Foundation Engineering
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Lecture – 60
Underground Conduits II

So, this class, I will discuss about the load transfer mechanism of the conduit and in the last class I have discuss that.

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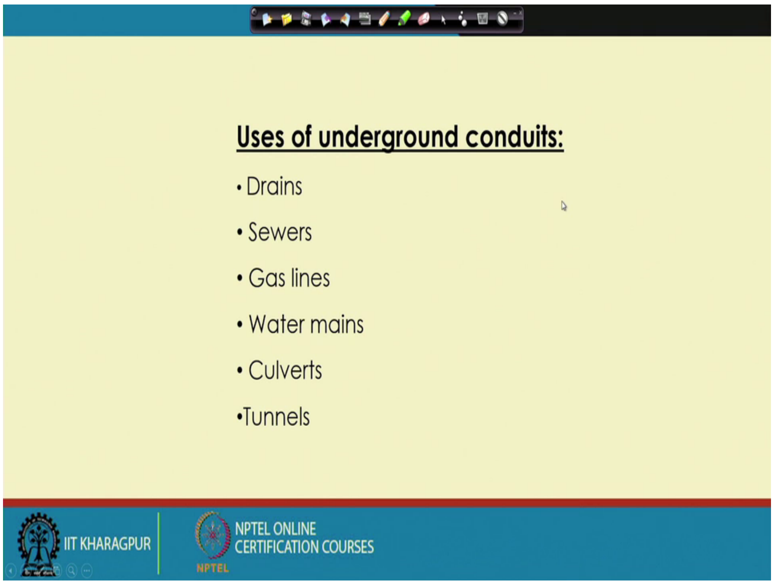

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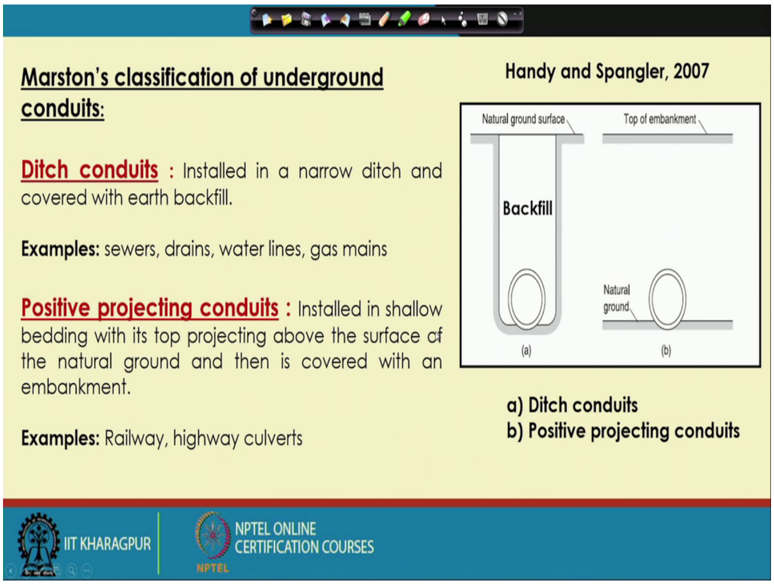

This is the application areas of the conduit. What are the different types of conduit? Ditch conduit, positive projecting conduits and then negative projecting conduit and then this is the your impact ditch conduits ok.

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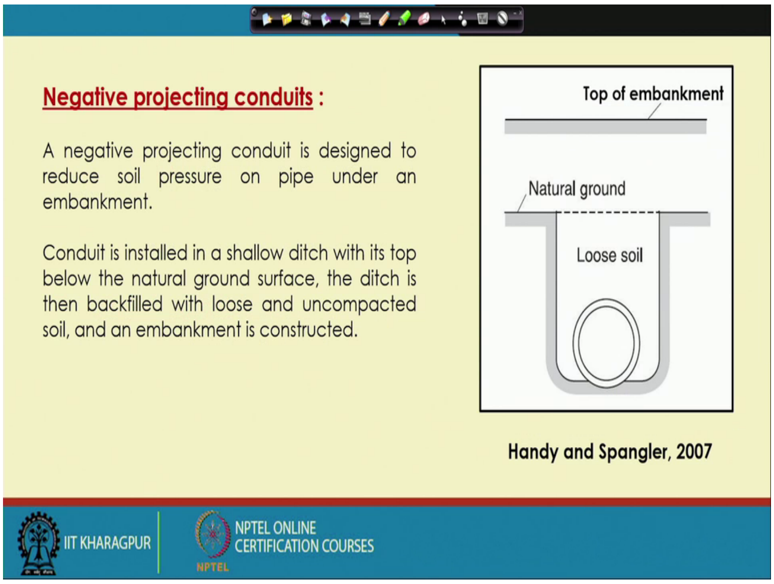

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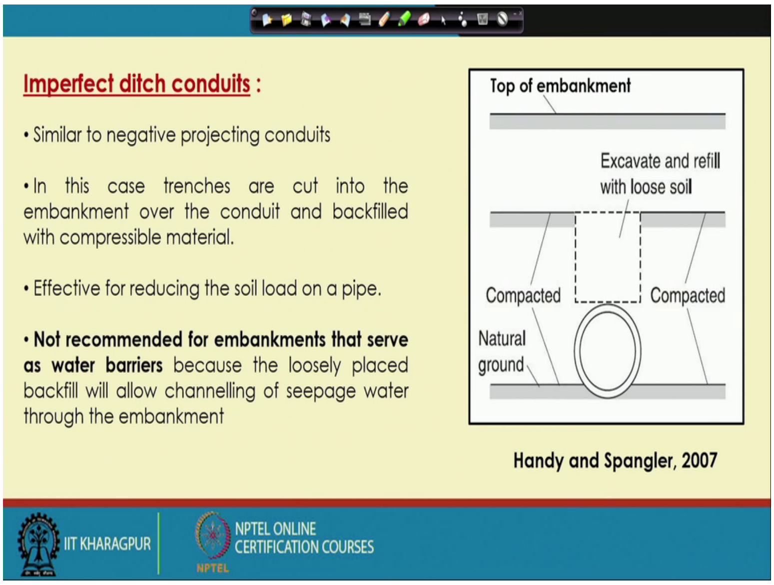

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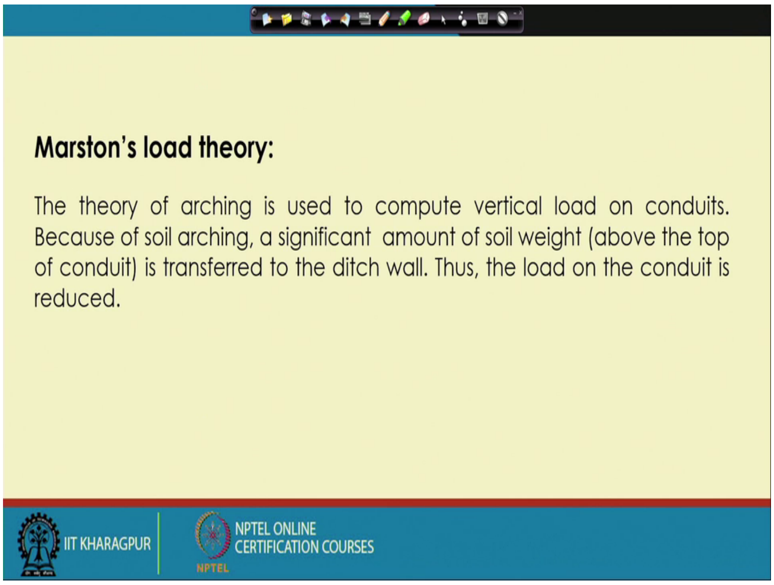

So, now in the, that class also I have discuss about the, your soil arching theories and then what is the active arching what is the passive arching. That I have discussed.

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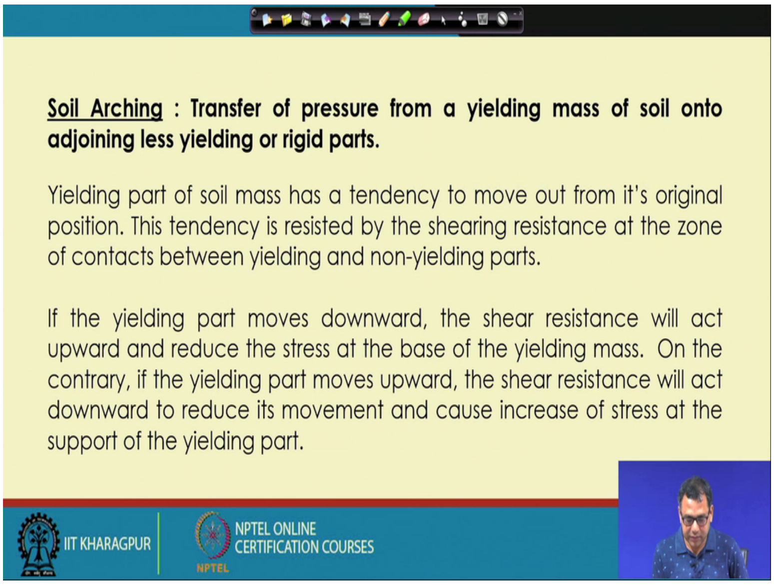

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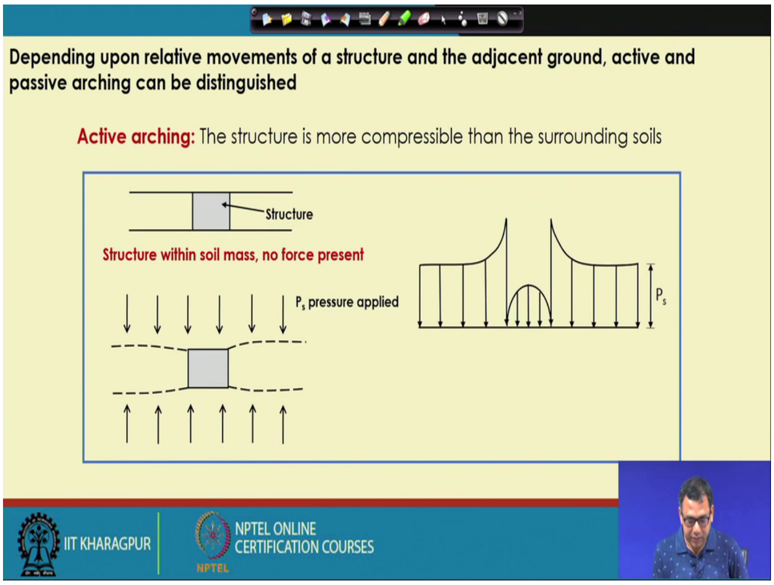

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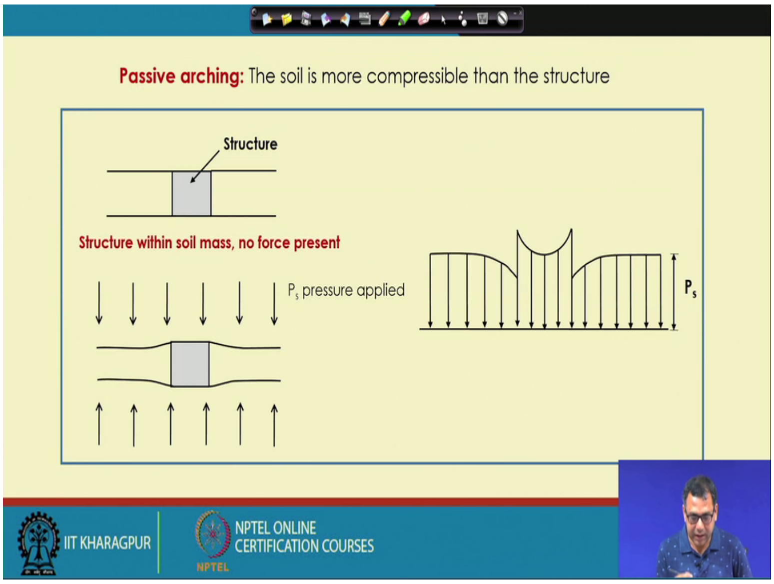

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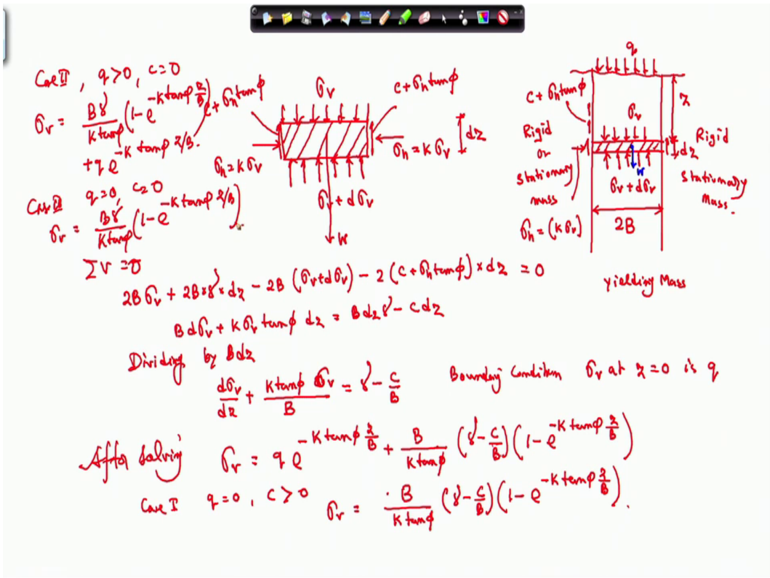

Now, this class what I will discuss about the how the load is transfer from this case ok. So, first I am considering that in my case that the stress on the conduit should be less it should be reduced. So, I will consider one case, where this is the, your narrow backfill or the backfill, which is loose. So, this will deform. So, this is the yielding part, where this is the ground surface ok. So, where the, we are applying a stress q ok. So, because that is the we will here that your, this is the yielding or moving part and this is the rigid part ok. So, this is the rigid part or the non less yielding part and this is the this side also rigid, rigid or less yielding this is the yielding part ok. So, this is the yielding mass and we can say rigid or stationary mass ok.

So, I am considering one particular strip, this is the particular strip which is at a depth of h from the ground surface and the thickness is dz ok. So, what is the stresses acting in this strip? the so, that mean the vertical stress that will act sigma v and in the bottom this stress will be sigma v plus d sigma v and the weight of this stress the strip we will also act ok, w is the weight of the strip and this side there will be friction or shears because this is here this portion is moving and this portion is not moving. So, there will be a friction and that force is equal to your, this is the or the as I mention because of this movement a shear and plane is developed.

So, this shear stress or the shear plane this I can write that c plus sigma h tan phi ok, this is this is again the soil versus soil, that is why I have written the phi and why sigma h because, this is the sigma h is acting here this is the sigma h and this sigma h is equal to K into sigma v ok.

So, finally, if I take this strip; so, this will be the sigma v, this will be sigma v plus d sigma v and the weight of the strip will also act and the here this is sigma h, which is K into sigma v this is also sigma h which is K into sigma v K is the coefficient of earth pressure. So, this value will be your c plus sigma h tan phi and this side also there will be stress this is c sigma h tan phi, this is the shear plane. So, and this thickness of this or the width of this trench is two B ok.

So, now finally, if I take the summation of vertical force is 0. So, this is the first top sigma V is acting downward. So, 2 B is the width into the sigma V that is the force, then the weight of the, this strip, weight of the strip will be 2 B into gamma into d h dz because this is dz. So, this is dz in to dz; then the these force is acting upward direction. So, this will be minus 2 B into sigma v plus del sigma v and the shear stress that is also acting upward. So, this will be 2 into c plus sigma h tan phi, why 2? Because it is acting in the both side in to dz it is acting on the dz distance. So, that is equal to 0.

So, finally, after simplifying I can write Bd dv plus K d sigma v plus K sigma b tan phi dz equal to b dz gamma minus c dz. So, dividing by B dz we will get d sigma v divided by dz plus K tan phi K tan phi into sigma v divided by B equal to B dz means gamma minus c by B ok. So, this is the expression. So, after solving so, we have the boundary conditions how many boundary condition is required, because one boundary condition required.

So, the boundary condition is the sigma v at z equal to 0 is q, because this is the sigma v at z equal to 0 mean surface, where q is acting ok. So, after solving with the boundary condition you will get sigma v is equal to q e to the power minus K tan phi z by B plus B K tan phi gamma minus c by B into 1 minus e to the power K minus K tan phi z by B ok. So, this is the expression final expression. So, that amount of stress will now act on to the conduit ok.

So, this will act on the conduit. So, because that this is the less amount of the stress or now for different condition that for the case 1, if your q is equal to 0 and c is greater than 0 or not equal to 0 then your sigma v will be q is 0. So, this part will be 0. So, this will be B by K tan phi gamma minus c by B 1 minus e K tan phi z by B ok.

Now, case 2 that your q is not equal to 0 c is equal to 0. So, in that case sigma v is B gamma that is your c is equal to 0. So, this will be B gamma divided by K tan phi and c part is 0 1 minus e minus K tan phi z by B plus q e minus K tan phi z by B. Now case 3, that your q is equal to 0 c is also equal to 0 ok. So, in that case sigma v is equal to B gamma K tan phi 1 minus e minus K tan phi z by B ok. So, these are the three cases we have considered ok.

So, now I will apply this one in tunnels, through sand ok.

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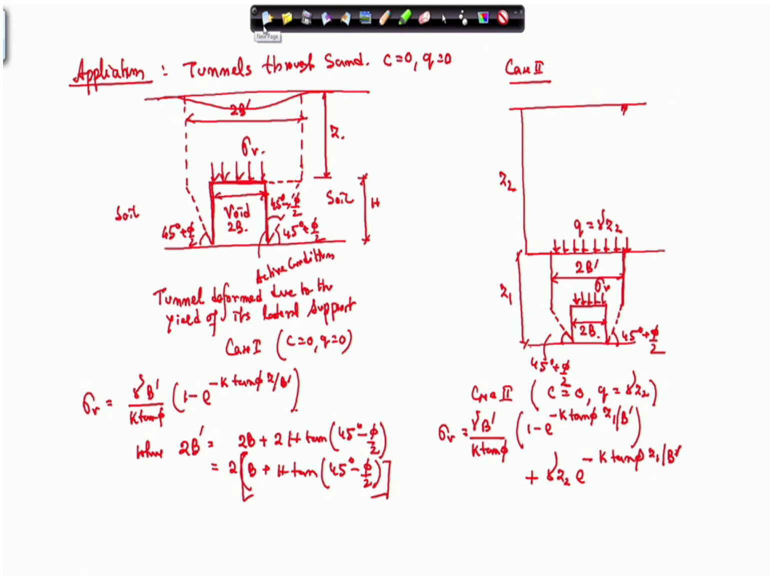

So, now, the next one, if I apply this, the application of this theory that we have a tunnels through sand ok. So, now, we have a if we have a tunnel through sand, suppose this is the tunnel or the you can use the culvert also; so, if this is the tunnel and this is the brace.

Now, you have a embankment on the or the soil above this tunnel. So, and this is. So, now, what will happen if it is a this is a within the relatively shallow depth. So, what will happen? This is the void or because this is tunnel this is void; so, here the soil this side also the soil.

So, so, the tunnel wall will deform with this wall will deform this side and this wall is also deform. So, because of deformation this soil will move ok. So, this there will be a failure plane will occur or the soil with the failure plane, because it is this wall is under active condition, because it is deformed because of the soil so; that means, we can say there will be a failure or the surface as it is an active condition. So, this will make an angle 45 degree plus phi by 2 and this side also there will be active condition, where this soil this surface will making an angle 45 degree plus 5 by 2 ok. So, this is the active condition, because this side is soil and this side also will soil.

So, if I and this surface if I so; that means, this portion of the soil will move. So, this portion of the soil will move so; that means, soil above this portion this also move ok. So, soil above this portion will also move. So, I can write that if this is twice B and this one is 2 B dash. So, I have derive the expression, where this is the twice B. So, here this total portion of the soil is moving here, this portion of the soil is moving because this soil this wall is deformed and this soil is move under active condition as these two parts of soil is move this soil also in stationary condition.

So, I can write that this case, tunnel deform due to the yield of it is lateral support, the support will move the soil is also moving so; that means, this soil is stationary and this soil is yielding ok, here the deformation pattern will be something like this.

So, now the stress on the on this tunnel will be. So, this is my case 1 ok. So, case 1 sigma v stress which is acting on the tunnel is will be gamma, because here this is a sand. So, c value is 0 and q value is also 0 ok. So, in the case 1 your c value is 0 q value is also 0. So, if the c value is 0 q value is 0. So, this is the expression. So, instead of B, because here B, I will write twice B dash. So, instead of B it will be B dash divided by K into tan phi 1 minus e to the power minus K tan phi z by B dash ok.

So, you can write this is the, if it is the height. So, instead of this is the z. So, this is the z if it is h instead of z you can use the h. So, why this is the 2 B dash? So now, how I can write, where how I can write 2 B dash? 2 B dash, will be twice B, because this is this is the width of this tunnel. So, this will be twice B plus this angle is 45 degree minus phi by 2 and this height is say H this height is H. So, this one this portion will be this is this is H this is 45 degree minus phi by 2. So, this portion will be H tan 45 degree minus phi by 2. So, and that is will be twice this side and this side. So, 2 B plus twice H tan 45 degree minus phi by 2 or you can write that, this is twice B dash twice B dash is 2 into B plus H tan 45 degree minus phi by 2.

So, this is the application. So, now, if these values are given and it is said that you determine the stress acting on the top of the tunnel, then you use this expression and determine the stress acting on the tunnel. Now in the case 2, where your tunnel is in very deep ok. So, suppose this is the ground surface and your tunnel is somewhere here, which is very deep again this is the twice B. So, this is the tunnel. So, again this is void the soil again here the this will be the 45 degree minus 45 degree plus phi plane and this is also 45 degree plus phi by 2 plane. So, and this soil we will deform ok.

And because of that there will be a stationary soil mass above the tunnel, but as the depth is very large. So, this deformation effect will not reach to the ground surface because here, case 1 it is the shallow depth relatively. So, deformation effect reaches the ground surface, but here it is the depth is very high. So, this deformation effect will not reach the ground surface. So, there will be a point where this deformation will not be there.

So, that point is say here, so; that means, here this deform after that this soil will not deform, because of this effect because it will not go up to the very large depth and it will not reach the ground surface so; that means, if I say this is the z 1 and this is the z 2.

So, now what will happen in this case, this is again the 2 B dash and 2 B dash, I can calculate with this equation, but instead of this now addition force will act is the surcharge. Now here, in this plane now suppose this is my, a new ground level and this soil up within the z 2 depth will act as a surcharge ok. So, this is the q, which is gamma into z 2.

So, now in the case 2, your c is equal to 0, but q is equal to gamma z 2. So, the sigma v, which is act on this on this the top of the tunnel that is sigma v is again, gamma B dash divided by K tan phi 1 minus e minus K tan phi into this will be the z 1 ok. This is the z 1 divided by B dash, then plus the q part that is gamma z 2 e to the power minus K tan phi then z 1 divided by B dash. So, you can see that, it is the q is there. So, this is q e to the power minus K tan phi z by B. So, this is also q is gamma into z 2 and e to the power minus K tan phi z 1 and B dash and B dash value will calculate from this same expression. So, these are the two cases I have discussed, where you can apply this theory and you can calculate the stresses acting on the tunnel or the conduit ok.

So, now I will show you few more applications, that how you can apply these theories.

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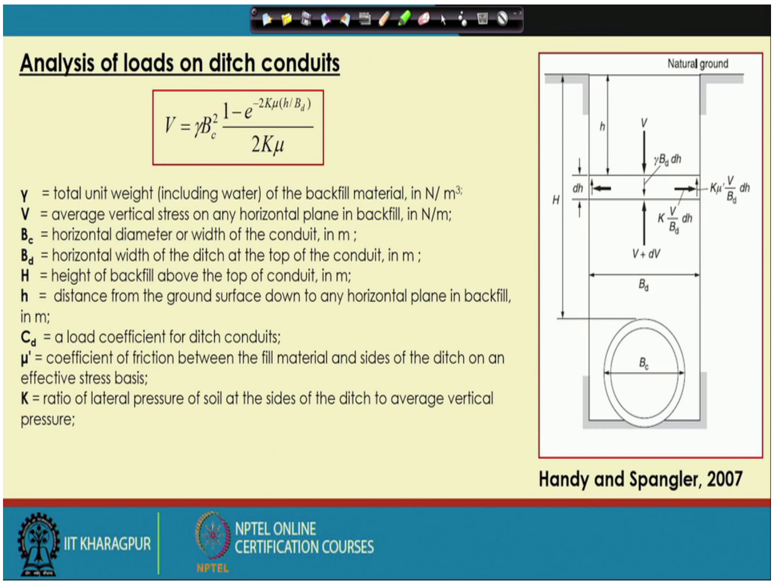

So, this is the your active and passive arching so, now the analysis of load on ditch conduit ok. So, so; that means, this conduit where I can calculate the stress, if this is the Bc is the diameter. So, we have the same expression, we are using that I have developed, but the where mu value is here value is mu. So, this mu is nothing, but the tan phi ok. So, in my previous expression, I have use the so, mu is tan phi. So, I have use the tan phi that is the mu K is the again your ratio of the lateral earth pressure at the side of the ditch to the average vertical pressure ok, that I have mention and this is the Bc is the horizontal diameter of the conduit and then h is the small h is the distance from the ground surface to any horizontal plane in the backfill. So, if it is up to here, if you want to calculate then instead of small h you have to use the capital H, H is the any distance below the ground surface.

You can see the similar expression, they have also derived that I have derived, so and if you want to determine the stress acting on this conduit ok. So, then instead of small h it will be the capital H other thing Bd is the width here remember that, I have use 2 B here, they are use the only B ok, that is why the equation is slightly different ok.

So, but the same way it is been derived and this is the so; that means, here remember that it is not the stress, because my case in the previous case the sigma v, which is the stress, but it is the force ok. So now, you know you have to multiply it to get the force. So, directly you get the much force is acting on the conduit ok.

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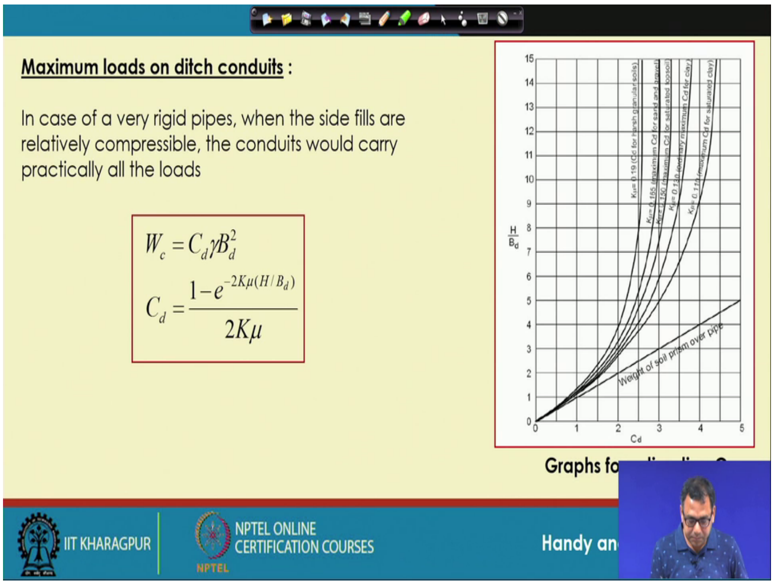

So, this is one thing now if it is the maximum load on a ditch conduit in case of very rigid pipe, if the conduit surface is conduit surface is very rich, when the side fills are relatively compressible then the conduit carried particularly all the loads as I mention, if the side surface are compress more compressible than the structure or the conduit, then the stress from the such surface to come on the on the soil on the structure ok.

So, here it will you will use this chart and then you will use this expression to get the forces. So, this is; that means, the all the all the forces will be taken by the conduit ok. So, this is the C d is the coefficient that we will get H, is the and the B d is this width, H is any height here, what is the, if you this is your H value calculate, what is the H? You know the B d so, from here depending upon the different types of soil ok. So, you get the Cd value from the curve or from the expression also use Cd value, then you calculate what is the force or what is the maximum load acting on a ditch conduit ok.

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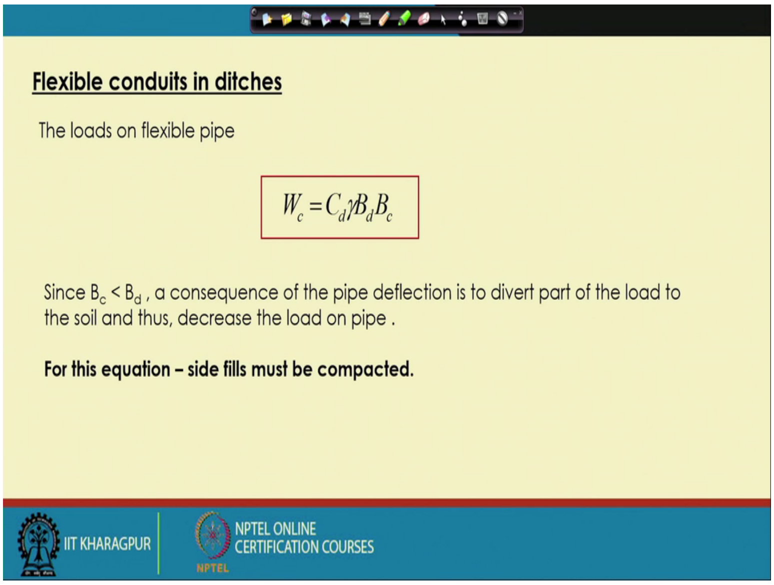

So, now if it is the flexible conduit; that means, your conduit or a conduit is more compressible compared to the surrounding soil, then will be reduction of the stress so; that means, here you can use these expression B c in a C b also you will get from the from the chart that I have given.

So, now here so, in this equation side fills must be conduct compacted, because otherwise the because, side fill must become compacted means they are more rigid or stationary mass and the soil above the conduit or we will be a yielding mass or the moving mass. So, that mean the stresses will be reduced it will transfer from the conduit surface to the stationary or the rigid soil ok.

So, this way you can determine the stresses acting on different types of conduit ok.

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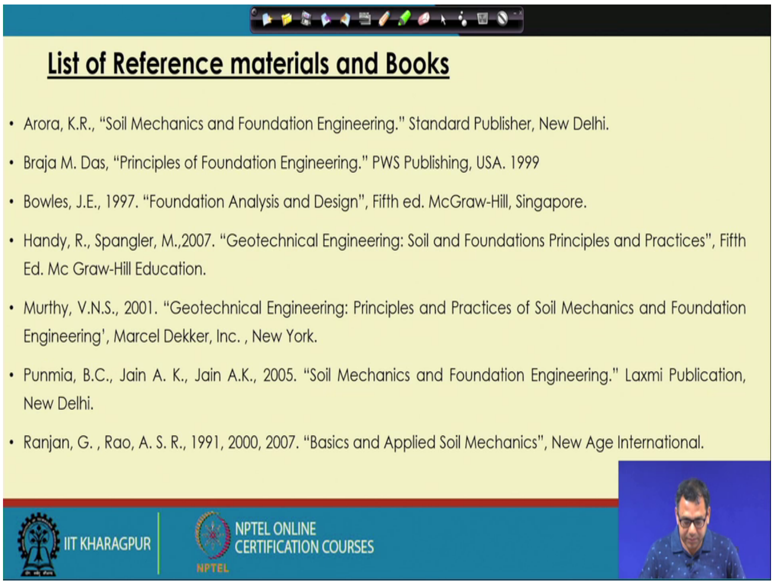

So, now so before I end this course; I am giving the references or the books from, where I have taken the materials, I have given in each and every slides. We lecture the references, where I have taken the materials. So, these are the books. So, you can see where, I have taken the materials and I am use these books for the materials in addition to these books, I have taken the photographs and I have given the source information below the each and every photographs. I have use some Youtube videos also, I have given the source of those files in the in the video links. So, all these information you will get that the video link source, photograph source even, the even I have given the photo from the book. I have also given the reference, which book I have taken the photograph or the figure if the, I am using any table, I am also given the reference. So, these are the books mainly from where I am taken the material.

So, before I finish this course, I want to mention few thing that the in the shallow foundation part the tables for the different bearing capacity theories, Hansen, basic, Meyerhof or the Iosco at the table that, I am giving that is that you have to use for in the exam ok. So that, I will judge based on those tables and the charts that I have given, so you have to use those charts only, if you have getting different charts and different tables in various books, but you have to use the tables that is given, in this course and the pile foundation as I have mention, I have explain the how to calculate the bearing capacity of pile based on the critical length concept with or without ok.

So, my suggestion if it is a homogenous soil use the critical length concept, if it is a layer soil sandy then use the critical depth concept, but if it is a sandy soil then clay layer, thick clay layer again the sandy soil then, better to consider the or determine the bearing capacity without considering the critical depth concept ok. So, these are the few suggestions that will help you during yours exam. So, I wish all of you all the best for the exam.

Thank you.