Port and Harbour Structures
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Module 4, Lecture 24
Active and Passive Earth Pressure
And Differential Water Pressure

This class we will discuss about Active, Passive and Differential Water Pressure. This Active Pressure and Earth Pressure and Differential Water pressure we have to calculate and apply as the load on to the structure. The passive earth pressure is the capacity of this structure. How much it can resist the loads. But it will resist the load depending on the resistance is equal to the amount of active and differential water pressure exerted on the structure. This point is clear.

Passive Earth pressure means, the passive earth resistance we call that is a maximum force that the style can mobilize to resist any external forces it can be to active act pressure or differential water pressure. So you can calculate active earth pressure, differential water pressure. Then you idealize by a soil support by a spring. Then find out what is the force on the spring that you compare with the passive earth resistance. So the passive earth resistance should be more than the spring force. Then the structure is safe.

So yesterday in the class I told you calculate the active earth pressure differential water pressure then find out the ratio between the passive earth resistance to the active and differential water pressure and that should be greater than 1.5 or 2, different ports give different values. Definitely it should not be equal to 1 or less than 1. It should be minimum 1.5 or it should be 2. And some of the failures that has happened has happened because of this design flaw in which we do not provide adequate Passive earth resistance. Yesterday some of you have answered you want to increase the passive earth resistance you have to increase the bounding level of the diaphragm wall that is what you have to do. First we will se what is earth pressure.

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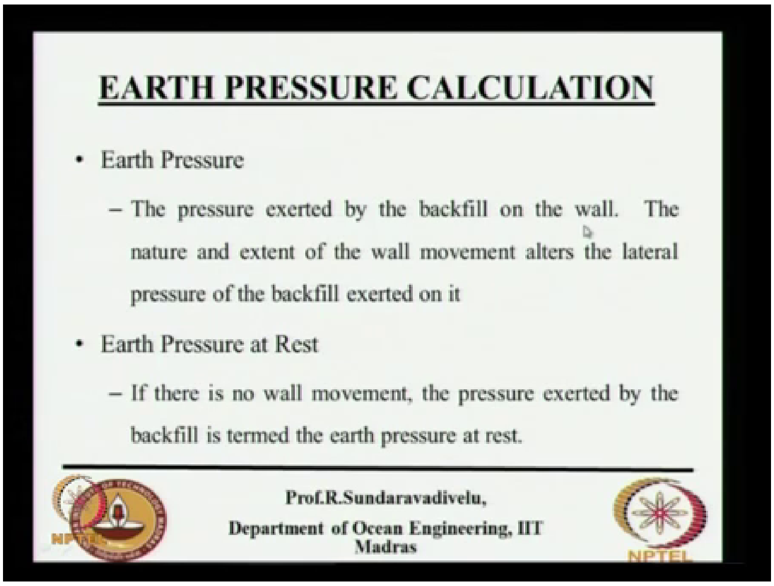

Earth pressure is exerted by the backfill on the wall in nature and extent of the wall movement alters the lateral pressure of the backfill exerted on it. That means when you have a wall on both the sides you have the soil then we have a pressure at rest on both the sides which are equal and opposite there is no earth pressure. If we start dredging on one side then the wall moves when the wall is moving the earth pressure coefficient at rest reduces down to active earth pressure. If there is no valve movement the pressure exerted by the backfill is termed as the pressure at rest.

It means if there is no movement of the soil then we have to calculate this earth pressure at rest. In case of massive gravity structures like cassions monoleath, even if you dredge on the other side the valve may not move, in that case we have to take pressure at rest.

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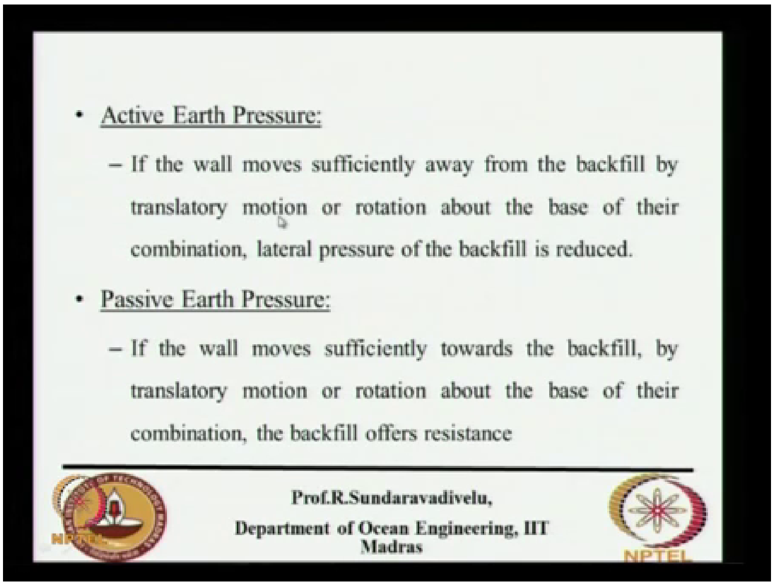

If the valve moves sufficiently from the backfill where translatory motion, or rotation about the base and their combination lateral pressure of the backfill is reduced from earth pressure at rest to active earth pressure. Passive earth pressure the valve moves sufficiently towards the backfill by translatory motion or rotation about the base or their combination the backfill offers resistance. So we use resistance for passive and pressure for active.

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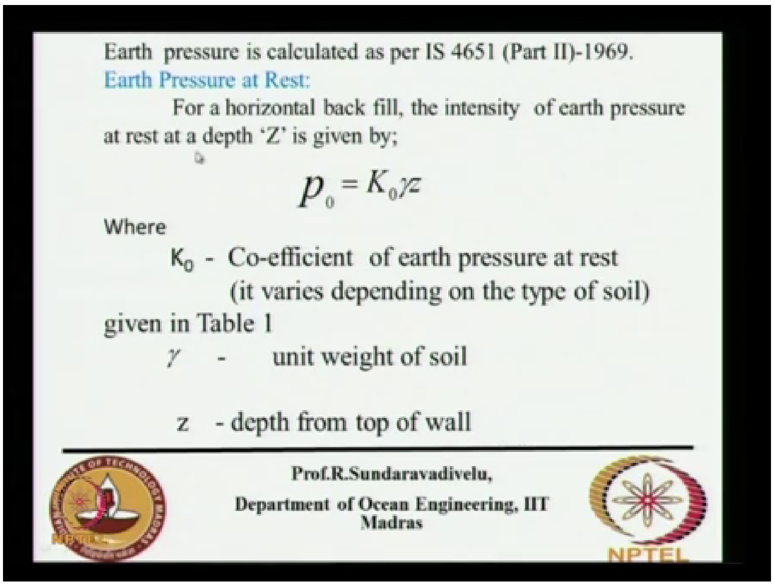

So how to calculate the earth pressure at rest is equal to p 0 multiplied by k 0 into gamma into E z where gamma is the unit weight of soil E z is the depth of the wall E 0 is the pressure k 0 is the non dimensional coefficient depending on the type of soil you can get these values. I do not have the table 1 here that I will present later. So k 0 typically is equal to 1 for most of the soils. So if we know the density of the soil and height of the soil to be be retained then you will get k 0, yz.

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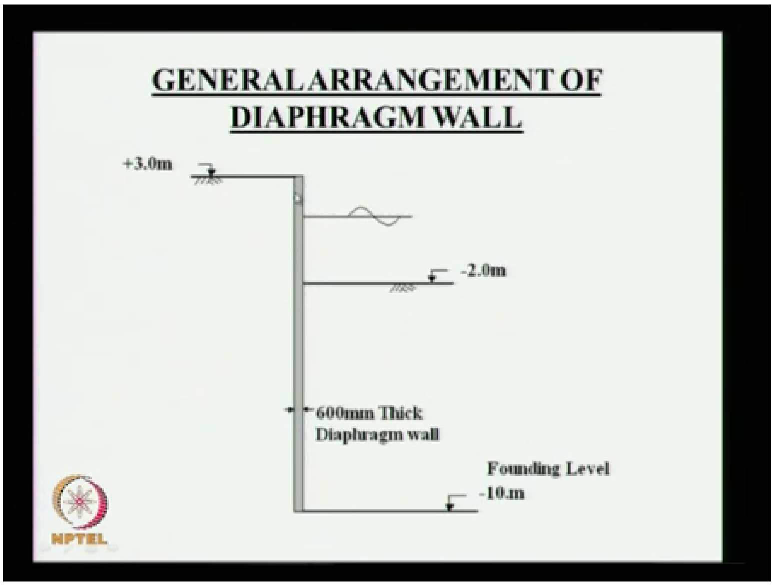

So this is the diaphragm valve means it is a structure which is from the top level of the berth to the founding level and this is called as the dredge level minus 2 meter is thickness of the diaphragm wall is 600 millimetres. Typically this thickness is 600 millimetre because we would like to do some boring and all when we do the boring then put a trummy pipe for concreting we need minimum thickness of 600 millimetres. We cannot do anything less than 600 millimetres you should know there are certain structures which minimum thickness is required.

What is the minimum diameter of the berth that can be used varying for concrete structures? hmm? 8 mm for columns? 12 mm What is the maximum diameter of the berth? Available? 50 mm but commonly used ? 32 mm.

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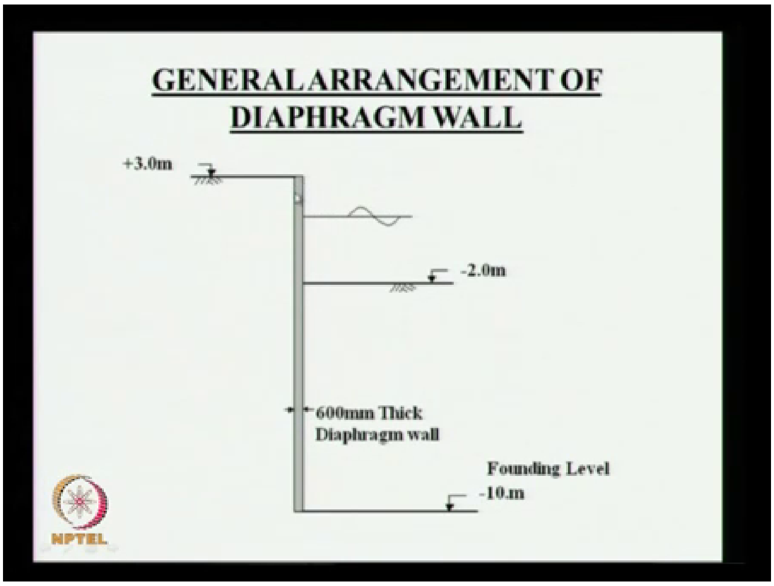

So similarly here also this thickness is 600 mm that is the minimum required this is called as a cantilever diaphragm wall. Why we say cantilever is? There will be a active earth pressure on this side there will be a passive resistance on this side. So this is minus 3 meter this is minus I am sorry this is plus 3 meter this is minus 2 meter the total unsupported length this is called as the unsupported length that is equal to 5 meters. This is called as the embedment depth from the dredge level to the founding level this is called as the embedment depth.

The embedment depth is about 8 meters.

Normally if this is 5 meters, 5 meter is sufficient; generally it is sufficient if the soil is very good. If the soil is not good it may go to 8 meters it depends on the type of soil. In some type of soil the embedment depth is equal to 0.75 times the unsupported length the soil is very good. So you should have some preliminary concept in deciding the founding level. This is important. This plus 3 meter how will you fix, how will you fix the top level of the berth? What are the criteria to fix the top level of the berth? What is it? Vessel free ford your navel architecture you are telling about vessel, vessel has nothing to do with the top level high water line.

If you have the high water line, high water line is high tide level plus tomser plus some air gap that only governs the top level of the berth. He was telling about the free board of the vessel all those things will govern the fender when you provide a fender what should be the bottom level of the fender and the top level of the fender depends on the draft and free board of the vessel. This is your bit level this depends on what? It is called as the dredge level also, what does it depend on? Now naval architecture comes into picture it comes into draft of the vessel plus under kill clearance. So that decides the dredge level.

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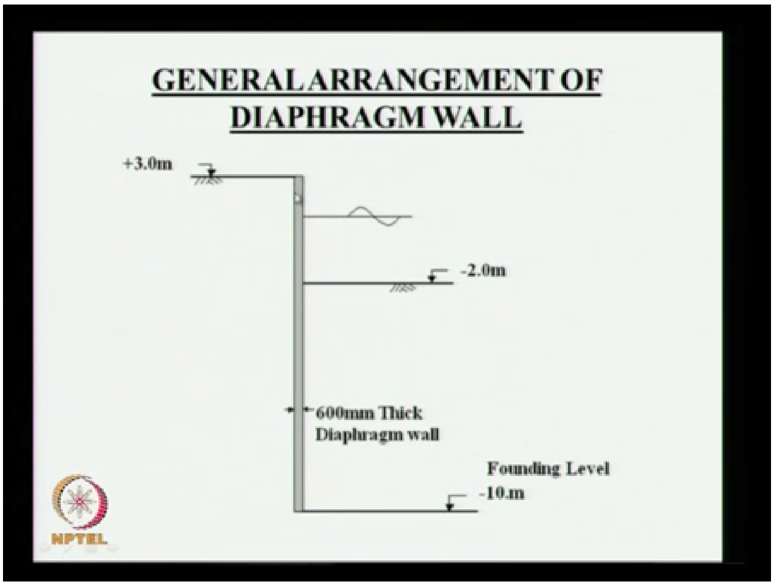

This is your water level what we have shown here this is your water level this water level will go up and down on the sea side because of the tide. What happens to water level on this side? This side also will go up and down. There will be some weak holes will be provided otherwise this also is not continuous there will be some joints which are not leak proof through that also water will not enter. So this water will also enter up and down when there is a flood or heavy monsoon rain the water level may go right up to the top.

All of us know about Tsunami when the tsunami happens the water level goes up I think the structure is being built in Cadalore Cadalore during Tsunami water level has gone about 10 meter above the normal water level. When this water level go down go up and then fill the entire area here. But during Tsunami the most dangerous part is not rising of water. Most dangerous part is lowering of the water.

The water level also may go down even it may go down right upto the bottom, upto minus 2 meter. Water level will you see some of the pictures we will see that some of the (())(09:43) which were in the water level about 4 5 meters completely the water is preceded back into the ocean. It is a long wave Tsunami is a very long wave that means the wave length may be in terms of kilo meters you see this is a wave. This is the profile of the wave.

When Tsunami comes this is about 1000 meters so some portion goes up and some portion goes down but you may not see the wave because it is very long 1000 meter, 1000 meter means from this point when this comes the water level may recied for a distance of about 1000 meters that is what happens. Suppose you want to build the structure like this diaphragm wall what we do is we fill up the entire area like this. We will fill up the entire area like this. Then we construct the structure afterwards we do the dredging.

So when you have the soil for the both the sides of the diaphragm wall this is called as the diaphragm wall you will have earth pressure at rest.on this side as well as earth pressure at rest on the other side. Once you build this diaphragm wall then if you start excavating the soil what will happen to the diaphragm wall? What will happen to it? The wall will be moving towards this side hmm towards the sea side towards the sea side.

That means the wall will be moving away from the soil then we will have the earth pressure. What happens to the wall here?The wall will also be moving it will be moving either towards this side or moving towards this side wherever it moves whether it is moving towards this side or this side you will have the passive pressure developed because the wall is moving towards the soil and it is moving towards the soil the wall is moving towards the soil when it is moving towards this side,ok.

So you will have this portion of the soil subjected to passive earth pressure this portion of the soil subjected to active earth pressure right? But when the wall is moving from this side to this side let us assume the wall reflects like this. So in that case we will have active as well as passive earth pressure.

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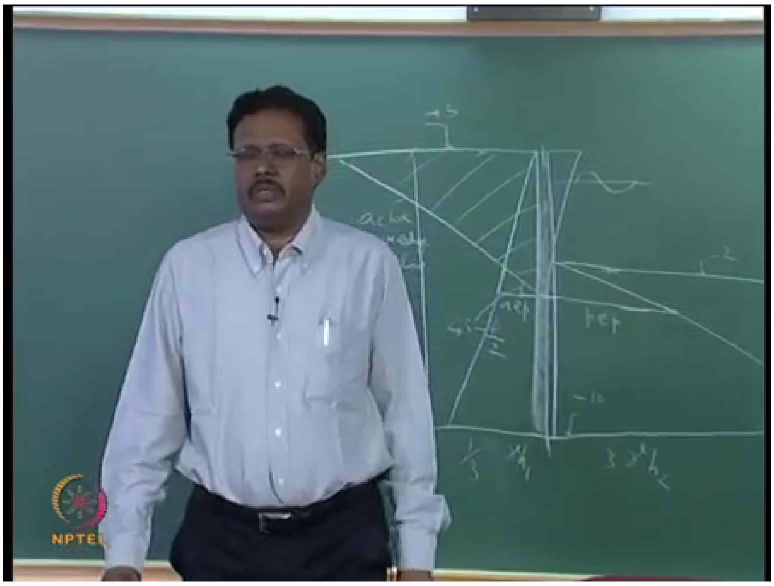

Whenever you draw a berthing structure this is structure this is a level on the land side, this is the level on the sea side this is your water level. These three things you should mark clearly, ok. Now let us assume that this wall is moving like this and the deflection is 0 below this point, ok. What happens now? So this is the point where the deflection is 0 this is your center line of the berth I am moving a wall,

so typically speaking you will have active earth pressure upto this point and passive earth pressure on this side, this is your active earth pressure this is your passive earth pressure. Passive earth pressure is very high it is the ordinate is very high active earth pressure is very less, that is why the ordinate is less. This wall is moving away from this soil so you will have active earth pressure right upto this point, ok.

This portion of the below this level this wall is moving towards the soil so you will have the passive earth pressure and from this point you will have wedge this is known as the active wedge line. This angle is 45 degree this minus pi by 2 it is angle which the active wedge line is formed. That means if you put any pile or anything that will not be able to resist any structure within this active zone. So this is your active zone it is this much of the soil moves along with the structure.

But when you do the calculation what you do is we calculate right upto the bottom active earth pressure and right upto the bottom passive earth pressure. Here we do not know the deflection, hmm? Deflection is what we have to find out? Once you know the deflection only you know at what point the deflection is 0. So what we do is we apply the active earth pressure land side.

And this passive earth pressure we cannot calculate you see the area of the angle will be typically one of the area of the modern triangle the site is more the site is less but this ordinate is very high . Typically if this is one third k, h this will be 3 times sorry k is 1 by 3 for 5 is equal to degree this will be 3 times, into h this will be h 2 let us say this is h 1, h 1 is this h 2 is .

So this value is plus 3 this is minus 10 so this h 1 will be about 18 meters. This is n is to so this will be about 8 meter. So h 2 is less than h 1 but this is 1 by 3 that is 3, that means area of this triangle will be almost twice or three times better area of this triangle. See one of the common mistake most of the people even experienced people do is they calculate their active earth pressure and apply the load on this side calculate the passive earth pressure and apply the load on the other side. That should not be done, is it clear?

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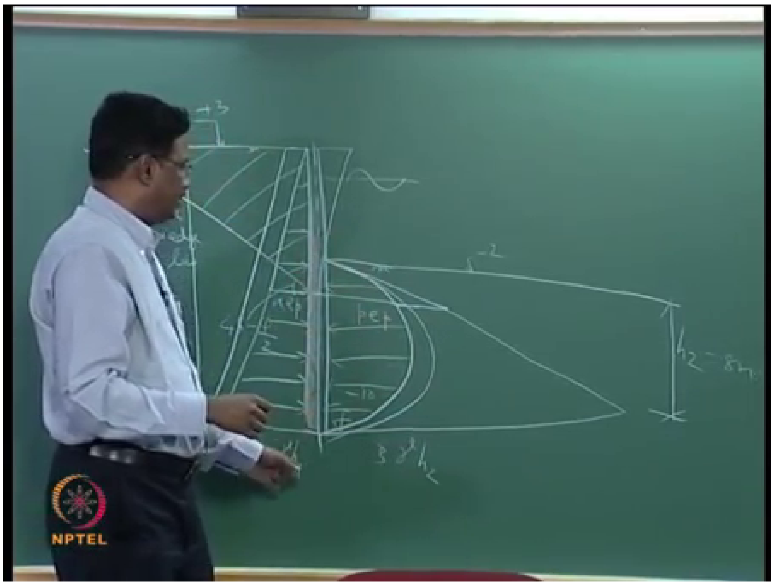

What will happen is the mobilization of passive earth pressure will be something like this. Area of this parabola will be equal to area of this triangle you have to estimate this pressure distribution, this point is clear? You can apply the active earth pressure as a load never apply the passive earth pressure as a load depending on how much load that is acting on this structure the passive earth resistance will be developed.

Initial position it will follow the line it will fully mobilize the passive earth resistance as you go it will reduced towards the end it will be nearly equal to 0 we have to find out this passive earth pressure. Suppose you put earth pressure due to surcharge on top of this then this curve will increase like this, suppose you calculate the differential water pressure when this curve will extend so you have to find out this.

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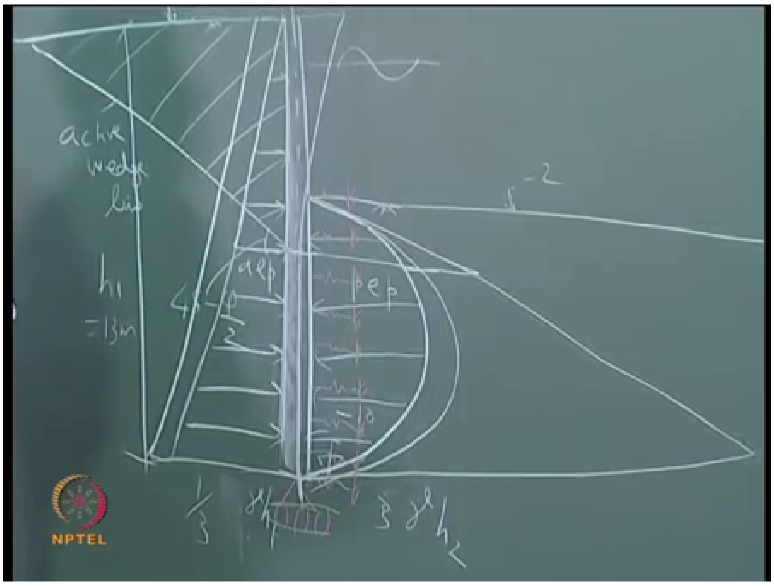

How to find out this/ What you do is? You put space, at various interval this is to idealize the soil support. We will be discussing about this in this class about this soil support also. When you do your finite element analysis boundary conditions are very much important if you do not provide a correct boundary conditions your solution will not take place put your roller support and put a spring here and the spacing of the springs should be very finite.

Finite means what? Finite means you know exactly what is the size infinite means we do not know finite means we should know what should be this distance. What should be this distance? We have this 8 meters can we put one spring here and one spring here and do the analysis? Yes or no we do not have time sir no then, how many springs you have to put? 100 springs? 1000 springs? Hmm? Question is clear, have you understood the question? Yes or no?

Answer how many springs you have to put? If we put 100 1000 springs your research will be definitely correct hmm? 100 1000 springs you can put it will be correct 1000 also it may be write 100 also it may be write, but if you put 100 springs you have to generate and you have to do the analysis computer also have to do lot of time and all. And how many springs you have to put? Hmm? Spacing is 1 meter he is telling I am not basis 1 meter , 1 is the unit of measurement, ok.

In olden days when Britishers were ruling us they have done the Civil Engineering they have a formula for 1 foot span the depth should be 1 inch because they know only inch and foot. That means if the span is 12 feet what will be the depth of the beam 12 inches, that means span by dept ratio is 1 by 12. So most of the things will be related to inch or foot. So he is telling related to meter. 1meter means foot 1 meter.

You should relate to some dimension which is given in this problem what dimension it is? Answer is always there but it is not in the board but it is there in the power point slide. What is not there in the board thickness hmm thickness so that is the answer. The spacing of the spring should be equivalent to thickness of the diaphragm wall. This cannot be done just like that I have one Phd student we varied the spring spacing then we found out for what spring spacing the convergence takes place.

Typically it takes place when the spring spacing is equal to the thickness of the diaphragm wall it is the pile diameter of the diaphragm wall, hmm? But you can have closer springs and as you go down you can increase the spacing of the spring. But when you increase it, it should be not more than 4 times the thickness of the diaphragm wall, ok. You cannot increase it indefinitely also. So we will be seeing both these aspects in this class that I will not be able to teach this spring does it needs 4 number of classes one day we will I will do it another power point lecture.

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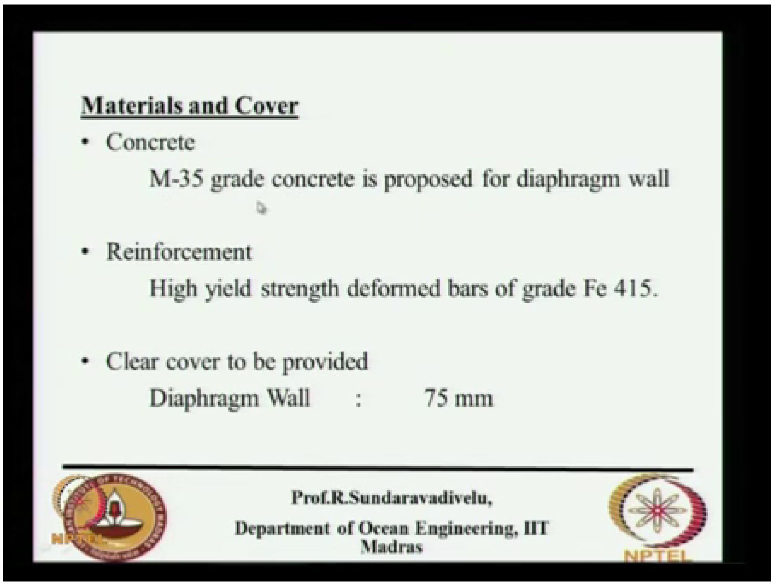

We have to use the grade of concrete we are using M 35 grade of steel 4 on 5. Now the 4 on 5 grade is not available in the market everybody has gone for 500. So 500 grade only is available cover to be provided is 75 mm civil concrete structures these are the requirement. Just for completion sake we have given.

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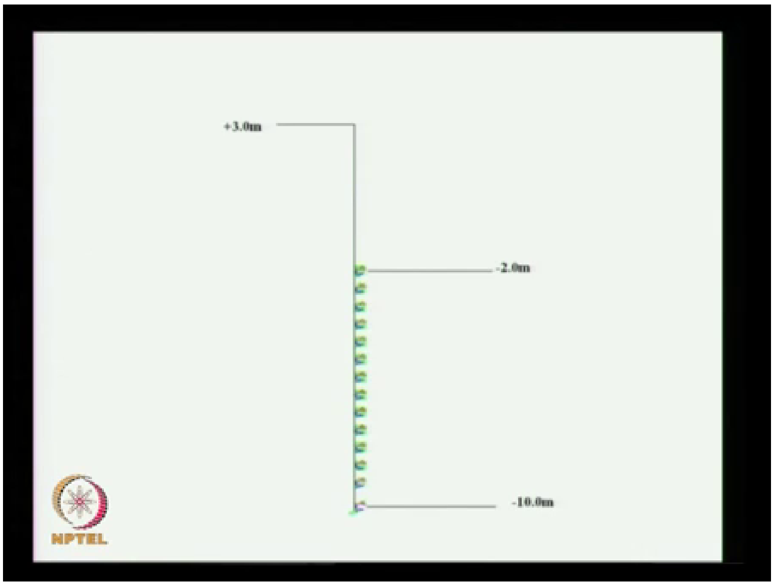

So these are the springs roller is provided, let us see how many springs they have given 1,2,3,4,5,6,7,8,9,10,11,12,13 and 14 springs, 14 springs means 18 spacing. So 8 by 13 will be approximately 0.6 meter we have provided 0.6 meter this is the top level this is the dredge level.

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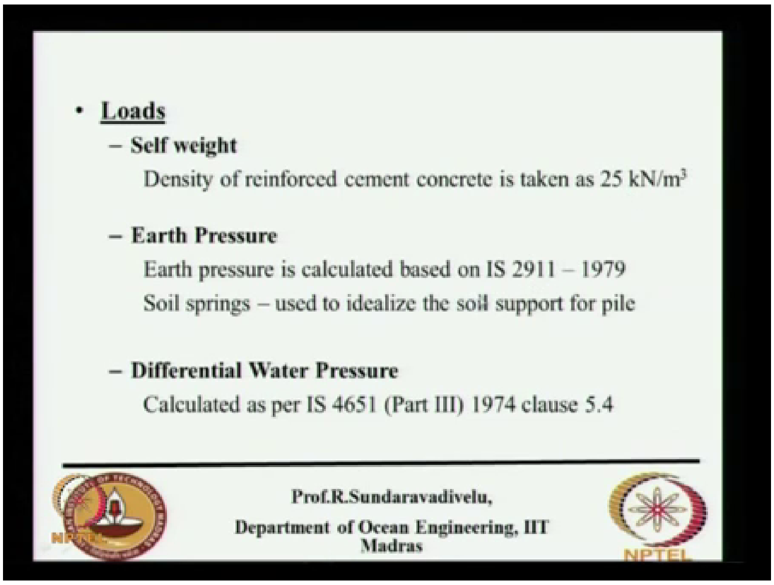

So you have to calculate the sulphide that is as per you have to assume the density earth pressure you are using IS 2911 and soil spring also is a procedure to idealize the soil support and differential water pressure we are calculating as per IS4651 (Part III) 1974 clause 5.4. This is a typical way in which we write the design methodologies most of you will be going for an Engineering job. So the presentation is very important when you want to say how you want to calculate the differential water pressure you should write the code number as soon as the clause number, year is also important which year it was revised.

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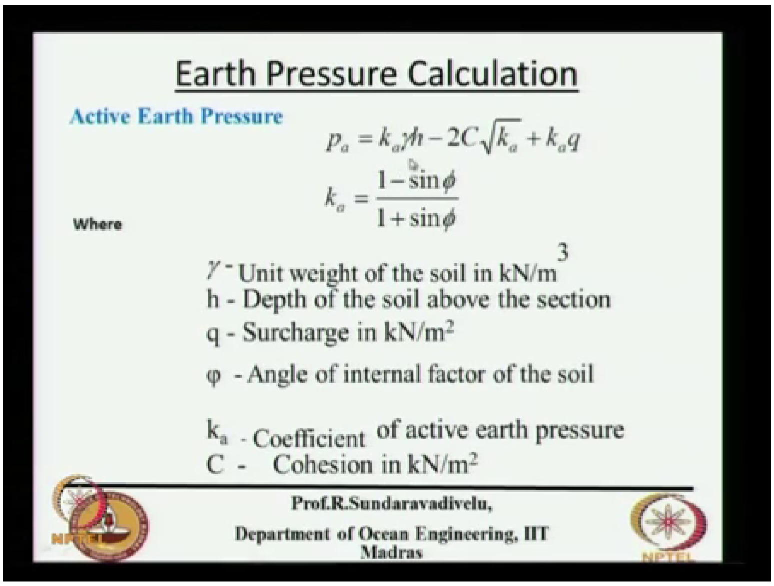

This is the expression for active earth pressure k a gamma h all of you know about this, this is for sandy soil minus 2 c into root of K a this is for cohesive soil. You may have a soil which is both having phi as well as c, phi c soil in that case you will use both the terms first term and second term.

If it is purely sand you will use only the first term if it is purely clay you will use only the second term. I am sorry! If it is clay you will use this as well as this both the things you have to use. This is due to surcharge, surcharge is the load which is acting on the back fill so we will be using some terms backfill.

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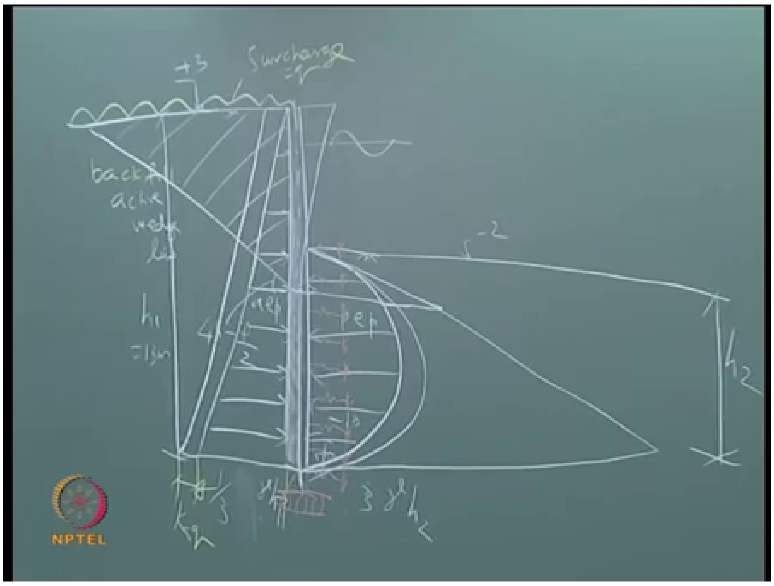

So this soil on this background this is called as the backfill this material what is here is the backfill and this is the load what is acting on this is called as the surcharge. So this surcharge is q then this value will be is equal to k a into q. This ordinate what we are marking this is your active earth pressure. K a is given by this formula 1 minus sin phi by 1 plus sin phi. So we have to get all these parameters that is phi is to be used to calculate k a and the value of phi as well as c this has to be taken from the soil investigation report.

Typically the surcharge is we have discussed in one thing uniformly distributed load as per IS it varies from 1 ton kilo Newton per meter square to 50 kilo Newton per meter square So typically a structure will have a apron that means a structure will be there big structure then behind only you will have a backfill, the backfill surcharge is typically 50 percent of the UDL on the apron or the berth.

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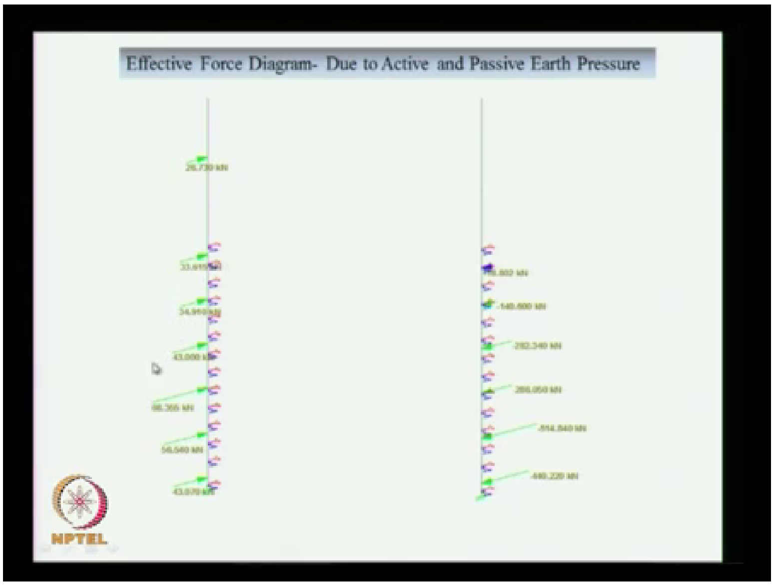

So they have calculated the active earth pressure it is not here the values vary from 26.73 this is the force they have calculated what you calculate is a pressure that pressure multiplied by the area which it is acting it will give the force we have one node here and another node here you calculate the active earth pressure as a triangle find out the area of the triangle in applying at the C g.

Then other active earth pressure loads are given. These values are very small these are compared to the passive earth pressure varying from 18 to 440 whereas here it is 26 to 58.54. Here it is less because they would have taken off the value here spacing when we calculate the area. So when you do the analysis we will know exactly how much force is developed that we will discuss in another class.

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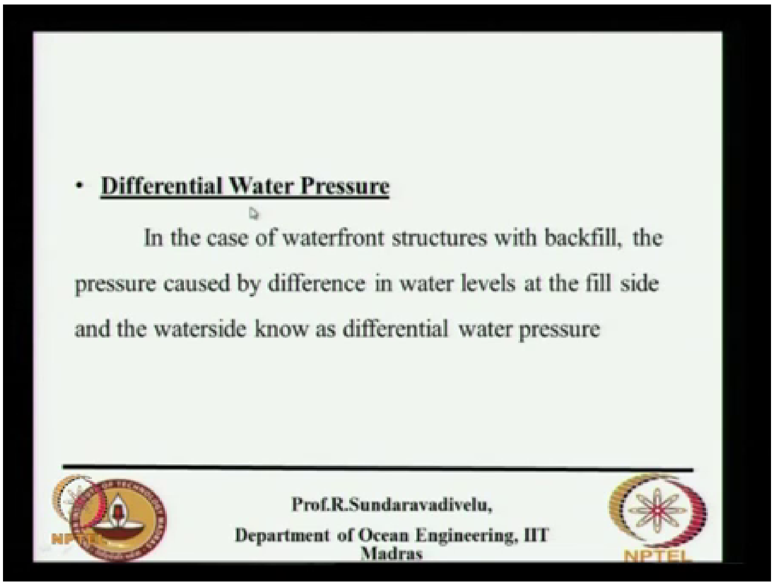

Then we have to calculate the differential water pressure in case of water front structure with backfill but there are some water front structure without backfill that is a open type structures where we do not have earth pressure or differential water pressure. The pressure caused by the difference in water level at the fill side and the water side is known as differential water pressure.

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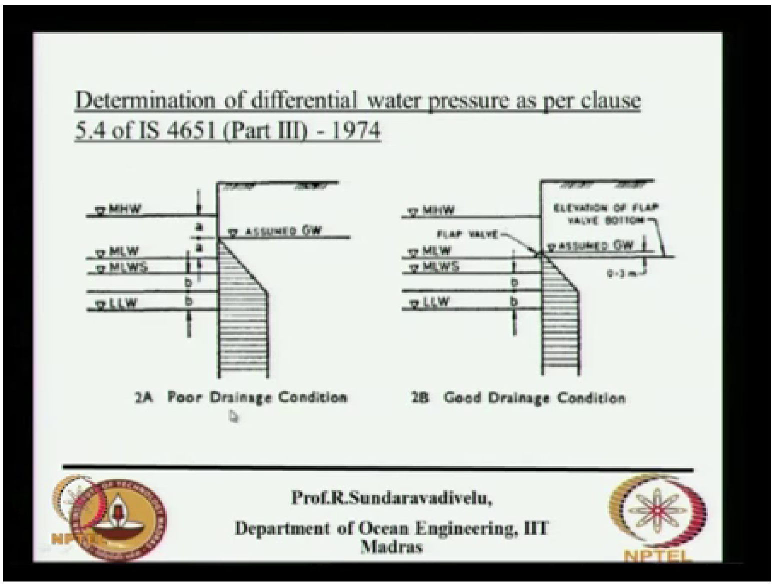

So this is a diagram taken from clause 5.4 there are two conditions given one is a poor drainage condition another is a good drainage condition. In a good drainage condition the water level below the deck is assume 0.3 meter mean low water but you have to provide a flap valve that means you have to provide some mip holes over the water will drain inside that is a good drainage condition.

Typically sandy soils are good drainage but we have cohesive soil the permeability is low in that case we have to assume the ground level as average between mean low water and mean high water near no we have to assume two water levels very simple. There will be a problem on this, so you remember how these values I will give mean low water mean high water spring and lowest low water. These 4 water levels will be given.

You will be asked to calculate the differential water pressure whether it is a poor drainage or good drainage. First you have to find out what is the water level below the top level of the berth. For a good drainage condition the water level is assumed as 0.3 meter above the mean low water. For the case of poor drainage it is assumed as average of mean high water and mean low water. In both the cases the water level on sea side is assumed as average of mean low water spring and waste low water, this side also mean low water spring and lowest low water.

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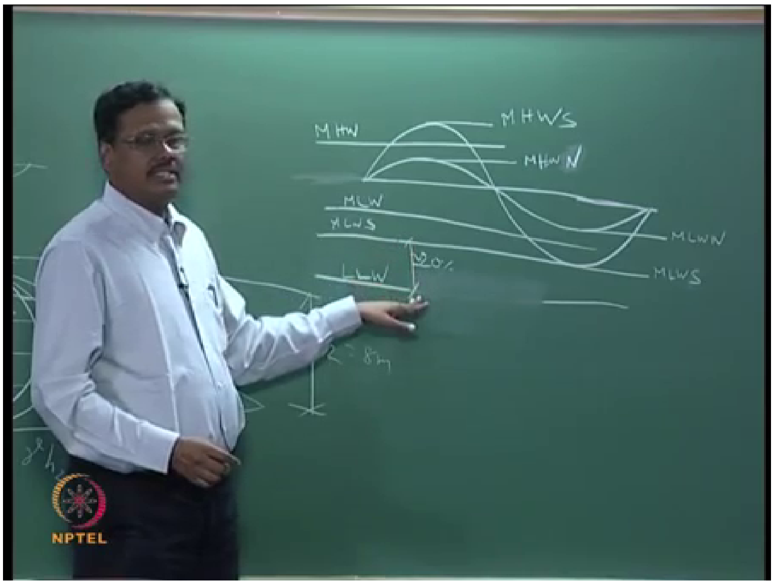

So now I have drawn this figure earlier may be I will draw this again so when you have this spring type you will have the spring type like this and we will have the nip tide you will have it like this. So this will be your mean high water this will be I am sorry high water spring this will be your main water spring this will be your mean low water nib. This depends on whether it is a full moon day or a new moon day.

These are the moon if you take so many full moon or new moon days and take the average that is called as mean high water spring tide mean low water nib tide what is mean sea level we want this mean high water what is mean high water? Mean high water is mean of these two, ok this is mean high water spring mean low water nib you take the mean of that, that what we will use is this is called as mean high water. Then we want to use the mean low water spring this level is what is being used.

Then we want to use the mean low water, mean low water is the average between these two, please try to understand because may not I will not give mean high water mean low water and all I will give only these four levels. From this you have to calculate mean high water and mean low water. Please draw the figure and try to understand otherwise you cannot answer the question I have corrected the papers some of you have scored only 4 5 marks maximum (8 and) 18 and half out of 25.

So please study properly, this is mean low water spring and lowest low water is some are here this lowest low water is approximately about 0.8 times mean low water spring. The difference between them is about 20 percent I will not write like this it is not correct, the difference between them will be about 20 percent approximately. Lowest low water will be about 20 percent less than the lowest low water.

In Engineering you should know what should be the parameter if you are giving if I am giving mean high water spring mean low water nib I am sorry there is a mistake here mean low water spring I am sorry this is mean high water spring, this is also wrong hmm? Mean low water spring it is correct only, only one thing is wrong this mean high water nib give mean high water spring mean high water nib mean low water nib and mean low water spring .

Average between these two will mean high water average between these two gives mean low water, mean low water spring as it is we are using lowest low water is about 20 percent less than the mean low water spring. Typically this is equal to 0.0 which is used as a short data. You please remember this figure you draw the figure and then try to calculate the earth pressure.