Soil Mechanics/Geotechnical Engineering I
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Lecture - 47
Earth Pressure

Prove to this soil mechanics and today I will again start a new topic that is earth pressure. So, far, we have completed origin classification, index properties, permeability sequence then vertical size distribution shear strength, then compressibility. And now, I am going to start on earth pressure and this is a new topic that for developing different type of facility like road, railways, our similar facilities sometime we have to retain the soil. You may have to cut some time, you may have to discover it, you may have to feel and while doing that soil may not be able to stand by itself.

So, you have to provide support by wall and they are call earth retaining wall and these earth retaining wall, when you do then when the back-pile soil will be there based on this back-pile soil, the pressure will be exerted on the wall. And how much pressure the wall can take? Then we have to for that reason, you have to learn how to find out the pressure behind the wall. And how it distributed? What are the major factors? Depend on which the pressure will come on the wall? Where it acts? All those things actually you need to know.

So, for that there are various earth pressure theories developed over the time will discuss one by one before going to that we will see the different types of retaining wall how principally. So, this is the different types of wall actually retaining wall and this retaining wall first of all you need to know different type retaining wall.

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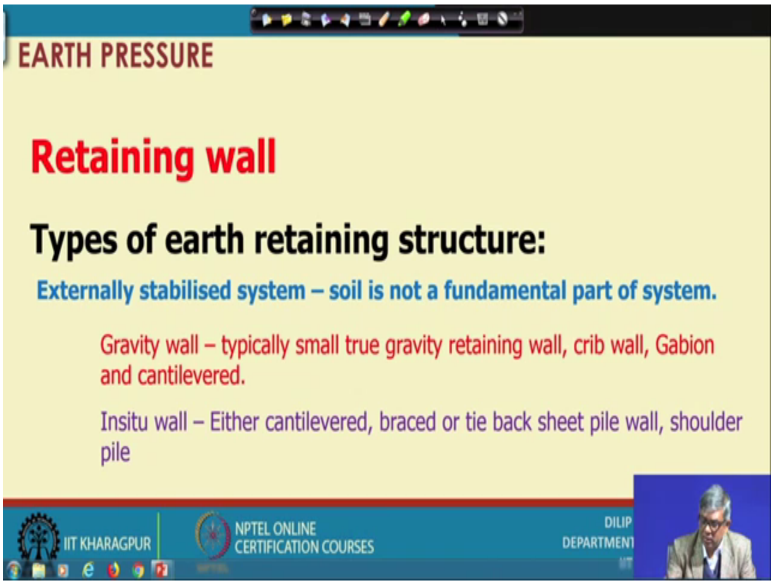

The types of earth retaining wall ok; So, this is the major or classification can be done externally stabilized system; that means what, soil is not a fundamental part of the system.

So, if I have a retaining wall soil wall a pressure, but in impact it cause it cause instability, but it is not help anywhere for stability of the system. So, because of that externally stabilised is the soil is not a fundamental part of the system. It will only give pressure nothing else and under that you have different types of retaining wall gravity wall. Typically, small true gravity retaining wall crib wall gabion wall cantilever also I will show one by one a gravity wall means it stability difference are is wide only.

So, it will be huge mass will be. So, typically gravity retaining wall will be something like this. So, it huge and then retain soil will be in the we saw here. So, this is typically gravity retaining wall and there is a crib wall. Crib basically you can say suppose, we have a number of then.

So, you can see so; that means, this there is a this little inclined and you can see there is a member here. On this there is another member inclined in this direction, then there is a 2-cross member, then there is a remember in this direction, then there will be 2 cross member, then member like that one after another will make a system and then soil will be retained here suppose it is a ground ok. So, this is ground.

So, this way where soil retained here and this type of wall is sufficiently flexible actually. So, during earth we can all generally it will be advantageous since it is it will not collapse; So, easily because it can tolerate significant amount of deformation. So, they are actually quite flexible and these are all inside gap also will be filled up with soil. So, there are there are suppose this is planks a cross plank this will a horizontal plane and in between there will be openings. And those opening can be filled up with water and then soil and then the back pile also soil.

And. So, because of this soil it will give some pressure here and some analysis can be done this type of wall. So, this is called crib wall crib wall and this is gravity. And similarly, we have gabion actually by using the either (Refer Slide Time: 05:52) or some other roof strong nylon roof can be made using those kind of a box like thing can be made and inside the big size of boulder will be entire the field.

So, like that a number of them can be made and will can do like this one after one we can put it. So, like that and finally, so, this is not the diagram correctly so I can put like this these are all gabion one these are all gabion. So, it is here then it will step behind step behind. So, that is stability will be better like the number of gabion will be there on the ground and this will be retain soil will retain. This is also then each gabion will be interconnected. So, that and they are quite heavy.

So, it is not so easily in washed away or fall. So, they are connected each other and each wall also self it is quite heavy. So, all together will work like a wall and this soil will be supported by this. This is also quite flexible and hilly areas this is a very good solution for retaining the rock and the soil. So, this is one are called gabion wall. And there is a another type that is cantilever retaining wall that is generally made of concrete and it will be typically it will be something like this there will be so soil will be like this side soil will be retain.

So, the cantilever mean this portion is cantilever. So, the this portion is cantilever. So, pressure will be there so because of that you have to put in a reinforcement otherwise the concrete thin section will be fail. So, this is actually almost like a structural a part and this side soil will be retained and this based on soil you have to calculate the pressure and based on this pressure you have to provide the reinforcement here.

So, this is typically known as cantilever retaining wall. So, they are actually all externally stabilized wall ok. So, this stability of the wall is depends on actually this soil around and this weight all together. And there are some type you insitu wall is there that is cantilever braced. So, insitu wall means there is a some waterfront structure.

So, we need to support this our gt. So, suppose there is a this will predicted water soil is here water is water is here and soil is here. So, this type of seat like metal structure can be predicted and this will be this side will be soil will be there and on this there kind be some facility. So, this cantilever this is called cantilever sheet pile wall because soil is here and beyond these this is free. It will be it will bend like this ok. So, this is a cantilever retaining wall then there is a braced tie.

So, sometime it is too high and deformation is too large then this type of system will not work. So, in that case we have to tie it and you have to connect somewhere here inside. So, that the deformation of this will be reduced; so, this is actually typically cantilever or braced and sheet pile wall. So, the externally stabilized wall cantilever, gravity, crib, gabion and sheet pile wall all those things are externally stabilized.

Now, next, I will see the other one.

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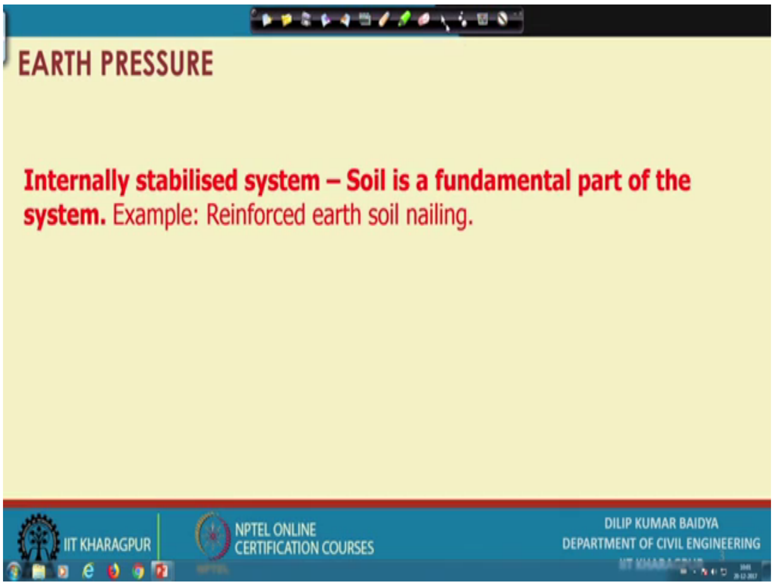

That is internally stabilized system internally stabilized system means what exactly internally stabilized system means actually see that soil itself will be act as a part of the stabilizing system. Soil is a fundamental part of the system example reinforced earth soil nailing. So, reinforced earth soil nailing what it is all of you might have seen that nowadays during the close to the bridge approach and all will see some decorated facing element and so, typically it will be if the wall is like this unlike a gravity or it are cantilever retaining wall it will be thin comparatively.

And there will be piece or small small pieces and each pieces with that will be some reinforcement connected like this, like this and soil will filled up. So, when the soil will be there here and height is quite significant. Then because of these this will try to move and then when will try to move this direction then this friction will develop between this reinforcement and the soil.

And that way actually you have to design of course, how frequently, how closely, you have to put. If you design properly, then with nominal thickness of the wall and with this reinforcement with the inside the soil one can make the wall then they are actually quite popular now and this is of course, quite economic also.

So, this is actually since the soil itself taking a fundamental for this soil and reinforcement interaction between these whatever fictional force develop that actually helping the stabilizing the wall. So, because of that this is called internally stabilised wall. So, this soil and the reinforcement they together interact and make the system stabilizer.

So, reinforced earth is the example and then there can be soil nailing also sometimes there is a hill area and sometimes we can we cannot make a very flat slope ok. So, in that case suppose is suppose desired to cut a slope like this and then this slope maybe may not be able to stand itself. So, in that case to strengthen this will generally provide soil nailing. So, at sufficient depth inside at some inclinations soil in reinforcement road will be first make the whole and then the grout and road together will put together and then finally, it will be sealed here.

So, all together will make a system like wall so that is called also soil nailing. So, this is also internally stabilised system. So, this for all those things of course, while designing on while are it is gravity retaining wall, whether it is a crib wall, whether it is a gabion retaining wall, whether it is a it is a cantilever retaining wall or whether it is a sheet pile wall or whether it is a reinforced soil retaining wall. Everywhere, we need to actually calculate the pressure what the depth? What is the pressure behind the wall?

So, that pressure actually is essential for calculation that what will be the depth what will be the thickness? What is the reinforcement? All details can be obtained by based on that amount of pressure we get from the wall. So, that can be for that actually we need to learn the earth pressure theory; So, will discuss that now different earth pressure theory.

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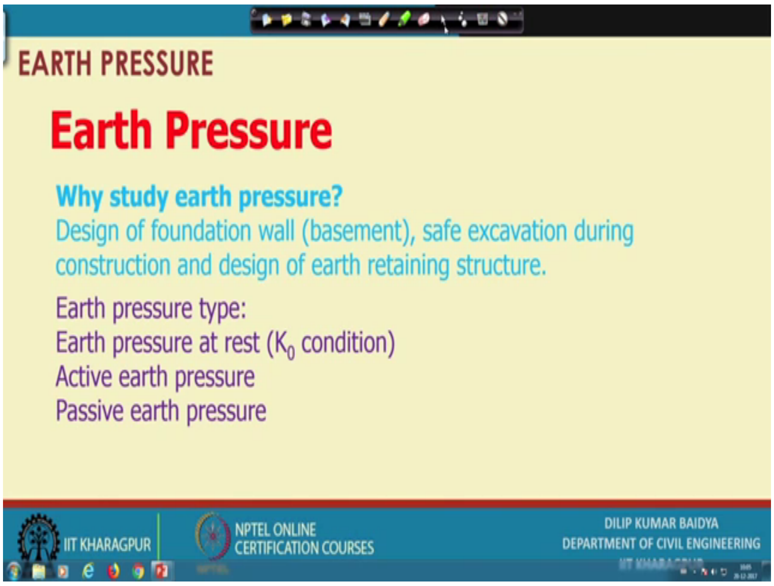

You can see earth pressure why study earth pressure ok. So, this is basically design of foundation wall basement safe excavation during construction and design of earth retaining wall all for those case actually you need to know earth pressure.

So, design of foundation wall; that means, basement suppose you have the your building starts from here, but you have some system below there is a basement. So, in that case you need to find out the pressure on these wall. So, that is one safe excavation during construction; that means, how much depth you can suppose you have to do for construction purpose you have to make some excavation and that excavation whether we can do without support or we need support, how to find out actually? You have to find out pressure and based on that you can.

So, suppose factorial cut and cover method they will quite deep for you have to cut you have to go metro rail mill somewhere here and surface is somewhere here such a high a wall a cannot be just like that.

So, what you have to do you have to give in between support. So, and there is some design. So, how to or what will be the are support? What is cross section? What is the spacing to find out? That you need to know the earth pressure; So, these are all various the areas requirement of earth pressure theories and earth pressure. Now, what are the different types of earth pressure.

There is a earth pressure at rest at rest earth pressure at rest means wall there is a wall suppose and retaining the soil here. And if there is a no movement of the wall then because of that whatever pressure coming on the wall that is called earth pressured at rest, but generally, where this type of back fill will be there on the wall. Then, there will be tendency to move the wall in the away from the back fill and sometime other way also possible.

So; that means, wall movement will take place and that when the wall movement is take place that will based on that we have another two types of pressure. One is called active earth pressure; another is called passive earth pressure. Active earth pressure is one actually when the wall moves away from the back fill and some of it is moving these direction then whatever pressure active on it that is actually active earth pressure. And suppose wall moves in this direction then the pressure on this because of the soil that is actually passive earth pressure.

Now, you have to know or you have to get idea this out of 3 earth pressure at rest active and passive. Which is the maximum? And which is the minimum? you can see that at rest condition whatever pressure will be there. If the wall moves away from the back it will loosen; that means, because of that pressure will be reduced definitely will be reduced. So, active earth pressure will have minimum pressure and it is. In fact, it is less than the pressure of at rest. And similarly, when wall moves towards the back fill the pressure will be increased and. In fact, it is more than the earth pressure at rest.

So, that mentioning maximum will be passive, intermediate will be at rest and active earth pressure will be minimum. So, this three preserve type of earth pressure is there. So, earth pressure at rest that is called K naught condition and.

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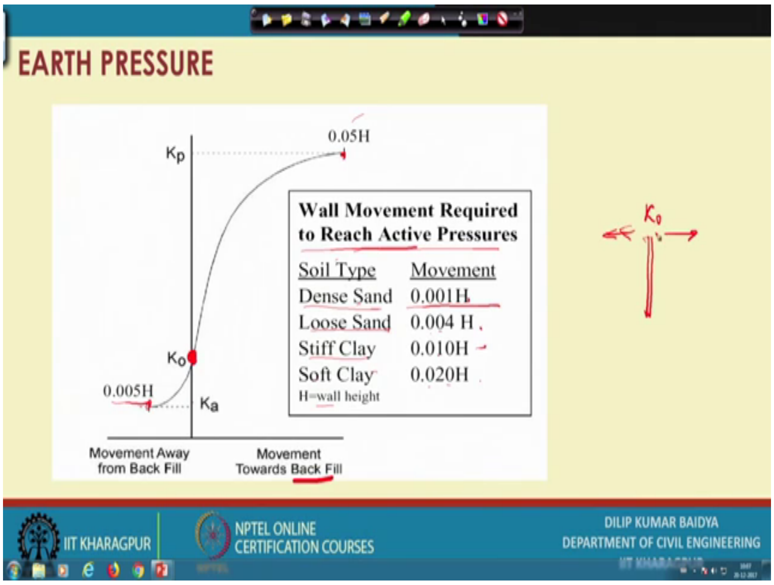

Now, you can see to get earth pressure as I have told you that wall moves. So, this is wall and suppose wall moves in this direction ok. How much movement is generally is expected before failure? Even movement is more than that then you consider is fail.

So, you can see this diagram shows you can see either already I have told that k naught condition this is the pressure and when it is Ka the movement will be this much 0.005H a movement away from the back fill and then movement towards back fill and that movement is 0.05 the height of the wall is H then 0.05H maximum wall movement can be there for passive case. Whereas, 0.005H movement is possible before failing in a active case.

And this movement is maximum is given, but again based on soil type again there is a dense sand this is actually 0.001H at to reach active pressure. This is for active not passive. So, here is given 0.005. So, here is dense sand it is given 0.001 loose sand it is 0.004, when a stiff clay 0.01 and when a soft clay it is 0.02. Where H equal to height of the wall so; that means, it wall movement is more than that that will take to as a failure actually.

And so, this is actually; that means, this is this is the diagram shows either quality it will I have mentioned that earth pressure at raised will be intermediate. And active will be small and passive will be big you can see the maximum wall movement, minimum minor movement, there is no movement. So, this is active this is passive and this is K naught they no movement.

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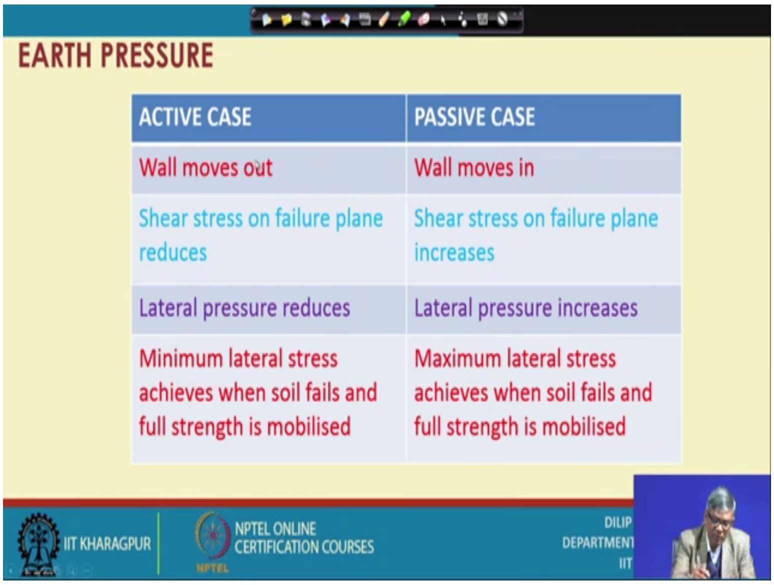

Now, one more qualitative observation and you can see active case and passive K naught case actually generally you do not discuss. So, elaborately because that is not a the problem most of the time we enquired are either active or passive.

So, you need to know more about active case and passive case. So, active case and passive case what is the highlight? Or what is the important characteristics? So, you can see when active case wall will be move wall move out.

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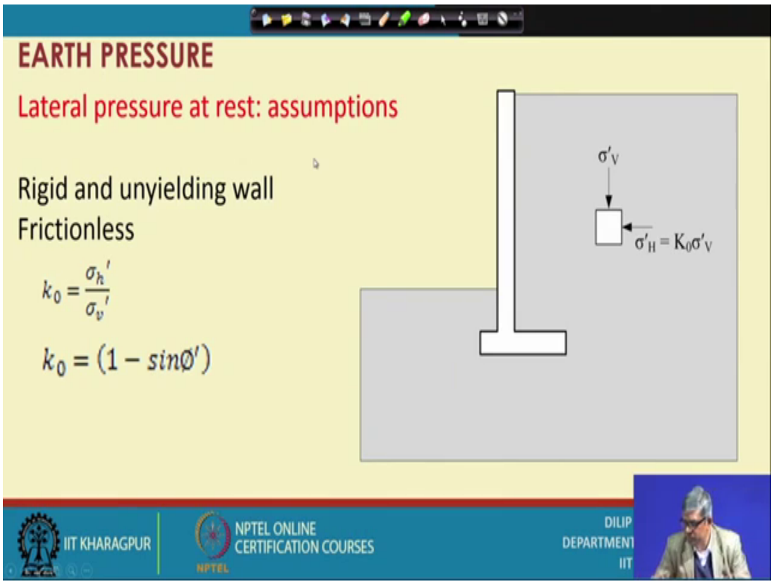

When active case when active case wall moves out whereas, in passive case wall move seen as I have told you this is a wall and this is a back fill. So, in the wall these is an active and wall is this towards back fill that is passive. And shear stress on failure plane reduces; that means, active case since you can see the wall when it is a no movement whatever pressure will be there it wall moves, that mean it will reducing pressure will be reducing over time.

So, shear stress on failure plane will be reduces in active case. Whereas, shear stress on failure plane will increase because wall is pushing this side; So, additional pressure will come lateral pressure reduces that will it was initially was sigma naught and then it is suppose sigma active. So, sigma naught will be greater than sigma active and lateral pressure increases, initially was sigma naught and then you become sigma p.

So, that is greater than sigma naught. The minimum lateral stress achieves when soil fails; that means, this sigma naught from sigma naught the pressure is reducing reducing. What would be the limit? Limit is finally, a at failure will reach just before failure reach to the minimum value. That is called when minimum lateral stress achieves when soil fails and full strength is mobilized.

And similarly, maximum lateral stress achieves when soil fails and full strength is mobilized. So, sigma naught to finally, this achieve sigma a or sigma naught to sigma p achieve here; So, thus before failure. You can see here that for a at rest condition you can see if the lateral pressure at rest. Suppose, we have to either have told that it may not be important aspect for most of the cases either you have to do active or passive sometimes we need to do at rest condition also.

So, at rest condition not much things are available or not must to do. So, k naught actually at this point suppose these are soil this is a wall and this back-fill soil and this is a foundation soil. At any point I can imagine a stress condition. So, here actually sigma b will be there what we can calculate based on the soil on it above it? And I can find out lateral stress. The lateral stress will be small less compared to that sigma b and which will be equal to K naught time sigma beta. So, K naught is the lateral earth pressure coefficient at rest condition.

So, this sigma h and this sigma h is same actually you can write small actually h. And so, and this is also small k you can write. So, k naught actually is nothing but sigma h dash by sigma v dash. So, at this point at any point suppose I consider one point here I find out what is the vertical stress and what is the horizontal stress this show sigma h by sigma v is the k naught and for k naught calculation it can be derived the course, but this is a well-known formula generally we use. K naught equal to 1 minus sin phi dash if the soil phi is a soil has internal friction angle is equal to phi, then 1 minus sin phi will be the k naught.

So, if you know this then multiplying by this with the pressure one can get the earth pressure at rest condition on the one.

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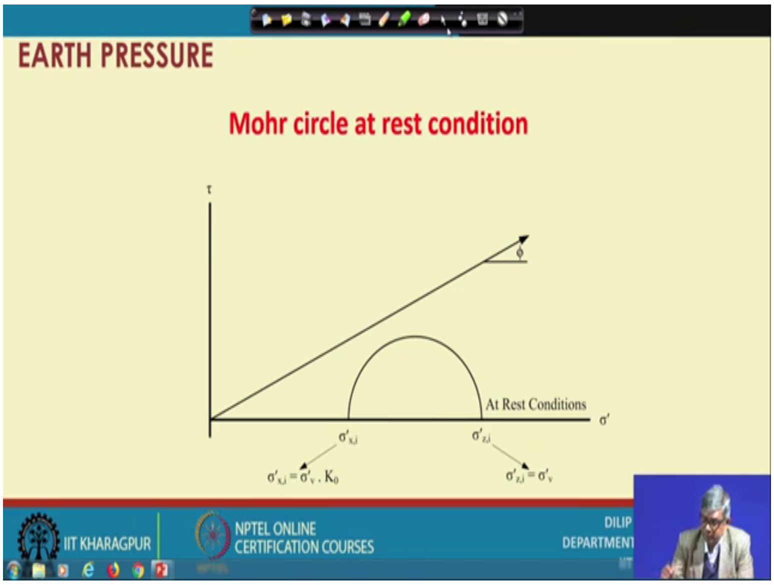

And you can see if I want to see the Mohr circle corresponding to the at rest condition you can see that if the soil as a friction angle equal to phi then this will be the your failure envelope ok. And your you are at rest condition sigma v suppose this one and sigma h suppose this one or sigma h or sigma h h or x h can be there it is z or v either or a.

So, if I draw a Mohr circle here and this Mohr circle it will be you can see as it is shown here. It will be much below the failure envelope. Because it has not rest failure where rest to the failure it will become tangential because Mohr circle we do and draw the tangent from there only you find out, but here if you have the if you if you have the at rest condition, if you calculate.

So, if if I draw a line with phi degrees phi angle which is the internal angle of the friction of the soil. That gives you the a failure envelop and now based on at any depth we find out sigma v and sigma h and if I plot this one of this Mohr circle and these Mohr circle will be always much below the failure envelop it will not never be tangential ok. So, at rest condition where as you can see that is at rest condition, we have some wall is intact.

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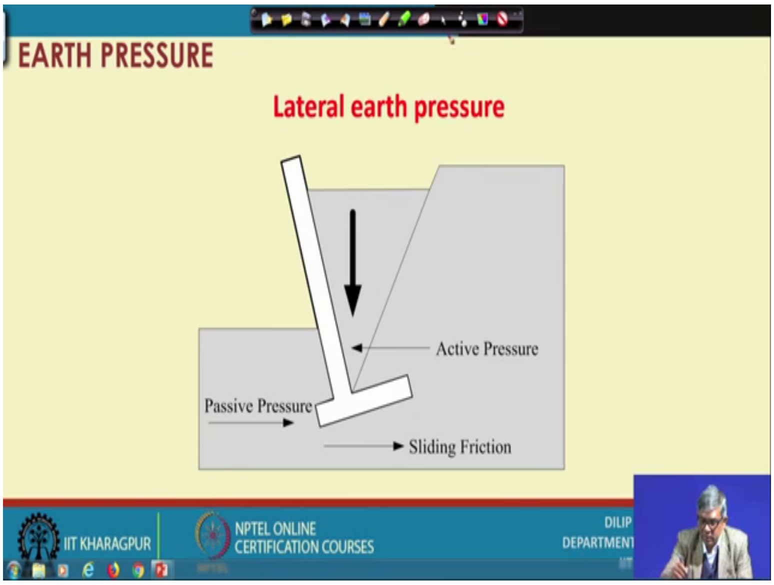

But when there is a lateral earth may see, then see this is of course, to a generated it is own you can see the wall is here and this type of ways in form and will try to go down.

So, because of this wall also move in this direction wall will move this direction and you can see so; that means, when wall moves out; that means, at this zone you are getting active pressure. Similarly, we can see here when there is a on the toe side on the toe side this much soil was there when wall is moving this side; that means, this one is moving this side then towards the soil so; that means, at this point you have passive pressure.

So, both if there is a toe side that is a soil then because of the active condition at the back-fill side then at the toe side there will be passive also. So, most of the time the passive pressure is help that stabilizing the wall. So, most of the time is whatever small height is there which one only ignore and if you ignore that you get the sepal value and this is so; that means, this weight will be trying to slide down and because of that wall move these direction.

And also because of these there can be tendency of movement of this wall like this laterally also, if this moves laterally then at the bottom also there will be some friction develop so, that is also there. So, all those things with there while doing the stability analysis we can consider all those and based on calculation.

So, first of all you have to calculate what is active pressure? What is passive pressure? What is sliding friction? Then only you have to do the stability analysis. So, before going to that let me take one more

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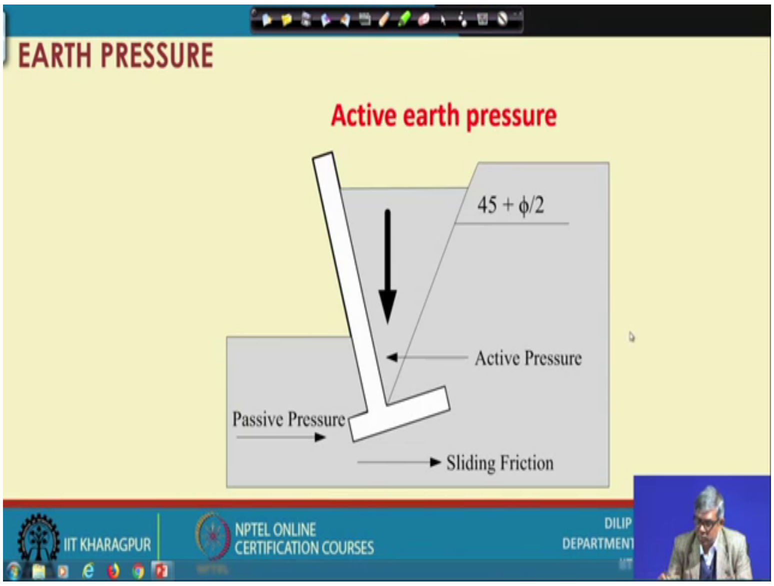

So, this is actually active earth pressure now what was that is a shown I general this is our active and. So, when this active earth pressure happened this way is actually from the horizontal this line, this failure plane makes an angle 45 degree plus phi by 2 where phi is the angle of internal friction of the soil. And so, this will be there and. So, based on that I can if I can now draw a Mohr circle you can see if you draw Mohr circle for active case.

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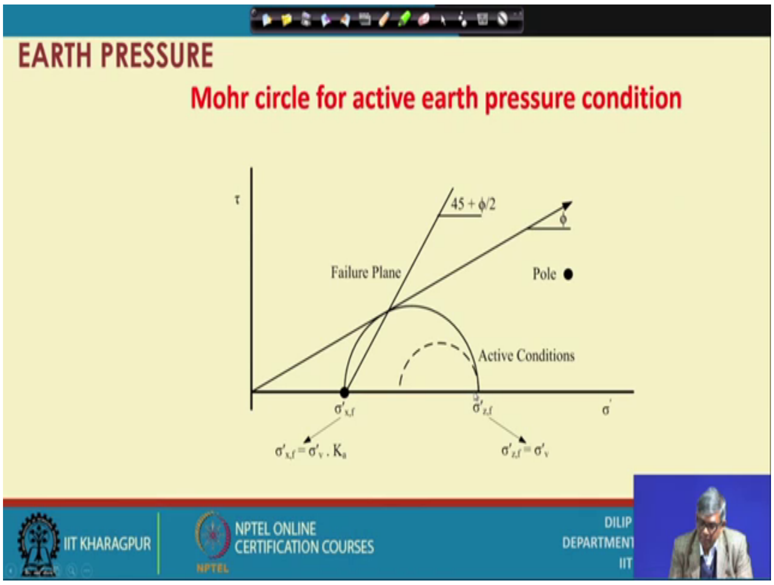

You can see this you can see there. So, this was at rest condition ok.

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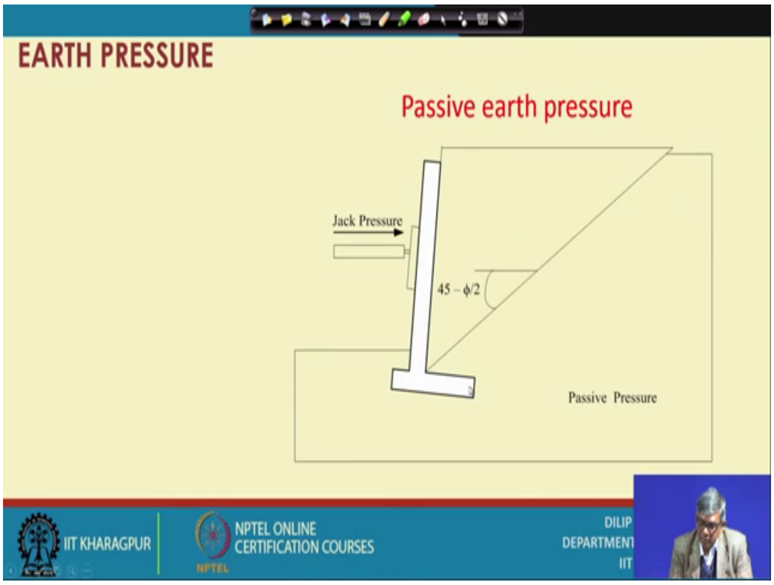

Sorry, this was this was at rest condition circle or this is the Mohr circle at rest condition. And this will not change actually and this is the wall because the movement of the wall, as I have told you that horizontal stress will be decreasing.

So, horizontal stress decreasing like that and finally, this to here just before failure. So, this is the value lowest value so in the active case, this is the Mohr circle and you see this Mohr circle. Now, become tangential to the envelop; So, what will be the failure plane?

This is a pool minimum value of stress are the failure from here to tangent to this circle, if you join that will the failure plane, and you can find out this angle is 45 degree plus phi by 2.

So, this is that means, your originals vertical stress this is actually this is major principle says and this one is minor principle says ok. So, with this I will just stop here for this slide this the module, I may take passive also and other aspect in the in the subsequent presentation.

Thank you.