Advanced Foundation Engineering
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Lecture - 32
Seismic Design of Retaining Wall (Contd.)

In the last class, I have discussed about the seismic retaining wall. Now, in the last section of this previous class I have discussed about the hydrodynamic force, during the seismic condition. So, today I will discuss about the how to determine the location of that hydrodynamic force in different condition.

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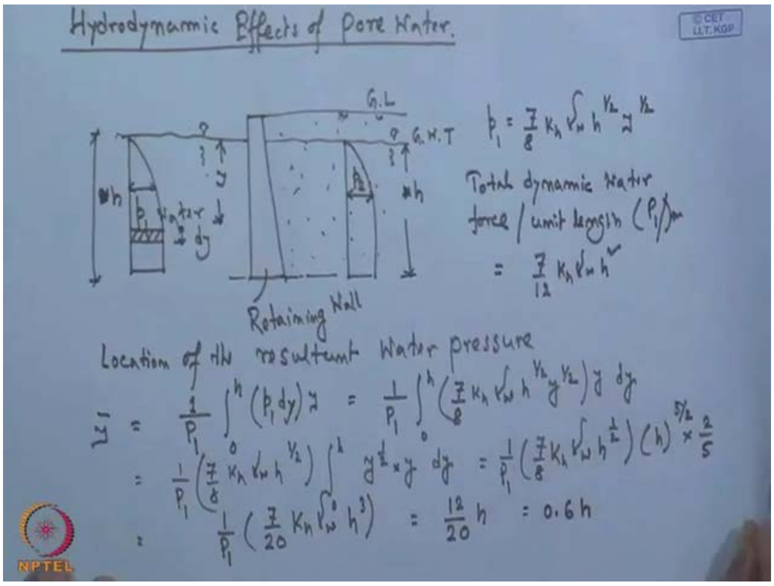

Hydrodynamic Effects of Pore Water.

$p_1 = \frac{7}{8} k_h \gamma_w h^{1/2} y^{1/2}$

Total dynamic water force / unit length $(P_1)_m$

$= \frac{7}{12} k_h \gamma_w h^2$

Location of the resultant water pressure

$$\bar{y} = \frac{1}{P_1}\int_0^h (p_1 dy)\, y = \frac{1}{P_1}\int_0^h \left(\frac{7}{8} k_h \gamma_w h^{1/2} y^{1/2}\right) y\, dy$$

$$= \frac{1}{P_1}\left(\frac{7}{8} k_h \gamma_w h^{1/2}\right)\int_0^h y^{\frac{1}{2}} \times y\, dy = \frac{1}{P_1}\left(\frac{7}{8} k_h \gamma_w h^{\frac{1}{2}}\right)(h)^{5/2} \times \frac{2}{5}$$

$$= \frac{1}{P_1}\left(\frac{7}{20} k_h \gamma_w h^3\right) = \frac{12}{20} h = 0.6 h$$

Now, for this section, now this pore water hydrodynamic effect of the pore waters, as I have discussed in the last class that if this is the retaining wall and these are, this side is water and this side if this is soil. And assume that water surface or ground water surface, so this is ground line or ground level at a ground water table, and the height of this water table is H. So, this is retaining wall, this side this is water free water and this side soil is there, inside the soil pores water are present and water surfaces. Again here also it is height is H from the base of the retaining wall.

So, as I have discussed that if I consider that this is the variation, and this variation is p 1. Similarly, we will get another variation here that is p 2. As it is shown that this condition and this condition are different, because it is the free water which is moving and here it is the water is within the soil pores. So, here we consider this variation same variation, but those values are different. Here I consider the p 1 at any depth from the top of the water table is p 1 stress and here p 2. And last class I have and it is mentioned that p 1 is 7 by 8 K h gamma w h to the power half, y to the power half. Here, if it is small h then this will be small h to the power half. If it is capital H, then this will be capital H.

Now, it is also derived that the total dynamic water force per unit length is given by 7 by 12 K h gamma w h square, where h is the height of the water and gamma w is the unit weight of the water, K h is the coefficient of horizontal seismic pseudo static seismic coefficient. So, now this was derived for the last class for water in the free condition. Now, similarly now we can we have to determine the location of the resultant water pressure. Now, here we know the total force that is P capital 1 per meter that is in 7 by 12 K h gamma w h square. Now, where it will act that will can determine that that location y w that will be equal to 1 by P 1 into integration 0 to h p 1 d 1 d y into y.

So, as we have considered a small segment of thickness d y at a height y from the water surface. So, that means y bar that is the location of these water pressure that will be 1 by P 1. P 1 is the total dynamic water force to 0 to h p y small p y is the pressure at any depth from the top into d y y. So, now we will guide that P 1 into capital 0 to h small p 1 is 7 by 8 K h gamma w h to the power half, y to the power half into y into d y. So, finally, we can write P 1 into 7 by 8 K h gamma w h to the power half 0 to h into y to the power half into y into d y.

So, after the integration we will get 1 by P 1 into 7 by 8 K h gamma w h to the power half into small h to the power 5 by 2 into 2 by 5. And we will get that 1 by P 1 into 7 by 20. So, this will be 7 by 20 K h gamma w h cube. So, finally, if I put the value of P y p y that is 7 by 12 K h gamma w h square. So, we will get this value 12 by 20 h. This 7 by 12 so this will be 12 by 20 into h K h gamma w and 1 h square, that will be cancel out from this value. So, now we will get this value is 0.6 of h. So, that means the location of the water force is 0.6 of h from the top of the water level and the total force is 7 by 12 K h gamma w h square.

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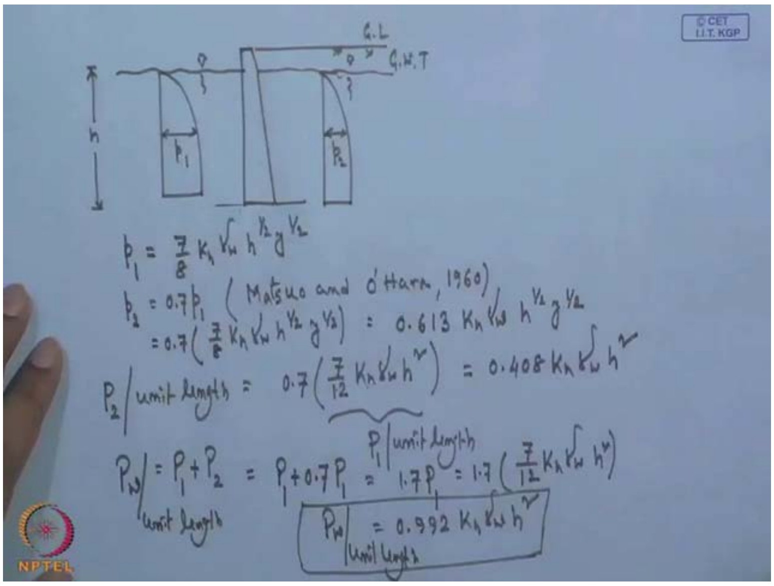

$$p_1 = \frac{7}{8} K_h \gamma_w h^{1/2} y^{1/2}$$

$$p_2 = 0.7 p_1 \text{ (Matsuo and O'Hara, 1960)}$$

$$= 0.7\left(\frac{7}{8} K_h \gamma_w h^{1/2} y^{1/2}\right) = 0.613 K_h \gamma_w h^{1/2} y^{1/2}$$

$$P_2/\text{unit length} = 0.7\underbrace{\left(\frac{7}{12} K_h \gamma_w h^2\right)}_{P_1/\text{unit length}} = 0.408 K_h \gamma_w h^2$$

$$P_w/_{\text{unit length}} = P_1 + P_2 = P_1 + 0.7 P_1 = 1.7 P_1 = 1.7\left(\frac{7}{12} K_h \gamma_w h^2\right)$$

$$\boxed{P_w/_{\text{unit length}} = 0.992 K_h \gamma_w h^2}$$

Now, once we get this value, next thing is that. So, if I draw the same figure again. So, this is the water, free water level, this is small h and this is ground water surface sorry ground level and the same water level here, ground water table, which is the base of the retaining wall. So, here we will get a variation that is p 1. So, similarly, we will get another very similar variation that is p 2 at any depth. Now, as it is mentioned that is given that p 1 is equal to 7 by 8 K h gamma w h to the power half y to the power half. Similar expression is proposed that p small p 2 is 0.7 times of p 1. So, this is given Matsuo and O'Hara 1960.

So, so here it is proposed that p 2 is 0.7 times of p 1 that means the stress distribution here water hydrodynamic pressure of water within the soil is less than the water pressure applied by free water. So, here it is free water. So, here this is p 1 small p 1. Now, here the water is within the void. So, this water pressure is less than the water pressure applied by the free water. Now, here if these expression is applied so that means this will be 7 and p 1 is 7 by 8 K h gamma w h to the power half y to the power half. So, this value will be 0.613 approximately K h gamma w h to the power half y to the power half.

So, now, if we integrate this force also then we will get the total dynamic hydrodynamic force applied by the water within the soils. So, thus P 2 per unit length that will be similar to 0.7 times of 7 by 12 K h gamma w h to the h square. So, that means this is basically P 1 per unit length. So, now we will get this expression that this will be 0.408 K h gamma w h square. So, the total force is applied by this free water is 7 by, this value is 7 by 12. Now, we know that 7 by 12 K h gamma w h square and then P 2 per unit length, that is the 0.7 times of P 1. So, this will be 0.408 K h gamma w h square.

Now, during an earthquake the force per unit area on the seaward, so suppose this is seaward, sea side and this is the cost area. Now, we can write the resultant force on a retaining wall during earthquake is P 1 plus P 2. So, the resultant force we are taking the maximum force on retaining wall that is equal to P 1 plus P 2. As this one side force is applied and another side it is released. Now, here the resultant one will be P 1 plus P 2. So, this value will be if I take P 1 plus P 2, then this will be P 1 plus 0.7 times of P 1.

So, this is also P w per unit length. So, we can write this is 1.7 times of P 1 and P value is 1.7 times 7 by 12 K h gamma w h square. So, that value will be 0.992 K h gamma w into h square. So, this is the force, total force applied on a retaining wall due to water pressure. If this side is water then and this side also water water both are in the same level, if it is in different level then this h value will be different and we have to adjust this value according to that. So, now if it is same level and this is 0.992 K h gamma w into h square. So, this is the total resultant force per unit length due to hydrodynamic force that is applied on a retaining wall. So, during the retaining wall we have to consider this force also during the design.

Now, these things are done for the hydrodynamics. Now, this, all the analysis that we have done is for the active case condition. Similarly, we can determine this values for the passive case condition also. The expression will be, only the coefficient expression will be different otherwise the process is same.

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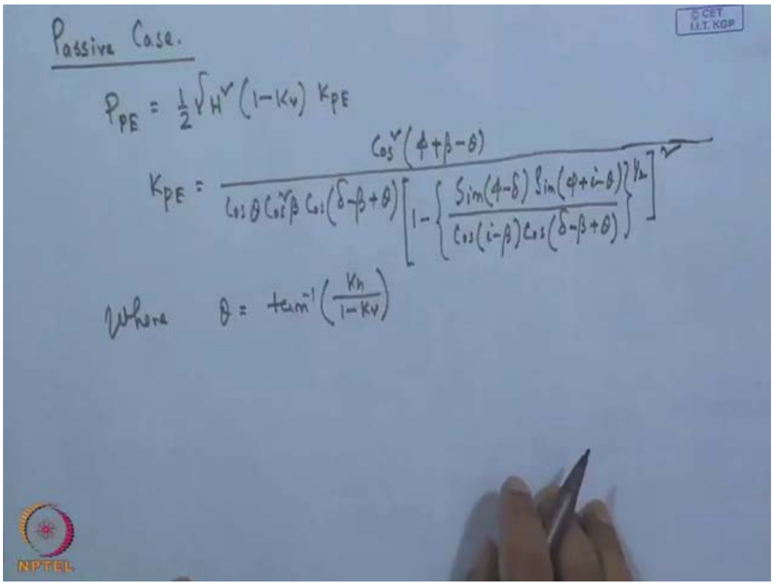

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Passive Case.

$$P_{PE} = \frac{1}{2}\gamma H^2 (1-K_v) K_{PE}$$

$$K_{PE} = \frac{\cos^2(\phi+\beta-\theta)}{\cos\theta \cos^2\beta \cos(\delta-\beta+\theta)\left[1-\left\{\frac{\sin(\phi-\delta)\sin(\phi+i-\theta)}{\cos(i-\beta)\cos(\delta-\beta+\theta)}\right\}^{1/2}\right]^2}$$

Where $\theta = \tan^{-1}\left(\frac{K_h}{1-K_v}\right)$

So, now for the passive case let P P earthquake or seismic that will be half gamma H square 1 minus K v into K P E where K v and all the other times are remain same as the active case, only this K P E expression that will change. So, this K P E expression is cos square phi plus beta minus theta, this is cos theta cos square beta cos delta minus beta plus theta 1 minus sin phi minus delta sin phi plus i minus theta cos i minus beta cos delta minus beta plus theta to the power half total square. So, this is the expression of K P E where theta is equal to tan inverse K h 1 minus K v.

So, other expression, other things are remain same. Only, this K P E expression, that will change. Now, these are the design steps for the seismic condition of retaining wall. So, these are our normal traditional retaining wall. So, what are the additional force that you have to consider during the earthquake condition and if water is present or if not. If water is present then you have to consider the hydrodynamic force. So, those things I have discussed. Now, these things are for the our normal retaining wall design.

Now, what will happen, what are the changes that we have to measure? We have, I have already discussed about the design step of reinforced retaining wall under static condition. Now, what are the additional steps or additional things we have to consider during the earthquake condition that we will discuss in the next section.

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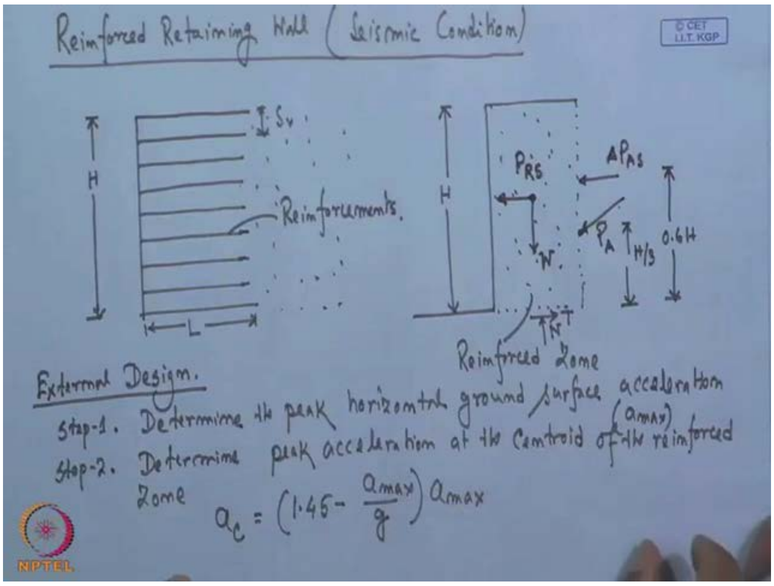

Reinforced Retaining Wall (Seismic Condition)

External Design.

Step-1. Determine the peak horizontal ground surface acceleration (a_{max})

Step-2. Determine peak acceleration at the Centroid of the reinforced Zone

$$a_c = \left(1.45 - \frac{a_{max}}{g}\right) a_{max}$$

So, now here, so for the reinforced retaining wall in the seismic condition so as I have mentioned that in the reinforced retaining wall design we have to consider two condition. One is for the internal stability check another is for the external stability check. So, internal stability basically we have to design the spacing between the reinforcement and the length of the reinforcement, I will provide. So, these things I have already been discussed.

So, now what are the additional things that we will consider for this this part that I will discuss. So, first we will consider the seismic condition, the retaining wall design that for suppose this this is the retaining wall and we are assuming, we are taking the uniform spacing and the length of the reinforcement. So, this is uniform spacing S v and this is L is the total length of the reinforcement layer including the anchorage length and the L r and L e including the anchorage length also, suppose this height of the retaining wall is H. So, these are reinforcements. Now, we can consider in the two parts this one, one is this is the H and this one is the up to there is reinforced zone, this is the reinforced zone. You can write this is the reinforced zone

So, in the retaining wall design so this is the reinforcement so reinforcement will provide up to this length so up to this one, this is reinforced zone and after that this one there also that is soil, but it is not reinforced one. This one is the unreinforced because required length of the reinforcement may be up to this. So, recall this is reinforced zone and this one is the unreinforced zone. So, what are the forces, additional force so suppose this is the weight of the reinforced zone that will act here. Now, first step that how we will decide this reinforced zone and unreinforced zone, that thing first we will design this retaining wall under static condition.

So, first we can design this retaining wall under static condition then we can we can determine how much length we will provide here and what are the S v value. So, there is a first step we can, we should say this is first iteration that we design this retaining wall under static condition. So and the how to design the retaining wall, how to calculate this length, spacing, that those things I have already been discussed. So, now we design this retaining wall under static condition then we will get this reinforced zone say and therefore, this is the reinforced zone, this is the length and height and here we will apply at horizontal pressure, that is pseudo static force that is P in the reinforced zone in the seismic condition.

So, here P R S is the horizontal force in the reinforce zone for the seismic condition. Now, here the P A that will act for the active pressure and that will act at a height of H by 3. Now similarly, annular force del P active in the seismic condition that will act at a height of 0.6 H. So, these are the forces and in additional, this is the T is the shear force and this N is the normal force. So, these are the forces that will act in a reinforced retaining wall structure. So, during the design of static condition then we consider this weight and this P A active force under static condition, only the two, these two forces we consider during the design of the retaining seismic retaining wall under static condition.

For the seismic condition, we have to add two additional force, this is horizontal force, we are neglecting the vertical one. This is the horizontal force P reinforced zone in seismic condition and this is the additional force due to the earthquake P A E S in the seismic condition. So, as it is known and the static force is acting H by 3 from the base of the retaining wall, and seismic force which act as a height of 0.6 H from the base of the retaining wall, so these are the force that will apply.

Now, we will design for the external designs and the internal design, so two design state. One is external and the internal design. So and it is assume it is already been designed for the seismic condition. So, know that this retaining wall is safe under external and internal design criteria’s under static condition. Let us see what are the additional steps that we have to consider for a seismic condition. For the external design the step 1 that determine the peak horizontal ground surface acceleration that is a max. So, during design we have to determine what will be the peak horizontal ground surface acceleration for a particular earthquake or that though so a max will determine first so that value it determine.

Now, step 2 once you know that so those are these are the process by which we can determine the a max. So, these are, this is so. Those things are the beyond the scope of this lecture. Now, we, here we assume that we know the a max. So, this a max we have to determine for a particular site and now once we know this a max for the seismic condition, then we have to determine peaks acceleration at the centroid of the reinforced zone reinforced zone.

So, this a max is the peak ground acceleration. Now, next we will calculate the peak acceleration as the centroid that means this centroid of the reinforced zone by this expression a c that is equal to 1.45 minus a max divided by g into a max.

So, first we will or determine the a max, the peak ground acceleration for any any particular area. So, once we get that a max for the design area then we will calculate that centroid peak acceleration and the centroid of the reinforced zone by using this expression 1.45 minus a max by g into a max.

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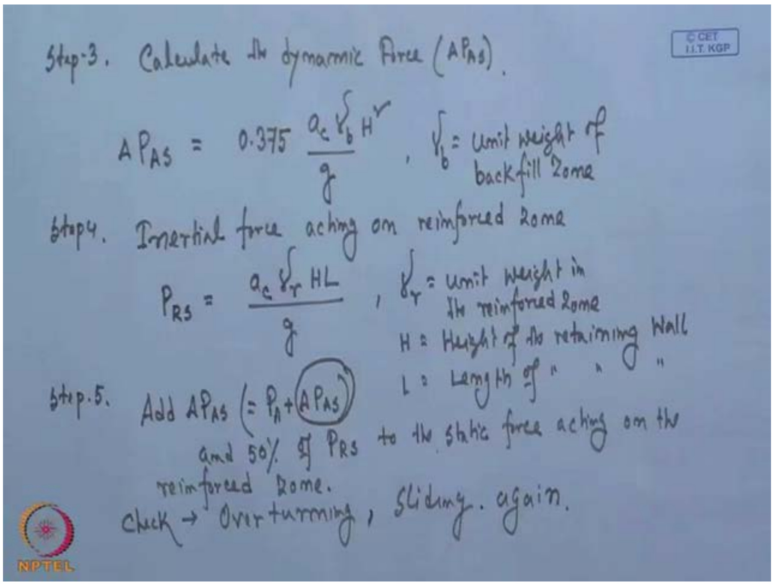

Step-3. Calculate the dynamic force (AP_{AS}).

$$AP_{AS} = 0.375\,\frac{a_c \gamma_b H^2}{g}\,, \quad \gamma_b = \text{unit weight of backfill zone}$$

Step 4. Inertial force acting on reinforced zone

$$P_{RS} = \frac{a_c \gamma_r HL}{g}\,, \quad \gamma_r = \text{unit weight in the reinforced zone}$$

H = Height of the retaining wall

L = Length of " " "

Step.5. Add AP_{AS} $(= P_A + \boxed{AP_{AS}})$ and 50% of P_{RS} to the static force acting on the reinforced zone.

Check → Overturning, sliding. again.

Now, the step 3 that once we get the a max then calculate dynamic force, this delta P A S. Now, what is the additional force that due to this earthquake condition this delta P A S we can calculate by using this expression 0.375 a c gamma b H square by g. Now what is gamma b? Now, gamma b is the here if I consider this is reinforced zone and this is the unreinforced zone, then we have two may be two different densities. So, these densities or unit weight is for the reinforced zone and this is for the backfill zone. So, this gamma b is the unit weight of the backfill zone and here gamma r is the unit weight of the reinforced zone.

So, in this expression that a c is the peak acceleration horizontal acceleration at the centroid of the reinforced zone, gamma b is the unit weight of backfill zone, H is the height of the retaining wall, g is the acceleration due to gravity. So, now once we get this value then the step 4 this will be that internal force that will calculate. So, here another force the internal force acting on the reinforced zone. Now, once we get this dynamic force P del P A S acting in seismic condition then we will get the inertial force acting on the reinforced zone. Step 4 to calculate inertial force acting on the reinforced zone and that is P R S actually that inertial force so that means what are the things in step 1 we will calculate the a max then in step 2 calculate the a c, in the step 3 we calculate this delta P A S, in step 4 we will calculate this force actually, this is P R S, this is the inertial force in the reinforced zone due to seismic condition.

So, this is P R S, P reinforced zone in the seismic condition, this is the inertial force acting on the reinforced zone about the expression of sigma c gamma r H into L divided by g which is very simple that it, this this is this gamma r H L by g this is n and this is c is the acceleration. So, n into acceleration, mass into acceleration that is the inertial force. So, here acceleration is in the reinforced zone is a c then here gamma r is unit weight in the reinforced zone, H is the height of the retaining wall, L is the length of the retaining wall and g is the acceleration due to gravity.

So, now step 5, now we know that dynamic force, we know the inertial force and the step 5 is add P A S that is equal to P A plus delta P A S. So, this is the total force during the seismic condition P A S so we have to add P A S and 50 percent of P R S to the static force on the reinforced zone. And we have to check the all the possibilities and then check overturning, sliding, again. So, that means, so as it is it was designed for that purpose that we have already checked all these overturning, sliding for the static condition. Now, in this with that static condition force we have to add this delta P A S with the static condition force. So, that means this P A is only for static condition.

Now, we add delta P A S. Now, we can write this is delta P A S and 50 percent of P R S. So, total dynamic force and 50 percent of inertial force to the static force. Now, static force is P A so we have to add delta P A S, so with that and 50 percent of P R S acting on the reinforced zone. And now once this force are added due to this dynamic force, dynamic force, and this inertial force then we have to check again this overturning, sliding similar to the static condition, because these things when we check these overturning and sliding we consider only the static forces that is P A.

Now we have to add delta P A S and 50 percent of inertial force that is P R S within the reinforced zone and then we have to check again all the forces that means overturning and the sliding again. Now, the question is why we have taken 50 percent of P R S, the reason is that, that it is the fact that maximum value of delta P A S and P R S are unlikely to occur at the same time, that means the same time the field value of delta P A S and this P R S will not exist. So, that is why we will take 50 percent of P R S and then we will check this overturning and sliding.

So, once we check this overturning and sliding if it is safe then fine if it is not safe then we have to make, we have to change the, our properties that means length of the reinforcement, other things to make this conditions safe for the seismic condition. So, this is safe, this reinforced retaining wall under seismic condition also. That means we have to redesign these things, we have to change the dimension of the retaining wall and the all the other parameters so that it can be safe under seismic condition also, this is the externals checks.

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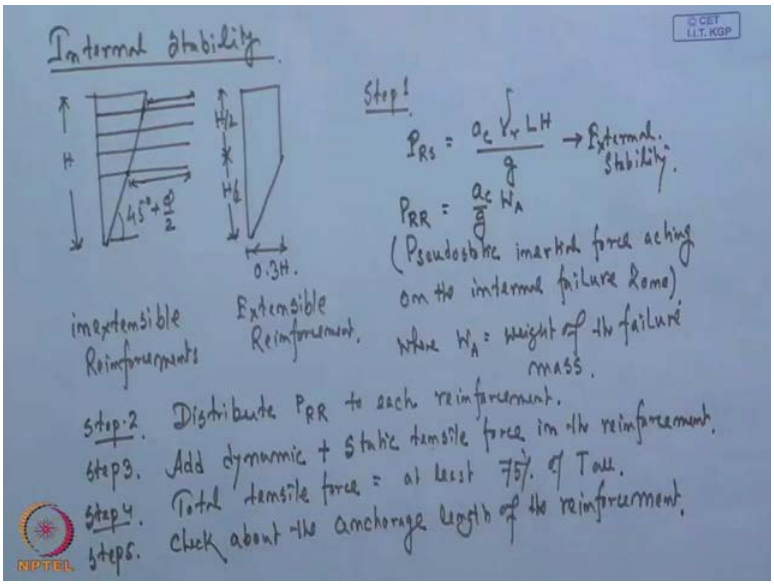

Internal stability.

inextensible Reinforcements

Extensible Reinforcement.

Step 1.

$P_{RS} = \frac{a_c \gamma_r LH}{g}$ → External. Stability.

$P_{RR} = \frac{a_c}{g} W_A$

(Pseudostatic internal force acting on the internal failure zone)

where W_A = weight of the failure mass.

Step 2. Distribute P_{RR} to each reinforcement.

Step 3. Add dynamic + static tensile force in the reinforcement.

Step 4. Total tensile force = at least 75% of T_{all}.

Step 5. Check about the anchorage length of the reinforcement.

Now, next to a part is for the internal checking of the reinforced wall. So, that means the internal stability checking. So and it is already been discussed that for the design criteria so this is the failure pattern for the 45 degree plus phi by 2 and this is another failure pattern for this two different types of reinforcement. So, this one is H by 2, this one also H by 2 and this total value is H and this value is given 0.3 of H. Now, this one is valid for inextensible reinforcement and this is extensible reinforcement. Now, based on that we have designed for the static condition also and we determine what are the spacing and the length. Now, let us check for the internal design steps further check the seismic condition stability.

Now, pseudo static internal force acting on the unstable internal failure zone, so we will calculate that P R S so that force we have already calculated that is sigma c, a c into gamma r L into H divided by g. So, these force we have already calculated. So, these force once we calculate this force, this is for the P R S that is our external design criteria. This is for the external stability check. So, when external stability so there is a difference between two forces. So, P R S we used for the external stability check condition. So, there we consider that for the forces acting here for this reinforced zone where this is L H and this is, so this weight and the force that P R S acting within the reinforced zone. So, that was used for the external checking condition.

Now, for the internal one we will calculate similar type of internal failure zone that is P R R so or we can write that is our pseudo static inertial force acting on the internal failure zone. So, that means in previous case we considered that the total weight of these zone. Now, here we will consider only failure zone. If this is for the failure zone for the inextensible reinforcement and if this is extensible reinforcement then we will get this type of failure. Now, I (( )) so we consider only the weight of these failure zone. So, now here for the internal checking that is this P R R that will be a c again divided by g into W A. Where W A is the weight of the failure mass so that means here, so that means external while consider the total weight of this zone, but in internal stability check we consider only the weight of this failure mass. So, we consider this weight of this failure mass for two different reinforcement condition. So, this is the only difference.

Now once we get this P R R now in the step 2 that will be the distribute this P R R P R R to each reinforcement. So, once we determine this P R R then we distribute this P R R to each reinforcement depending upon its area. Why we can distribute this reinforcement, this force, this additional force due to seismic condition equally to each reinforcement or you can, we can distribute is proportionately according to the area this reinforcement is covering to this reinforce because it is not always mandatory that reinforcement spacing a length would be same. It may be different so if it is different then proportionately we can distribute this additional force to the reinforcement.

And then and then an another condition that as I have mentioned that this is the length which is, if this is failure zone we can provide reinforcement up to this so that means there is a anchorage length and that if it is varying. Now, if it is not same for all the reinforcement. So, here this anchorage length that we have provided is more compared to the anchored length that we have provided here. So, depending upon the area of the anchorage length and the spacing we can distribute this force to the each reinforcement layer because then this design be more economical because here more, this force it can resist more if the anchorage length is more

So, we can distribute according to proportionately to the reinforcement. Then the step 3, then add the dynamic force, this additional force with the static force. Now, add now here the previously we have considered the static tensile force and based on that we have considered the, so previously based on the tension force developed with a reinforcement we design our spacing and then the length. So, now this static tensile force due to this dynamic force there will be the additional force that will developed within the reinforcement. So, this additional tensile force we will develop within the reinforcement so we have to add this additional tensile force with the static tensile force in the reinforcement that is developed within the reinforcement.

Now, the step 4 now that is once we add this dynamic and the static reinforcement, now this total tensile force that should be at least 75 percent of tau allowable. Now, that means the total tensile force and that will, this is due to the dynamic and the static that should be around the 75 percent of the tau allowable because at least 75 percent of the tau allowable.

So, the now the theme is that. So, suppose if we design it considering the total tensile force within the reinforcement, during the static design if we take the total allowable tensile force that is equal to and this this is full fully it will be utilize during the static condition. Then definitely if we design that thing for the seismic condition it will be unsafe, because we have already taken the total allowable tensile force of the reinforcement during the design of the static condition. So, the additional force during the dynamic condition, if it will act then we definitely this will be unsafe design. So, the option is that initially we do not, if we do not consider the total allowable force during a design that is one option and another option we can change the spacing and the length of the reinforcement so that we can account the static and the dynamic condition both.

So, that means when we consider the static condition, then we design our internal so initially we we consider that this is our static tensile force and now due to this dynamic force there to be a additional force act, will act within the reinforcement. So, this additional dynamic force also we have to incorporate within these allowable tensile strength of the reinforcement. So, we have redesign, we have to design the spacing and the length of the reinforcement so that it can account this additional tensile force.

Now, step 5 we have to check about the anchorage length of the reinforcement also. Once we take take the tensile strength of the reinforcement then there is another possibility, we have to check about the anchorage length of the reinforcement so that it can account both static and the dynamic condition. So, that we have to apply proper anchorage length beyond the failure surface so that it can account the both tensile and the static and the tensile condition. So, now here we have to design this if I consider the overall summary of this additional design. So, that means first we have to design for the static condition. So, then we will get an idea what would be the required length on and that thing we can use for the first all conditions. What would be the length of the reinforcement and what is the height and spacing? So, based on that we will design determine what would be the the area of the reinforced zone.

So, then there will be two different density. One is in the reinforced zone, another in the outside the reinforced zone. So, once we get the reinforced zone and based on that we will calculate that inertial force within the reinforced zone and then once we, then this inertial force and the dynamic force that will act that we have to add with static force to during the the external check of the stability. So, once we add these things then we have to check it again whether this is faced against overturning or sliding not. If it is safe fine, otherwise we have to redesign the reinforcement length and another parameter so that it can take the dynamic load also.

So, then there is two part. One is external another is internal. So, the internal one we have to again calculate the internal inertial force and that is for considering within the failure mass only, so on and then we have to distribute that force within the reinforcement and so that end up proportionality also. And then we have to check whether the tensile strength or tensile force which developed within the reinforcement due to the static condition and dynamic condition that is within the allowable limit or not. If it is not within the allowable limit then we have to check the design criteria and then we have to, in, change the spacing and the length of the reinforcement and as well as we have to check whether this anchorage length that we have provided during the static condition, that is sufficient or not during the dynamic or seismic condition or not.

If it is not sufficient then we have to provide more anchorage length so that this system can take the seismic load also. So, these are the steps of the design of the retaining wall, reinforced retaining wall under seismic condition.

So, now the next step that, another possibility is that so suppose another example how to shape the our structure for the reinforcement.

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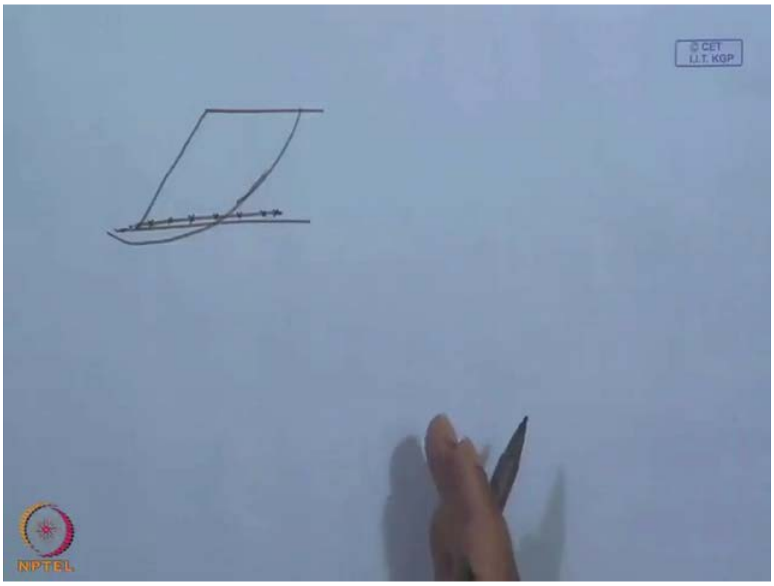

Suppose, if there is a slope and this slope is unstable during the, suppose this is this is the slope failure line and this is the unstable, it is it is stable during static condition, but it is unstable during seismic condition. So, there also if I provide a reinforcement layer here then we can shape the design against seismic condition also. That means there is possibility that these are the technique that we can make this design shape for the seismic condition. One example that I have already explained that how to shape this design against retaining wall, then we can account the seismic condition also. Then also we can make the our slope stable if I provide reinforcement also in the seismic condition. So, that is one option of making the structure stable against seismic condition.

So, then in the next section or the next class I will explain about the how this soil foundation interaction, and how this soil and found is they interact each other in the during the loading condition and different other condition. Those things I will explain in next few classes.

Thank you.