Application of Soil Mechanics
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Lecture – 19

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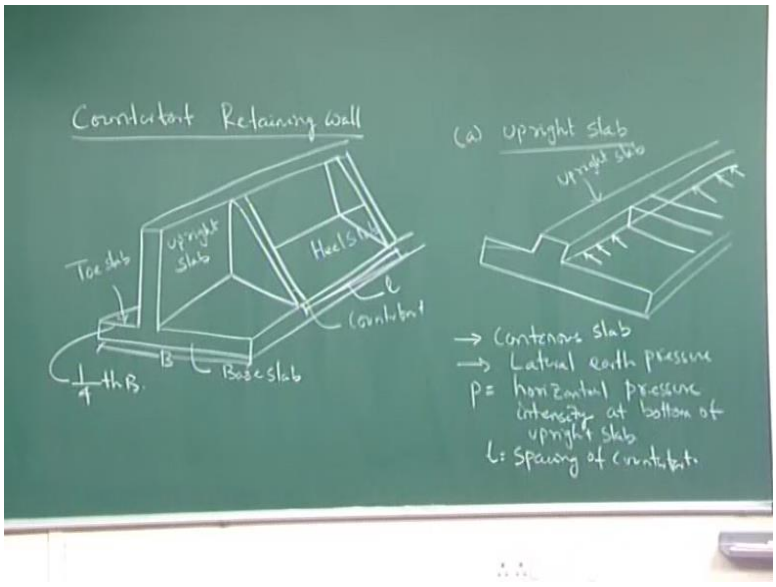

Now, design of counter fort retaining wall counter fort retaining wall, I am just drawing a single section of counter fort retaining wall. If you look at this, if I am taking making it inclined this is a cantilever retaining wall with these cantilever retaining wall for height more than twenty meter you resisting is the pending movement counter forts has been provided at regular interval. So, that it will resist at one a. So, that there will be a less pending particularly in the stame in that cantilever retaining wall. So, this whole site is called counter fort retaining wall.

Now, this if I make it to this is called you are upright slab upright slab this is your toe slab now this is your counter fort this part is called heel slab. So, as I said complete design consist of three parts one is your dimension second part is your stability analysis third is your structural design.

In these case in particularly in structural design will have to design for upright slab heel slab, and toe slab as well as the counter fort. So, first case one first one is your upright slab in these case of upright slab if I take a section here if I caught it a section here here, then how it looks look at the forces here now these part is your upright slab now if I

caught a section here at this point this upright slab is looking like this, and now what are the supports the supports are this counter forts this is your counter fort one, then counter fort two counter fort three, and these are earlier earth pressure by soil is retaining up to this height up to this height soil is retaining. So, it is giving your lateral pressure so; that means, it will be designed as a it will be designed as a continuous slab continuous slab spanning horizontal on counter forts, and it subjected to subjected to lateral earth pressure.

So, let p is equal to let p is equal to horizontal pressuring density horizontal pressuring density horizontal pressuring density are bottom of upright slab; that means, this p e g or horizontal pressure are bottom of your upright slab this upright slab is going like these at bottom of the upright slab p is equal to horizontal pressure l is equal to spacing of this counter fort if I draw one more counter fort here. If I draw one more counter fort here now. So, t his is your this part is spacing l l is equal o spacing of counter fort spacing of counter forts.

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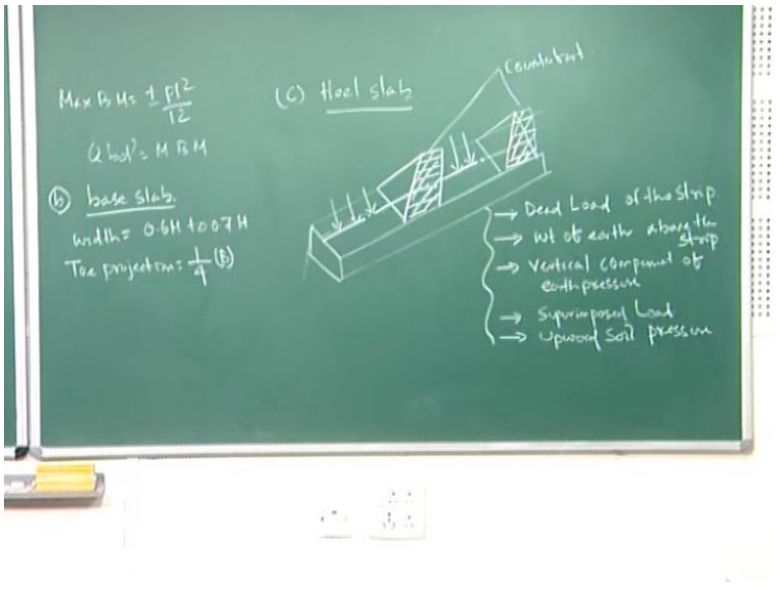

Now, maximum Pending movement, now maximum Pending movement which is equal to plus minus pl square by twelve, because this is a continuous slab with the supports are there. So, it will p l square by twelve, and based on this maximum bending movement as I have discussed once you get maximum bending movement these has to be equated to q b d square is equal to maximum bending movements q b d square is equal to maximum

bending movement from there you can find it out d is what is that thickness deep for this upright slab, then design can be design can be calculated.

Now, second part is your base slab base slab this is your base slab, but b is your base slab in this base slab generally we take width is equal to zero point six h to zero point seven h; that means, width from here to here this width be has to be taken zero point six h to zero point seven h a is h is equal to total height of the base slab is total height of this counter fort retaining wall. So, it will be approximated zero point seven h to zero point six, and toe projection what is your toe projection toe projection is how are the toe had been projected away from the wall this part is your toe projection. So, toe projection is about one fourth one fourth of total width of base slab one fourth of total width of base slab if total width of base slab, if I write it b. So, these toe projection is equal to one fourth of b one fourth of b

Now, this third part which is is called heel slab this counter fort retaining wall has been designed as a slab design first one is your upright slab, second is your base slab, third is your heel slab heel slab means, this part is your, this part is your heel slab. So, this heel slab if I make it this heel slab I caught it. So, how it looks.

Now, I have got it this complete heel slab taking a section heel slab taking a section are this point I am cutting this taking a section are this point. So, this part is like heel slab now what are the forces coming to this here the forces are coming here look at here. If there is a soil mass retain in these part the soil has your lateral earth pressure upon your upright slab as well as vertical pressure vertical pressure on these heel slab. So, this is your vertical pressure on this heel slab, and these are all my these are all counter fort these are all your counter fort.

So, what are the lower suppose to come here the load will be dead load of the strip dead load of the strip; that means, these dead load are self weight; that means, if it is r c c concrete, then it is a concrete weight of this, then next part which your weight of earth pressure weight of earth not earth pressure sorry, weight of earth above the strip; that means, if the soil is retained in these part if soil is retained soil has its own weight soil has its own weight that is your weight of your soil or earth above the strip, then vertical component vertical component of earth pressure. Vertical component of earth pressure means if this is the total earth pressure is it has two component vertical as well as

horizontal components. So, the vertical component downward it is that is your vertical component of your earth pressure.

Then any superimposed load any superimposed load, then upward soil pressure, because once there is a retaining wall for heel slab there is a pressure give maximum, and give minimum are you have discuss there will be also upward soil pressure. So, then you consider also upward soil pressure upward soil pressure.

So, total net load will be what is your net load it is downward or upward, if you look at here, dead load of the strip is vertical, and second part weight of earth above the strip weight of the soil weight of the soil above heel slab again it is vertical, then is your vertical component of earth pressure again it is vertical only, and superimposed load any superimposed load is they are again it is vertical only upward soil pressure will be your upward. So, the total force will be it will be total load will be downward.

So, in these case maximum bending movement maximum bending movement which is equal to q l square by twelve q is equal to net load per unit area q is equal to net load per unit area net load per unit area. So, there will be a positive, and negative positive as well as negative; that means, sagging, and hogging movement will be there. So, hogging movement will be over the support, and sagging movement will be section between the counter fort sagging will be like this hogging movement will be over the support these kind of things will come. So, hogging movement will be on the support sagging will be between this supports between this counter fort. it will be sagging movement. So, as as I said once you get your maximum bending movement once you get the bending movement, then you quit to your cube d square than you can hand it out the thickness of your heel slab, then once you get your thickness, then find it out how much is your red court deal is required for designing of your heel slab area of steel.

Once you get are of strip, then you can find it out what is the spacing of still between each other, then you can design your structural part of your heel slab as a there has been three slabs once again I am repeating there has been three slabs particularly in case of counter fort retaining wall one is your upright slab second is your base slab third is your heel slab.

So, in case of upright slab if I caught a section here. So that means, the pressure, because of your soil retain here lateral earth pressure; that means, in lateral direction will be, and

this will be counter fort will be arced as a support. So, it has to be designed as a continuous slab as a continuous slab. So, maximum bending movement will be your p l square by twelve. So, p is equal to your horizontal pressure intensity at the bottom of upright slab l is your spacing between your spacing between your counter forts.

So, once you get maximum bending movement from there you will have to find it out your thickness of your upright slab, then area of steel, then design has to be made. Similarly, for base slab base slab if we look at this base slab there are two parts one is your toe slab one is your part of this this part is your base slab or this entire is called base slab.

So, in these case toes slab has to be designed based on the what are the load coming as the heel slab. So, base slab has been divided into two parts one is your toes slab other is your heel slab the design of toes slab will be as per the design of cantilever retaining wall the toe slab will be same.

In case of heel slab, if I caught a section here here the heel slab what are the load suppose to come; one is your dead weight of the strip, then second is your weight of earth; that means, the major part is your weight of soil retaining above the heel slab, then third one is your any superimposed load any superimposed load, because of your traffic load, then component of your earth pressure as I said there are two component horizontal as well as vertical, and vertical component of your earth pressure they of course there is a, because of soil pressure there is a upward pressure at the base slab.

So, net component load will be downward. So, box maximum bending movement is equal to your q l square by twelve q is equal to net load for unit area now this l is your l is your the spacing means distance between this counter fort. So, there will be a this kind of bending movement you will get it sagging you will get between this counter forts hogging will be get at the mat of your support you will get it once you get maximum bending movement if you can equate this maximum bending movement is equal to q b d square from there you can find it your thickness. So, q is your factor it depends upon your grade of concrete, and grade of the steel has to be used for this a a construction or design. So, based on that you can find it out your thickness once you get the thickness, then you can find it out area of steel recover may, then what are the reinforcement what time meter you are suppose to provide, and what is its proportion means spacing, and

other reinforce makes your structural design has to be done. Now next part is your what is your thickness of base width you find it out the base width, but thickness has not yet decided.

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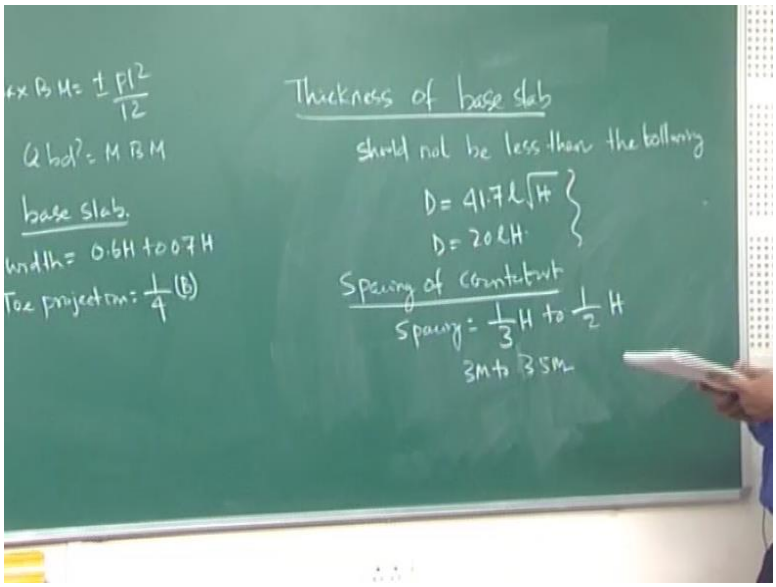

So, thickness of base slab. So, these may be it should not be less than the following; that means, thickness should not be less than the following should not be less than the following if you look at here d is equal to the thickness of base slab forty one point seven l root a for of h, and d is equal to twenty l h. So, d is your thickness of base slab l is your spacing between this counter fort h is equal to over all height of the wall over all height of the wall. So, generally it should not be less whatever d provided it is to be more than these calculations.

Now, spacing of the counter fort spacing of counter fort spacing of counter fort the spacing is one third h to half h, it varies from it varies from three meter to three meter to three point five meter, but generally spacing should be provided one third of total height h to half of total height h the generally, this is the specification for providing the spacing it generally varies from three meter to three point five meter. Now, comeback to your comeback to your bars reinforcement bars, if I draw this reinforcement bars how it looks horizontal ties connecting the main counter for an upright slab.

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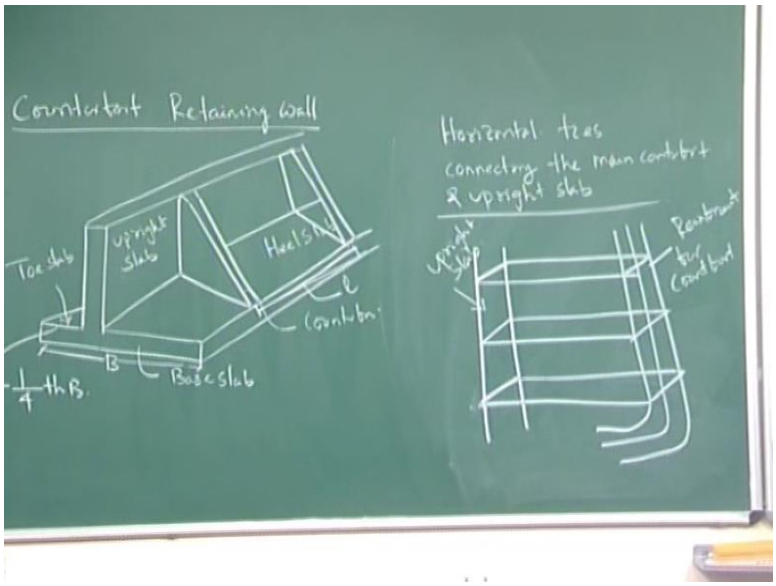

If you look at this upright slab this is your main counter fort this is your counter fort, and this part is your upright slab how it has been particularly in these junction, how it has been connected this upright slab has been taken to here back to the heel slab a sorry this reinforcement of main counter fort has been taken back to your bay heel slab, and this is your reinforcement bar reinforcement bar particularly upright slab. If I say this is my upright slab this is your reinforcement bars main reinforcement bar has been provided. So, at these point it will counter fort, and upright slab these has been connected these your all these are all yours your enforcement. So, that it will be connected upright slab as well as your counter fort. If I say this is my reinforcement for counter fort for counter fort, and this is for your upright slab. So, these are all your sortie or soiree enforcements. So, that there will be a proper connection between connection between upright slab as well as for counter fort reinforcement for counter forts.

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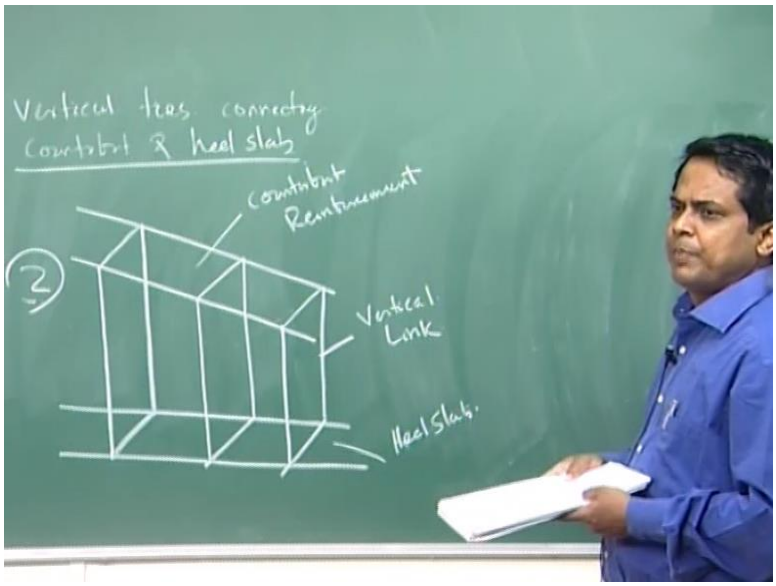

Now, vertical ties connecting counter fort, and heel slab you see why I am discussing these these counter forts these counter forts of reinforcement bars has to be connected with your upright slab as well as your heel slabs it has to be connected. So, that it should not be separated after this design is over.

So, now if I take it how it has been connected this is your vertical link vertical link, and this is your main reinforcement counter fort reinforcement counter fort reinforcement, and this is particularly your this part of here heel slab heel slab if you look at here look at this heel slab; that means, look at this heel slab it is going. So, these are the bars of this main reinforcement of real slab, and if you look at this counter fort was it is inclined; that means, it is passing from here to here I put it counter fort main counter fort reinforcement here to here. So, that there is a link this vertical or soiree enforcement has been connected. So, that it will be in induce without any changing it will be in induce once this design is over once this design is over; that means, this counter fort retaining wall will be induce with your upright slab, and this counter fort counter forts also will be induce with your heel slab Iin both way; that means, if you look at these section particularly these junction say number one, and these junction say number two. So, this is your number one point this is your number two point.

In these case number one point upright slabs this is your upright slab. So, these are all your main reinforcement, and counter fort was counter fort counter fort is going on. So,

these are horizontal links between upright slabs, and counter fort reinforcements.

Now, similarly in these case counter fort is passing particularly heel slab it is connected at an influencer, and heel slab is going in these directions. So, in these case this counter fort is inclined, then this is your heal slab, and vertical link has been connected between this counter fort well as the heel slab.

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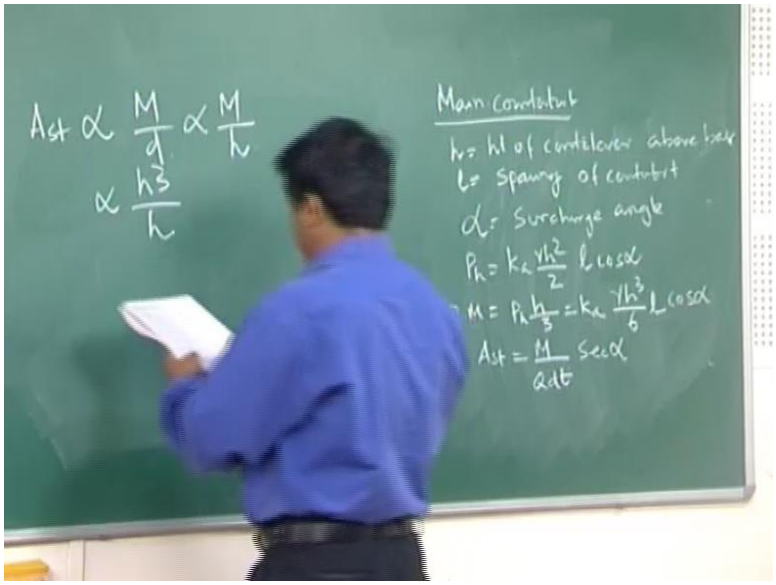

Now, main main, then then come back to your main counter fort counter fort in these counter fort let us say h is equal to height of cantilever above the base height of cantilever above base the small height h is equal to height of cantilever height above the base from here to here the total height h is equal to from here to here, but h small h is equal to here to here this is your height of cantilever above the base. Let us say l is equal to spacing of counter fort alpha is equal to surcharge angle alpha is equal to surcharge angle in these case the horizontal pressure earth pressure p h is equal to ka gamma h square by two l cos alpha.

If you look at these l is equal to spacing l is equal to spacing this is alpha is equal to surcharge angle l cos alpha it is coming. So, maximum bending movement is equal to or bending movement is equal to p h into h by three which is equal to k a gamma h cube by six l cos alpha, now area of steel are of steel area of steel is equal to m by q d t sec alpha, because area of steel is equal to bending movement l cos alpha it is a reverse one by cos alpha it will be a sec alpha movement by q d t sec alpha is your area of still requirement

now curtailment of bars. Now this curtailment bars particularly in counter forts area of steel is equal to a s t is directly proportional to if you look at here it will be m by d d is equal to m by d which is equal to m by h. So, which is equal to directly proportional to h q by h m e if we look at the m is, it is in terms of h q, which is equal to h q by h; that means, it is directly proportional to your h square total height of the h square; that means, curtailment of bar at the bottom means at the top there is not re equipment it is required how much bars you are going to quartile that requires your that depends upon your height square. So, based on that curtailment of bar has to be done. So, next class I will solve way complete problem of these counter fort retaining wall including structural design completely.

Thanks.