I think you might have studied in your applied mechanics. The mechanism by which the load, the true failure load will be smaller corresponding to a mechanism basically formation of wedges

So we will see both of the cases for simple type of soil basically we will see the sea equal to zero that means a purely sandy material and clay type of soil to understand, but then when we go to a comprehensive sea phi soil the derivation may become little bit bigger you try to derive but finally I will give the equations which could be used for, so in this basic idea is you may have several solutions we already have got 3 types of failure modes

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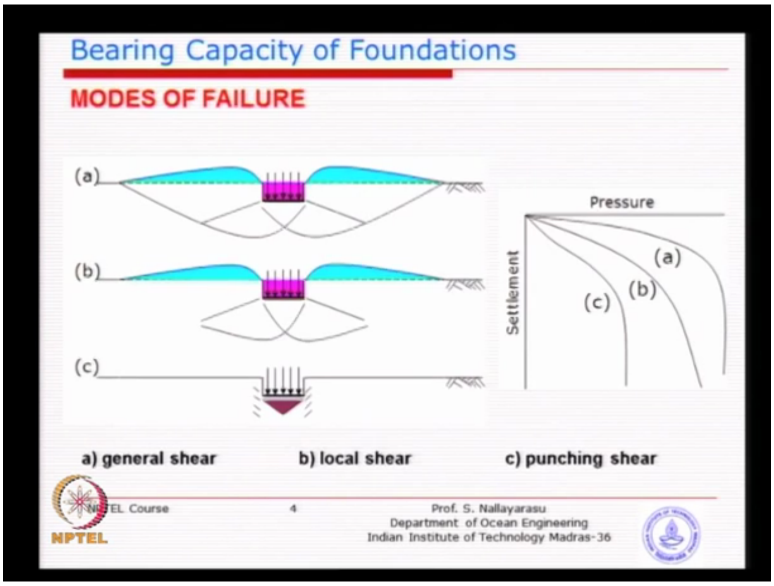

And if you look at the shape of this several researchers have proposed different angle different shapes to these wedges of active and passive side triangles and basically can apply this one to pure sand pure clay or sea phi soil. So you will have several solutions

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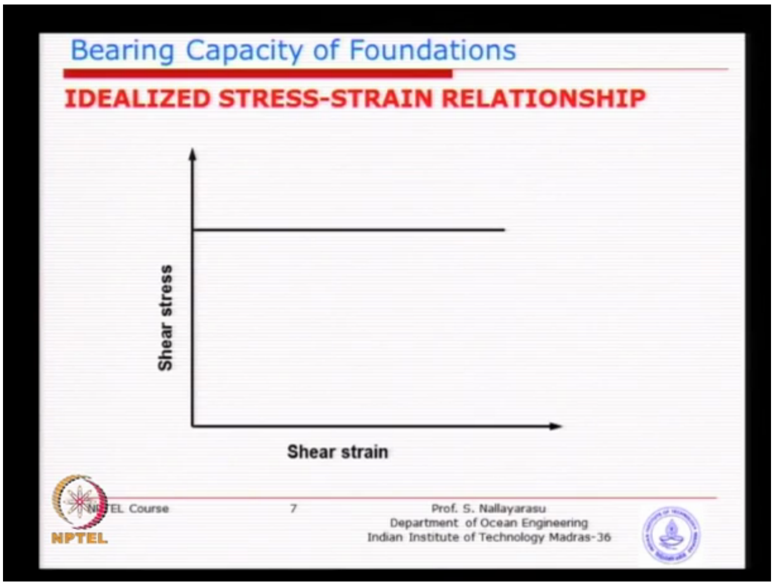

so the idea of the perfectly plastic stress strain principle is so we don't have a tensile capacity for sand so when you have the contact stresses once its dislocated it cannot be brought back. So that's one the biggest worry in soil behaviour, once you disturb and dislocate for example you have a foundation once its (())(33:11) the bond is broken for example at this place, it cannot be brought back because its permanently settled which you cannot bring it back unless like unless is like other types of steel material or other structural materials where.

As long as if it is within the elastic limit once the load is removed it will come back whereas in this case once you break the bond or once you make this strain to happen under soil even if you remove the load afterwards what will happen? It will never be able to come back because it is not a structural bonding is there that is one of the problem that's why we need to be very careful when we reach this capacity it is not good .

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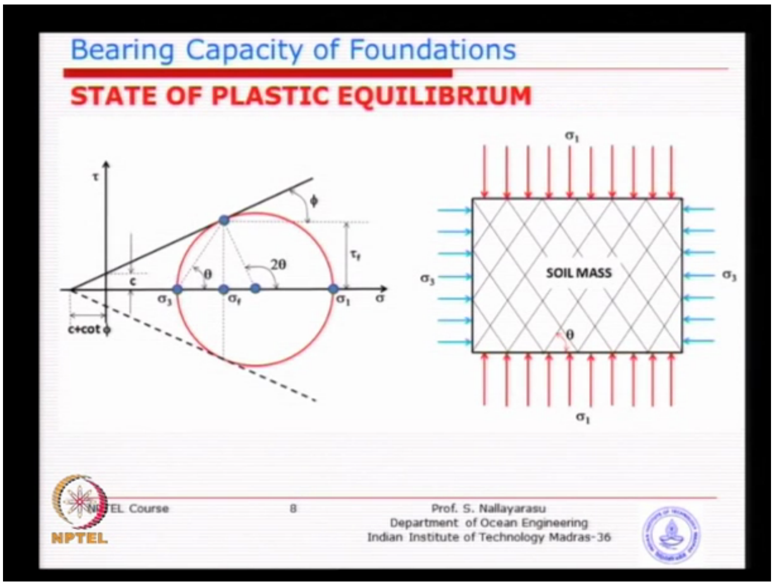

So we need to be finding a factor safety on this stress the shear stress or shear strength .Basically somewhere here we should stop so that it doesn't permanently break and basically that's the easiest way of adapting the foundation failure

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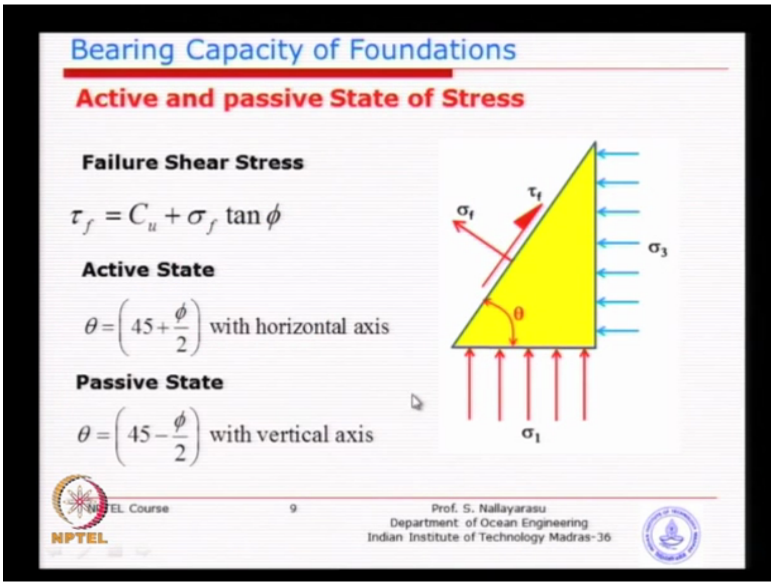

So we just I think is a similar picture what we were seeing for the active case sigma 1 and sigma 3 which is a basically small soil element some Mohr circle is drawn there .

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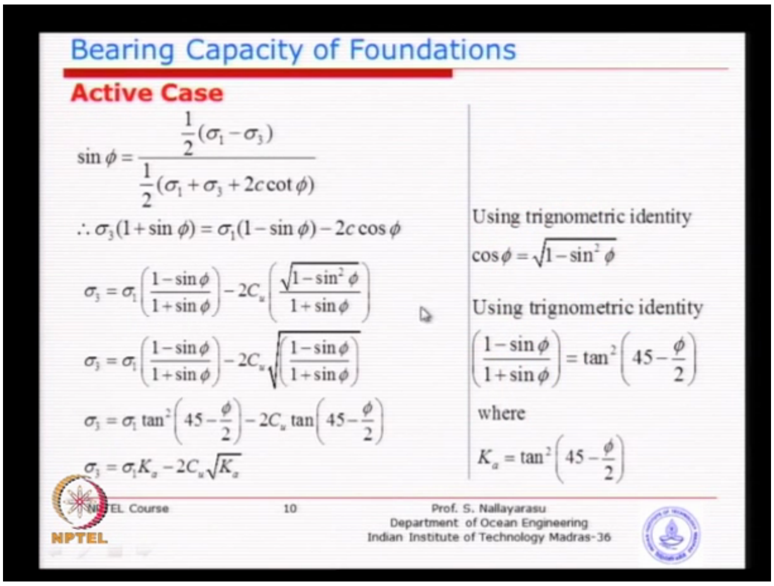

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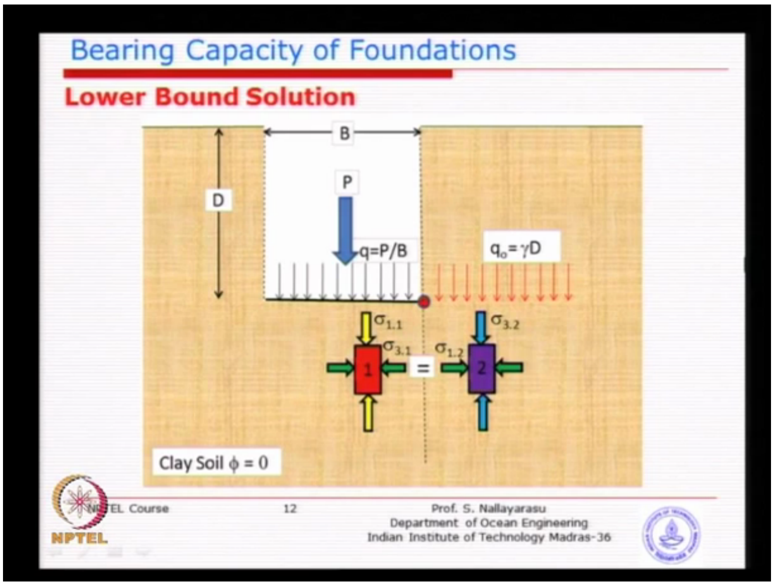

I think is a repeated from what we have just re-summarized because I used to take this one in the end so in any case you don't need to read again.

Now you look at this picture we will just look at one of the lower bound of the solution today, when you apply P is the foundation load coming from super structure over a area of say foundation with the B we just now consider this as a script footing that is continuous for a longer distance so only a two dimensional effect will be there later will see the three dimensional effect if the foundation with this or length is smaller so when you apply the pressure will be the load divided by B multiplied by one unit width or unit length I would say

So you have a pressure applied is Q and soil beneath here is applied by the vertical stress which is in yellow colour and horizontal stress which is generated due to the active depth pressure case so which we denote as sigma 3 . So this sigma 3 must be equal to the stress at the element on the side so that these true soil elements one and two are not moving they will be in equilibrium.

If the soil element two is start to move because the soil pressure on the side is or the vertical pressure is on the side is not enough soil will give up, because the produced sigma 3 will be higher than what you actually gain from sigma nut , so that's the equilibrium so the whole thing is very simple idea apply a pressure here this soil element generates the active case and transfer to the side element as a passive case and basically is sustained by the overburden pressure , we called it overburden basically this is the soil that keeps this two elements in equilibrium condition

Imagine if that is not the case we can always go and put some weight there, isn't it? The larger the weight you put on the sides the more the pressure that you can apply to the, the foundation itself. So that's the idea so you can see here now very important matter is the active and passive earth pressure case is here and the overburden pressure the weight of the soil on the side is going to be very important. As long as you can understand this principle this is the principle that will be adapted almost throughout the foundation design case that means the evaluation of overburden pressure is a important activity in the whole process of estimation of foundation capacity.

So how do we derive this relationship, that's what we were spending a lot of time this morning. Basically this is sigma V and sigma A you try to find out .And then take this sigma A apply to the side element as sigma P and try to find out sigma V and once you equate this to this that is the point of equilibrium and basically very simple idea we can find out we can come reverse way we can come reverse way to find out what should be the Q value at which the equilibrium exist and that's what we are interested that we called it ultimate bearing capacity or bearing strength. I will just summarize all of the you can easily go through

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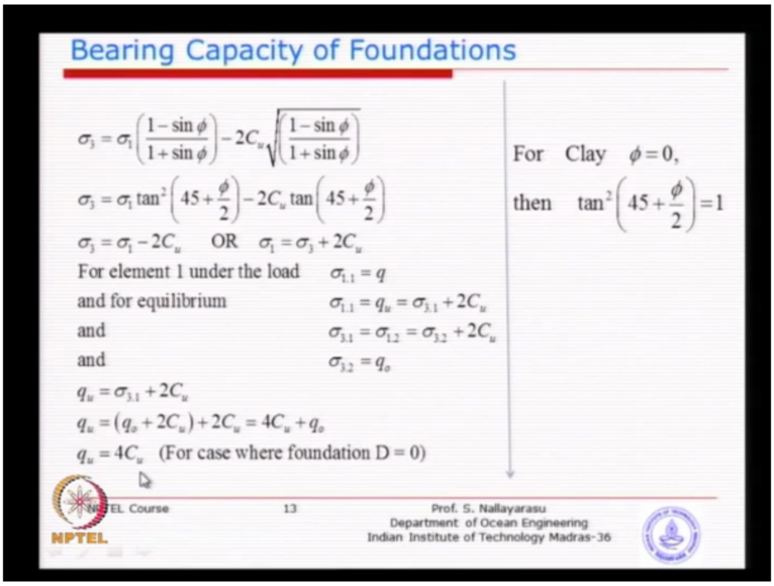

the principle behind is equating two soil elements one beneath one other side, by doing this all of them what you see here Q U I am getting because this I have taken as pure clay type of soil you see on the left side phi C is equal to 0 I assume it's a pure clay for a simplified case because when you go for other cases you will find little bit difficult just to understand so when I do all this substitutions I get Q ultimate is a 4 times the sear strength of the soil at that layer and when foundation D is zero. Basically I think this depth that means this brought to the surface level because when you make this foundation to the surface level the overburden pressure is gamma is there but D is zero.

So you have so that is the case that you get this otherwise the ultimate bearing capacity will be four times shear strength plus whatever the surcharge pressure you have , the deeper that you go you get a better situation, isn't it? That's very easy to understand and when you bring to the surface you get your limiting value is four times the sear strength.

Now imagine most of the shallow footings in building construction you just go and make a cut and do it whereas in the jacket case when we have a mudmatt I think I have explain what is mudmatt no last time, is a temporary foundation required for stabilizing the jacket on the seabed ,which will be kept under surface . So this will be the case where we will not burry the jacket underground, we will be placing the on the surface that this will be case that will be looking at. So what we need is what is this factor? Factor four we called it bearing capacity factor. Later on you know this various researchers came with different values this is only a simplified derivation and you will find in literatures different values slightly bigger than what is derived for this so called lower consulation..