Application of Soil Mechanics

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Lecture - 21

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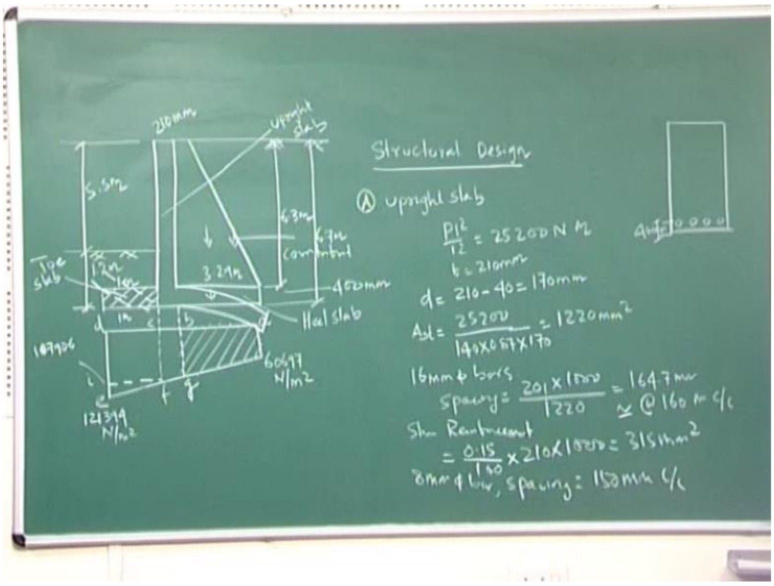

Earlier we have gone through this design of counter for retaining walls. Up to these dimensions, then stability analysis, we have finished this stability analysis. So, then we will calculated this soil pressure at the base of the retaining wall. And this will be if I take a, b, c and d and this term to be if I make it into i, e, f and this is my g this value will be e is equal to one two one three nine four, and this value comes out to be six zero six nine seven newton per meter square. And this dimensions, we have calculated earlier this dimensions, this is your 5.5 meters, and this dimension is your 1.2 meter, and this is 1 meter, and this is your 3.29 meter, and this completely 6.3 meter and this value of 6.7 meter.

Now, also you have checked this stability analysis criteria, all the four criteria it has satisfied. Now we will go for a design of… So, first part with your dimensions tentative dimensions or maybe dimensions. Once dimensions have been established then we have done this stability analysis, geotechnical point of view. Stability analysis is your overturning movement at the safety against overturning movement, at the safety against sliding, and e should be less than or equal to b by six and also bearing capacity failure check. Then after stability analysis once it is then whatever dimensions we have taken in consideration for this design of counter for retaining wall, this dimensions are ok.

Now, after this two steps over then we will got the pressure below this retaining wall. Now third part is your RCC design or maybe structural design, structural design. In case of structural design, so particular design of we can start with this upright slab, this is your upright slab, this part is your heel slab, and this is your toe slab, and this this is your counter force counter force. So, for upright slabs bending moment we have earlier calculated it is equal to p l square two l, this comes out to be 25200 newton meter.

And overall thickness, if you look at this thickness, this upright slab of thickness of 210 mm. So, overall thickness is equal to t is equal to 210 mm. Now effective depth, now effective depth can find it out 210 minus your 40 mm for your concrete that comes out to be 170 mm. Now area of the steel required is equal to moment of resistance that is your 25200 divided by divided by 140 - a stress in steel to 0.87, this is the value of q into 170 effective depth this comes out to be 1220 mm square. That means for design of upright slab this is your steel reinforcement this amount of area this steel reinforcement is required.

So, you can take whatever the available in the market, if I take sixteen mm phi bars, this is available in the market then the spacing comes out to be spacing which is equal to pi by four into d square, this is your two zero one into one thousand by one two two zero. This comes out to be 164.7 mm and it can take it as at the rate of hundred sixty mm center to center.

Now, this is your main reinforcement as I said earlier for cantilever retaining wall, you can go for also after main reinforcement you can go for shear reinforcement that distribution is your point one five percent. So, shear reinforcement reinforcement that is your point one five percent zero point one five by hundred into two ten into one thousand which is coming about to be three fifteen mm square. If I take eight mm phi bar, the spacing come out to be spacing is equal to your hundred fifty mm bars means hundred fifty mm center to center.

Now, this structural design, this is similar same as you have done earlier particularly in the case of cantilever retaining walls, this will be same for upright slab as well as toe slab and heel slab. First we will have to find it out maximum bending moment, how much your bending movement is coming. Then depending upon your bending moment, once you get it, you make it to into b t square you can find it out your total depth d or total thickness t. Then you can find it out, if I give depth if you have your in this case your upright slab this thickness of this upright slab from this dimensions, it is given 210.

So, effective depth if forty mm is your clear cover for concrete, how I have done it. As I said earlier if this is the cross sectional view. So, these are the reinforcement this cover generally your forty m m clear cover beyond your reinforcement that is your forty m m. So, this effective depth is comes out to be two ten minus forty this is your hundred seventy m m then if I quit with your movement to this movement is equal to your stress in steel, I can find it out what is your maximum area of steel means how much reinforcement is required. So, reinforcement required is one into two zero mm square then it can take it as per the availability locally is mm is available in twelve sixteen eighteen twenty twenty five mm bars. You can choose any of the bars in this case sixteen m m pi bars has been chosen and spacing comes out to be hundred sixty m m center to center.

Then as per the high score for structural design for particularly working stress method this shear reinforcement has to be provided here about zero point one five percent and from there the reinforcement comes out to be three one five m m square. So, now, we provide eight m m pi bars of spacing hundred fifty m m center to center the moment you go there. So, bending movement will be more and here it will be less. So, curtailment of bar will be there as I said earlier alternative bar to be curtail so; that means, out of hundred fifty m m alternative bar should be curtailed means the spacing become three hundred m m center to center.

Now, design of the toe slab, if you look at this part considering only this part from here to from here to here this part is your toe slab. Now I will have to consider the pressure at the base and pressure above the toe slab and what is your net pressure. So, in this case, net pressure coming about to be net pressure coming about to be more in the base then your turf. So, we can find it out this toe slab. So, toe slab, if I write it into this upward pressure upward pressure. So, like c d i f then if you look at this c d i f, this is rectangle then i f e, there are two components because this component represent the component you can find it out directly upward pressure, or you can make it into two component one component this and other component is your triangular component.

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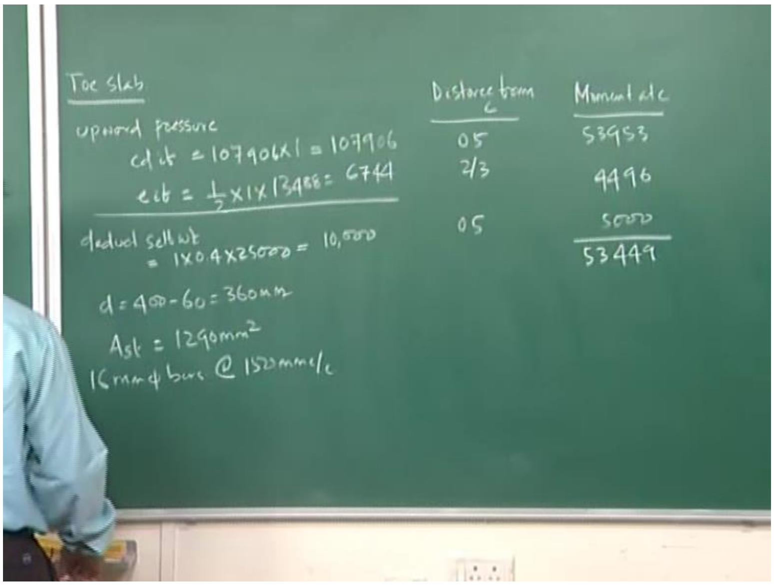

So, c d i f i got this calculations one for this one zero seven nine zero six into one. This distance is one meter, and here it is here, it is your one zero one zero seven nine zero six by simple distribution triangular distribution I can find it out this pressure here. So, this value comes out to be this value comes out to be one zero seven nine zero six. Now upward pressure of e i f, this comes out to be half into one into one three four eight eight. So, if this to this pressure is one two one three nine four and this to this is your one zero one zero one zero one zero seven nine zero six. So, this part will be one two one three nine four minus one zero seven nine zero six.

So, this comes out to be this comes out to be like six seven four four. So, this is your total upward pressure then you can deduct then you can deduct this self weight. Self weight is coming downward, self weight of this is coming downward with the deduct self weight which is equal to one into zero point four into twenty five thousand. This comes out to be ten thousand, and distance from c. If I am taking from distance from c, it is coming above to be zero point five two third. And this is your zero point five and moment at c moment at c this comes above to be five three nine five three then four four nine six then this is your five thousand this comes out to be five three four four nine.

Now, this is your maximum bending moment after deducting self weight and taking into consideration of upward pressure so that means, this maximum bending moment which coming to be it should coming like this it will bend like this. So, with this, help we can find it out, you can find it out which depth is given. This depth is given four hundred mm. This part is given is your four hundred mm from your dimension calculations then you can find it out effective depth comes out to be four hundred minus sixty which is equal to three sixty mm. Now we can find it out area of steel like this, you can find it out area of steel, it comes out to be one two nine zero mm square.

Now, you can take either sixteen big edge you are taking this sixteen m m pi bars you can take sixteen m m pi bars. So, it is sixteen mm phi bars then you can find it out spacing about hundred fifty mm center to center. Similarly shear reinforcement shear reinforcement, you can take it about eight mm phi bars and shear reinforcement you can find it out eight mm phi bars eight mm phi bars eight m m pi bars at the rate of it comes out to be hundred sixty m m center to center. So, the way I have done this, the way I have done this design of of toe slab same way, you can do it this part, this design of the heel slab am not doing that you have to it the way I have done for the toe slab particularly this heel slab you consider the part of the pressures.

You consider the part of the load coming what are the part of the load coming supposed to come particularly heel slab one is yourself weight, it is coming downward the weight of earth. That means, weight of soil it is coming downward in weight of counter force because this is R c, c it is coming downward then any super imposed load that also you consider. Then afterwards then you take from here to here this part to this part the pressure distribution, I would deduct and see whether the upward pressure distribution is more or downward pressure distribution is more. In this case, downward whatever the self weight coming to the pressure because this the retained part of the soil mass. So, the pressure will be more.

So, this case how it will be bent this will be bent in this way. So, it will do it like this, the way I have done for toe slab ,you can do it for heel slab, and do this calculation find it out your maximum moment. You can find it out at the distance from this point b and take moment above point b then your maximum moment after deducting this self-weight deducting this base pressure. Then you find it out what is your area of steel required and main reinforcement as well as shear reinforcement.

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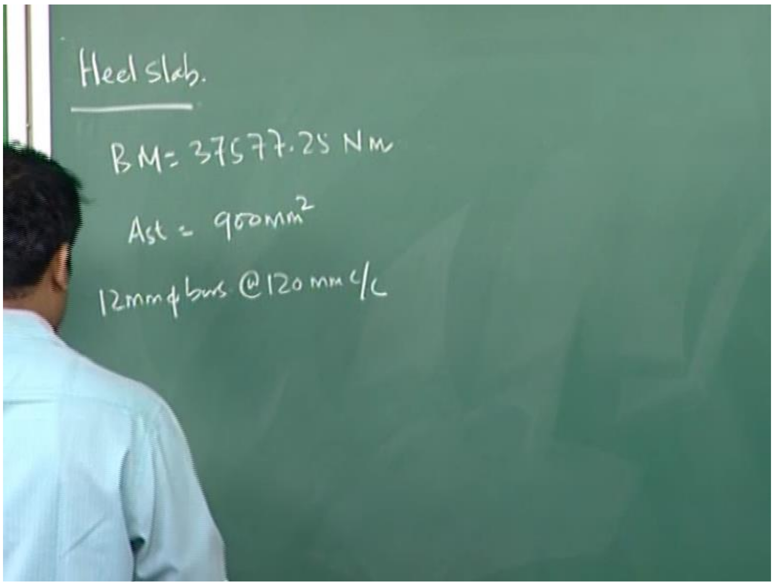

If you look at this heel slab heel slab your maximum bending moment comes out to be heel slab maximum bending moment comes out to be three seven five seven seven point two five newton meter. And this maximum bending moment from there you can find it out your area of steel it comes out to be nine hundred mm square then you can take twelve mm phi bars. So, at the rate of spacing hundred to twenty m m center to center then also you can provide minimum shear reinforcement also. So, toe slab and heel slab as well as upright slab all this slab design has been over only remaining part is that here this counter force counter forts structure design has to be carried out this

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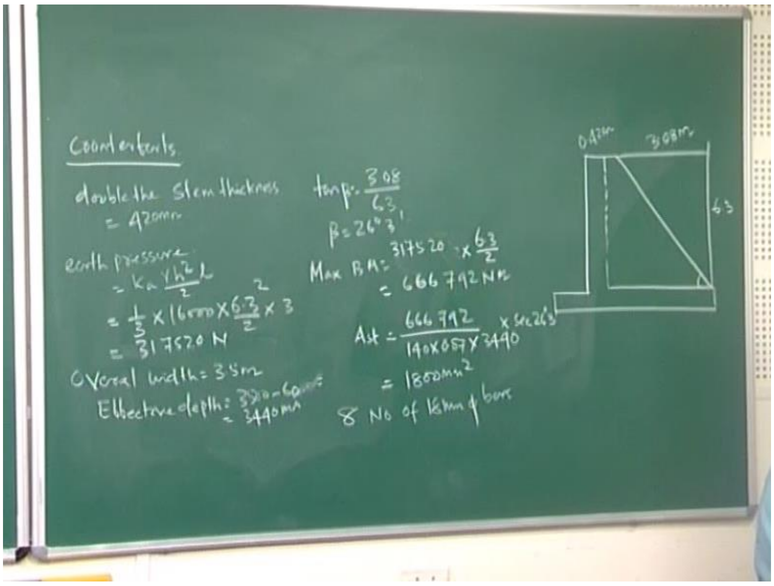

Now, we will start this counter forts walls r c c design you have to counter forts your walls or counter forts if you look at this counter fort. This top weight whatever the weight here, this width comes out here from this dimension, generally this width would take same width of these like two ten m m in this case. So, this comes out to be four twenty mm; that means, double the thickness double the (( )) thickness it comes out to be four twenty mm of width of counter forts the walls. Then once you get the width of the counter fort wall then once you get the width of the counter forts walls. Then you can look the next step which is you will find it out earth pressure distribution or pressure distribution earth pressure. If soil is retaining like this one pressure is giving soil pressure on the upright slab, the other way pressure is also giving to your counter fort walls.

So, this comes out to be k a gamma h square l by two which is equal to one third k is equal to one third gamma is equal to sixteen thousand into six point three. This distance from here to here is your six point three into six point three whole square by two into l is equal to three l id l is your spacing between this counter fort this is above two three. So, this comes about to be six six six seven nine two newton meter. So, overall width of the counter fort at the base overall width of the counter fort at the base we can provide three point five meter, why it is three point five meter three at the center to center base three and three point zero eight.

If you look at this, if I draw this diagram, how this three point five comes into picture. This is your zero point four two meter, then from there, you provide this then if I take it to to the six point three meters this comes out to be three point three point zero eight meter three point zero eight meter. So, now, overall width, if I add it three point three point zero eight plus zero point four two, this comes out to be three point five. Overall width is equal to three point five meter. Now effective depth effective depth minus sixty mm, this is for sixty concrete, this comes out to be three four four zero mm.

Let us put it beta is your beta is your inclination of the main steel with your vertical beta is your inclination of the main steel with vertical either you take it or you can take it. And beta comes out to be now tan beta three point zero eight three point zero eight divided by six point three. So, beta is equal to twenty six degree three minute now area of steel required once you have asked pressure with these from this earth pressure this is your bending moment comes out to be, so k a gamma h square by two. So, then from there maximum bending moment we got it from earth pressure this is your newton meter your maximum bending moment maximum bending moment comes out to be earth pressure six six six seven nine two into six point three by two this comes out to be six six sorry.

There is a calculation mistake here this part is your three one seven five two zero newton. So, this will be your three one seven five two zero. So, this comes out to be six six six seven nine two newton meter. Now you have your effective depth you have your maximum bending moment then from this you can find it out your area of steel what is your area of steel. So, area of steel comes out to be a s t is equal to maximum bending moment seven nine two divided by stress in steel hundred forty into q is equal to zero point eight seven into effective depth which is equal to three four four zero into sec beta or twenty sixty degree three minute. This comes out to be your eighteen hundred m m square now we can provide eight eight numbers of eighteen m m pi bars look at these for counter fort retaining wall counter fort retaining wall what we have done we need a thickness we need a thickness this thickness two ten mm is your thickness appears.

Then generally, we counter fort retaining wall is has been constructed along with this. So, whatever the thickness generally we got it to make it double. So, available thickness means double the thickness, this is your thickness that is your coming four twenty mm then if soil is retaining like this. If soil is retaining like this it will give earth pressure on this laterally one direction on your stem as well as laterally to your to your counter fort retaining wall from there earth pressure comes out to be k a gamma h square by two into l l is equal to spacing between your earth pressure. So, one third into sixteen thousand into six point three whole square by two into three, this comes out to be three one seven five two zero newton. Now overall weight, I have calculated by taking this zero point four two meter now this overall width is coming three point zero eight plus zero point four two this comes out to be three point five meters. So, effective depth comes out three four four four zero mm.

Then I calculate tan beta these is your twenty six degree three minute maximum bending moment will comes out from your earth pressure diagram from this earth pressure. So, this is the maximum bending moment once you get maximum bending moment you can find it out your area of steel then area of steel comes out to be eighteen hundred m m square. So, you take what is the available locally available you can take it sixteen m m pi bar twelve m m pi bar or eighteen m m pi bar this comes out to be eight numbers of bars.

So, this is your once you get there reinforcement then you can think about your shear reinforcement and as well as all also curtailment of bars. Now, as I said earlier as I said earlier in this case we need to harp this curtailment of bars because at the base bending moment will be more at the top bending moment will be less.

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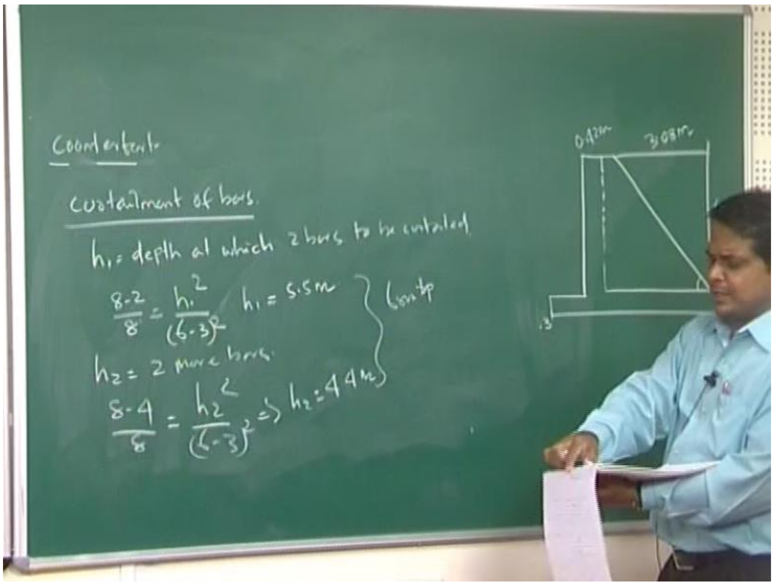

So, curtailment of bars will be curtailment of bars let h one be the depth at which let h one is your depth at which say total eight number of bars two bars let us say two bars to be curtailed I put it in a even number two four six. So, two bar to be curtailed then I can find it out eight minus two eight is your bar minus two by eight this is the bar then h one h square minus six minus divided by six minus three whole square. So, this comes out to be h one is equal to h one is equal to comes to be five point five meter.

That means below five point five meter we can curtail the bar of every two bars if there are eight bars; that means, two then next two bar to be curtailed then six then six two bar to be curtailed. So, similarly you can go for h two let us say h two is equal to another two more bar two more bar curtailed. So, you can find it out eight minus four by eight this comes out to be h two whole square by six minus three whole square this comes out to be h two is equal to four point four meter from top this is your from top. So, in this way you decide from the top at what distance two bar to be curtailed in another another distance an additional two more bar to be curtailed.

In this way, we proceed the curtailment of bars, now then you will have to find it out this connection between this counter fort and upright slabs, because once this counter fort retaining wall you get your main reinforcement. This main reinforcement has to be connected to your counter fort retaining wall has to be connected with this upright slab as well as heel slab. How this connection has to be done, this has to be also again calculated I will do it next class along with this all detail reinforcement drawings.

Thanks a lot.